0042754

JACOBS ENGINEERING GROUP, INC.
1995

(CALCULATIONS)

JAN 1996
RECEIVED
EDMC

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Safety: Transportation Accident Calculations

ORIGINATOR Michael R. Harker DATE 12/1/95

REVISION NO. 0

OBJECTIVE Provide number of fatalities and injuries resulting from employee vehicle accidents and transport (truck & rail) accidents.

METHODOLOGY Determine distance traveled in population zone and multiply distance by appropriate injury & fatality incidence rates.

ASSUMPTIONS

1- each person works 260 days a year. 2) round trip distance traveled to work from Tri Cities was 140 Km. 3) 1.35 passengers per vehicle. 4) Vitrified glass shipped to Yucca Mt. 2.938E+03 Km round trip by rail.

(Continue on another sheet if necessary)

SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

	EX SITU INTERMEDIATE SEPARATIONS ALTERNATIVE							
RETRIEVAL								
Waste Transport						total		
Onsite Truck						1.25E+04		
							Total	1.25E+04
Construction								
Offsite Truck			trips/yr	km/trip	yr	total		
	concrete		4.80E+02	1.40E+02	2.00E+01	1.34E+06		
	raw material		4.50E+01	8.00E+02	2.00E+01	7.20E+05		
	equipment		2.50E+01	1.00E+04	2.00E+01	5.00E+06		
	miscellaneous		5.20E+03	1.40E+02	2.00E+01	1.46E+07		
	steel W-314		5.30E+01	8.00E+02		4.24E+04		
	cement W-314		1.00E+02	1.40E+02		1.40E+04	Total	2.17E+07
Offsite Rail			trips/yr	km/trip	yr	total		
	raw material		1.00E+01	8.00E+02	2.00E+01	1.60E+05	Total	1.60E+05
Onsite Truck								
	borrow W-314		1.38E+03	1.00E+01		1.38E+04	Total	1.38E+04
VITRIFICATION								
Construction								
Onsite Truck			trips	km/trip		total		
	borrow		5.20E+04	1.00E+01		5.20E+05		
							Total	5.20E+05
Offsite Truck			trips	km/trip		total		
	concrete		2.90E+04	1.40E+02		4.06E+06		
	steel		9.50E+03	8.00E+02		7.60E+06		
			trips/yr	km/trip	yr			
	miscellaneous		5.20E+03	1.40E+02	1.00E+01	7.28E+06		
							Total	1.89E+07
Processing								
Offsite Truck			trips/yr	km/trip	yr	total		
	glassformer/chem		2.30E+01	8.00E+02	1.95E+01	3.59E+05		
	miscellaneous		5.20E+03	1.40E+02	1.95E+01	1.42E+07		
							Total	1.46E+07
Offsite Rail			trips/yr	km/trip	yr	total		
	glassformer/chem		2.60E+02	8.00E+02	1.95E+01	4.06E+06		
							Total	4.06E+06
VITRIFIED HLW TRANSPORT								
Offsite Rail			trips	km/trip		total		
	Yucca Mountain		1.70E+02	2.93E+03		4.98E+05		
							Total	4.98E+05
CLOSURE								
Onsite Truck			cu yd	trip/cu yd	km/trip	total		
	fill		9.86E+05	1.00E-01	1.00E+01	9.86E+05		

	silt		6.93E+05	1.00E-01	3.00E+01	2.08E+06		
	riprap		1.05E+06	1.00E-01	3.20E+01	3.36E+06		
	ag/sand		7.93E+05	1.00E-01	1.00E+01	7.93E+05		
							Total	7.22E+06
GROUT FILL IMUST								
Onsite Truck sand/gravel			2.20E+03	1.00E+01		2.20E+04	Total	2.20E+04
Offsite Truck cement			4.63E+02	1.40E+02		6.48E+04	Total	6.48E+04
Onsite Truck (km)		7.79E+06						
Onsite Rail (km)		0.00E+00						
Offsite Truck (km)		5.52E+07						
Offsite Rail (km)		4.71E+06						
EMPLOYEE VEHICLE								
Retrieval		person-yr	trip/yr	km/trip	car pool	total		
	Const.	1.06E+04	2.60E+02	1.40E+02	7.41E-01	2.86E+08		
	Ops/D&D	3.74E+04	2.60E+02	1.40E+02	7.41E-01	1.01E+09		
Vitrification								
	Const.	1.98E+04	2.60E+02	1.40E+02	7.41E-01	5.34E+08		
	Ops/D&D	1.73E+04	2.60E+02	1.40E+02	7.41E-01	4.67E+08		
Closure		4.90E+02	2.60E+02	1.40E+02	7.41E-01	1.32E+07		
							Total	2.31E+09
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	5.52E+07	5.00E-02			2.76E+06		
	Rail	4.71E+06	5.00E-02			2.36E+05		
Suburban								
	Truck	5.52E+07	5.00E-02		7.79E+06	1.05E+07		
	Rail	4.71E+06	5.00E-02			2.36E+05		
Rural								
	Truck	5.52E+07	9.00E-01			4.97E+07		
	Rail	4.71E+06	9.00E-01			4.24E+06		
Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			2.76E+06	2.36E+05	1.05E+07	2.36E+05	4.97E+07	4.24E+06
urban truck fat/km		7.50E-09	2.07E-02					

urban truck inj/km		3.70E-07	1.02E+00					
urban rail fat/km		1.70E-08		4.01E-03				
urban rail inj/km		3.30E-08		7.78E-03				
sub truck fat.km		1.30E-08			1.37E-01			
sub truck inj/km		3.80E-07			4.01E+00			
sub rail fat/km		1.70E-08				4.01E-03		
sub rail inj/km		3.30E-08				7.78E-03		
rural truck fat/km		5.30E-08					2.63E+00	
rural truck inj/km		8.00E-07					3.98E+01	
rural rail fat/km		1.70E-08						7.21E-02
rural rail inj/km		3.30E-08						1.40E-01
	TOTAL FATALITIES		2.87E+00					
	TOTAL INJURIES		4.50E+01					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	2.31E+09	8.98E-09	2.07E+01				
	injuries	2.31E+09	7.14E-07	1.65E+03				
Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		2.87E+00	2.07E+01	2.36E+01			
	INJURIES		4.50E+01	1.65E+03	1.69E+03			

		EX SITU NO SEPARATIONS ALTERNATIVE					
RETRIEVAL							
Waste Transport					total		
Onsite Truck					1.25E+04	Total	1.25E+04
Construction							
Offsite Truck		trips/yr	km/trip	yr	total		
	concrete	4.80E+02	1.40E+02	2.00E+01	1.34E+06		
	raw material	4.50E+01	8.00E+02	2.00E+01	7.20E+05		
	equipment	2.50E+01	1.00E+04	2.00E+01	5.00E+06		
	miscellaneous	5.20E+03	1.40E+02	2.00E+01	1.46E+07		
	steel W-314	5.30E+01	8.00E+02		4.24E+04		
	cement/misc W-314	1.53E+02	1.40E+02		2.14E+04	Total	2.17E+07
Offsite Rail		trips/yr	km/trip	yr	total		
	raw material	1.00E+01	8.00E+02	2.00E+01	1.60E+05	Total	1.60E+05
Onsite Truck							
	borrow W-314	1.38E+03	1.00E+01		1.38E+04	Total	1.38E+04
VITRIFICATION							
Construction							
Onsite Truck		trips	km/trip		total		
	borrow	2.02E+04	1.00E+01		2.02E+05	Total	2.02E+05
Offsite Truck		trips	km/trip		total		
	Try Cities	1.30E+04	1.40E+02		1.82E+06		
	Portland/Seattle	5.00E+03	8.00E+02		4.00E+06		
		trips/yr	km/trip	yr			
	miscellaneous	5.20E+03	1.40E+02	5.50E+00	4.00E+06	Total	9.82E+06
Processing							
Offsite Truck		trips/yr	km/trip	yr	total		
	Portand/Seattle	5.00E+01	8.00E+02	1.40E+01	5.60E+05		
	miscellaneous	5.20E+03	1.40E+02	1.40E+01	1.02E+07	Total	1.08E+07
Offsite Rail		trips/yr	km/trip	yr	total		
	Portland/Seattle	1.03E+02	8.00E+02	1.40E+01	1.15E+06	Total	1.15E+06
VITRIFIED HLW TRANSPORT							
Offsite Rail		trips	km/trip		total		
	Yucca Mountain	2.14E+03	2.93E+03		6.27E+06	Total	6.27E+06
CLOSURE							
Onsite Truck		cu yd	trip/cu yd	km/trip	total		
	fill	9.86E+05	1.00E-01	1.00E+01	9.86E+05		

	silt		4.93E+05	1.00E-01	3.00E+01	1.48E+06		
	riprap		8.35E+05	1.00E-01	3.20E+01	2.67E+06		
	ag/sand		5.43E+05	1.00E-01	1.00E+01	5.43E+05	Total	5.68E+06
GROUT FILL IMUST								
Onsite Truck sand/gravel			2.20E+03	1.00E+01		2.20E+04	Total	2.20E+04
Offsite Truick cement			4.63E+02	1.40E+02		6.48E+04	Total	6.48E+04
Onsite Truck (km)		5.93E+06						
Onsite Rail (km)		0.00E+00						
Offsite Truck (km)		4.23E+07						
Offsite Rail (km)		7.58E+06						
EMPLOYEE VEHICLE								
Retrieval		person-yr	trip/yr	km/trip	car pool	total		
	Const.	1.06E+04	2.60E+02	1.40E+02	7.41E-01	2.86E+08		
	Ops	3.50E+03	2.60E+02	1.40E+02	7.41E-01	9.44E+07		
Vitrification								
	Const.	1.48E+04	2.60E+02	1.40E+02	7.41E-01	3.99E+08		
	Ops	9.78E+03	2.60E+02	1.40E+02	7.41E-01	2.64E+08		
Closure		4.62E+02	2.60E+02	1.40E+02	7.41E-01	1.25E+07		
	total	3.91E+04					Total	1.06E+09
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	4.23E+07	5.00E-02			2.12E+06		
	Rail	7.58E+06	5.00E-02			3.79E+05		
Suburban								
	Truck	4.23E+07	5.00E-02		5.93E+06	8.05E+06		
	Rail	7.58E+06	5.00E-02			3.79E+05		
Rural								
	Truck	4.23E+07	9.00E-01			3.81E+07		
	Rail	7.58E+06	9.00E-01			6.83E+06		
Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			2.12E+06	3.79E+05	8.05E+06	3.79E+05	3.81E+07	6.83E+06
urban truck fat/km		7.50E-09	1.59E-02					
urban truck inj/km		3.70E-07	7.83E-01					
urban rail fat/km		1.70E-08		6.45E-03				
urban rail inj/km		3.30E-08		1.25E-02				

sub truck fat.km		1.30E-08			1.05E-01			
sub truck inj/km		3.80E-07			3.06E+00			
sub rail fat/km		1.70E-08				6.45E-03		
sub rail inj/km		3.30E-08				1.25E-02		
rural truck fat/km		5.30E-08					2.02E+00	
rural truck inj/km		8.00E-07					3.05E+01	
rural rail fat/km		1.70E-08						1.16E-01
rural rail inj/km		3.30E-08						2.25E-01
	TOTAL FATALITIES		2.27E+00					
	TOTAL INJURIES		3.46E+01					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	1.06E+09	8.98E-09	9.48E+00				
	injuries	1.06E+09	7.14E-07	7.54E+02				
Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		2.27E+00	9.48E+00	1.17E+01			
	INJURIES		3.46E+01	7.54E+02	7.88E+02			

		EX SITU EXTENSIVE SEPARATIONS ALTERNATIVE						
RETRIEVAL								
Waste Transport						total		
Onsite Truck						1.25E+04	Total	1.25E+04
Construction								
Offsite Truck			trips/yr	km/trip	yr	total		
	concrete		4.80E+02	1.40E+02	2.00E+01	1.34E+06		
	raw material		4.50E+01	8.00E+02	2.00E+01	7.20E+05		
	equipment		2.50E+01	1.00E+04	2.00E+01	5.00E+06		
	miscellaneous		5.20E+03	1.40E+02	2.00E+01	1.46E+07		
	steel W-314		5.30E+01	8.00E+02		4.24E+04		
	cement/misc W-314		1.53E+02	1.40E+02		2.14E+04	Total	2.17E+07
Offsite Rail			trips/yr	km/trip	yr	total		
	raw material		1.00E+01	8.00E+02	2.00E+01	1.60E+05	Total	1.60E+05
Onsite Truck								
	borrow		1.38E+03	1.00E+01		1.38E+04	Total	1.38E+04
VITRIFICATION								
Construction								
Onsite Truck			trips	km/trip		total		
	borrow		6.10E+04	1.00E+01		6.10E+05	Total	6.10E+05
Offsite Truck			trips	km/trip		total		
	Tri-Cities		2.70E+04	1.40E+02		3.78E+06		
	Portland/Seattle		1.10E+04	8.00E+02		8.80E+06		
			trips/yr	km/trip	yr			
	miscellaneous		5.20E+03	1.40E+02	9.00E+00	6.55E+06	Total	1.91E+07
Processing								
Offsite Truck			trips/yr	km/trip	yr	total		
	glassformer/chem		5.13E+02	8.00E+02	1.60E+01	6.57E+06		
	miscellaneous		5.20E+03	1.40E+02	1.60E+01	1.16E+07	Total	1.82E+07
Offsite Rail			trips/yr	km/trip	yr	total		
	glassformer/chem		6.37E+02	8.00E+02	1.60E+01	8.15E+06	Total	8.15E+06
VITRIFIED HLW TRANSPORT								
Offsite Rail			trips	km/trip		total		
	Yucca Mountain		1.00E+01	2.93E+03		2.93E+04	Total	2.93E+04
CLOSURE								
Onsite Truck			cu yd	trip/cu yd	km/trip	total		
	fill		9.86E+05	1.00E-01	1.00E+01	9.86E+05		

	silt		6.93E+05	1.00E-01	3.00E+01	2.08E+06		
	riprap		1.05E+06	1.00E-01	3.20E+01	3.36E+06		
	ag/sand		7.93E+05	1.00E-01	1.00E+01	7.93E+05	Total	7.22E+06
GROUT FILL IMUST								
Onsite Truck sand/gravel			2.20E+03	1.00E+01		2.20E+04	Total	2.20E+04
Offsite Truck cement			4.63E+02	1.40E+02		6.48E+04	Total	6.48E+04
Onsite Truck (km)		7.88E+06						
Onsite Rail (km)		0						
Offsite Truck (km)		5.91E+07						
Offsite Rail (km)		8.34E+06						
EMPLOYEE VEHICLE								
Retrieval		person-yr	trip/yr	km/trip	car pool	total		
	Const.	1.06E+04	2.60E+02	1.40E+02	7.41E-01	2.86E+08		
	Ops/D&D	3.74E+04	2.60E+02	1.40E+02	7.41E-01	1.01E+09		
Vitrification								
	Const.	2.58E+04	2.60E+02	1.40E+02	7.41E-01	6.96E+08		
	Ops/D&D	6.95E+03	2.60E+02	1.40E+02	7.41E-01	1.87E+08		
Closure		4.90E+02	2.60E+02	1.40E+02	7.41E-01	1.32E+07		
	total	8.12E+04					Total	2.19E+09
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	5.91E+07	5.00E-02			2.95E+06		
	Rail	8.34E+06	5.00E-02			4.17E+05		
Suburban								
	Truck	5.91E+07	5.00E-02		7.88E+06	1.08E+07		
	Rail	8.34E+06	5.00E-02			4.17E+05		
Rural								
	Truck	5.91E+07	9.00E-01			5.32E+07		
	Rail	8.34E+06	9.00E-01			7.51E+06		
Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			2.95E+06	4.17E+05	1.08E+07	4.17E+05	5.32E+07	7.51E+06
urban truck fat/km		7.50E-09	2.22E-02					
urban truck inj/km		3.70E-07	1.09E+00					

urban rail fat/km		1.70E-08		7.09E-03				
urban rail inj/km		3.30E-08		1.38E-02				
sub truck fat.km		1.30E-08			1.41E-01			
sub truck inj/km		3.80E-07			4.12E+00			
sub rail fat/km		1.70E-08				7.09E-03		
sub rail inj/km		3.30E-08				1.38E-02		
rural truck fat/km		5.30E-08					2.82E+00	
rural truck inj/km		8.00E-07					4.26E+01	
rural rail fat/km		1.70E-08						1.28E-01
rural rail inj/km		3.30E-08						2.48E-01
	TOTAL FATALITIES		3.12E+00					
	TOTAL INJURIES		4.80E+01					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	2.19E+09	8.98E-09	1.97E+01				
	injuries	2.19E+09	7.14E-07	1.56E+03				
Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		3.12E+00	1.97E+01	2.28E+01			
	INJURIES		4.80E+01	1.56E+03	1.61E+03			

	IN SITU VITRIFICATION ALTERNATIVE							
RETRIEVAL								
Waste Transport								
Onsite Truck						0.00E+00		
							Total	0.00E+00
Construction - (W-314)								
Offsite Truck			trips	km/trip		total		
	steel		5.30E+01	8.00E+02		4.24E+04		
	cement		1.00E+02	1.40E+02		1.40E+04		
	miscellaneous		5.30E+01	1.40E+02		7.42E+03		
							Total	6.38E+04
Onsite Truck			trips	km/trip		total		
	borrow		1.38E+03	1.00E+01		1.38E+04		
							Total	1.38E+04
VITRIFICATION								
Construction								
Onsite Truck			trips	km/trip		total		
	borrow		2.12E+05	1.00E+01		2.12E+06		
							Total	2.12E+06
Offsite Truck			trips/yr	km/trip	yr	total		
	miscellaneous		5.20E+03	1.40E+02	1.90E+01	1.38E+07		
							Total	1.38E+07
Offsite Rail			cars	trip/cars	km/trip	total		
	steel		2.60E+03	5.00E-02	8.00E+02	1.04E+05		
	cement		1.70E+03	5.00E-02	8.00E+02	6.80E+04		
							Total	1.72E+05
Processing								
Offsite Truck			trips/yr	km/trip	yr	total		
	miscellaneous		5.20E+03	1.40E+02	1.20E+01	8.74E+06		
							Total	8.74E+06
Offsite Rail			trips/yr	km/trip	yr	total		
	chem.		4.00E+00	8.00E+02	1.20E+01	3.84E+04		
							Total	3.84E+04
Grout Fill IMUSTs (outside tank farm areas)								
Onsite Truck			trips	km/trip		total		
	sand/gravel		7.70E+02	1.00E+01		7.70E+03	Total	7.70E+03
Offsite Truck			trips	km/trip		total		
	cement		1.60E+02	1.40E+02		2.24E+04	Total	2.24E+04
CLOSURE								
Onsite Truck			cu yd	trip/cu yd	km/trip	total		
	fill		0.00E+00	0.00E+00	0.00E+00	0.00E+00		

	silt		4.93E+05	1.00E-01	3.00E+01	1.48E+06		
	riprap		8.34E+05	1.00E-01	3.20E+01	2.67E+06		
	ag/sand		5.43E+05	1.00E-01	1.00E+01	5.43E+05		
							Total	4.69E+06
Onsite Truck (km)		6.83E+06						
Onsite Rail (km)		0						
Offsite Truck (km)		2.27E+07						
Offsite Rail (km)		2.10E+05						
EMPLOYEE VEHICLE								
Routine		person-yr	trip/yr	km/trip	car pool	total		
W-314		1.83E+04	2.60E+02	1.40E+02	7.41E-01	4.94E+08		
	Ops	1.63E+02	2.60E+02	1.40E+02	7.41E-01	4.40E+06		
Vitrification								
	Const.	2.20E+04	2.60E+02	1.40E+02	7.41E-01	5.93E+08		
	Ops/D&D	8.05E+03	2.60E+02	1.40E+02	7.41E-01	2.17E+08		
Closure		3.19E+02	2.60E+02	1.40E+02	7.41E-01	8.60E+06		
							Total	1.32E+09
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	2.27E+07	5.00E-02			1.13E+06		
	Rail	2.10E+05	5.00E-02			1.05E+04		
Suburban								
	Truck	2.27E+07	5.00E-02		6.83E+06	7.97E+06		
	Rail	2.10E+05	5.00E-02			1.05E+04		
Rural								
	Truck	2.27E+07	9.00E-01			2.04E+07		
	Rail	2.10E+05	9.00E-01			1.89E+05		
Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			1.13E+06	1.05E+04	7.97E+06	1.05E+04	2.04E+07	1.89E+05
urban truck fat/km		7.50E-09	8.50E-03					
urban truck inj/km		3.70E-07	4.19E-01					

urban rail fat/km		1.70E-08		1.79E-04				
urban rail inj/km		3.30E-08		3.47E-04				
sub truck fat.km		1.30E-08			1.04E-01			
sub truck inj/km		3.80E-07			3.03E+00			
sub rail fat/km		1.70E-08				1.79E-04		
sub rail inj/km		3.30E-08				3.47E-04		
rural truck fat/km		5.30E-08					1.08E+00	
rural truck inj/km		8.00E-07					1.63E+01	
rural rail fat/km		1.70E-08						3.22E-03
rural rail inj/km		3.30E-08						6.25E-03
	TOTAL FATALITIES		1.20E+00					
	TOTAL INJURIES		1.98E+01					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	1.32E+09	8.98E-09	1.18E+01				
	injuries	1.32E+09	7.14E-07	9.40E+02				
Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		1.20E+00	1.18E+01	1.30E+01			
	INJURIES		1.98E+01	9.40E+02	9.60E+02			

			NO ACTION ALTERNATIVE					
RETRIEVAL								
Waste Transport								
Onsite Truck						0.00E+00		
							Total	0.00E+00
Construction								
Offsite Truck			trips/yr	km/trip	yr	total		
	concrete		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
	raw material		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
	equipment		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
	miscellaneous		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
							Total	0.00E+00
Offsite Rail			trips/yr	km/trip	yr	total		
	raw material		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
							Total	0.00E+00
ROUTINE								
Construction								
Onsite Truck			trips	km/trip		total		
	borrow		0.00E+00	0.00E+00		0.00E+00		
							Total	0.00E+00
Offsite Truck			trips/yr	km/trip	yr	total		
	miscellaneous		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
			trips	km/trip				
	Tri-Cities		0.00E+00	0.00E+00		0.00E+00		
	Portland/Seattle		0.00E+00	0.00E+00		0.00E+00		
							Total	0.00E+00
			-					
	Onsite Truck (km)		0.00E+00					
	Onsite Rail (km)		0.00E+00					
	Offsite Truck (km)		0.00E+00					
	Offsite Rail (km)		0.00E+00					
EMPLOYEE VEHICLE								
Routine		person-yr	trip/yr	km/trip	car pool	total		
	Const.	0.00E+00				0.00E+00		
	Ops	1.04E+05	2.60E+02	1.40E+02	7.41E-01	2.81E+09		
							Total	2.81E+09
Distance traveled in population zones								

Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	0.00E+00	5.00E-02			0.00E+00		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Suburban								
	Truck	0.00E+00	5.00E-02		0.00E+00	0.00E+00		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Rural								
	Truck	0.00E+00	9.00E-01			0.00E+00		
	Rail	0.00E+00	9.00E-01			0.00E+00		

Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
urban truck fat/km		7.50E-09	0.00E+00					
urban truck inj/km		3.70E-07	0.00E+00					
urban rail fat/km		1.70E-08		0.00E+00				
urban rail inj/km		3.30E-08		0.00E+00				
sub truck fat.km		1.30E-08			0.00E+00			
sub truck inj/km		3.80E-07			0.00E+00			
sub rail fat/km		1.70E-08				0.00E+00		
sub rail inj/km		3.30E-08				0.00E+00		
rural truck fat/km		5.30E-08					0.00E+00	
rural truck inj/km		8.00E-07					0.00E+00	
rural rail fat/km		1.70E-08						0.00E+00
rural rail inj/km		3.30E-08						0.00E+00
	TOTAL FATALITIES		0.00E+00					
	TOTAL INJURIES		0.00E+00					

Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	2.81E+09	8.98E-09	2.52E+01				
	injuries	2.81E+09	7.14E-07	2.00E+03				

Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		0.00E+00	2.52E+01	2.52E+01			
	INJURIES		0.00E+00	2.00E+03	2.00E+03			

		ONSITE DRY STORAGE ALTERNATIVE						
ROUTINE								
Construction								
Onsite Truck			trips	km/trip		total		
	borrow		1.00E+02	1.00E+01		1.00E+03		
							Total	1.00E+03
Offsite Truck			trips	km/trip		total		
	encasement pipe		1.40E+01	8.00E+02		1.12E+04		
	WESF modification		2.00E+02	1.40E+02		2.80E+04		
							Total	3.92E+04
Capsule Transport								
Onsite Truck			trips	km/trip		total		
	to dry storage		1.84E+02	3.20E+01		5.89E+03		
							Total	5.89E+03
		Onsite Truck (km)		6.89E+03				
		Onsite Rail (km)		0.00E+00				
		Offsite Truck (km)		3.92E+04				
		Offsite Rail (km)		0.00E+00				
EMPLOYEE VEHICLE								
Routine		person-yr	trip/yr	km/trip	car pool	total		
	Const.	2.10E+02	2.60E+02	1.40E+02	7.41E-01	5.66E+06		
	Packaging	1.94E+02	2.60E+02	1.40E+02	7.41E-01	5.23E+06		
	Storage	8.90E+02	2.60E+02	1.40E+02	7.41E-01	2.40E+07		
							Total	3.49E+07
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	3.92E+04	5.00E-02			1.96E+03		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Suburban								
	Truck	3.92E+04	5.00E-02		6.89E+03	8.85E+03		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Rural								
	Truck	3.92E+04	9.00E-01			3.53E+04		
	Rail	0.00E+00	9.00E-01			0.00E+00		

Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			1.96E+03	0.00E+00	8.85E+03	0.00E+00	3.53E+04	0.00E+00
urban truck fat/km		7.50E-09	1.47E-05					
urban truck inj/km		3.70E-07	7.25E-04					
urban rail fat/km		1.70E-08		0.00E+00				
urban rail inj/km		3.30E-08		0.00E+00				
sub truck fat.km		1.30E-08			1.15E-04			
sub truck inj/km		3.80E-07			3.36E-03			
sub rail fat/km		1.70E-08				0.00E+00		
sub rail inj/km		3.30E-08				0.00E+00		
rural truck fat/km		5.30E-08					1.87E-03	
rural truck inj/km		8.00E-07					2.82E-02	
rural rail fat/km		1.70E-08						0.00E+00
rural rail inj/km		3.30E-08						0.00E+00
	TOTAL FATALITIES		2.00E-03					
	TOTAL INJURIES		3.23E-02					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	3.49E+07	8.98E-09	3.13E-01				
	injuries	3.49E+07	7.14E-07	2.49E+01				
Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		2.00E-03	3.13E-01	3.15E-01			
	INJURIES		3.23E-02	2.49E+01	2.50E+01			

		OVERPACK AND SHIP ALTERNATIVE						
ROUTINE								
Construction								
Onsite Truck			trips	km/trip		total		
	borrow		0.00E+00	0.00E+00		0.00E+00		
							Total	0.00E+00
Offsite Truck			trips	km/trip		total		
	encasement pipe		0.00E+00	0.00E+00		0.00E+00		
	WESF modification		2.00E+02	1.40E+02		2.80E+04		
							Total	2.80E+04
Capsule Transport								
Offsite Rail			trips	km/trip		total		
	Yucca		5.00E+00	2.93E+03		1.47E+04		
							Total	1.47E+04
		Onsite Truck (km)		0.00E+00				
		Onsite Rail (km)		0.00E+00				
		Offsite Truck (km)		2.80E+04				
		Offsite Rail (km)		1.47E+04				
EMPLOYEE VEHICLE								
Routine		person-yr	trip/yr	km/trip	car pool	total		
	Const.	1.00E+02	2.60E+02	1.40E+02	7.41E-01	2.70E+06		
	Packaging	5.10E+01	2.60E+02	1.40E+02	7.41E-01	1.38E+06		
	Storage	9.00E+01	2.60E+02	1.40E+02	7.41E-01	2.43E+06		
							Total	6.50E+06
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	2.80E+04	5.00E-02			1.40E+03		
	Rail	1.47E+04	5.00E-02			7.33E+02		
Suburban								
	Truck	2.80E+04	5.00E-02		0.00E+00	1.40E+03		
	Rail	1.47E+04	5.00E-02			7.33E+02		
Rural								
	Truck	2.80E+04	9.00E-01			2.52E+04		
	Rail	1.47E+04	9.00E-01			1.32E+04		

Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			1.40E+03	7.33E+02	1.40E+03	7.33E+02	2.52E+04	1.32E+04
urban truck fat/km		7.50E-09	1.05E-05					
urban truck inj/km		3.70E-07	5.18E-04					
urban rail fat/km		1.70E-08		1.25E-05				
urban rail inj/km		3.30E-08		2.42E-05				
sub truck fat.km		1.30E-08			1.82E-05			
sub truck inj/km		3.80E-07			5.32E-04			
sub rail fat/km		1.70E-08				1.25E-05		
sub rail inj/km		3.30E-08				2.42E-05		
rural truck fat/km		5.30E-08					1.34E-03	
rural truck inj/km		8.00E-07					2.02E-02	
rural rail fat/km		1.70E-08						2.24E-04
rural rail inj/km		3.30E-08						4.35E-04
	TOTAL FATALITIES		1.61E-03					
	TOTAL INJURIES		2.17E-02					

Fatalities/Injuries resulting from Employee vehicle accidents				
		km	rate/km	TOTAL
	fatalities	6.50E+06	8.98E-09	5.84E-02
	injuries	6.50E+06	7.14E-07	4.64E+00

Cumulative fatalities/injuries from traffic impacts				
		transport	employee	TOTAL
	FATALITIES	1.61E-03	5.84E-02	6.00E-02
	INJURIES	2.17E-02	4.64E+00	4.66E+00

		VITRIFY WITH TANK WASTE ALTERNATIVE						
ROUTINE								
Construction								
Onsite Truck			trips	km/trip		total		
	borrow		0.00E+00	0.00E+00		0.00E+00		
							Total	0.00E+00
Offsite Truck			trips	km/trip		total		
	encasement pipe		0.00E+00	0.00E+00		0.00E+00		
	WESF modification		2.00E+02	1.40E+02		2.80E+04		
							Total	2.80E+04
Capsule Transport								
Onsite Truck			trips	km/trip		total		
	to vitrification plant		1.84E+02	3.20E+01		5.89E+03		
							Total	5.89E+03
		Onsite Truck (km)		5.89E+03				
		Onsite Rail (km)		0.00E+00				
		Offsite Truck (km)		2.80E+04				
		Offsite Rail (km)		0.00E+00				
EMPLOYEE VEHICLE								
Routine		person-yr	trip/yr	km/trip	car pool	total		
	Const.	1.00E+02	2.60E+02	1.40E+02	7.41E-01	2.70E+06		
	Packaging	5.10E+01	2.60E+02	1.40E+02	7.41E-01	1.38E+06		
	Storage	9.00E+01	2.60E+02	1.40E+02	7.41E-01	2.43E+06		
							Total	6.50E+06
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	2.80E+04	5.00E-02			1.40E+03		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Suburban								
	Truck	2.80E+04	5.00E-02		0.00E+00	1.40E+03		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Rural								
	Truck	2.80E+04	9.00E-01			2.52E+04		
	Rail	0.00E+00	9.00E-01			0.00E+00		

Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			1.40E+03	0.00E+00	1.40E+03	0.00E+00	2.52E+04	0.00E+00
urban truck fat/km		7.50E-09	1.05E-05					
urban truck inj/km		3.70E-07	5.18E-04					
urban rail fat/km		1.70E-08		0.00E+00				
urban rail inj/km		3.30E-08		0.00E+00				
sub truck fat.km		1.30E-08			1.82E-05			
sub truck inj/km		3.80E-07			5.32E-04			
sub rail fat/km		1.70E-08				0.00E+00		
sub rail inj/km		3.30E-08				0.00E+00		
rural truck fat/km		5.30E-08					1.34E-03	
rural truck inj/km		8.00E-07					2.02E-02	
rural rail fat/km		1.70E-08						0.00E+00
rural rail inj/km		3.30E-08						0.00E+00
	TOTAL FATALITIES		1.36E-03					
	TOTAL INJURIES		2.12E-02					

Fatalities/Injuries resulting from Employee vehicle accidents				
		km	rate/km	TOTAL
	fatalities	6.50E+06	8.98E-09	5.84E-02
	injuries	6.50E+06	7.14E-07	4.64E+00

Cumulative fatalities/injuries from traffic impacts				
		transport	employee	TOTAL
	FATALITIES	1.36E-03	5.84E-02	5.97E-02
	INJURIES	2.12E-02	4.64E+00	4.66E+00

			IN SITU FILL AND CAP					
Construction - (W-314)								
Offsite Truck			trips	km/trip		total		
	steel		5.30E+01	8.00E+02		4.24E+04		
	cement		1.00E+02	1.40E+02		1.40E+04		
	miscellaneous		5.30E+01	1.40E+02		7.42E+03		
							Total	6.38E+04
Onsite Truck			trips	km/trip	yr	total		
	borrow		1.38E+03	1.00E+01		1.38E+04		
							Total	1.38E+04
Grout Fill IMUSTs								
Construction								
Onsite Truck			trips	km/trip		total		
	sand/gravel		2.20E+03	1.00E+01		2.20E+04		
							Total	2.20E+04
Offsite Truck			trips	km/trip		total		
	cement		4.63E+02	1.40E+02		6.48E+04		
	Portland/Seattle		0.00E+00	0.00E+00		0.00E+00		
			trips/yr	km/trip	yr			
	miscellaneous		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
							Total	6.48E+04
Processing								
Offsite Truck			trips/yr	km/trip	yr	total		
	glassformer/chem		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
	miscellaneous		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
							Total	0.00E+00
Offsite Rail			trips/yr	km/trip	yr	total		
	glassformer/chem		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
							Total	0.00E+00
VITRIFIED HLW TRANSPORT								
Offsite Rail			trips	km/trip		total		
	Yucca Mountain		0.00E+00	0.00E+00		0.00E+00		
							Total	0.00E+00
CLOSURE								
Onsite Truck			cu yd	trip/cu yd	km/trip	total		
	fill		9.03E+05	1.00E-01	1.00E+01	9.03E+05		

	silt		4.93E+05	1.00E-01	3.00E+01	1.48E+06		
	riprap		8.34E+05	1.00E-01	3.20E+01	2.67E+06		
	ag/sand		5.43E+05	1.00E-01	1.00E+01	5.43E+05		
							Total	5.59E+06
Onsite Truck (km)		5.63E+06						
Onsite Rail (km)		0						
Offsite Truck (km)		1.29E+05						
Offsite Rail (km)		0.00E+00						
EMPLOYEE VEHICLE								
Routine		person-yr	trip/yr	km/trip	car pool	total		
	W-314	1.63E+02	2.60E+02	1.40E+02	7.41E-01	4.40E+06		
	Ops/D&D	2.39E+04	2.60E+02	1.40E+02	7.41E-01	6.45E+08		
Fill Tanks with Gravel								
	Const.	9.50E+01	2.60E+02	1.40E+02	7.41E-01	2.56E+06		
	Ops/D&D	1.51E+03	2.60E+02	1.40E+02	7.41E-01	4.07E+07		
Closure		4.67E+02	2.60E+02	1.40E+02	7.41E-01	1.26E+07		
	total	2.61E+04					Total	7.05E+08
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	1.29E+05	5.00E-02			6.43E+03		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Suburban								
	Truck	1.29E+05	5.00E-02		5.63E+06	5.64E+06		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Rural								
	Truck	1.29E+05	9.00E-01			1.16E+05		
	Rail	0.00E+00	9.00E-01			0.00E+00		
Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			6.43E+03	0.00E+00	5.64E+06	0.00E+00	1.16E+05	0.00E+00
urban truck fat/km		7.50E-09	4.82E-05					
urban truck inj/km		3.70E-07	2.38E-03					

urban rail fat/km		1.70E-08		0.00E+00				
urban rail inj/km		3.30E-08		0.00E+00				
sub truck fat.km		1.30E-08			7.33E-02			
sub truck inj/km		3.80E-07			2.14E+00			
sub rail fat/km		1.70E-08				0.00E+00		
sub rail inj/km		3.30E-08				0.00E+00		
rural truck fat/km		5.30E-08					6.14E-03	
rural truck inj/km		8.00E-07					9.26E-02	
rural rail fat/km		1.70E-08						0.00E+00
rural rail inj/km		3.30E-08						0.00E+00
	TOTAL FATALITIES		7.95E-02					
	TOTAL INJURIES		2.24E+00					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	7.05E+08	8.98E-09	6.33E+00				
	injuries	7.05E+08	7.14E-07	5.03E+02				
Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		7.95E-02	6.33E+00	6.41E+00			
	INJURIES		2.24E+00	5.03E+02	5.06E+02			

		EX SITU COMBINATION					
RETRIEVAL							
Waste Transport					total		
Onsite Truck					0.00E+00		
Construction							
Offsite Truck		trips/yr	km/trip	yr	total		
	concrete	2.40E+02	1.40E+02	2.00E+01	6.72E+05		
	raw material	2.25E+01	8.00E+02	2.00E+01	3.60E+05		
	equipment	1.25E+01	1.00E+04	2.00E+01	2.50E+06		
	miscellaneous	2.60E+03	1.40E+02	2.00E+01	7.28E+06		
	steel W-314	5.30E+01	8.00E+02		4.24E+04		
	cement/misc W-314	1.53E+02	1.40E+02		2.14E+04	Total	1.09E+07
Offsite Rail		trips/yr	km/trip	yr	total		
	raw material	5.00E+00	8.00E+02	2.00E+01	8.00E+04	Total	8.00E+04
Onsite Truck							
	borrow W-314	1.38E+03	1.00E+01		1.38E+04	Total	1.38E+04
VITRIFICATION							
Construction							
Onsite Truck		trips	km/trip		total		
	borrow	2.60E+04	1.00E+01		2.60E+05	Total	2.60E+05
Offsite Truck		trips	km/trip		total		
	concrete	1.45E+04	1.40E+02		2.03E+06		
	steel	4.75E+03	8.00E+02		3.80E+06		
		trips/yr	km/trip	yr			
	miscellaneous	2.60E+03	1.40E+02	1.00E+01	3.64E+06	Total	9.47E+06
Processing							
Offsite Truck		trips/yr	km/trip	yr	total		
	glassformer/chem	1.15E+01	8.00E+02	1.95E+01	1.79E+05		
	miscellaneous	2.60E+03	1.40E+02	1.95E+01	7.10E+06	Total	7.28E+06
Offsite Rail		trips/yr	km/trip	yr	total		
	glassformer/chem	1.30E+02	8.00E+02	1.95E+01	2.03E+06	Total	2.03E+06
VITRIFIED HLW TRANSPORT							
Offsite Rail		trips	km/trip		total		
	Yucca Mountain	8.50E+01	2.93E+03		2.49E+05	Total	2.49E+05
CLOSURE							
Onsite Truck		cu yd	trip/cu yd	km/trip	total		
	fill	9.36E+05	1.00E-01	1.00E+01	9.36E+05		

	silt		5.76E+05	1.00E-01	3.00E+01	1.73E+06		
	riprap		9.21E+05	1.00E-01	3.20E+01	2.95E+06		
	ag/sand		6.43E+05	1.00E-01	1.00E+01	6.43E+05	Total	6.25E+06
GROUT FILL IMUST								
Onsite Truck sand/gravel			2.20E+03	1.00E+01		2.20E+04	Total	2.20E+04
Offsite Truck cement			4.63E+02	1.40E+02		6.48E+04	Total	6.48E+04
Onsite Truck (km)		6.55E+06						
Onsite Rail (km)		0.00E+00						
Offsite Truck (km)		2.77E+07						
Offsite Rail (km)		2.36E+06						
EMPLOYEE VEHICLE								
Retrieval		person-yr	trip/yr	km/trip	car pool	total		
	Const.	6.36E+03	2.60E+02	1.40E+02	7.41E-01	1.72E+08		
	Ops/D&D	2.24E+04	2.60E+02	1.40E+02	7.41E-01	6.04E+08		
Vitrification								
	Const.	1.19E+04	2.60E+02	1.40E+02	7.41E-01	3.21E+08		
	Ops/D&D	1.04E+04	2.60E+02	1.40E+02	7.41E-01	2.81E+08		
Fill tank								
	Const.	5.70E+01	2.60E+02	1.40E+02	7.41E-01	1.54E+06		
	Ops/D&D	1.80E+03	2.60E+02	1.40E+02	7.41E-01	4.86E+07		
Closure		5.74E+02	2.60E+02	1.40E+02	7.41E-01	1.55E+07		
							Total	1.44E+09
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	2.77E+07	5.00E-02			1.38E+06		
	Rail	2.36E+06	5.00E-02			1.18E+05		
Suburban								
	Truck	2.77E+07	5.00E-02		6.55E+06	7.93E+06		
	Rail	2.36E+06	5.00E-02			1.18E+05		
Rural								
	Truck	2.77E+07	9.00E-01			2.49E+07		
	Rail	2.36E+06	9.00E-01			2.12E+06		
Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			1.38E+06	1.18E+05	7.93E+06	1.18E+05	2.49E+07	2.12E+06
urban truck fat/km		7.50E-09	1.04E-02					

urban truck inj/km		3.70E-07	5.12E-01					
urban rail fat/km		1.70E-08		2.00E-03				
urban rail inj/km		3.30E-08		3.89E-03				
sub truck fat.km		1.30E-08			1.03E-01			
sub truck inj/km		3.80E-07			3.02E+00			
sub rail fat/km		1.70E-08				2.00E-03		
sub rail inj/km		3.30E-08				3.89E-03		
rural truck fat/km		5.30E-08					1.32E+00	
rural truck inj/km		8.00E-07					1.99E+01	
rural rail fat/km		1.70E-08						3.61E-02
rural rail inj/km		3.30E-08						7.00E-02
	TOTAL FATALITIES		1.47E+00					
	TOTAL INJURIES		2.35E+01					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	1.44E+09	8.98E-09	1.30E+01				
	injuries	1.44E+09	7.14E-07	1.03E+03				
Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		1.47E+00	1.30E+01	1.44E+01			
	INJURIES		2.35E+01	1.03E+03	1.05E+03			

			LONG-TERM MANAGEMENT ALTERNATIVE					
RETRIEVAL								
Waste Transport								
Onsite Truck						0.00E+00		
							Total	0.00E+00
Construction								
Offsite Truck			trips/yr	km/trip	yr	total		
	concrete		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
	raw material		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
	equipment		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
	miscellaneous		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
							Total	0.00E+00
Offsite Rail			trips/yr	km/trip	yr	total		
	raw material		0.00E+00	0.00E+00	0.00E+00	0.00E+00		
							Total	0.00E+00
ROUTINE								
Construction								
Onsite Truck			trips	km/trip		total		
	borrow		3.24E+04	1.00E+01		3.24E+05		
							Total	3.24E+05
Offsite Truck			trips/yr	km/trip	yr	total		
	miscellaneous		5.20E+03	1.40E+02	1.90E+01	1.38E+07		
			trips	km/trip				
	Tri-Cities		2.01E+04	1.40E+02		2.81E+06		
	Portland/Seattle		7.75E+03	8.00E+02		6.20E+06		
							Total	2.28E+07
	Onsite Truck (km)		3.24E+05					
	Onsite Rail (km)		0.00E+00					
	Offsite Truck (km)		2.28E+07					
	Offsite Rail (km)		0.00E+00					
EMPLOYEE VEHICLE								
Routine		person-yr	trip/yr	km/trip	car pool	total		
	Const.	3.75E+03	2.60E+02	1.40E+02	7.41E-01	1.01E+08		
	Ops	1.04E+05	2.60E+02	1.40E+02	7.41E-01	2.81E+09		
							Total	2.91E+09

Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	2.28E+07	5.00E-02			1.14E+06		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Suburban								
	Truck	2.28E+07	5.00E-02		3.24E+05	1.47E+06		
	Rail	0.00E+00	5.00E-02			0.00E+00		
Rural								
	Truck	2.28E+07	9.00E-01			2.06E+07		
	Rail	0.00E+00	9.00E-01			0.00E+00		
Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			1.14E+06	0.00E+00	1.47E+06	0.00E+00	2.06E+07	0.00E+00
urban truck fat/km		7.50E-09	8.57E-03					
urban truck inj/km		3.70E-07	4.23E-01					
urban rail fat/km		1.70E-08		0.00E+00				
urban rail inj/km		3.30E-08		0.00E+00				
sub truck fat.km		1.30E-08			1.91E-02			
sub truck inj/km		3.80E-07			5.57E-01			
sub rail fat/km		1.70E-08				0.00E+00		
sub rail inj/km		3.30E-08				0.00E+00		
rural truck fat/km		5.30E-08					1.09E+00	
rural truck inj/km		8.00E-07					1.64E+01	
rural rail fat/km		1.70E-08						0.00E+00
rural rail inj/km		3.30E-08						0.00E+00
	TOTAL FATALITIES		1.12E+00					
	TOTAL INJURIES		1.74E+01					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	2.91E+09	8.98E-09	2.61E+01				
	injuries	2.91E+09	7.14E-07	2.08E+03				

Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		1.12E+00	2.61E+01	2.72E+01			
	INJURIES		1.74E+01	2.08E+03	2.09E+03			

	TOTAL ALTERNATIVE						
RETRIEVAL							
Waste Transport					total		
Onsite Truck					1.25E+04	Total	1.25E+04
Construction							
Offsite Truck		trips/yr	km/trip	yr	total		
	concrete	4.80E+02	1.40E+02	2.00E+01	1.34E+06		
	raw material	4.50E+01	8.00E+02	2.00E+01	7.20E+05		
	equipment	2.50E+01	1.00E+04	2.00E+01	5.00E+06		
	miscellaneous	5.20E+03	1.40E+02	2.00E+01	1.46E+07		
	borrow (W-314)	1.38E+03	1.00E+01		1.38E+04	Total	2.16E+07
Offsite Rail		trips/yr	km/trip	yr	total		
	raw material	1.00E+01	8.00E+02	2.00E+01	1.60E+05		
	steel (W-314)	5.30E+01	8.00E+02		4.24E+04		
	cement (W-314)	1.00E+02	1.40E+02		1.40E+04	Total	2.16E+05
VITRIFICATION							
Construction							
Onsite Truck		trips	km/trip		total		
	borrow	2.80E+04	1.00E+01		2.80E+05	Total	2.80E+05
Offsite Truck		trips	km/trip		total		
	concrete	1.57E+04	1.40E+02		2.20E+06		
	steel	1.21E+03	8.00E+02		9.68E+05		
	miscellaneous	2.92E+04	1.40E+02		4.09E+06	Total	7.25E+06
Processing							
Offsite Truck		trips	km/trip		total		
	glassformer/chem	3.72E+03	8.00E+02		2.98E+06		
	miscellaneous	1.03E+05	1.40E+02		1.44E+07		
	process material	3.57E+03	1.40E+02		5.00E+05	Total	1.79E+07
Offsite Rail		trips	km/trip		total		
	glassformer/chem	2.75E+03	8.00E+02		2.20E+06	Total	2.20E+06
VITRIFIED HLW TRANSPORT							
Offsite Rail		trips	km/trip		total		
	Yucca Mountain	1.70E+02	2.93E+03		4.98E+05	Total	4.98E+05
CLOSURE							
Onsite Truck		cu yd	trip/cu yd	km/trip	total		
	fill	9.86E+05	1.00E-01	1.00E+01	9.86E+05		

	silt		6.93E+05	1.00E-01	3.00E+01	2.08E+06		
	riprap		1.05E+06	1.00E-01	3.20E+01	3.36E+06		
	ag/sand		7.93E+05	1.00E-01	1.00E+01	7.93E+05		
	grout fill sand IMUST		2.20E+03	1.00E+01		2.20E+04	Total	7.24E+06
Offsite Truck			trips	km/trip		total		
	groutfill cement IMUS		4.63E+02	1.40E+02		6.48E+04	Total	6.48E+04
Onsite Truck (km)		7.53E+06						
Onsite Rail (km)		0.00E+00						
Offsite Truck (km)		4.69E+07						
Offsite Rail (km)		2.91E+06						
EMPLOYEE VEHICLE								
Phase 1		person-yr	trip/yr	km/trip	car pool	total		
	Const.	1.16E+04	2.60E+02	1.40E+02	7.41E-01	3.13E+08		
	Ops/D&D	6.77E+03	2.60E+02	1.40E+02	7.41E-01	1.83E+08		
Phase 2								
	Const.	1.98E+04	2.60E+02	1.40E+02	7.41E-01	5.34E+08		
	Ops/D&D	4.33E+04	2.60E+02	1.40E+02	7.41E-01	1.17E+09		
							Total	2.20E+09
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	4.69E+07	5.00E-02			2.34E+06		
	Rail	2.91E+06	5.00E-02			1.46E+05		
Suburban								
	Truck	4.69E+07	5.00E-02		7.53E+06	9.88E+06		
	Rail	2.91E+06	5.00E-02			1.46E+05		
Rural								
	Truck	4.69E+07	9.00E-01			4.22E+07		
	Rail	2.91E+06	9.00E-01			2.62E+06		
Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			2.34E+06	1.46E+05	9.88E+06	1.46E+05	4.22E+07	2.62E+06
urban truck fat/km		7.50E-09	1.76E-02					

urban truck inj/km		3.70E-07	8.67E-01					
urban rail fat/km		1.70E-08		2.48E-03				
urban rail inj/km		3.30E-08		4.81E-03				
sub truck fat.km		1.30E-08			1.28E-01			
sub truck inj/km		3.80E-07			3.75E+00			
sub rail fat/km		1.70E-08				2.48E-03		
sub rail inj/km		3.30E-08				4.81E-03		
rural truck fat/km		5.30E-08					2.23E+00	
rural truck inj/km		8.00E-07					3.37E+01	
rural rail fat/km		1.70E-08						4.46E-02
rural rail inj/km		3.30E-08						8.66E-02
	TOTAL FATALITIES		2.43E+00					
	TOTAL INJURIES		3.84E+01					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	2.20E+09	8.98E-09	1.97E+01				
	injuries	2.20E+09	7.14E-07	1.57E+03				
Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		2.43E+00	1.97E+01	2.22E+01			
	INJURIES		3.84E+01	1.57E+03	1.61E+03			

	PHASE 1 IMPLEMENTATION SUB-ALTERNATIVE							
RETRIEVAL								
WASTE TRANSFER SYSTEM UPGRADE (W-314)								
Onsite Truck			trips	km/trip		total		
	borrow		1.38E+03	1.00E+00		1.38E+03	Total	1.38E+03
Offsite Truck								
	steel		5.30E+01	8.00E+02		4.24E+04		
	cement		1.00E+02	1.40E+02		1.40E+04	Total	5.64E+04
VITRIFICATION								
Construction								
Onsite Truck			trips	km/trip		total		
	borrow		1.96E+03	1.00E+01		1.96E+04	Total	1.96E+04
Offsite Truck			trips	km/trip		total		
	concrete		1.20E+03	1.40E+02		1.68E+05		
	steel		7.32E+03	8.00E+02		5.86E+06		
	miscellaneous		3.18E+03	1.40E+02		4.45E+05	Total	6.47E+06
Processing								
Offsite Truck			trips	km/trip		total		
	glassformer/chem		3.50E+03	8.00E+02		2.80E+06		
	glassformer/chem		3.57E+03	1.40E+02		5.00E+05		
	miscellaneous		5.20E+04	1.40E+02		7.28E+06	Total	1.06E+07
Offsite Rail			trips	km/trip		total		
	glassformer/chem		2.18E+02	8.00E+02		1.74E+05	Total	1.74E+05
VITRIFIED HLW TRANSPORT								
SITE RESTORATION								
Onsite Truck			trips	km/trip		total		
	contaminated waste		1.50E+03	1.61E+01		2.42E+04		
	noncont. waste		6.23E+04	1.61E+01		1.00E+06	Total	1.03E+06

GROUT FILL IMUST								
Onsite Truck (km)		1.05E+06						
Onsite Rail (km)		0.00E+00						
Offsite Truck (km)		1.71E+07						
Offsite Rail (km)		1.74E+05						
EMPLOYEE VEHICLE								
		person-yr	trip/yr	km/trip	car pool	total		
	Const.	1.07E+04	2.60E+02	1.40E+02	7.41E-01	2.89E+08		
	Ops/D&D	6.93E+03	2.60E+02	1.40E+02	7.41E-01	1.87E+08	Total	4.76E+08
Distance traveled in population zones								
Urban		Offsite km	zone fraction		Onsite	TOTALS		
	Truck	1.71E+07	5.00E-02			8.55E+05		
	Rail	1.74E+05	5.00E-02			8.72E+03		
Suburban								
	Truck	1.71E+07	5.00E-02		1.05E+06	1.90E+06		
	Rail	1.74E+05	5.00E-02			8.72E+03		
Rural								
	Truck	1.71E+07	9.00E-01			1.54E+07		
	Rail	1.74E+05	9.00E-01			1.57E+05		
Fatalities/Injuries resulting from Truck and Rail transportation accidents								
			urban km		suburban km		rural km	
			truck	rail	truck	rail	truck	rail
			8.55E+05	8.72E+03	1.90E+06	8.72E+03	1.54E+07	1.57E+05
urban truck fat/km		7.50E-09	6.41E-03					

urban truck inj/km		3.70E-07	3.16E-01					
urban rail fat/km		1.70E-08		1.48E-04				
urban rail inj/km		3.30E-08		2.88E-04				
sub truck fat.km		1.30E-08			2.47E-02			
sub truck inj/km		3.80E-07			7.23E-01			
sub rail fat/km		1.70E-08				1.48E-04		
sub rail inj/km		3.30E-08				2.88E-04		
rural truck fat/km		5.30E-08					8.16E-01	
rural truck inj/km		8.00E-07					1.23E+01	
rural rail fat/km		1.70E-08						2.67E-03
rural rail inj/km		3.30E-08						5.18E-03
	TOTAL FATALITIES		8.50E-01					
	TOTAL INJURIES		1.34E+01					
Fatalities/Injuries resulting from Employee vehicle accidents								
		km	rate/km	TOTAL				
	fatalities	4.76E+08	8.98E-09	4.27E+00				
	injuries	4.76E+08	7.14E-07	3.40E+02				
Cumulative fatalities/injuries from traffic impacts								
			transport	employee	TOTAL			
	FATALITIES		8.50E-01	4.27E+00	5.12E+00			
	INJURIES		1.34E+01	3.40E+02	3.53E+02			

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING ; FLUX FROM TANKS DURING RETRIEVAL

ORIGINATOR COLIN HENDERSON DATE

REVISION NO. ~~0~~ 1 2/27/95

OBJECTIVE DETERMINE FLUX and Concentration of leakage ASSOCIATED WITH Retrieval of SSTs.

METHODOLOGY See ATTACHED

ASSUMPTIONS SEE ATTACHED

(Continue on another sheet if necessary)

Colin Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

PRELIMINARY

METHOD:

— CALCULATE THE SOLUBILITY OF TANK CONSTITUENTS BASED ON THE RATIO OF THE MASS OF EACH CONSTITUENT TO THE MASS OF NITRATE MULTIPLIED BY SOLUBILITY OF NO_3

— SOLUBILITY NO_3 = 360 g/L (Serne & Wood 1990)

— CONVERT RADIONUCLIDES from Ci to grams using SPECIFIC ACTIVITY CHART FROM ASI. (ATTACHED) AND FROM WHC-EP-0063-4 Appendix C

— THE TANK INVENTORY provided ON DISK BY ASI.

ASSUMPTIONS

1. LEAKAGE VOLUME PER TANK = 15140 l (4,000 gal)

   BASED ON Waste Retrieval and transfer data package WHICH USED 1/10 of LEAKAGE VOL estimated for TANK 106C

2. RETRIEVAL DURATION IS 15 YR (2003/2018)

3. SOLUBILITIES are proportional to mass Ratio of Each CONSTITUENT TO NITRATE.

4. LEAKAGE IS saturated WITH CONTAMINANTS.

5. NO LEAKAGE FROM DSTs

6. RADIONUCLIDES Decayed to 1995 USED AS INVENTORY DOES NOT CORRESPOND TO RETRIEVAL DATE.

RESULTS:

FOR EACH TANK GROUP THE Release Concentration is taken from TABLE 1 FOR RADIONUCLIDES AND TABLE 2 for CHEMICALS. BOTH TABLES ARE IN grams/liter, THE ANNUAL LEAKAGE FROM EACH TANK GROUP IS FROM TABLE 3.

TABLE 1A Provided for Reference and is the inventory in grams, Specific Activity Shown IN left hand Column.

		Radionucli	Decayed to 12/31/1995				
	SPECIFIC ACT	# of Tanks	40	43	40	16	10
	Ci/g.	Ci	1WSS	2WSS	1ESS	2ESS	4ESS
	5.80E+04	Ac-225	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	72.3	Ac-227	0.005179	0.004258	0.008844	0.001552	0.000277
	3.43	Am-241	2261.046	12602.86	9961.252	12927.14	6139.114
	8040	Am-242	2.676083	19.36104	18.82025	19.97412	8.668311
	9.71	Am-242m	2.688882	19.45364	18.91026	20.06965	8.70977
	0.199	Am-243	1.015628	7.824369	9.568559	11.64296	3.122778
	1.61E+12	At-217	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	5.37E+08	Ba-137m	844480.3	3775456	3538440	126183.6	136522.7
	1.24E+05	Bi-210	1.5E-08	1.16E-08	1.34E-08	7.03E-09	2.81E-09
	4.18E+08	Bi-211	0.005179	0.004258	0.008844	0.001552	0.000277
	1.46E+05	Bi-212	0	0	0	0	0
	1.38E+04	Bi-213	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	4.41E+07	Bi-214	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08
	4.45	C-14	1952.428	3373.591	12587.81	1479.091	1250.91
	3300	Cm-242	2.219645	16.05879	15.61023	16.5673	7.189828
	80.8	Cm-244	3.216887	23.89107	50.0855	53.42385	7.202217
	0.172	Cm-245	0.000208	0.001744	0.003826	0.004092	0.000551
	1.15E-03	Cs-135	20.65955	67.89432	52.72478	1.611265	2.130069
	86.4	Cs-137	892685.3	3990968	3740423	133386.4	144315.7
	1.77E+08	Fr-221	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	3.86E+07	Fr-223	7.15E-05	5.88E-05	0.000122	2.14E-05	3.82E-06
	1.76E-04	I-129	5.189401	13.39034	27.88373	1.821797	0.520811
	2.63E+02	Nb-93m	85.37654	675.9455	371.1179	404.9119	1504.691
	0.0807	Ni-59	0	1707.296	3325.23	0	0
	58.8	Ni-63	6834.228	48601.69	53030.59	58729.78	109051.8
	7.04E-04	Np-237	8.264374	11.00118	49.58412	0.3368	0.448371
	2.59E+05	Np-238	0.012799	0.092599	0.090013	0.095532	0.041459
	2.32E+05	Np-239	1.015628	7.824369	9.568559	11.64296	3.122778
	4.72E-02	Pa-231	0.009613	0.007326	0.01526	0.003377	0.000637
	2.07E+04	Pa-233	8.264374	11.00118	49.58412	0.3368	0.448371
	1.99E+04	Pa-234	0.275063	0.103494	0.260803	0.103241	0.026397
	6.86E+08	Pa-234m	171.9143	64.68359	163.0022	64.52547	16.49811
	4.59E+04	Pb-209	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	76.4	Pb-210	1.5E-08	1.16E-08	1.34E-08	7.03E-09	2.81E-09
	2.47E+07	Pb-211	0.005179	0.004258	0.008844	0.001552	0.000277
	1.38E+04	Pb-212	0	0	0	0	0
	3.28E+07	Pb-214	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08
	5.14E-04	Pd-107	9.0336	23.27601	49.54251	3.664392	0.974433
	4.49E+03	Po-210	1.5E-08	1.16E-08	1.34E-08	7.03E-09	2.81E-09
	1.04E+11	Po-211	1.41E-05	1.16E-05	2.41E-05	4.24E-06	7.56E-07
	2.95E+13	Po-212	0	0	0	0	0
	1.26E+16	Po-213	1.69E-06	2.81E-06	5.9E-06	2.2E-06	2.78E-06
	3.22E+14	Po-214	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08
	2.95E+13	Po-215	0.005179	0.004258	0.008844	0.001552	0.000277
	3.57E+11	Po-216	0	0	0	0	0
	2.83E+08	Po-218	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08

Sheet1

CONT FROM Pg 1

	17.1	Pu-238	209.6931	296.1764	184.9489	198.7904	223.7023	
	0.0619	Pu-239	2522.875	4350.621	3522.892	5871.238	5570.596	
	0.227	Pu-240	486.5172	940.262	825.2579	1472.858	1389.286	
	103	Pu-241	3917.129	6358.175	8460.234	13183.46	11080.7	
	3.93E-03	Pu-242	1.33E-05	9.59E-05	9.32E-05	9.89E-05	4.29E-05	
	5.12E+04	Ra-223	0.005179	0.004258	0.008844	0.001552	0.000277	
	1.61E+05	Ra-224	0	0	0	0	0	
	3.92E+04	Ra-225	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06	
	0.988	Ra-226	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08	
	272	Ra-228	0	0	0	0	0	
	3.55E+09	Rh-106	6.11E-05	0.016964	0.082485	0.097283	0.396806	
	1.30E+10	Rn-219	0.005179	0.004258	0.008844	0.001552	0.000277	
	9.21E+08	Rn-220	0	0	0	0	0	
	1.54E+05	Rn-222	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08	
	3.34E+03	Ru-106	6.11E-05	0.016964	0.082485	0.097283	0.396806	
	8.35E+04	Sb-126	7.936369	23.28679	6.712138	13.94531	35.94768	
	7.85E+07	Sb-126m	56.68835	166.3342	47.94384	99.60934	256.7691	
	6.96E-02	Se-79	97.05961	251.0777	521.4021	32.2847	9.509629	
	26.3	Sm-151	64317.33	189324.1	56333.67	104150.4	255351.4	
	0.0283	Sn-126	56.68835	166.3342	47.94384	99.60934	256.7691	
	139	Sr-90	1513650	14476169	8411675	4949226	19174943	
	0.0169	Tc-99	3387.614	8743.647	18136.74	1132.886	331.8042	
	3.07E+04	Th-227	0.005107	0.004199	0.008722	0.001531	0.000273	
	819	Th-228	0	0	0	0	0	
	0.212	Th-229	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06	
	2.02E-02	Th-230	9E-06	7.86E-06	7.51E-06	4.51E-06	3.11E-06	
	5.29E+03	Th-231	7.217891	2.933397	6.922466	2.809554	0.697812	
	1.10E-07	Th-232	1.85E-14	3.57E-14	3.13E-14	5.59E-14	5.27E-14	
	2.31E+04	Th-234	171.9143	64.68359	163.0022	64.52547	16.49811	
	1.90E+08	Tl-207	0.005164	0.004247	0.008819	0.001548	0.000276	
	2.96E+08	Tl-208	0	0	0	0	0	
	4.09E+08	Tl-209	3.73E-08	6.21E-08	1.3E-07	4.85E-08	6.13E-08	
	9.64E-03	U-233	0.001199	0.001753	0.00591	0.000807	0.001178	
	6.24E-03	U-234	0.04907	0.045905	0.043094	0.030365	0.025199	
	2.16E-06	U-235	7.217891	2.933397	6.922466	2.809554	0.697812	
	6.46E-05	U-236	0.000216	0.000418	0.000367	0.000654	0.000617	
	8.15E+04	U-237	0.09597	0.155775	0.207276	0.322995	0.271477	
	3.36E-07	U-238	171.9143	64.68359	163.0022	64.52547	16.49811	
	5.41E+03	Y-90	1513650	14476169	8411675	4949226	19174943	
	2.51E-03	Zr-93	45.38102	800.02	241.6636	562.6344	2286.793	

tank contents in grams				
40	43	40	16	10
1WSS	2WSS	1ESS	2ESS	4ESS
2.97E-11	4.96E-11	1.04E-10	3.87E-11	4.89E-11
7.16E-05	5.89E-05	0.000122	2.15E-05	3.83E-06
659.197	3674.302	2904.155	3768.847	1789.829
0.000333	0.002408	0.002341	0.002484	0.001078
0.276919	2.003464	1.947504	2.066906	0.89699
5.10366	39.31844	48.08321	58.50734	15.69235
1.07E-18	1.79E-18	3.75E-18	1.39E-18	1.76E-18
0.001573	0.007031	0.006589	0.000235	0.000254
1.21E-13	9.36E-14	1.08E-13	5.67E-14	2.27E-14
1.24E-11	1.02E-11	2.12E-11	3.71E-12	6.62E-13
0	0	0	0	0
1.25E-10	2.08E-10	4.37E-10	1.63E-10	2.06E-10
1.38E-15	1.14E-15	1.18E-15	6.76E-16	3.58E-16
438.7478	758.1104	2828.721	332.38	281.1035
0.000673	0.004866	0.00473	0.00502	0.002179
0.039813	0.295682	0.61987	0.661186	0.089136
0.001209	0.010138	0.022243	0.023793	0.003206
17964.83	59038.54	45847.63	1401.1	1852.234
10332.01	46191.76	43291.93	1543.824	1670.321
9.75E-15	1.63E-14	3.41E-14	1.27E-14	1.6E-14
1.85E-12	1.52E-12	3.16E-12	5.55E-13	9.9E-14
29485.23	76081.49	158430.3	10351.12	2959.154
0.324626	2.570135	1.411095	1.539589	5.721258
0	21156.09	41204.83	0	0
116.2284	826.5593	901.8807	998.8058	1854.622
11739.17	15626.67	70431.98	478.4089	636.8901
4.94E-08	3.58E-07	3.48E-07	3.69E-07	1.6E-07
4.38E-06	3.37E-05	4.12E-05	5.02E-05	1.35E-05
0.203666	0.155203	0.323304	0.071551	0.013501
0.000399	0.000531	0.002395	1.63E-05	2.17E-05
1.38E-05	5.2E-06	1.31E-05	5.19E-06	1.33E-06
2.51E-07	9.43E-08	2.38E-07	9.41E-08	2.4E-08
3.76E-11	6.27E-11	1.31E-10	4.89E-11	6.19E-11
1.97E-10	1.52E-10	1.75E-10	9.2E-11	3.68E-11
2.1E-10	1.72E-10	3.58E-10	6.28E-11	1.12E-11
0	0	0	0	0
1.85E-15	1.53E-15	1.59E-15	9.09E-16	4.81E-16
17575.1	45284.06	96386.22	7129.167	1895.785
3.34E-12	2.58E-12	2.98E-12	1.57E-12	6.27E-13
1.36E-16	1.12E-16	2.32E-16	4.07E-17	7.27E-18
0	0	0	0	0
1.34E-22	2.23E-22	4.68E-22	1.74E-22	2.2E-22
1.89E-22	1.56E-22	1.62E-22	9.26E-23	4.9E-23
1.76E-16	1.44E-16	3E-16	5.26E-17	9.39E-18
0	0	0	0	0
2.15E-16	1.78E-16	1.84E-16	1.05E-16	5.57E-17

12.26275	17.32026	10.81573	11.62517	13.082
40757.26	70284.68	56912.63	94850.37	89993.48
2143.248	4142.124	3635.497	6488.36	6120.203
38.03038	61.72985	82.13819	127.9948	107.5796
0.003372	0.024397	0.023715	0.025169	0.010923
1.01E-07	8.32E-08	1.73E-07	3.03E-08	5.41E-09
0	0	0	0	0
4.4E-11	7.34E-11	1.54E-10	5.73E-11	7.24E-11
6.15E-08	5.09E-08	5.27E-08	3.02E-08	1.6E-08
0	0	0	0	0
1.72E-14	4.78E-12	2.32E-11	2.74E-11	1.12E-10
3.98E-13	3.28E-13	6.8E-13	1.19E-13	2.13E-14
0	0	0	0	0
3.95E-13	3.26E-13	3.38E-13	1.94E-13	1.02E-13
1.83E-08	5.08E-06	2.47E-05	2.91E-05	0.000119
9.5E-05	0.000279	8.04E-05	0.000167	0.000431
7.22E-07	2.12E-06	6.11E-07	1.27E-06	3.27E-06
1394.535	3607.438	7491.41	463.8606	136.6326
2445.526	7198.636	2141.965	3960.091	9709.18
2003.122	5877.533	1694.129	3519.765	9073.114
10889.57	104145.1	60515.65	35605.95	137949.2
200450.5	517375.5	1073180	67034.7	19633.39
1.66E-07	1.37E-07	2.84E-07	4.99E-08	8.89E-09
0	0	0	0	0
8.14E-06	1.36E-05	2.84E-05	1.06E-05	1.34E-05
0.000445	0.000389	0.000372	0.000223	0.000154
0.001364	0.000555	0.001309	0.000531	0.000132
1.68E-07	3.24E-07	2.85E-07	5.08E-07	4.79E-07
0.007442	0.0028	0.007056	0.002793	0.000714
2.72E-11	2.24E-11	4.64E-11	8.15E-12	1.45E-12
0	0	0	0	0
9.11E-17	1.52E-16	3.18E-16	1.19E-16	1.5E-16
0.124419	0.181847	0.61306	0.083734	0.122188
7.863758	7.356635	6.906132	4.866185	4.038277
3341616	1358054	3204845	1300719	323060.9
3.345725	6.465961	5.674911	10.12839	9.553981
1.18E-06	1.91E-06	2.54E-06	3.96E-06	3.33E-06
5.12E+08	1.93E+08	4.85E+08	1.92E+08	49101503
279.7875	2675.817	1554.838	914.8293	3544.352
18080.09	318733.1	96280.32	224157.1	911072.8

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Table 1 Rev A

Tank Release Concentration grams/liter for radionuclides

	release concentration grams/liter				
	1WSS	2WSS	1ESS	2ESS	4ESS
Ac-225	4.07E-19	3.92E-19	1.98E-18	5.4E-17	3.6E-18
Ac-227	9.8E-13	4.66E-13	2.33E-12	3E-11	2.82E-13
Am-241	9.02E-06	2.91E-05	5.53E-05	0.005259	0.000132
Am-242	4.56E-12	1.91E-11	4.46E-11	3.47E-09	7.94E-11
Am-242m	3.79E-09	1.59E-08	3.71E-08	2.88E-06	6.6E-08
Am-243	6.99E-08	3.11E-07	9.16E-07	8.16E-05	1.16E-06
At-217	1.47E-26	1.41E-26	7.13E-26	1.95E-24	1.3E-25
Ba-137m	2.15E-11	5.56E-11	1.26E-10	3.28E-10	1.87E-11
Bi-210	1.66E-21	7.4E-22	2.06E-21	7.91E-20	1.67E-21
Bi-211	1.7E-19	8.06E-20	4.03E-19	5.18E-18	4.88E-20
Bi-212	0	0	0	0	0
Bi-213	1.71E-18	1.65E-18	8.32E-18	2.27E-16	1.51E-17
Bi-214	1.89E-23	9.02E-24	2.25E-23	9.43E-22	2.63E-23
C-14	6.01E-06	6E-06	5.39E-05	0.000464	2.07E-05
Cm-242	9.21E-12	3.85E-11	9.01E-11	7.01E-09	1.6E-10
Cm-244	5.45E-10	2.34E-09	1.18E-08	9.23E-07	6.56E-09
Cm-245	1.65E-11	8.02E-11	4.24E-10	3.32E-08	2.36E-10
Cs-135	0.000246	0.000467	0.000873	0.001955	0.000136
Cs-137	0.000141	0.000365	0.000825	0.002154	0.000123
Fr-221	1.33E-22	1.29E-22	6.49E-22	1.77E-20	1.18E-21
Fr-223	2.53E-20	1.2E-20	6.02E-20	7.74E-19	7.29E-21
I-129	0.000404	0.000602	0.003018	0.014443	0.000218
Nb-93m	4.44E-09	2.03E-08	2.69E-08	2.15E-06	4.21E-07
Ni-59	0	0.000167	0.000785	0	0
Ni-63	1.59E-06	6.54E-06	1.72E-05	0.001394	0.000137
Np-237	0.000161	0.000124	0.001342	0.000668	4.69E-05
Np-238	6.76E-16	2.83E-15	6.62E-15	5.15E-13	1.18E-14
Np-239	5.99E-14	2.67E-13	7.86E-13	7E-11	9.91E-13
Pa-231	2.79E-09	1.23E-09	6.16E-09	9.98E-08	9.94E-10
Pa-233	5.46E-12	4.2E-12	4.56E-11	2.27E-11	1.59E-12
Pa-234	1.89E-13	4.11E-14	2.5E-13	7.24E-12	9.77E-14
Pa-234m	3.43E-15	7.46E-16	4.53E-15	1.31E-13	1.77E-15
Pb-209	5.14E-19	4.96E-19	2.5E-18	6.83E-17	4.55E-18
Pb-210	2.69E-18	1.2E-18	3.34E-18	1.28E-16	2.71E-18
Pb-211	2.87E-18	1.36E-18	6.82E-18	8.77E-17	8.25E-19
Pb-212	0	0	0	0	0
Pb-214	2.54E-23	1.21E-23	3.02E-23	1.27E-21	3.54E-23
Pd-107	0.000241	0.000358	0.001836	0.009948	0.00014
Po-210	4.58E-20	2.04E-20	5.68E-20	2.18E-18	4.61E-20
Po-211	1.86E-24	8.84E-25	4.42E-24	5.69E-23	5.35E-25
Po-212	0	0	0	0	0
Po-213	1.83E-30	1.77E-30	8.92E-30	2.43E-28	1.62E-29
Po-214	2.58E-30	1.23E-30	3.08E-30	1.29E-28	3.61E-30
Po-215	2.4E-24	1.14E-24	5.71E-24	7.34E-23	6.91E-25
Po-216	0	0	0	0	0
Po-218	2.94E-24	1.4E-24	3.5E-24	1.47E-22	4.1E-24

$$\text{Conc} = \left(\frac{\text{mass isotope}}{\text{mass } NO_3 \text{ in tank group}}\right) \times 36$$

in grams/liter

2/27/95

Table 1 Rev A
Tank Release Concentration grams/liter for radionuclides

Pu-238	1.68E-07	1.37E-07	2.06E-07	1.62E-05	9.63E-07
Pu-239	0.000558	0.000556	0.001084	0.132349	0.006625
Pu-240	2.93E-05	3.28E-05	6.92E-05	0.009054	0.000451
Pu-241	5.21E-07	4.88E-07	1.56E-06	0.000179	7.92E-06
Pu-242	4.62E-11	1.93E-10	4.52E-10	3.51E-08	8.04E-10
Ra-223	1.38E-15	6.58E-16	3.29E-15	4.23E-14	3.98E-16
Ra-224	0	0	0	0	0
Ra-225	6.02E-19	5.81E-19	2.93E-18	7.99E-17	5.33E-18
Ra-226	8.42E-16	4.02E-16	1E-15	4.21E-14	1.18E-15
Ra-228	0	0	0	0	0
Rh-106	2.36E-22	3.78E-20	4.43E-19	3.82E-17	8.23E-18
Rn-219	5.45E-21	2.59E-21	1.3E-20	1.67E-19	1.57E-21
Rn-220	0	0	0	0	0
Rn-222	5.4E-21	2.58E-21	6.44E-21	2.7E-19	7.54E-21
Ru-106	2.51E-16	4.02E-14	4.7E-13	4.06E-11	8.75E-12
Sb-126	1.3E-12	2.21E-12	1.53E-12	2.33E-10	3.17E-11
Sb-126m	9.88E-15	1.68E-14	1.16E-14	1.77E-12	2.41E-13
Se-79	1.91E-05	2.85E-05	0.000143	0.000647	1.01E-05
Sm-151	3.35E-05	5.7E-05	4.08E-05	0.005526	0.000715
Sn-126	2.74E-05	4.65E-05	3.23E-05	0.004911	0.000668
Sr-90	0.000149	0.000824	0.001153	0.049683	0.010156
Tc-99	0.002744	0.004094	0.020442	0.093537	0.001445
Th-227	2.28E-15	1.08E-15	5.41E-15	6.96E-14	6.55E-16
Th-228	0	0	0	0	0
Th-229	1.11E-13	1.07E-13	5.42E-13	1.48E-11	9.86E-13
Th-230	6.1E-12	3.08E-12	7.08E-12	3.12E-10	1.13E-11
Th-231	1.87E-11	4.39E-12	2.49E-11	7.41E-10	9.71E-12
Th-232	2.3E-15	2.57E-15	5.42E-15	7.09E-13	3.53E-14
Th-234	1.02E-10	2.22E-11	1.34E-10	3.9E-09	5.26E-11
Tl-207	3.72E-19	1.77E-19	8.84E-19	1.14E-17	1.07E-19
Tl-208	0	0	0	0	0
Tl-209	1.25E-24	1.2E-24	6.07E-24	1.65E-22	1.1E-23
U-233	1.7E-09	1.44E-09	1.17E-08	1.17E-07	9E-09
U-234	1.08E-07	5.82E-08	1.32E-07	6.79E-06	2.97E-07
U-235	0.045741	0.010745	0.061045	1.814957	0.023784
U-236	4.58E-08	5.12E-08	1.08E-07	1.41E-05	7.03E-07
U-237	1.61E-14	1.51E-14	4.84E-14	5.53E-12	2.45E-13
U-238	7.003571	1.523161	9.240486	267.9629	3.614835
Y-90	3.83E-06	2.12E-05	2.96E-05	0.001277	0.000261
Zr-93	0.000247	0.002522	0.001834	0.312777	0.067073

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Table 2
Chemical Release Concentrations Nonradioactive Chemicals for Single Shell Tanks

solubility grams/liter

Chemical	1WSS	2WSS	1ESS	2ESS	4ESS
Ag (1)	5.63E-10	5.11E-10	3.80E-09	1.24E-08	1.97E-10
Al (1)	4.55E+00	8.75E+00	1.53E+01	5.37E+02	1.94E+00
Al+3	9.75E-01	5.73E+00	1.13E+01	8.06E+02	1.87E+00
AlO2-	6.23E+00	8.47E+00	1.37E+01	1.05E+02	1.34E+00
Ba+2 (1)	4.91E-04	1.34E-03	1.95E-03	1.52E-01	1.40E-02
Bi+3	2.28E+00	2.21E-03	1.79E+00	8.27E-01	
C2H3O3 (1)	7.28E-02	2.25E-02	6.15E-03	1.65E-01	2.19E-01
C6H5O7 (1)	7.47E+00	5.21E+00	2.33E+01	1.53E+02	1.79E+00
CO3-2	9.68E+00	1.27E+00	1.22E+01	8.62E+01	2.80E+00
Ca+2	2.72E-03	4.60E-02	1.04E+00	9.16E+01	1.13E-01
Cd+2 (2)					
Ce+3	1.59E+00	2.50E-01	1.68E+00	3.67E-01	1.29E-01
Cl-	3.00E-01	4.28E-02	2.40E-01	5.58E-02	4.44E-03
Cr+3	1,73E-02	6.59E-01	1.38E-02	2.30E-01	6.07E-02
CrO4-2	4.28E-03	1.63E-01	3.42E-03	5.69E-02	1.50E-02
EDTA (1)	5.58E-01	1.73E-01	4.71E-02	1.27E+00	1.67E+00
F-	1.97E+00	2.38E-01	4.42E+00	5.56E+02	2.27E-02
Fe+3	2.33E+00	6.47E-01	2.70E+00	7.72E+01	1.31E+01
Fe(CN)6-4	3.00E-02	1.08E-02	4.72E+00	9.73E+01	3.90E-03
HEDTA (1)	1.01E+00	3.14E-01	9.41E-02	2.30E+00	3.04E+00
Hg+ (2)					
K+ (1)	6.85E-02	2.00E-01	5.50E-01	2.56E-01	3.33E-02
La+ (1)	2.03E-02		7.60E-03		
Mn+4	2.87E-01	8.92E-02	2.49E-01	7.12E+01	1.73E+00
Na+	1.99E+02	1.67E+02	2.20E+02	2.92E+03	2.78E+02
Ni+2	6.88E-02	2.64E-02	2.37E+00	6.12E+01	7.31E-02
NO2-	2.41E+01	6.33E+00	3.92E+01	6.59E-01	1.71E+01
NO3-	3.60E+02	3.60E+02	3.60E+02	3.60E+02	3.60E+02
OH-	6.20E+00	1.82E+01	1.98E+01	1.97E+03	1.28E+01
PO4-3	3.66E+01	8.70E-01	3.44E+01	4.14E+01	6.34E-02
Pb (1)	3.22E-02	3.06E-02	8.04E+00	9.48E+00	7.60E-03
SiO3-	7.67E+00	1.90E+00	7.68E+00	9.83E-01	1.54E-01
Sn (1)			1.02E-04		
SO4-2	8.68E+00	1.96E+00	1.05E+01	1.86E+02	6.15E+00
Sr+2	1.28E-05	5.52E-04	6.82E-01	3.52E-02	4.25E-03
W+4 (2)					
Zr+4	1.92E-01	1.83E-01	1.24E-01	2.82E+02	9.41E-03

TABLE 3

SST RETRIEVAL LEAK ESTIMATES

TANK GROUP	1WSS	2WSS	1ESS	2ESS	4ESS
NO. TANKS	40	43	40	16	10
RETRIEVAL LEAK VOLUME (LITERS)	605600	651020	605600	242240	151400
RETRIEVAL LEAK RATE (LITERS/YR)	40373	43401	40373	16149	10093
SST RETRIEVAL OPERATIONS =15 YRS MIN PRETREAT AND TPA					
SST RETRIEVAL PERIOD 2003/2018					

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(DK-ADJ.XLW)Radnuclide Data

Atomic Wieght (A)	Isotope	Half-Life (T)	Units	Specific Activity (TBq/g)	Specific Activity (Ci/g)	Decay Constant (per day)
3	H-3	1.24E+01	y	3.57E+02	9.64E+03	1.54E-04
7	Be-7	53.440	d	1.29E+04	3.49E+05	1.30E-02
11	C-11	20.380	m	3.10E+07	8.38E+08	4.90E+01
13	N-13	9.970	m	5.36E+07	1.45E+09	1.00E+02
14	C-14	5.73E+03	y	1.65E-01	4.45E+00	3.31E-07
16	N-16	7.20E+00	s	3.62E+09	9.78E+10	8.32E+03
18	F-18	1.829	h	3.50E+04	9.47E+05	9.10E+00
22	Na-22	2.60E+00	y	2.31E+02	6.24E+03	7.29E-04
24	Na-24	15.000	h	3.20E+03	8.66E+04	1.11E+00
32	P-32	14.290	d	1.06E+04	2.85E+05	4.85E-02
35	S-35	87.440	d	1.58E+03	4.26E+04	7.93E-03
36	Cl-36	3.01E+05	y	1.22E-03	3.30E-02	6.30E-09
41	Ar-41	1.827	h	1.54E+04	4.16E+05	9.11E+00
42	K-42	51.500	d	2.23E+03	6.03E+04	1.35E-02
45	Ca-45	163.000	d	6.58E+02	1.78E+04	4.25E-03
46	Sc-46	83.830	d	1.25E+03	3.38E+04	8.27E-03
51	Cr-51	27.704	d	3.42E+03	9.23E+04	2.50E-02
54	Mn-54	312.500	d	2.86E+02	7.73E+03	2.22E-03
55	Fe-55	2.70E+00	y	8.90E+01	2.41E+03	7.03E-04
56	Mn-56	2.579	h	7.99E+03	2.16E+05	6.45E+00
57	Co-57	270.900	d	3.13E+02	8.45E+03	2.56E-03
59	Ni-59	7.50E+04	y	2.99E-03	8.07E-02	2.53E-08
59	Fe-59	44.528	d	1.84E+03	4.97E+04	1.56E-02
60	Co-60	5.27E+00	y	4.18E+01	1.13E+03	3.60E-04
63	Ni-63	1.00E+02	y	2.10E+00	5.66E+01	1.90E-05
64	Cu-64	12.701	h	1.42E+03	3.84E+04	1.31E+00
65	Zn-65	243.900	d	3.04E+02	8.23E+03	2.84E-03
65	Ni-65	2.520	h	7.04E+03	1.90E+05	6.60E+00
72	Ga-72	14.100	h	1.14E+03	3.07E+04	1.18E+00
76	As-76	26.320	h	5.77E+02	1.56E+04	6.32E-01
79	Se-79	6.50E+04	y	2.57E-03	6.96E-02	2.92E-08
82	Br-82	35.300	h	3.99E+02	1.08E+04	4.71E-01
86	Rb-86	18.660	d	3.01E+03	8.13E+04	3.71E-02
89	Sr-89	50.500	d	1.07E+03	2.90E+04	1.37E-02
90	Sr-90	2.86E+01	y	5.13E+00	1.39E+02	6.64E-05
90	Y-90	64.100	h	2.00E+02	5.41E+03	2.60E-01
92	Y-92	3.540	h	3.54E+03	9.56E+04	4.70E+00
92	Sr-92	2.710	h	4.63E+03	1.25E+05	6.14E+00
93	Nb-93m	1.46E+01	y	9.73E+00	2.63E+02	1.30E-04
93	Zr-93	1.53E+06	y	9.29E-05	2.51E-03	1.24E-09
95	Zr-95	63.980	d	7.94E+02	2.15E+04	1.08E-02
95	Nb-95	35.150	d	1.45E+03	3.91E+04	1.97E-02
99	Mo-99	66.000	h	1.77E+02	4.77E+03	2.52E-01
99	Tc-99m	6.020	h	1.94E+03	5.23E+04	2.76E+00
99	Tc-99	2.13E+05	y	6.27E-04	1.69E-02	8.91E-09
103	Ru-103	39.280	d	1.19E+03	3.22E+04	1.76E-02
106	Ru-106	368.200	d	1.24E+02	3.34E+03	1.88E-03

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(DK-ADJ.XLW)Radnuclide Data

Atomic Weight (A)	Isotope	Half-Life (T)	Units	Specific Activity (TBq/g)	Specific Activity (Ci/g)	Decay Constant (per day)
106	Rh-106	2.99E+01	s	1.31E+08	3.55E+09	2.00E+03
107	Pd-107	6.50E+06	y	1.90E-05	5.14E-04	2.92E-10
110	Ag-110m	249.900	d	1.76E+02	4.75E+03	2.77E-03
110	Ag-110	2.46E+01	s	1.54E+08	4.17E+09	2.43E+03
123	I-123	13.200	h	7.11E+02	1.92E+04	1.26E+00
125	I-125	60.140	d	6.42E+02	1.74E+04	1.15E-02
126	Sb-126	12.400	d	3.09E+03	8.35E+04	5.59E-02
126	Sb-126m	19.000	m	2.90E+06	7.85E+07	5.25E+01
126	Sn-126	1.00E+05	y	1.05E-03	2.83E-02	1.90E-08
129	I-129	1.57E+07	y	6.52E-06	1.76E-04	1.21E-10
131	I-131	8.040	d	4.58E+03	1.24E+05	8.62E-02
132	Te-132	76.200	h	1.12E+02	3.02E+03	2.13E-01
132	I-132	2.300	h	3.80E+03	1.03E+05	7.23E+00
133	Ba-133	1.05E+01	y	9.46E+00	2.56E+02	1.61E-04
133	Xe-133	5.245	d	6.92E+03	1.87E+05	1.32E-01
133	I-133	20.800	h	4.17E+02	1.13E+04	8.00E-01
133	Te-133	12.450	m	4.20E+06	1.13E+08	8.02E+01
134	Cs-134	2.06E+00	y	4.78E+01	1.29E+03	9.20E-04
135	I-135	6.610	h	1.29E+03	3.49E+04	2.52E+00
135	Ba-135m	28.700	h	2.98E+02	8.05E+03	5.80E-01
135	Cs-135	2.30E+06	y	4.26E-05	1.15E-03	8.25E-10
136	Cs-136	13.100	d	2.71E+03	7.32E+04	5.29E-02
137	Cs-137	3.02E+01	y	3.20E+00	8.64E+01	6.29E-05
137	Ba-137m	2.552	m	1.99E+07	5.37E+08	3.91E+02
140	Ba-140	12.740	d	2.71E+03	7.31E+04	5.44E-02
140	La-140	40.272	h	2.05E+02	5.53E+03	4.13E-01
141	Ce-141	32.501	d	1.05E+03	2.85E+04	2.13E-02
143	Ce-144	284.300	d	1.19E+02	3.21E+03	2.44E-03
143	Pr-143	13.560	d	2.49E+03	6.73E+04	5.11E-02
143	Ce-143	33.000	h	2.44E+02	6.61E+03	5.04E-01
144	Pr-144	17.280	m	2.79E+06	7.55E+07	5.78E+01
147	Pm-147	2.62E+00	y	3.43E+01	9.26E+02	7.23E-04
151	Sm-151	9.00E+01	y	9.72E-01	2.63E+01	2.11E-05
154	Eu-154	8.590	y	9.99E+00	2.70E+02	2.21E-04
181	Ta-181	121.200	d	2.20E+02	5.95E+03	5.72E-03
182	Ta-182	115.000	d	2.31E+02	6.23E+03	6.03E-03
185	W-185	75.100	d	3.47E+02	9.39E+03	9.23E-03
192	Ir-192	74.020	d	3.40E+02	9.18E+03	9.36E-03
198	Au-198	2.696	d	9.04E+03	2.44E+05	2.57E-01
199	Au-199	3.139	d	7.73E+03	2.09E+05	2.21E-01
203	Hg-203	46.600	d	5.10E+02	1.38E+04	1.49E-02
204	Tl-204	3.78E+00	y	1.71E+01	4.63E+02	5.02E-04
207	Tl-207	4.770	m	7.04E+06	1.90E+08	2.09E+02
208	Tl-208	3.053	m	1.09E+07	2.96E+08	3.27E+02
209	Pb-209	3.253	h	1.70E+03	4.59E+04	5.11E+00
209	Tl-209	2.200	m	1.51E+07	4.09E+08	4.54E+02
210	Pb-210	2.23E+01	y	2.83E+00	7.64E+01	8.53E-05

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(DK-ADJ.XLW)Radnuclide Data

Atomic Weight (A)	Isotope	Half-Life (T)	Units	Specific Activity (TBq/g)	Specific Activity (Ci/g)	Decay Constant (per day)
210	Bi-210	5.012	d	4.59E+03	1.24E+05	1.38E-01
210	Po-210	138.378	d	1.66E+02	4.49E+03	5.01E-03
211	Bi-211	2.130	m	1.55E+07	4.18E+08	4.69E+02
211	Pb-211	36.100	m	9.12E+05	2.47E+07	2.78E+01
211	Po-211	5.16E-01	s	3.83E+09	1.04E+11	1.15E+05
212	Po-212	2.98E-07	s	6.60E+15	1.79E+17	2.01E+11
212	Bi-212	1.009	h	5.39E+03	1.46E+05	1.65E+01
212	Pb-212	10.643	h	5.11E+02	1.38E+04	1.56E+00
213	Bi-213	45.650	m	7.15E+05	1.93E+07	2.19E+01
213	Po-213	4.20E-06	s	4.66E+14	1.26E+16	1.43E+10
214	Bi-214	19.900	m	1.63E+06	4.41E+07	5.02E+01
214	Pb-214	26.800	m	1.21E+06	3.28E+07	3.72E+01
214	Po-214	1.64E-04	s	1.19E+13	3.22E+14	3.66E+08
215	Po-215	1.78E-03	s	1.09E+12	2.95E+13	3.37E+07
216	Po-216	1.46E-01	s	1.32E+10	3.57E+11	4.10E+05
217	At-217	3.23E-02	s	5.95E+10	1.61E+12	1.85E+06
218	Po-218	3.050	m	1.05E+07	2.83E+08	3.27E+02
219	Rn-219	3.96E+00	s	4.81E+08	1.30E+10	1.51E+04
220	Rn-220	5.56E+01	s	3.41E+07	9.21E+08	1.06E+03
221	Fr-221	4.800	m	6.55E+06	1.77E+08	2.08E+02
222	Rn-222	3.824	d	5.69E+03	1.54E+05	1.81E-01
223	Fr-223	21.800	m	1.43E+06	3.86E+07	4.58E+01
223	Ra-223	11.434	d	1.89E+03	5.12E+04	6.06E-02
224	Ra-224	3.620	d	5.95E+03	1.61E+05	1.91E-01
225	Ac-225	10.000	d	2.15E+03	5.80E+04	6.93E-02
225	Ra-225	14.800	d	1.45E+03	3.92E+04	4.68E-02
226	Ra-226	1.60E+03	y	3.65E-02	9.88E-01	1.19E-06
227	Th-227	18.718	d	1.14E+03	3.07E+04	3.70E-02
227	Ac-227	2.18E+01	y	2.67E+00	7.23E+01	8.72E-05
228	Ra-228	5.75E+00	y	1.01E+01	2.72E+02	3.30E-04
228	Th-228	1.91E+00	y	3.03E+01	8.19E+02	9.92E-04
228	Ac-228	6.130	h	8.25E+02	2.23E+04	2.71E+00
229	Th-229	7.34E+03	y	7.86E-03	2.12E-01	2.59E-07
230	Th-230	7.70E+04	y	7.46E-04	2.02E-02	2.46E-08
231	Th-231	25.520	h	1.96E+02	5.29E+03	6.52E-01
231	Pa-231	3.28E+04	y	1.75E-03	4.72E-02	5.79E-08
232	Th-232	1.41E+10	y	4.05E-09	1.10E-07	1.35E-13
232	U-232	7.20E+01	y	7.91E-01	2.14E+01	2.64E-05
233	U-233	1.59E+05	y	3.57E-04	9.64E-03	1.19E-08
233	Pa-233	27.000	d	7.67E+02	2.07E+04	2.57E-02
233	Th-233	22.300	m	1.34E+06	3.62E+07	4.49E+01
234	U-234	2.45E+05	y	2.31E-04	6.24E-03	7.76E-09
234	Th-234	24.100	d	8.56E+02	2.31E+04	2.88E-02
234	Pa-234	6.700	h	7.36E+02	1.99E+04	2.48E+00
234	Pa-234m	1.170	m	2.54E+07	6.86E+08	8.53E+02
235	U-235	7.04E+08	y	7.99E-08	2.16E-06	2.70E-12
236	U-236	2.34E+07	y	2.39E-06	6.46E-05	8.10E-11

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15/16

(DK-ADJ.XLW)Radnuclide Data

Atomic Wieght (A)	Isotope	Half-Life (T)	Units	Specific Activity (TBq/g)	Specific Activity (Ci/g)	Decay Constant (per day)
236	Pu-236	2.85E+00	y	1.96E+01	5.31E+02	6.66E-04
237	U-237	6.750	d	3.02E+03	8.15E+04	1.03E-01
237	Np-237	2.14E+06	y	2.61E-05	7.04E-04	8.87E-10
238	U-238	4.47E+09	y	1.24E-08	3.38E-07	4.25E-13
238	Pu-238	8.77E+01	y	6.33E-01	1.71E+01	2.16E-05
238	Np-238	2.117	d	9.58E+03	2.59E+05	3.27E-01
239	Pu-239	2.41E+04	y	2.29E-03	6.19E-02	7.86E-08
239	Np-239	2.355	d	8.57E+03	2.32E+05	2.94E-01
240	Pu-240	6.57E+03	y	8.38E-03	2.27E-01	2.89E-07
241	Am-241	4.32E+02	y	1.27E-01	3.43E+00	4.39E-06
241	Pu-241	1.44E+01	y	3.81E+00	1.03E+02	1.32E-04
242	Am-242	16.020	h	2.98E+02	8.04E+03	1.04E+00
242	Am-242m	1.52E+02	y	3.59E-01	9.71E+00	1.25E-05
242	Cm-242	163.200	d	1.22E+02	3.30E+03	4.25E-03
242	Pu-242	3.76E+05	y	1.45E-04	3.93E-03	5.05E-09
243	Am-243	7.38E+03	y	7.37E-03	1.99E-01	2.57E-07
244	Cm-244	1.81E+01	y	2.99E+00	8.08E+01	1.05E-04
245	Cm-245	8.50E+03	y	6.35E-03	1.72E-01	2.23E-07
252	Cf-252	2.64E+00	y	1.99E+01	5.37E+02	7.19E-04

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REFERENCES.

SERNE, R.J. AND M.I. Wood, 1990 HANFORD WASTE FORM RELEASES AND SEDIMENT INTERACTIONS, PNL 7297, BATTELLE PACIFIC NORTHWEST LABORATORY, RICHLAND WASHINGTON.

WASTE RETRIEVAL AND TRANSFER DATA PACKAGE EA FREDENBURG, WHC-SD-WM-EV-097 RevA Draft RECVD 11/8/94.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering / Preliminary SITING MAPS for TWRS Complex

ORIGINATOR Colin Henderson DATE 11/16/95

REVISION NO. 0

OBJECTIVE Identify Preliminary Siting Areas Reviewed for location of the TWRS Processing facilities. See also (SHORD 1995) WHC-SD-WM-SE-021

METHODOLOGY N/A

ASSUMPTIONS None

(Continue on another sheet if necessary)

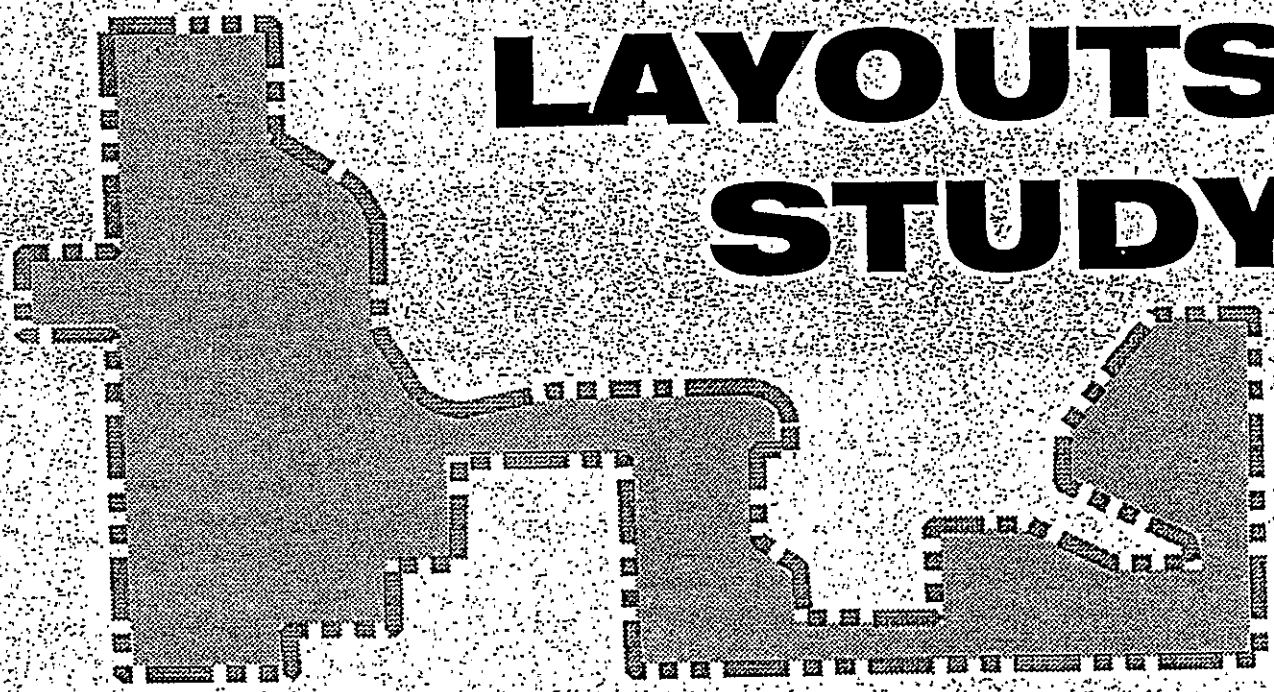
Col. Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

TANK WASTE REMEDIATION SYSTEM

SITE EVALUATION ALTERNATIVE LAYOUTS STUDY



DRAFT

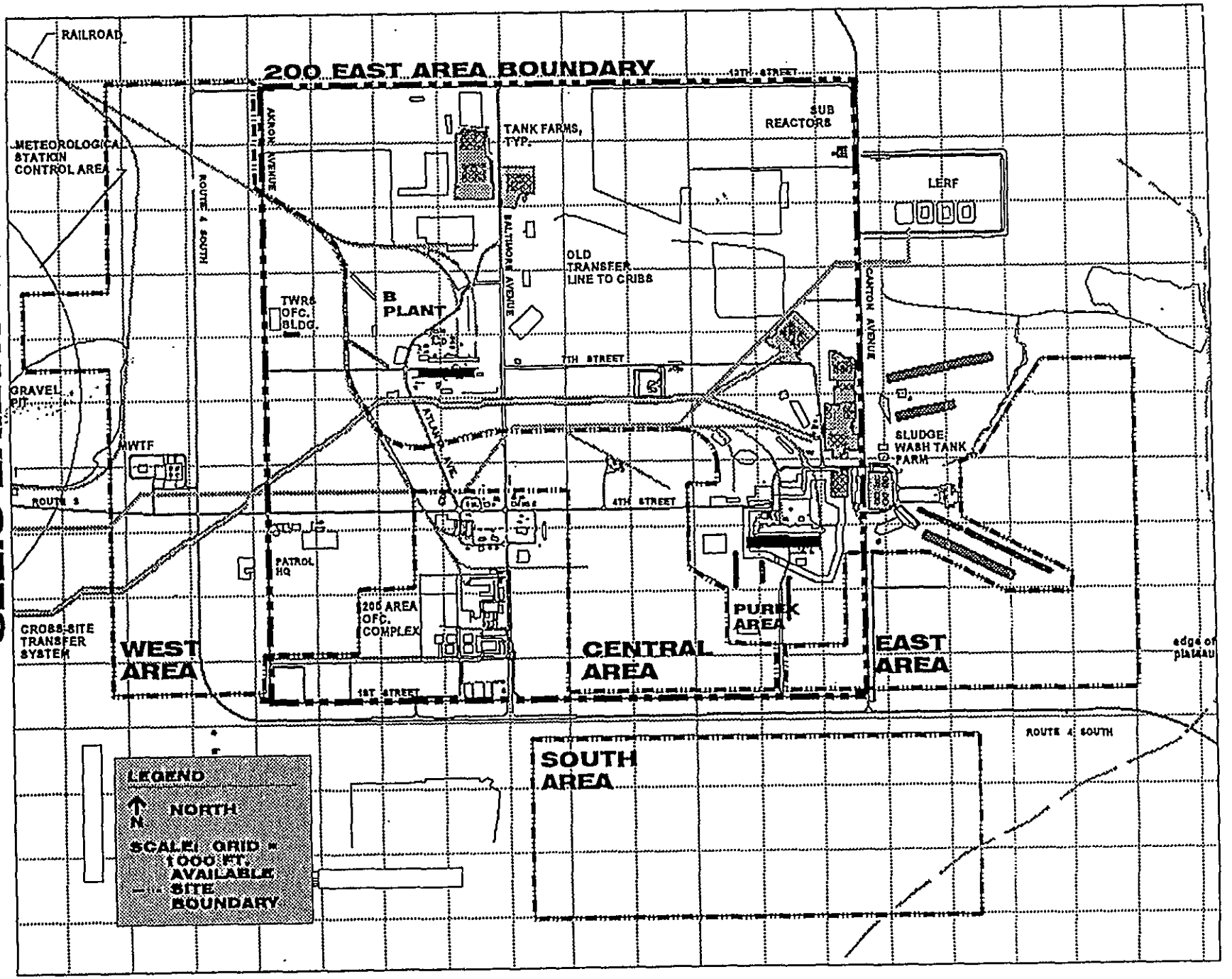
August 8, 1994

TWRS MASTER SITE PLAN

HANFORD, WASHINGTON

FLUOR DANIEL

TWRS ALTERNATIVE SITES



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Area No	Project Abbrev.	Building Name	net area s.f.	bldg area	TOTAL @100% future exp.	Project Totals	equiv. acres
1	**200 Ofc.**	200 East Ofc. Bldg.	35,000.00	105,000.00	350,000.00	350,000.00	8.03
2	**XTS**	None listed	0.00	0.00	0.00	0.00	0.00
3	**HLWV**	High Level Waste Vit. Facility	106,225.00	189,000.00	738,062.50	738,062.50	16.94
4	**LLVF**	Low Level Waste Vit. Facility	546,875.00	189,000.00	1,839,687.50	1,839,687.50	42.23
5	**MWTF**	Admin. Building	37,500.00	21,000.00	146,250.00		3.36
	MWTF	Support Facility, MWTF	84,500.00	14,700.00	248,000.00		5.69
	MWTF	Weather Enclosure, MWTF	n/a -use tanks	8,400.00	21,000.00		0.48
	mwtf	(4) 1 million Gal. DST Tanks	87,120.00				
	Proj. sum		209,120.00	44,100.00	633,050.00	633,050.00	14.53
6	**MWSF**	Administration Building	37,500.00	21,000.00	146,250.00		3.36
	MWSF	Support Facility, MWSF	84,500.00	14,700.00	248,000.00		5.69
	MWSF	Weather Enclosure, MWSF	n/a -use tanks	8,400.00	21,000.00		0.48
	mwsf	(8) 1 million Gal. DST Tanks	174,240.00				
	Proj. sum		296,240.00	44,100.00	650,850.00	850,850.00	19.53
7	**NTF**	Northern Areas Training Facilty	30,000.00	63,000.00	232,500.00	232,500.00	5.34
8	**PF**	Pretreatment Facility	22,076.00	63,000.00	212,695.00	212,695.00	4.88
9	**STEAM**	Steam Plant	150,000.00	2,800.00	382,000.00	382,000.00	8.77
10	**TOB**	Gatehouse/Timekeeping Bldg.	2,160.00	9,240.00	28,500.00		0.65
	TOB	HWVP trailer village	10,080.00	29,400.00	98,700.00		2.27
	TOB	Operations Administration Bldg	63,000.00	210,000.00	682,500.00		15.67
	TOB	Temporary Construction Wrhse.	15,000.00	0.00	37,500.00		0.86
	Proj. sum	include only OAB in area totals	63,000.00	210,000.00	682,500.00	682,500.00	15.67
11A	**CLOSE SHARED SUPPORT**						
	TSC	Operations Control Building	70,000.00	52,500.00	306,250.00		7.03
	TSC	Low Level Vit Vaults (50)	31,250.00	1,260.00	3,909,400.00		89.75
	trade study	Regulated Entrance Bldg.	30,000.00		75,000.00		1.72
	trade study	Bulk Cold Chem. Bldg.	90,000.00		225,000.00		5.17
	trade study	Receipt /stor. tanks (6 pack)	21,000.00		105,000.00		2.41
	trade study	Cooling tower	12,000.00		30,000.00		0.69
	Proj. sum		254,250.00	53,760.00	4,650,650.00	4,650,650.00	106.76
11B	**DISTANT SHARED SUPPORT**						
	TSC	Operations Support Building #1	70,000.00	126,000.00	490,000.00		11.25
	TSC	Operations Support Building #2	70,000.00	126,000.00	490,000.00		11.25
	TSC	Diesel Generator Building	45,000.00	2,940.00	119,850.00		2.75
	TSC	Warehouse #1	110,000.00	18,900.00	322,250.00		7.40
	TSC	Warehouse #2	110,000.00	18,900.00	322,250.00		7.40
	TSC	Warehouse #3	110,000.00	18,000.00	320,000.00		7.35
	TSC	Fab. Shop & Mock up Building	110,000.00	14,700.00	311,750.00		7.16
	TSC	Self-shielding cask pad #1	210,000.00	0.00	525,000.00		12.05
	TSC	Self-shielding cask pad #2	210,000.00	0.00	525,000.00		12.05
	TSC	Self-shielding cask pad #3	210,000.00	0.00	525,000.00		12.05
	trade study	Mech. elec. bldg	90,000.00		225,000.00		5.17
	trade study	Fire water pump house	1,200.00		3,000.00		0.07
	trade study	Vit fire water pump house	1,200.00		3,000.00		0.07
	trade study	Raw water pump house	1,200.00		3,000.00		0.07
	trade study	Fire water tank	9,503.64		23,759.11		0.55
	trade study	Vit fire water tank	7,854.25		19,635.63		0.45
	trade study	Shipping/receiving	6,000.00		15,000.00		0.34
	trade study	Service & Storage yards	90,000.00		225,000.00		5.17
	Proj. sum		1,461,957.89	33,600.00	3,738,894.73	3,738,894.73	85.83
12	**TFIIS**	Central Ofc. Fac'lty & Ops Sys.	6,256.00	18,900.00	62,890.00	62,890.00	1.44
13	**WSSTF**	Waste Sample Stor./ Train. Fac.	12,000.00	8,000.00	50,000.00	50,000.00	1.15
14	**SS**	Power Substation	360,000.00	na	720,000.00	720,000.00	16.53
	Totals		3,553,001.89	1,024,800.00	15,143,779.73	15,143,779.73	347.65

Building / Project Area Table

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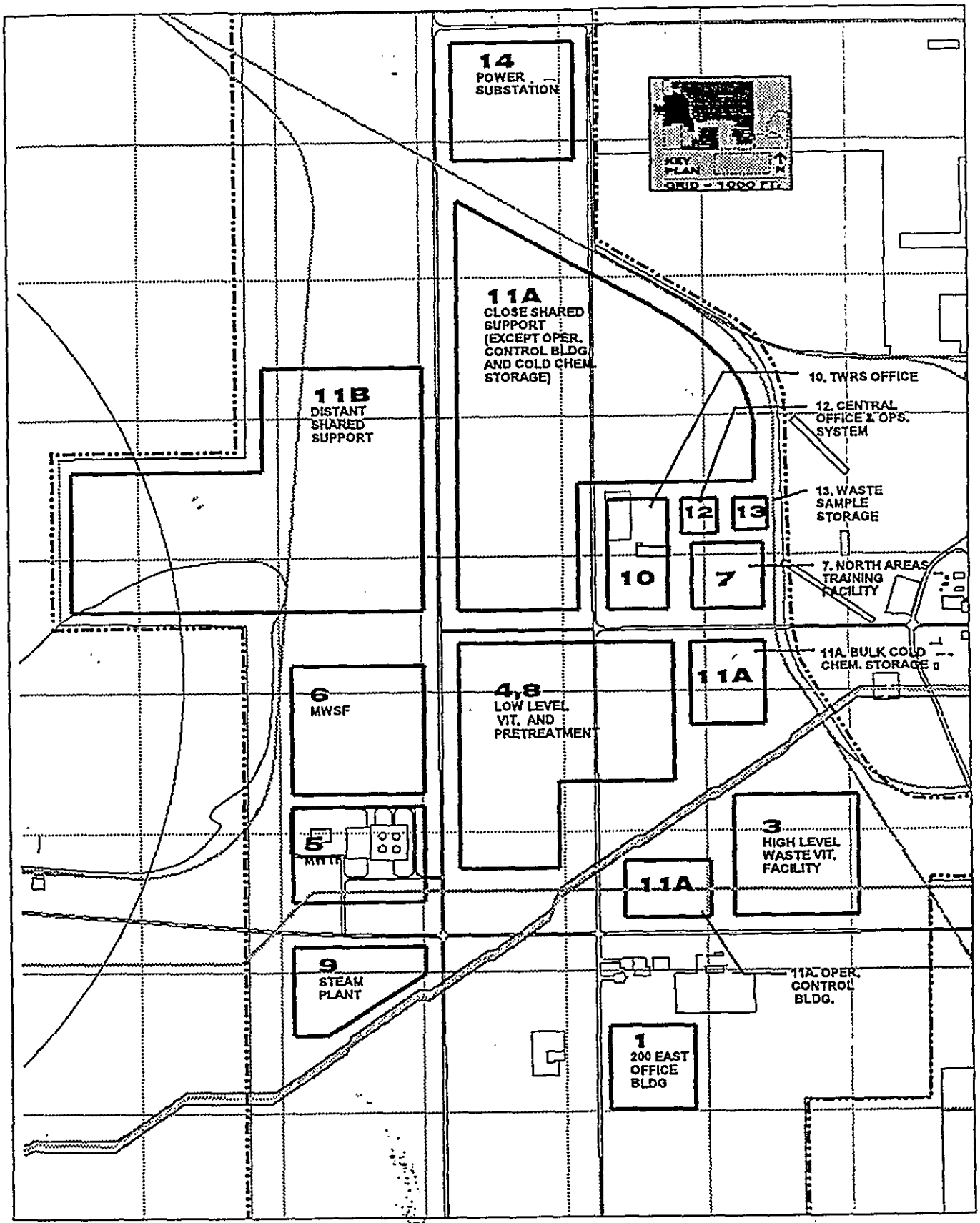

ALTERNATE LAYOUT 1

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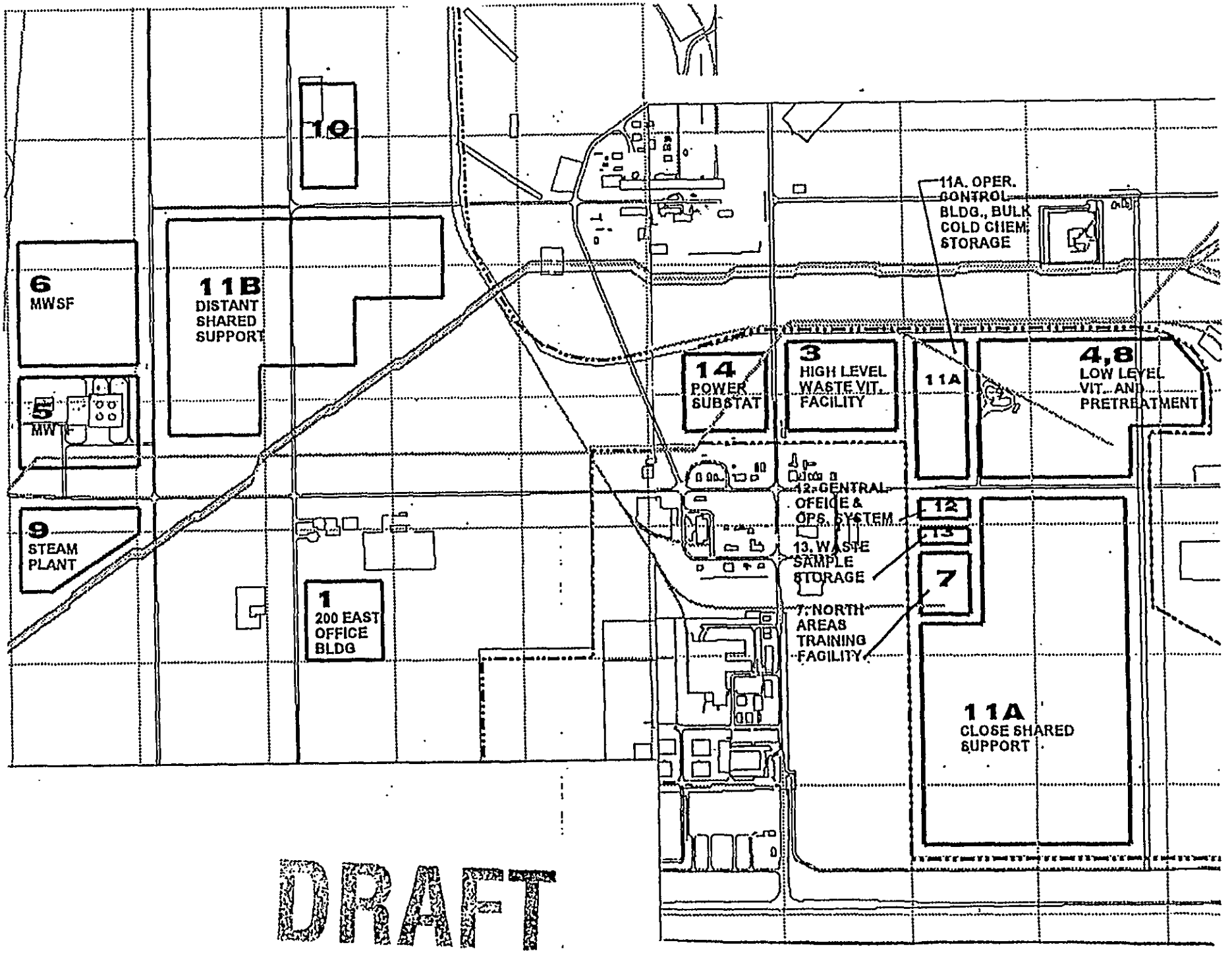
ALTERNATE LAYOUT 2



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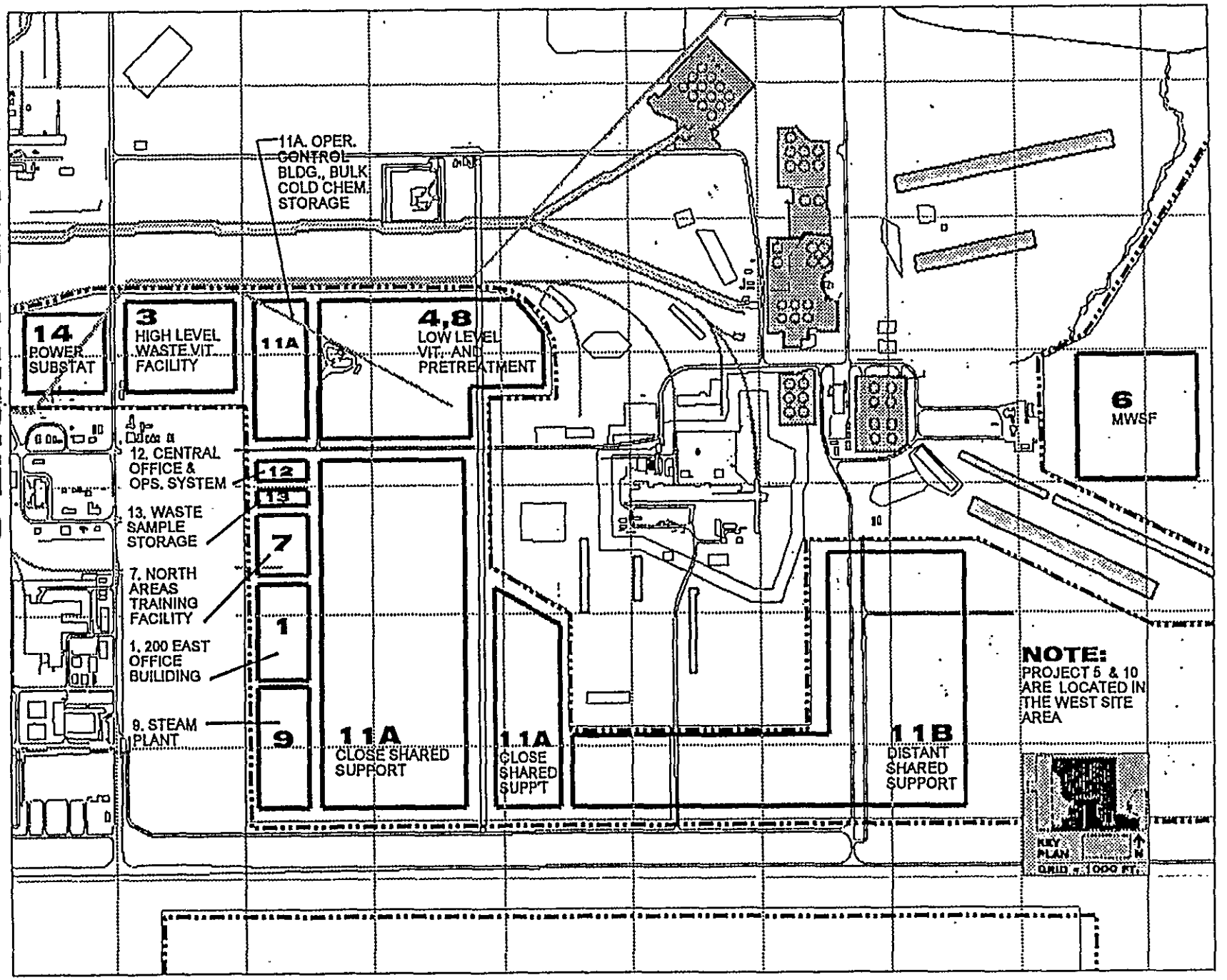
created 08/02/94 edit/printed August 8, 1994

ALTERNATE LAYOUT 3



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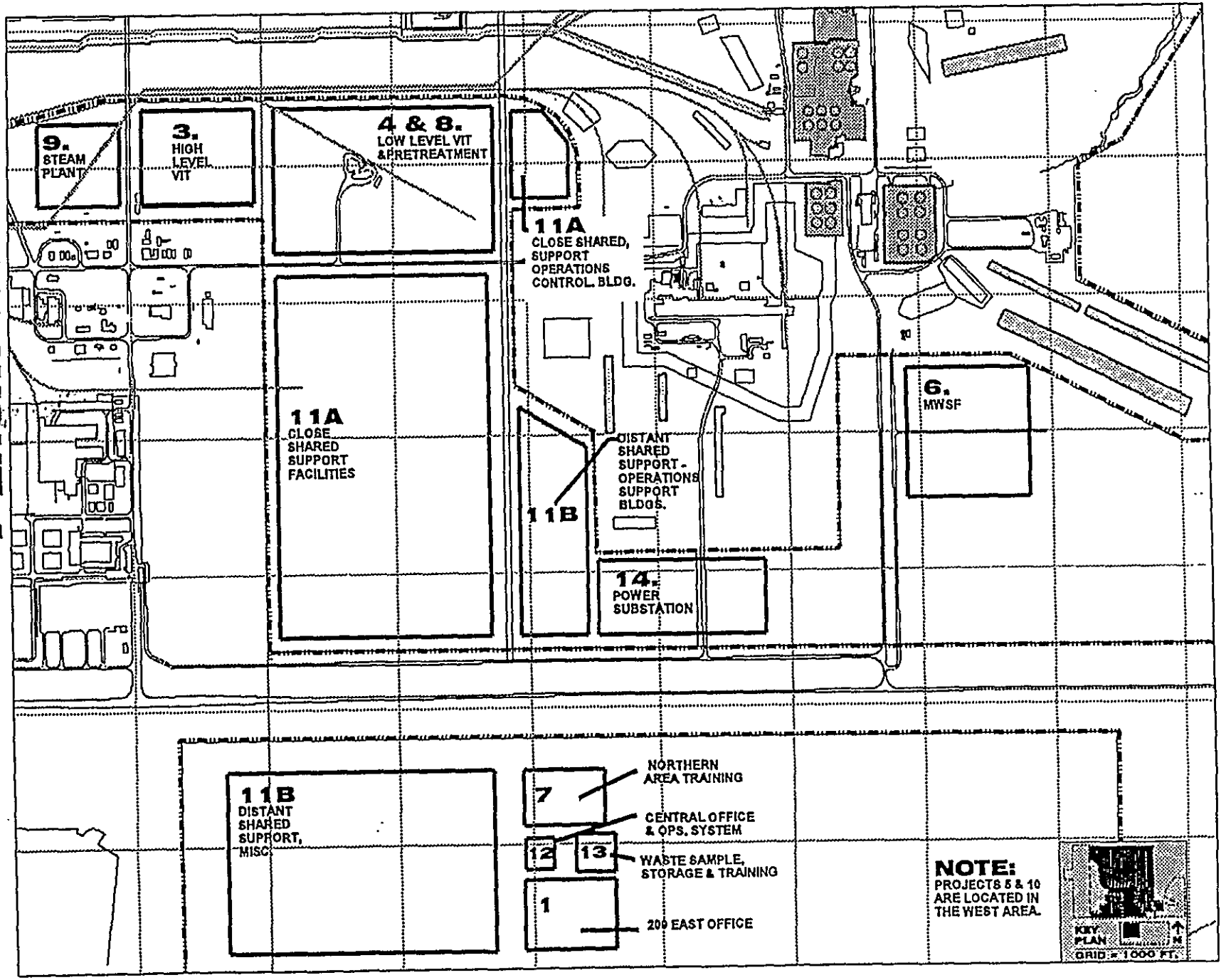
ALTERNATE LAYOUT 4



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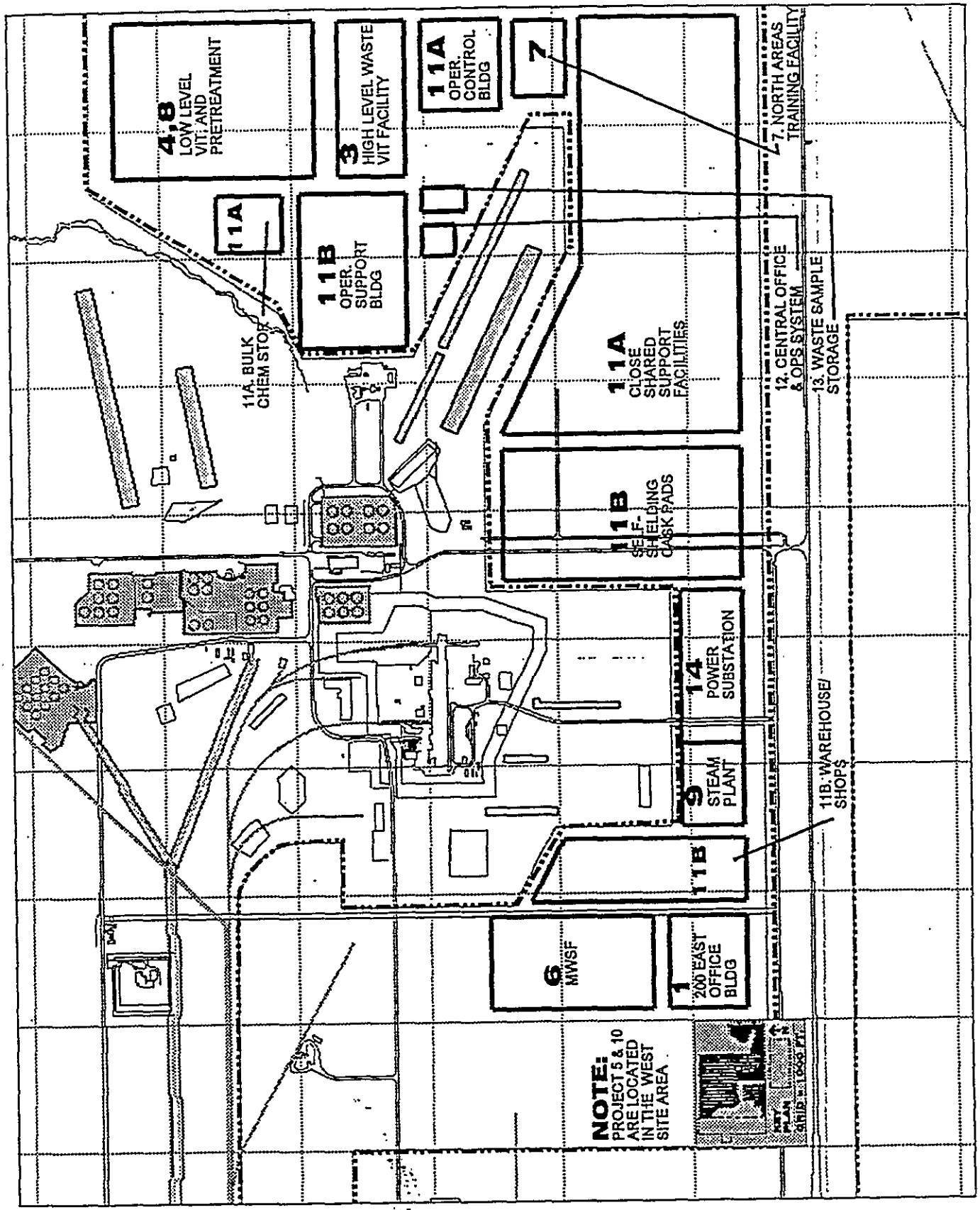

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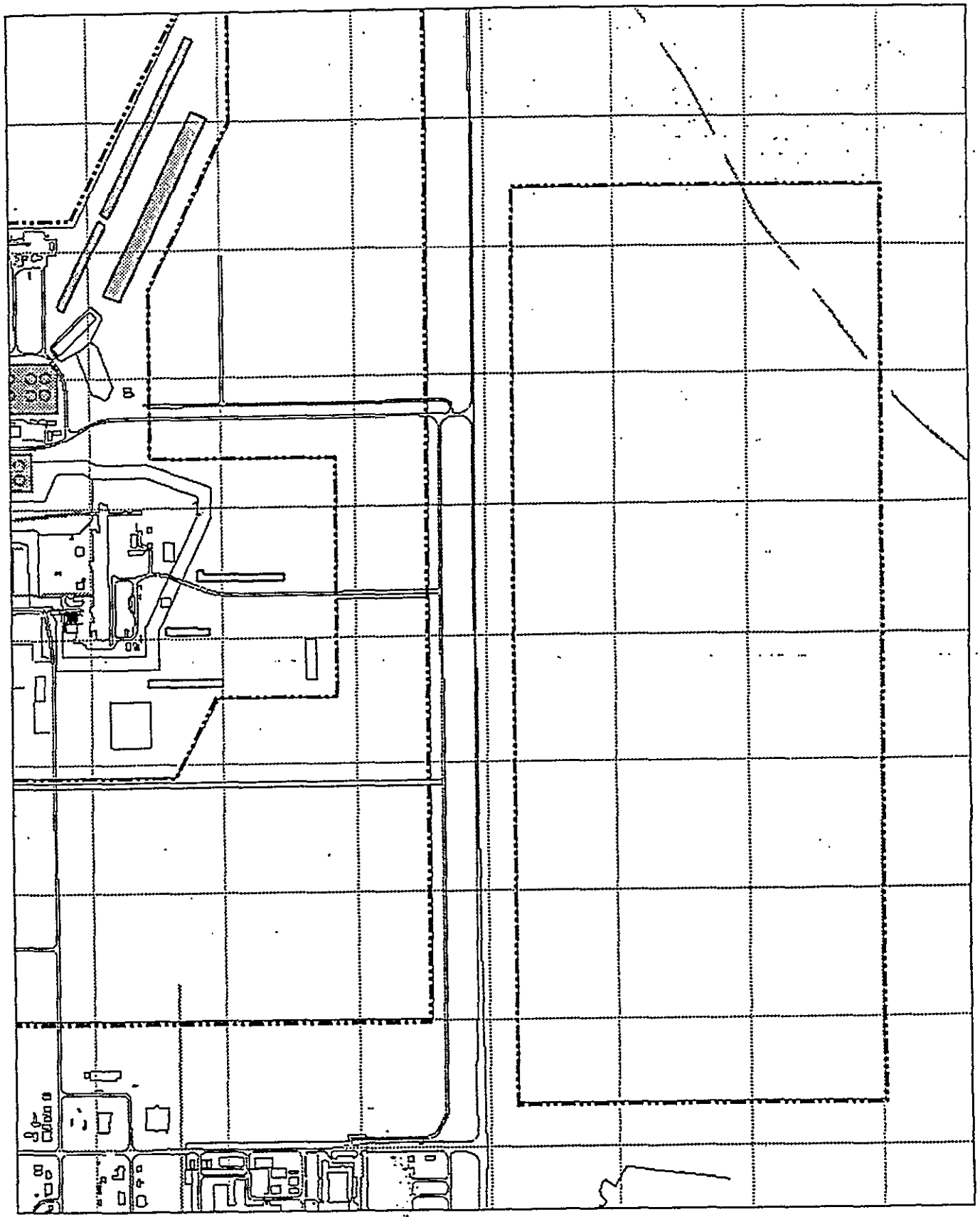

ALTERNATE LAYOUT 6

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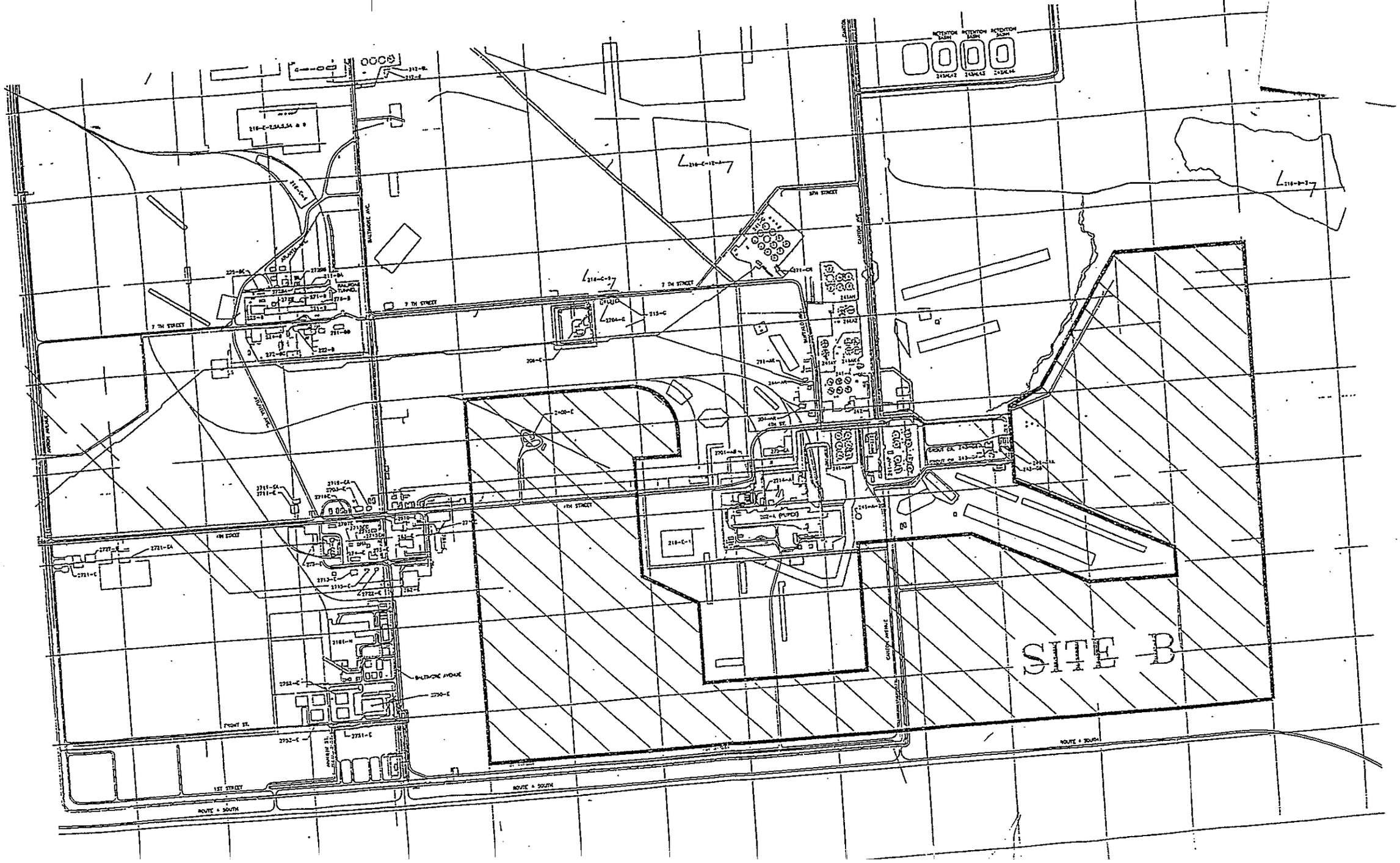
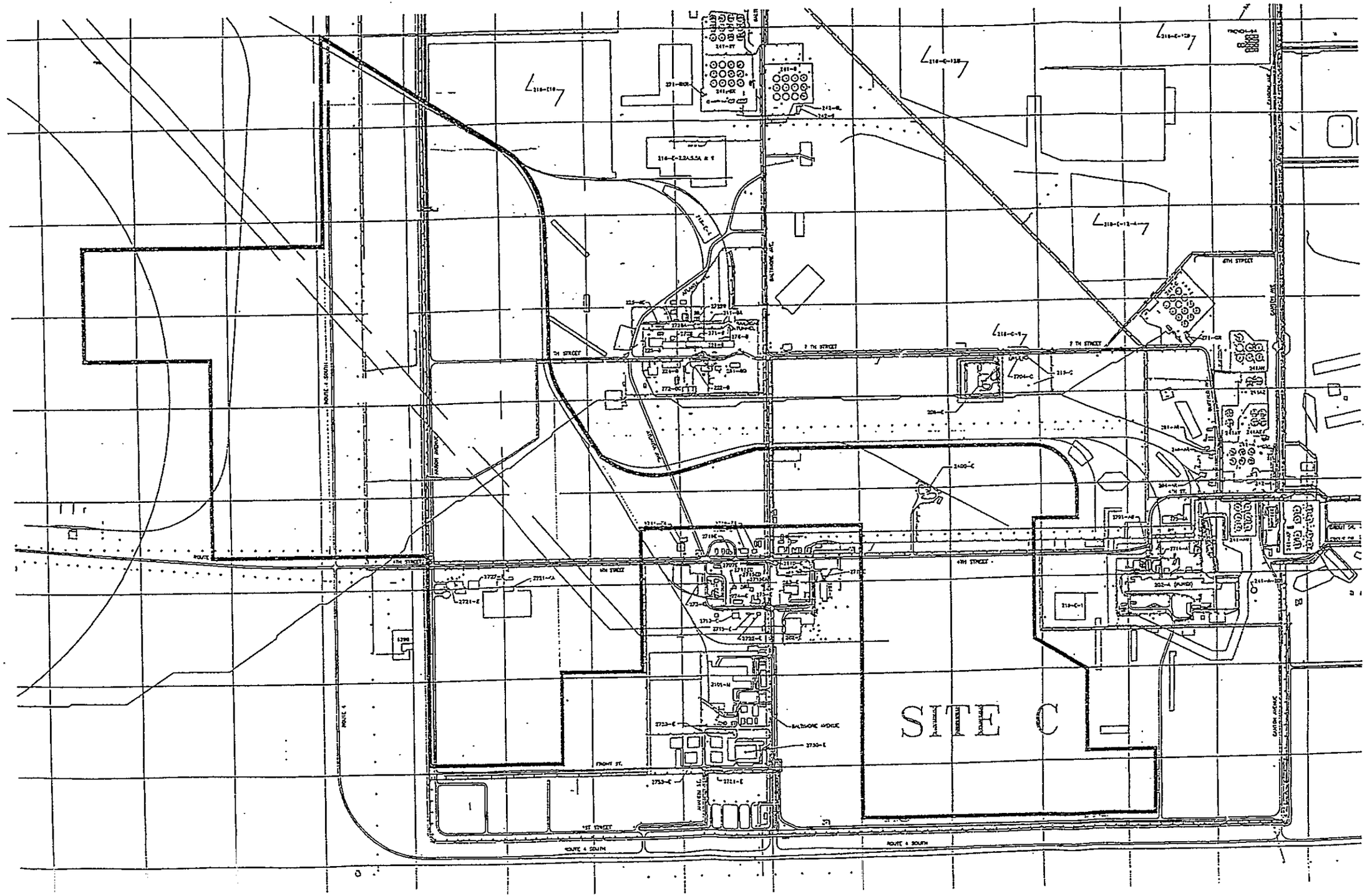
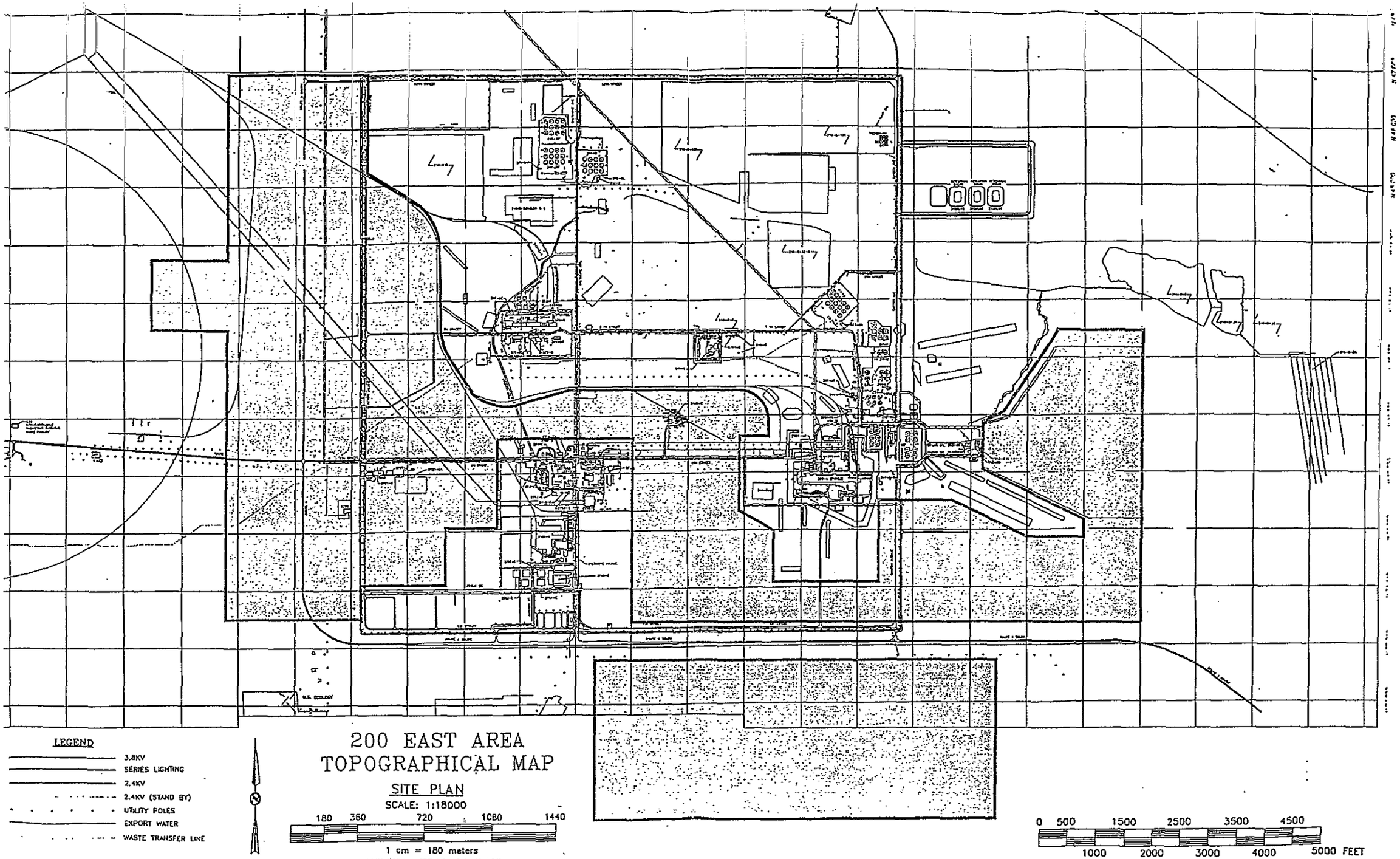

SITE B
7TH STREET
4TH STREET
1ST STREET
BALTIMORE AVE
CANTON AVE
ROUTE 4 SOUTH
RETENTION BASIN
RETENTION BASIN
RETENTION BASIN


SITE C
ROUTE 4 SOUTH
ROUTE 4
4TH STREET
2 TH STREET
1ST STREET
FRONT ST.
BALTIMORE AVENUE
CANTON AVENUE
ATLANTA AVE.
BALTIMORE AVE.
ROUTE 4 SOUTH



NOTE: THIS MAP IS TO BE USED FOR REFERENCE PURPOSES ONLY.
DO NOT USE THIS MAP FOR CONSTRUCTION PURPOSES.

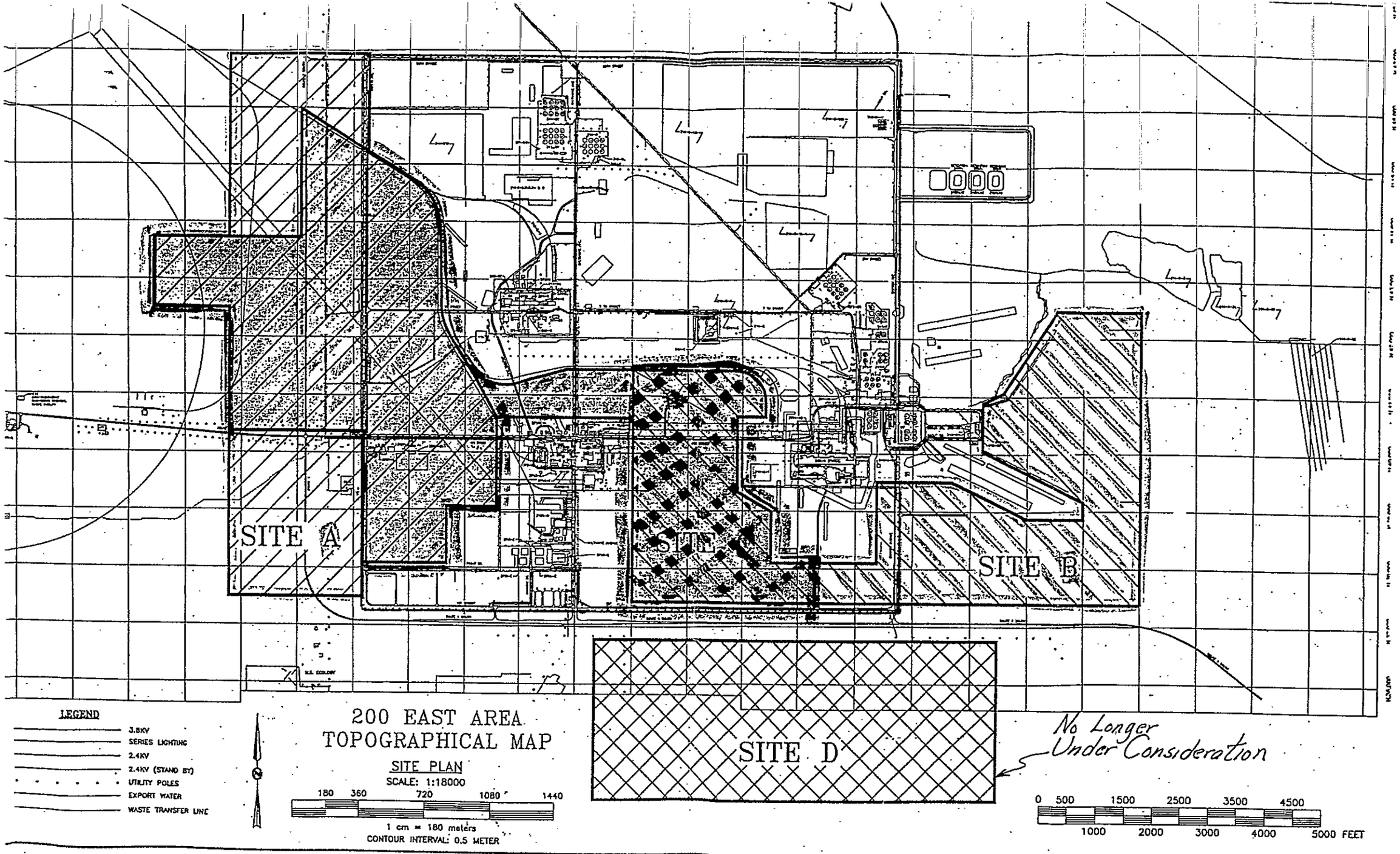
Kaiser Engineers Hanford Company
Mapping Services

CADFILE ZRBT0193
DATE 7-14-94

CUSTOMER DUTCH OEDEWALDT
DRAWN BY RAFAEL TORRES

TITLE 200 EAST AREA CANDIDATE SITI
FOR TWRS COMPLEX

SITE A



NOTE: THIS MAP IS TO BE USED FOR REFERENCE PURPOSES ONLY. DO NOT USE THIS MAP FOR CONSTRUCTION PURPOSES.

Kaiser Engineers Hanford Company
Mapping Services

CADFILE 2RBT0153	CUSTOMER DUTCH GEDEWALDT	TITLE 200 EAST AREA FUTURE PROJECTS
DATE 6-27-94	DRAWN BY RAFAEL TORRES	

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Natural Resources. Transportation (Vehicular Traffic Impacts)

ORIGINATOR A. Bachrach DATE 11/10/95

REVISION NO. 3

OBJECTIVE Estimate Impact of Vehicular Traffic Associated with TWRS alternatives on Baseline Traffic Conditions in Alternatives' Peak Year. Roadways are Stevens Rd at 1100 Area and Route 4 West of Wye Barricade.

METHODOLOGY 1) Estimate Future Baseline Traffic Volumes. 2) Estimate Peak Year Traffic Volume for each TWRS alternative and Sum 1)+2). Use Sum to evaluate level of traffic congestion

ASSUMPTIONS (attached)

(Continue on another sheet if necessary)

Carmi Bachrach
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT TRAFFIC IMPACTS ASSUMPTIONS SHEET NO. 1

BY _____ CHKD. _____ JOB NO. _____

1) Future Baseline Traffic Volume (Average Daily Traffic or ADT) and Future Baseline AM Peak Hour volume will follow historical patterns. Ratio of Total Site Employment to ADT on Stevens Rd. at 1100 Area is 1.725 (Benton Franklin Regional Commission 1993). Ratio of Total Site Employment to ADT on Route 4 West of Wye Barricade is .50 (WHC 1994) Above values used for all alternatives.

2) Use of alternate routes to 200 Areas (versus. Stevens Road and Route 4) based on Benton Franklin Regional Commission SR 240 Corridor Study of 1993). 11% of Site employees commute from Benton City/Yakima (West) and would use SR 24 and Route 11A. 6% of Site employees commute from West Richland and would use Route 10. 700 Vehicles would use State Route 240/240 Access Road. Above values used for all alternatives.

3) TWRS Peak Year employment obtained from Jacobs 1995 and are same values used in Economic Impact analysis

4) All TWRS Construction employment would work M-F day shift and would all be in peak hour.

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 2

BY _____ CHKD. _____ JOB NO. _____

5) TWRS Operations phase employment would include some workers not working M-F, day shift because of 7 day operating work schedule. 50% of non-exempt workers only assumed to work M-F day shift. All

6) exempt employees would work M-F day shift.

7) Per WHC Site planning factor, TWRS employees would have 1.35 person/vehicle to account for carpools and vanpools. (1/1.35 = .74 Factor). Value used for all TWRS alternatives.

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 3

BY _____ CHKD. _____ JOB NO. _____

Peak Year Employment (M-F Day Shift)

Alternative	Total # of Employees	M-F day	Year
No Action	760 (Routine Ops. only)	760	2001
Long-Term Mgmt.	760 (Routine Ops. only)	760	2001
[No analysis of impacts in 2030's during retrieval ops. Analysis of Traffic Impacts 40 years in future of no value]			
In Situ Fill + Cap	<150	(No analysis)	
In Situ Vitrification	2600	2600	2004
Ex Situ Intermediate Separations	4100	4000	2001
Ex Situ No Separations	4400	4100	2000
Ex Situ Extensive Separations	7000	6700	2003
Ex Situ/In Situ Combination	2500	2400	2001
Phased Implementation (Phase I)	3300	3300	1999
Capsules (all alts.)	<100	(No Analysis)	

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 4

BY _____ CHKD. _____ JOB NO. _____

Stevens Road Future Baseline Volumes

$\frac{\text{1992 ADT}}{\text{1992 Peak Hour}} = \frac{28,231}{3,362}$ Site Employment (1992) = 16,364

Employment: ADT = 1.725

Peak Hour: ADT = .119 (11.9%)

	Site Employment	ADT	Peak Hour
1999	14,758	25,460	3030 (3000)
2000	14,580	25,150	2990 (3000)
2001	14,366	24,780	2949 (2900)
2002	13,976	24,110	2870 (2900)
2003	13,527	23,330	2780 (2800)
2004	13,120	22,630	2690 (2700)

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 5

BY _____ CHKD. _____ JOB NO. _____

Route 4 Future Baseline

ADT 1994 (July) = 9201 Site Employment - 18,436 = (50%)

AM Peak Hour ~~2389~~ 1994 (July) 2389 Employment: ADT = 50%

ADT/Peak Hour Ratio = 26%

	Site Employ.	Route 4 ADT	Route 4 Peak Hour
1999 =	14,758 X .5 =	7380 X .26	1920 (1900)
2000 =	14,580 X "	7290 X "	1890 (1900)
2001 =	14,366 X "	7180 X "	1860 (1900)
2002 =	13,976 X "	6990 X "	1820 (1800)
2003 =	13,527 X "	6760 X "	1760 (1800)
2004 =	12,795 X "	6400 X "	1660 (1700)

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 6

BY _____ CHKD. _____ JOB NO. _____

No Action + Long Term Management (2001 – all employment is Routine Tank Farm Operations)

Stevens Road at 1100 Area

Baseline ADT = 24,780

Baseline AM Peak = 2900

TWRS Employment = 760 X .741 (Occupancy Factor) = 560

- 280 Vehicles (50%) use SR 240/240 Access Road
- 62 Vehicles (11%) use Route 11A (West – Benton City)
- 34 Vehicles (6%) use Route 10 (West Richland)

– 376 (380) use alternates

AM Peak Hour Volume = 2900 (Baseline) + 180 (TWRS) = (3100)

Route 4 West of Wye Barricade

Baseline ADT = 7380

Baseline AM Peak = 1920

TWRS Volum = 180 (– 50% using alternate: Rt 2/11A) = 90

AM Peak Hour Volume = 1920 + 90 = 2010 (2000)

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 7

BY _____ CHKD. _____ JOB NO. _____

In Situ Vitrification (Peak Year = 2004)

Stevens Rd. at 1100 Area

Baseline ADT = 22,630

Baseline AM Peak = 2700

TWRS Employees = 2600 X .74 (Occupancy Factor) = 1920

- 700 vehicles using SR 240/240 Access
- 210 vehicles (11%) using Route 11A (Benton City)
- 120 vehicles (6%) using Route 10 (West Richland)

= 1030 vehicles using alternates

AM Peak Hour Volume = 2700 (Baseline) + 900 (TWRS) = 3600

Route 4 ~~pat~~ Wye Barricade

Baseline ADT = 6,400

Baseline AM Peak = 1660

TWRS Volume = 900 - 500 vehicles using Rt 2/11A = ~~500~~ 400

AM Peak Hour Volume = 1,660 (Baseline) + ~~900~~ (TWRS) = ~~2060~~ (2100)

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 8

BY _____ CHKD. _____ JOB NO. _____

Ex Situ Intermediate Separations (Peak Year = 2001)

Stevens Road at 1100 Area

Baseline ADT = 24,780

Baseline AM Peak = 2900

TWRS Employees = 4000 X .74 (Occupancy Factor) = 2960

- 700 Vehicles using SR 240/240 Access Road
- 330 vehicles using Route 11A
- 180 vehicles using Route 10
- 1210 using alternates

AM Peak Hour Volume = 2900 (Baseline) + 1750 (TWRS) = 4650 (4700)

Route 4 West of Wye Barricade

Baseline ADT = 7180

Baseline AM Peak = 1860

TWRS Volume = 1750 - 500 using Rt 2/11A alternate = 1250

AM Peak Hour Volume = 1860 (Baseline) + 1250 (TWRS) = 3110 (3100)

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 9

BY _____ CHKD. _____ JOB NO. _____

Ex Situ No Separations (Peak Year = 2000)

Stevens Road

Baseline ADT = 25,150

Baseline AM Peak = 3000

TWRS Employment = 4100 X .74 (Occupancy Factor) = 3030

- 700 Vehicles using SR 240/240 Access Road
- 330 vehicles using Route 11A
- 180 vehicles using Route 10

1210 using alternates

AM Peak Hour = 3000 (Baseline) + 1800 (TWRS) = 4,800

Route 4

Baseline ADT = 7290

Baseline AM Peak = 1890

TWRS Volume = 1800 − 500 vehicles using Route 2/11A) = 1300

AM Peak Hour Volume = 1890 (~~+ 1300~~ Baseline) + 1300 (TWRS) = 3200

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 10

BY _____ CHKD. _____ JOB NO. _____

Ex Situ Extensive Separations (Peak Year = 2003)

Stevens Road

Baseline ADT = 23,330

Baseline AM Peak = 2800

TWRS Employment = 6700 X .74 (Occupancy Factor) = 4960

- 700 Vehicles using SR 240/240 Access Rd.
- 550 Vehicles using Rt. 11A
- 300 Vehicles using Rt. 10

1550 vehicles using alternate

AM Peak Hour Volume = 2800 (Baseline) + 3400 (TWRS) = 6200

Route 4

Baseline ADT = 6760

AM Peak Hour = 1760

TWRS Volume = 3400 - 500 using Rt. 2/11A alternate

AM Peak Hour Volume = 1760 (Baseline) + 2900 (TWRS) = 4700

FORM 31-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 11

BY _____ CHKD. _____ JOB NO. _____

Ex Situ / In Situ Combination (Peak Year = 2001)

Stevens Road

Baseline ADT = 24,780

Baseline AM Peak = 2900

TWRS Employment = 2400 X .74 (Occupancy Factor) = 1780

- 700 vehicles using SR/240/240 Access
- 200 vehicles using Route 11A
- 110 vehicles using Route 10

1010 vehicles using alternates

AM Peak Hour Volume = 2900 (Baseline) + 770 (TWRS) = 3670 (3700)

Route 4

Baseline ADT = 7180

Baseline AM Peak = 1860

TWRS Volume = 770 - 400 using Rt. 2/11A alternate = 370

AM Peak Hour Volume = 1860 (Baseline) + 370 (TWRS) = 2230 (2200)

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 12

BY _____ CHKD. _____ JOB NO. _____

Phased Implementation (Phase 1) Peak Year = ~~2000~~ 1999

Stevens Rd

Baseline ADT = 25,460

Baseline AM Peak = 3000

TWRS Employment = 3300 X .74 (Occupancy Factor) = 2440

- 700 vehicles using SR 240 / 240 Access Rd.
- 270 vehicles using Route 11A
- 150 vehicles using Route 10

- 1120 vehicles using alternates

AM Peak Hour Volume = 3000 (Baseline) + 1300 (TWRS) = 4300

Route 4

Baseline ADT = 7380

Baseline AM Peak = 1920

TWRS Volume = 1300 - 500 using Rt. 2/11A alternate = 800

AM Peak Hour Volume = 1920 + 800 = 2720 (2700)

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Socioeconomics - School Enrollment Increases resulting from TWRS Alternatives

ORIGINATOR A. Bachrach DATE 10/5/95

REVISION NO. 2

OBJECTIVE Estimate increased enrollment in major Tri-Cities School Districts (Richland, Kennewick, Pasco, Kiona-Benton) in peak year of TWRS alternative impact

METHODOLOGY 1) Estimate % of population increase that is school age (use 1994 Population + School District Enrollment data as basis) 2) Allocate Peak Year Growth in Enrollment for each Alternative to each District based on 1994 share of Total Enrollment of all 4 Districts.

ASSUMPTIONS

1) Ratio of School Enrollment to Population will remain same as 1994
2) Ratio of each District's share of Tri-Cities enrollment total will remain the same as 1994)

(Continue on another sheet if necessary)

Anni Bachrach
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CALCULATION & RESULTS ATTACHED

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DATE _____ SUBJECT _____ SHEET NO. 10/5/95 (1)

BY _____ CHKD. _____ JOB NO. _____

SCHOOL ENROLLMENT IMPACTS

(% of Peak Year Population Growth Allocated to Primary Tri-Cities School Districts)

1) % of Total Population Growth Enrolled in School)

$$\frac{\text{1994 School District Population}}{\text{1994 Community Population}}$$

Pasco	Kennewick	Richland	Tri-Cities Average
7,700	13,125	8686	25,581
22,170	46,960	35,430	104,560

TRI-CITIES AVERAGE = 28.3% of Population enrolled in K-12

2) Allocation of Peak Year Population Growth is by Each District's Percentage of 1994 Total of All Relevant Districts

Kennewick	Richland	Pasco	Kiona-Benton
$\frac{13,125}{31,105} = 42.2\%$	$\frac{8,686}{31,105} = 27.9\%$	$\frac{7,770}{31,105} = 25.0\%$	$\frac{1,524}{31,105} = 4.9\%$

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 2

BY _____ CHKD. _____ JOB NO. _____

Alternative (Peak Years)	Peak Population △ / Peak Total School Pop. △	Kennewick	Richland	Pasco	Kiona-Benton
No Action (2025)	2350 / 670	280	190	170	30
Long-Term Management (2035)	3200 / 900	380	250	230	40
In Situ Filled Cap (2001)	460 / 130	60	40	30	10
In Situ Vitrification (2001)	6350 / 1800	760	500	450	90
Ex Situ Intermediate Vitrification (2002)	9900 / 2800	1200	780	700	140
Ex Situ Extensive Separations (2004)	17,800 / 5050	2100	1400	1300	250
Ex Situ No Separations (2000)	11700 / 3350	1400	920	830	160
Ex Situ/In Situ Combination (2000)	6000 / 1700	720	470	430	80
Phased Implementation (Phase 1 only) (1994)	8600 / 2400	1030	680	610	120

*Totals Rounded to 2 Significant Digits

FORM 21-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Natural Resources: Land Use and Biology Impacts

ORIGINATOR A Bachrach DATE 11/3/95

REVISION NO. 3

OBJECTIVE Estimate land commitment (temporary and permanent) for all TWRS alternatives and estimate how much of committed land is currently shrub-steppe habitat

METHODOLOGY Estimate (obtain) acreage required for each element of each alternative's Construction/Operations/Post-Remediation phases. Estimate percentage of areas to be affected that are currently shrub-steppe (versus already disturbed or otherwise non-shrub-steppe)

ASSUMPTIONS

1) All Tank farm areas and surrounding vicinity are already disturbed
2) Barrier Construction occurs in already disturbed area
3) 67% of 200 East Ex Situ Vit Plant Site is Shrub-Steppe, 1/3 disturbed
4) 33% of Power Corridor for In Situ Vit Alternative is Shrub-steppe; 67% disturbed
5) ~~Borrow Sites: Vernita (80% Shrub-Steppe); McGee Ranch (75% Shrub-Steppe; Pit 30 (90% Shrub-Steppe~~
6) 70% of Phased Implementation Site in 200 East is Shrub-Steppe

(Continue on another sheet if necessary)

Ann Bachrach
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11/3/95 (1)

Land Commitment → Shrub-Steppe Impacts

Alternative	Temporary	Permanent
NO ACTION	0 ha	17 ha (Tank Farms) (0% Shrub-Steppe)
LONG TERM MANAGEMENT	50 ha (20% Shrub-steppe)	17 ha (TF - 0% SS) 8 ha (new TF - 20% SS) 25

IN SITU FILL + CAP

Ret = 0

Ops.
- 25 Pit 30 (90% SS)
- 1 TFs (0% S-S)

Post +
- 20 Barrier/Const. (0 S-S)
- 14 Pit 30 (90% S-S)
- 16 McGee (75% S-S)
- 21 Vernita (80% S-S

97

25 ha - TFs + Barriers (0 - SS)

25

IN SITU VITRIFICATION

Ret = 0

Ops.
- 21 TF (0% S-S)
- 70 Power Lines (33% S-S)

Post +
- 20 Pit 30 (90% S-S)
- 20 Barrier Const (0 S-S)
- 14 Pit 30 (90% S-S)
- 16 McGee (75% S-S)
- 21 Vernita (80% S-S)

182

25 ha - TF/Barrier (0 S-S)

25

EX SITU INTERMEDIATE SEPARATIONS

108 - 200 Areas
105 - Borrow Site

Ret.
- 3. Annexes (0 S-S)

Ops.
- 1 Pit 30 (90% S-S)
- 81 Vit Plant (67% S-S)

Post +
- 11 Pit 30 (90% S-S)
- 24 Barrier Const. (0 S-S)
- 45 Pit 30 (90% S-S)
- 21 McGee (75% S-S)
- 27 ~~Pit 30~~ Vernita (80% S-S)

Tot 213 ~~213~~ 213

0.4 Annexes
7 Vit Plant
33 TF/Barriers + LAW Vaults/Barri (0% S-S)

40

	Temporary		Permanent

EX SITU NO SEPARATIONS

Ret	3	Annexes (0 S-S)	
	1	Pit 30 (90% S-S)	0.4 Annex
Ops.	60	Vit Plant (67% S-S)	2 Vit
	4	Pit 30 (90% S-S)	25 TF/Barrier
Post-Rem.	20	Barrier Const. (0 S-S)	(0% S-S)
	39	Pit 30 (90% S-S)	
	16	McGee (75% S-S)	27
	21	Vernita (80% S-S)	
	164		

EX SITU EXTENSIVE SEPARATIONS

Ret.	3	Annex (0 S-S)	
	1	Pit 30 (90% S-S)	0.4 Annex
Ops	81	Vit Plant (67% S-S)	7 Vit Plant
	12	Pit 30 (90% S-S)	33 TF/Barriers/Vaults
Post	24	Barrier Const. (0 S-S)	(0% S-S)
	46	Pit 30 (90% S-S)	
	21	McGee (75% S-S)	40
	27	Vernita (80% S-S)	
	215		

Ex Situ/In Situ COMBINATION

Ret.	2	Annexes (0 S-S)	
	1	Pit 30 (90% S-S)	0.2 Annex
Ops	82	Vit Plant (67% S-S)	8 Vit Plant
	5	Pit 30 (90% S-S)	29 TF/Barriers/Vaults
Post	22	Barrier Const. (0 S-S)	
	26	Pit 30 (90% S-S)	37
	18	McGee (75% S-S)	
	23	Vernita (80% S-S)	
	179		

PHASED IMPLEMENTATION

			Permanent
Ret	~~4~~	~~Annex/Pit 30 (1 ha S-S)~~	0
Const/Ops	~~3~~	~~Vit Plant Site (30 ha S-S)~~	
	~~6~~	~~Roads/Utilities (5 ha~~	
	~~8~~	~~Aggregate (Pit 30) (1 ha S-S)~~	
Closure Post	8	Annex/Pit 30 1 ha (1% S-S)	
		Vit Plant Site 26 ha (18 ha S-S)	
		Water/Power/Roads 5 ha (2 ha S-S)	
		Pit 30 1 ha (1 S-S)	

33

	Temporary	Permanent
Capsules		
No Action	4	0.6 (WESF) – 0 S-S
On-Site ~~Storage~~ Disposal	4 (Dry-Well) [1.5 ha S-S]	1.8 (1 ha S-S)
Overpack + Ship	2 (~~inc. w/~~ Vit Site)	N/A
Vitrify with Tank Waste	1 (Vit Site)	N/A
All Alternatives	< 5 (< 2 ha S-S)	< 2 (1 ha S-S)

Shrub-Steppe Habitat Disturbed

No Action	0
Long Term Management	50 ha X 20% = 10 (New TFs)
In Situ Fill+Cap	39 ha X 90% = 35 (Pit 30)
	16 X 75% = 12 (McGee)
	21 X 80% = 17 (Vernita)
	TOTAL = 64
In Sit Vitrification	70 X 33% = 23 (Power Lines)
	34 X 90% = 31 (Pit 30)
	16 X 75% = 12 (McGee)
	21 X 80% = 17 (Vernita)
	TOTAL = 83
Ex Situ Intermediate Seps	57 X 90% = 51 (Pit 30)
	81 X 67% = 54 (Vit Plant)
	21 X 75% = 17 (McGee)
	27 X 80% = 22 (Vernita)
	TOTAL = 144
Ex Situ No Seps	44 X 90% = 40 (Pit 30)
	60 X 67% = 40 (Vit Plant)
	16 X 75% = 12 (McGee)
	21 X 80% = 17 (Vernita)
	TOTAL = 109
Ex Situ Extensive Seps	59 X 90% = 53 (Pit 30)
	81 X 67% = 54 (Vit Plant)
	21 X 75% = 14 (McGee)
	27 X 80% = 22 (Vernita)
	TOTAL = 143

Ex

Shrub-Steppe Habitat Disturbed

Ex Situ/In Situ Combination

32 ha X 90% = 29 (Pit 30)
82 X 67% = 54 (Vit Plant)
18 X 75% = 14 (McGee)
23 X 80% = 18 (Vernita)
TOTAL = 115

Phased Implementation (Phase I)

18 ha (Vit Site)
2 ha Roads/Utilities
2 ha Pit 30
Total 22 ha

Capsules (All alternatives) < 5 ha X 40% = < 2 ha

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering - Calcination Alternative

ORIGINATOR Joseph Scott DATE 9-18-95

REVISION NO. 0

OBJECTIVE Calculate heat balance around spray calcination unit to establish electric power or kerosene fuel requirement for calciner heating

METHODOLOGY Use previous mass balance data for mass and composition of input and output streams to calciner. Use references to obtain enthalpy of each input and output stream

ASSUMPTIONS 1) Liquid feed to calciner is at a temperature of 50°C

2) Steam to feed atomizer is 50 psig saturated steam

3) Heats of solution for dissolved salts in liquid feed neglected in enthalpy balance.

(Continue on another sheet if necessary)

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Assumptions continued.

4) Oxygen feed to calciner is pure oxygen gas at 1 atm pressure and 25 °C

5) Calciner operates at 700 °C and approximately 1 atm pressure

6) Data on enthalpies for various species obtained from following sources:
   a) "Thermochemical Data of Pure Substances
   b) "JANAF Thermochemical Tables"
   c) "CRC Handbook of Chemistry and Physics"
   d) "Perry's Chemical Engineer's Handbook 6th ed"

7) For determination of kerosene fuel requirement kerosene treated as n-dodecane burned in pure oxygen.

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Calculate heat balance for spray calcination unit to provide quantity of kerosene combustion required for heating unit.

Base calculation on results for complete mass balance for calcination unit which was previously completed.
Heat balance based on enthalpies of mass streams entering and exiting unit.

Stream (A) - Liquid Feed from Evaporator.

From mass balance Stream (A) is a liquid (aqueous) stream containing:

Water	2.55×10^8 Kg
$NaNO_3$ (aq)	1.45×10^8 Kg
$NaNO_2$ (aq)	1.43×10^7 Kg
NaOH (aq)	1.52×10^7 Kg
TOC (aq)	1.42×10^6 Kg
Sucrose ($C_{12}H_{22}O_{11}$) (aq)	3.28×10^7 Kg
other solids (aq)	2.69×10^7 Kg
TOC (solid)	1.16×10^5 Kg
other solids (solid)	1.93×10^7 Kg

$NaNO_3$, $NaNO_2$, NaOH, and $C_{12}H_{22}O_{11}$ react in calciner as dissussed in mass balance calculations.
TOC (aq) and TOC (solid) is oxidized in calciner as dissussed in mass balance calculations
Water is vaporized in calciner as discussed in mass balance calculations.
All other species do not react and exit calciner as dry solids.

By assumption liquid feed to reactor is at a temperature of 50 °C following evaporator.

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Calculate enthalpy of Stream (A)

Approach: Obtain enthalpies of formation for $H_2O_{(l)}$, $NaNO_{3(s)}$, $NaNO_{2(s)}$, $NaOH_{(s)}$, $C_{12}H_{22}O_{11(s)}$ at 50 °C from data tables. This approach ignores heat of solution for dissolving in water. Will check significance of this later.
Treat TOC as n-dodecane [$C_{12}H_{26}$] liquid as before for mass balance and obtain enthalpy of formation from data tables.
Treat all remaining solids (aqueous or suspended) as inert material. Set enthalpy for Stream (A) at zero. Will use estimated value of heat capacity to estimate enthalpy of inert solids exiting calciner at 700 °C.

1) H_2O liquid @ 50 °C 2.55×10^8 Kg

Linear interpolation of values from reference "Thermochemical Data of Pure Substances"

25 °C	H =	-285.83	KJ/mole
50 °C	H =	-283.9	KJ/mole
100 °C	H =	-280.17	KJ/mole

-283.9 KJ/mole $\times$ 1 mole/18.02 g $\times$ 10^3 g/Kg $\times$ 2.55×10^8 Kg
$= -4.02 \times 10^{12}$ KJ

2) $NaNO_3$ solid @ 50 °C 1.45×10^8 Kg

Linear interpolation of values from reference "Thermochemical Data of Pure Substances"

25 °C	H =	-467.98	KJ/mole
50 °C	H =	465.4	KJ/mole
126.9 °C	H =	-457.33	KJ/mole

-465.4 KJ/mole $\times$ 10^3 mole/84.99 Kg $\times$ 1.45×10^8 Kg
$= -7.94 \times 10^{11}$ J

3) $NaNO_2$ solid @ 50 °C 1.43×10^7 kg

Linear interpolation of values from reference "Thermochemical Data of Pure Substances"

25 °C	H = −358.99 kJ/mole
50 °C	H = −357.02 kJ/mole
126.9 °C	H = −350.94 kJ/mole

-357.02 kJ/mole $\times 10^3$ mole/69.00 kg $\times 1.43 \times 10^7$ kg
$= -7.40 \times 10^{10}$ kJ

4) NaOH solid @ 50 °C 1.52×10^7 kg

Linear interpolation of values from reference "JANAF Thermochemical Tables"

25 °C	H = −425.93 kJ/mole
50 °C	H = −423.88 kJ/mole
126.9 °C	H = −417.58 kJ/mole

-423.88 kJ/mole $\times 10^3$ mole/40.00 kg $\times 1.52 \times 10^7$ kg
$= -1.61 \times 10^{11}$ kJ

5) TOC liquid @ 50 °C 1.42×10^6 kg

By assumption TOC ≡ n-dodecane $C_{12}H_{26}$
Data from "Perry's Chemical Engineering Handbook 6th Edition"
n-dodecane heat of combustion @ 25 °C

$$C_{12}H_{26(l)} + 18\tfrac{1}{2}O_{2(g)} \longrightarrow 13\,H_2O_{(l)} + 12\,CO_{2(g)}$$
$$\Delta H^c = -1932.59 \text{ Kcal/mole}$$

at 25 °C heats of formation:

$O_{2(g)}$ = 0 Kcal/mole
$H_2O_{(l)}$ = −68.32 Kcal/mole
$CO_{2(g)}$ = −94.05 Kcal/mole

So for $C_{12}H_{26(l)}$ at 25 °C

$H = 13 \times (-68.32) + 12 \times (-94.05) - (-1932.59)$
$= -84.17$ Kcal/mole

Specific heat for dodecane 0 - 50° C
= 0.498 cal/g °C
0.498 cal/g-°C × 170.3 g/mole = 84.91 cal/mole °C

50°C H = -84.17 kcal/mole + 25 °C × (0.08491 kcal/mol °C)
= -82.05 kcal/mole

-82.05 kcal/mole × 10^3 mole/170.3 kg × 1.42×10^6 kg
= -6.84×10^8 kcal × 4.186 kJ/kcal
= -2.86×10^9 kJ

6) Sucrose [$C_{12}H_{22}O_{11}$] solid @ 50°C 3.28×10^7 kg
Data from "CRC Handbook of Chemistry & Physics"
Sucrose heat of combustion at 25°C

$$C_{12}H_{22}O_{11(s)} + 17\tfrac{1}{2}O_{2(g)} \longrightarrow 11\,H_2O_{(l)} + 12\,CO_{2(g)}$$

$\Delta H^c = -1348.2$ kcal/mole

So @ 25°C for $C_{12}H_{22}O_{11(s)}$
H = 11 × (-68.32) + 12 × (-94.05) - (-1348.2)
= -531.92 kcal/mole

Specific heat sucrose = 0.299 cal/g °C @ 20°C
0.299 cal/g-°C × 342.3 g/mole = 0.1023 kcal/mole °C
50°C H = -531.92 kcal/mole + 25 °C × (0.1023 kcal/mole °C)
= -529.4 kcal/mole
-529.4 kcal/mole × 4.186 kJ/kcal = -2215.9 kJ/mole

-2215.9 kJ/mole × 10^3 mole/342.3 kg × 3.28×10^7 kg
= -2.12×10^{11} kJ

7) all other solids
By assumption all other solids in stream (A)
enthalpy H = ∅

Total enthalpy stream (A) = $\sum_1^7 H$
= -5.27×10^{12} kJ

Check approximate significance of neglecting heats of solution for aqueous solids in calculating

enthalpy of feed stream. Consider effect of heat of solution of $NaNO_3$, $NaNO_2$, $NaOH$, and $C_{12}H_{22}O_{11}$.

Heats of solution at infinite dilution from "Perry's Chemical Engineer's Handbook 6th edition"

$NaNO_3$: -5.05 Kcal/mole $\times 10^3$ mole/84.99 kg $\times 1.45\times10^8$ kg $= -8.62\times10^9$ Kcal $\times$ 4.186 kJ/Kcal $= -3.61\times10^{10}$ kJ

$NaNO_2$: -3.6 Kcal/mole $\times 10^3$ mole/69 kg $\times 1.43\times10^7$ kg $= -7.5\times10^8$ Kcal $\times$ 4.186 kJ/Kcal $= -3.1\times10^9$ kJ

$NaOH$: $+10.18$ Kcal/mole $\times 10^3$ mole/40 kg $\times 1.52\times10^7$ kg $= 3.87\times10^9$ Kcal $\times$ 4.186 kJ/Kcal $= 1.62\times10^{10}$ kJ

Sucrose: -1.32 Kcal/mole $\times 10^3$ mole/342.3 kg $\times 3.28\times10^7$ kg $= -1.26\times10^8$ Kcal $\times$ 4.186 kJ/Kcal $= 5.3\times10^8$ kJ

Approx total correction for heats of solution -2.4×10^{10} kJ. Insignificant compared to total stream (A) enthalpy of -5.27×10^{12} kJ

Stream (B) – Atomization Steam

50 psig saturated steam 2.55×10^8 kg

From steam tables 50 psig steam temperature = 147.5 °C
enthalpy = $-13{,}200$ kJ/kg

$-13{,}200$ kJ/kg $\times 2.55\times10^8$ kg $= -3.37\times10^{12}$ kJ

Stream (C) – Oxygen

Pure oxygen gas fed at 25 °C and 1 atm
1.06×10^7 kg
Data from "JANAF Thermochemical Tables"
H = ϕ kJ/mol

Stream (D) – Gas Discharge.
Gas discharge at 700 °C and 1 atm.

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From previous mass balance calculations:

H_2O	5.15×10^8 kg
NO_2	4.41×10^7 kg
NO	2.88×10^7 kg
CO_2	5.72×10^6 kg

1) H_2O vapor at 700 °C, 1 atm 5.15×10^8 kg

Linear interpolation of values from reference "Thermochemical Data of Pure Substances"

626.9 °C	H = −89.220 kJ/mole
700 °C	H = −82.69 kJ/mole
726.9 °C	H = −80.287 kJ/mole

-82.69 kJ/mol $\times 10^3$ mole/18.02 kg $\times 5.15 \times 10^8$ kg
$= -2.36 \times 10^{12}$ kJ

2) NO_2 gas @ 700 °C, 1 atm 4.41×10^7 kg
Linear interpolation of values from reference "JANAF Thermochemical Tables"

626.9 °C	H = 27.179 kJ/mol
700 °C	H = 30.95 kJ/mol
726.9 °C	H = 32.344 kJ/mol

30.95 kJ/mol $\times 10^3$ mol/46.01 kg $\times 4.41 \times 10^7$ kg
$= 2.97 \times 10^{10}$ kJ

3) NO gas @ 700 °C, 1 atm 2.88×10^7 kg
Linear interpolation of values from reference "JANAF Thermochemical Tables"

626.9 °C	H = 18.858 kJ/mol
700 °C	H = 21.32 kJ/mol
726.9 °C	H = 22.229 kJ/mol

21.32 kJ/mol $\times 10^3$ mol/30.01 kg $\times 2.88 \times 10^7$ kg
$= 2.05 \times 10^{10}$ kJ

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4) CO_2 gas @ 700 °C, 1 atm 5.72×10^6 kg

Linear interpolation of values from reference "JANF Thermochemical Tables"

626.9 °C	H = -366.790 kJ/mole
700 °C	H = -363.12 kJ/mole
726.9 °C	H = -361.775 kJ/mole

-363.12 kJ/mol $\times 10^3$ mol/44.01 kg $\times 5.72 \times 10^6$ kg
$= -4.72 \times 10^{10}$ kJ

Total enthalpy stream (D) $= \sum_1^4 H$
$= -2.36 \times 10^{12}$ kJ

Stream (E) – Solids Discharge

From mass balance stream (E) is a solid powder at 700 °C containing:

Na_2CO_3	1.22×10^8 kg
Other inert solids	4.62×10^7 kg

1) Na_2CO_3 solid @ 700 °C 1.22×10^8 kg

Linear interpolation of values from reference "JANAF Thermochemical Tables"

626.9 °C	H = -1040.163 kJ/mole
700 °C	H = -1027.54 kJ/mole
726.9 °C	H = -1022.894 kJ/mole

-1027.54 kJ/mol $\times 10^3$ mol/105.99 kg $\times 1.22 \times 10^8$ kg
$= -1.18 \times 10^{12}$ kJ

2) Other inert solids @ 700 °C 4.62×10^7 kg

For Stream (A) – input of inert solids @ 25 °C assumed enthalpy of zero.

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At 700 °C $H = [\phi + (700\,°C - 25\,°C) \cdot C_p] \times 4.62 \times 10^7$ kg
where C_p = avg heat capacity for inert solids in kJ/kg °C

Inert solids include inorganic oxides, sulfates, hydroxides, etc. Look at specific heat capacity for several compounds to get approximation of heat capacity for solids:
alumina 0.2 cal/g-°C, magnesia 0.23 cal/g-°C, sand 0.19 cal/g-°C, MnO_2 0.12 cal/g-°C
Based on this use approx heat capacity for inert solids of 0.15 cal/g °C
= 0.15 kcal/kg-°C × 4.184 kJ/kcal
= 0.63 kJ/kg-°C

$H = 675\,°C \times 0.63\ kJ/kg\text{-}°C \times 4.62 \times 10^7\ kg$
$= 2.0 \times 10^{11}$ kJ.

Enthalpy balance around calciner
enthalpy output − enthalpy input = energy which must be added

input = -5.27×10^{12} kJ + -3.37×10^{12} kJ
= -8.64×10^{12} kJ

output = -2.36×10^{12} kJ + -1.18×10^{12} kJ + 2.0×10^{11} kJ
= -3.34×10^{12} kJ

output − input = 5.3×10^{12} kJ energy input.

Assume get this energy from combustion of kerosene (n-dodecane) in pure oxygen to H_2O & CO_2.

Previous calculations heat of combustion −1932 kcal/mole
= −8083 kJ/mole

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$n \cdot 8083$ KJ/mole $= 5.3 \times 10^{12}$ KJ

$n = 6.56 \times 10^{8}$ mole n-dodecane

6.56×10^{8} mol $\times 0.1703$ Kg/mol $= 1.12 \times 10^{8}$ Kg dodecane
$\simeq 1.1 \times 10^{8}$ Kg kerosene

Oxygen required

6.56×10^{8} mol $\times$ 18.5 $= 1.21 \times 10^{10}$ mol $\times$ 16.0 Kg/10^{3} mol
$= 1.9 \times 10^{8}$ Kg O_2

CO_2 produced

6.56×10^{8} mol $\times$ 12 $= 7.87 \times 10^{9}$ mol $\times$ 44.01 Kg/10^{3} mol
$= 3.5 \times 10^{8}$ Kg

H_2O produced

6.56×10^{8} mol $\times$ 13 $= 8.53 \times 10^{9}$ mol $\times$ 18.02 Kg/10^{3} mol
$= 1.5 \times 10^{8}$ Kg

If electric heat 5.3×10^{12} KJ
$= 8.8 \times 10^{10}$ KW-h

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering - Calcination Alternative

ORIGINATOR Joseph Scott DATE 9-28-95

REVISION NO. 0

OBJECTIVE Calculate air emissions of carbon-14 expected for ex situ calcination alternative

METHODOLOGY Calculate mass balance for carbon for calcination process and assume carbon-14 follows equivalent balance

ASSUMPTIONS 1) Only source of C^{14} into process is that C^{14} present in raw waste from tanks. Amount of C^{14} in raw waste taken from Appendix A of Westinghouse data package for Ex Situ Vitrification with No Separations.
2) The amount of C^{14} added to calcination

(Continue on another sheet if necessary)

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Assumptions (continued)

process by the addition of sugar is negligible and can be neglected

3) All of the sugar added to calcination reactor reacts completely with sodium salts in raw waste to form sodium carbonate. This sodium carbonate solid becomes part of the solid product discharged from the calcination process

4) All carbonate present in the raw waste originally either as a suspended or dissolved solid, is retained in the solid product discharged from the calcination process.

5) The total organic carbon (TOC) present in the raw waste is oxidized to CO_2 gas which leaves the calcination process as a gas exhaust

6) The ratio of C^{14} to total carbon is the same for both the solid product from the calcination process and the gas exhaust from the calcination process.

7) The quantity of C^{14} emitted from burning of kerosene to heat the calcination reactor is negligible and is neglected.

Mass balance for carbon around calcination reactor to predict quantity of C^{14} emitted in off-gas from calcination reactor.

Sources of carbon input to calcination reactor:

1) Raw waste feed from Stream #1 in Appendix A of Westinghouse data package for Ex Situ Vitrification No formations

Liquid components

CO_3^- = 3.37×10^6 kg
TOC = 1.42×10^5 kg
C^{14} = 0.743 kg

Solid components

CO_3^- = 2.25×10^5 kg
TOC = 1.16×10^5 kg
C^{14} = 0.453 kg

This accounts for all carbon and all carbon-14 in raw waste feed

Convert to total mass of carbon and carbon-14

Total CO_3^- = 3.595×10^6 kg $\times$ 12.011 kg C / 60.009 kg CO_3^- = 7.195×10^5 kg C

Total TOC = 2.58×10^5 kg

Total carbon = $2.58 \times 10^5 + 7.20 \times 10^5 = 9.78 \times 10^5$ kg

Total C^{14} = 0.743 kg + 0.453 kg = 1.196 kg

C^{14} half-life = 5730 years = 1.807×10^{11} s

To convert kg C^{14} to Ci activity

$1.196 \text{ kg } C^{14} \times 10^3 \text{ g/kg} \times 1 \text{ mole}/14.00 \text{ g}$
$\times 6.023 \times 10^{23} \text{ atom/mole} \times 0.693$
$\div 1.807 \times 10^{11} \text{ s} = 2.847 \times 10^{14} \text{ dis/s}$
$\times 1 \text{ Ci}/3.7 \times 10^{10} \text{ dis/s} = 7.7 \times 10^3 \text{ Ci}$

2) Sugar feed to calciner

From previous mass balance calculations
mass of $C_{12}H_{22}O_{11}$ = 3.28×10^7 kg

$3.28 \times 10^7 \text{ kg } C_{12}H_{22}O_{11} \times 144.13 \text{ kg C}/342.30 \text{ kg } C_{12}H_{22}O_{11}$
$= 1.38 \times 10^7$ kg C

Assume quantity of naturally occuring C^{14} in sugar is so small that it can be neglected.

Total carbon input to calciner

$9.78 \times 10^5 \text{ kg} + 1.38 \times 10^7 \text{ kg} = 1.479 \times 10^7 \text{ kg}$

$C^{14} = 1.196$ kg
$= 7.7 \times 10^3$ Ci

Carbon output from reactor is in off-gas as CO_2 and in solids as carbonate salts. From previous mass balance calculations

1) Sugar added to calciner reactor

reacts with nitrate and hydroxide sodium salts in raw feed to form solid sodium carbonates

2) Carbonate salts originally present in raw feed remain as carbonate salts in solid product

3) Total organic carbon (TOC) in raw feed is oxidized to CO_2 and exits as CO_2 off-gas from calciner reactor

Under these assumptions the mass of carbon exiting in off-gas is

$$5.72 \times 10^6 \text{ kg } CO_2 \times 12.011 \text{ kg C}/44.01 \text{ kg } CO_2 = 1.561 \times 10^6 \text{ kg C}$$

Total carbon input to reactor is 1.479×10^7 kg

So percent of carbon input which leaves in off-gas

$$1.561 \times 10^6 / 1.479 \times 10^7 \times 100 = 10.55 \%$$

Assume that C^{14} partitions in same way between off-gas and solids

C^{14} in off-gas from calciner

$$1.196 \text{ kg} \times 0.1055 = 0.126 \text{ kg } C^{14} = 8.12 \times 10^2 \text{ Ci}$$

C^{14} in solid product from calciner

$$1.196 \text{ kg} \times 0.8945 = 1.070 \text{ kg } C^{14} = 6.89 \times 10^3 \text{ Ci}$$

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DATE 9-28-95 SUBJECT TWRS EIS SHEET NO. 4 of 4

BY JPS CHKD. JOB NO.

Total C^{14} emitted as gas from plant

1) Assume no removal of C^{14} in off-gas treatment system

2) Assume the kerosene burned as fuel to heat calciner reactor has negligible quantity of C^{14} and can be neglected.

Emission of C^{14} = 0.126 kg
= 8.12×10^{2} Ci

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering - Calcination Alternative -

ORIGINATOR Joseph Scott DATE 9-14-95

REVISION NO. 0

OBJECTIVE Calculate mass quantities of sugar and oxygen raw materials to feed calciner during calcination of tank waste

METHODOLOGY Calculate mass of sugar and mass of oxygen based on masses of sodium salts present in liquid waste and stoichometry of calcine reactions.

ASSUMPTIONS 1) The calculations are based on the mass of sodium salts present in the tank waste as presented in the Westinghouse data package prepared for the ex situ vitrification with no separations alternative, ~~Table~~ Appendix A stream #1. (Continued)

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Assumptions (continued)

2) The mass calculations consider only the sodium salts $NaNO_3$, $NaNO_2$, and $NaOH$ since these three salts make up greater than 85 % of the total mass of sodium salts present in the feed and 100 % of the simple nitrogen oxide or hydroxide sodium salts.

3) The relevant calcination reactions for these three salts are:

$$C_{12}H_{22}O_{11} + 24\,NaNO_3 \rightarrow 12\,Na_2CO_3 + 12\,NO + 12\,NO_2 + 11\,H_2O$$

$$C_{12}H_{22}O_{11} + 24\,NaNO_2 + 12\,O_2 \rightarrow 12\,Na_2CO_3 + 12\,NO + 12\,NO_2 + 11\,H_2O$$

$$C_{12}H_{22}O_{11} + 24\,NaOH + 12\,O_2 \rightarrow 12\,Na_2CO_3 + 23\,H_2O$$

4) Pure sucrose [$C_{12}H_{22}O_{11}$] and oxygen gas [O_2] are used as raw feed materials and a stoichometric quantity of each is required.

5) The calcination reactions proceed to 100 % completion.

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SHEET NO 1 OF 3
CALCULATED BY J. Scott DATE 9-14-95
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Calculate total requirement for sugar and oxygen in spray calcination.

Calculations based on major sodium rompounds present in liquid feed including $NaNO_3$, $NaNO_2$, and NaOH. From mass balance data for no separations vitrification:

$NaNO_3$	1.45×10^8	Kg
$NaNO_2$	1.43×10^7	Kg
NaOH	1.52×10^7	Kg
total	1.75×10^8	Kg

Other sodium salts present in feed $< 2.6 \times 10^7$ Kg (15%) of top three.

Relevant reactions:

1) $C_{12}H_{22}O_{11} + 24NaNO_3 \rightarrow 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$
(sucrose)

2) $C_{12}H_{22}O_{11} + 24NaNO_2 + 12O_2 \rightarrow 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$

3) $C_{12}H_{22}O_{11} + 24NaOH + 12O_2 \rightarrow 12Na_2CO_3 + 23H_2O$

Assuming that the above three reactions proceed to completion and that stoichiometric quantities of sucrose and oxygen are required:

$NaNO_3$ Rxn 1

1.45×10^8 Kg $NaNO_3 \div 84.99$ Kg/Kmole $= 1.71 \times 10^6$ Kmole $NaNO_3$

$1.71 \times 10^6 \div 24 = 7.13 \times 10^4$ Kmole $C_{12}H_{22}O_{11}$

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$1.71 \times 10^6 \times 12/24 = 8.55 \times 10^5$ Kmole Na_2CO_3

$1.71 \times 10^6 \times 12/24 = 8.55 \times 10^5$ Kmole NO

$1.71 \times 10^6 \times 12/24 = 8.55 \times 10^5$ Kmole NO_2

$1.71 \times 10^6 \times 11/24 = 7.84 \times 10^5$ Kmole H_2O

$NaNO_2$ Rxn 2

1.43×10^7 Kg $NaNO_3 \div 69.00$ Kg/Kmole $= 2.07 \times 10^5$ Kmole $NaNO_3$

$2.07 \times 10^5 \div 24 = 8.63 \times 10^3$ Kmole $C_{12}H_{22}O_{11}$

$2.07 \times 10^5 \times 12/24 = 1.04 \times 10^5$ Kmole O_2

$2.07 \times 10^5 \times 12/24 = 1.04 \times 10^5$ Kmole Na_2CO_3

$2.07 \times 10^5 \times 12/24 = 1.04 \times 10^5$ Kmole NO

$2.07 \times 10^5 \times 12/24 = 1.04 \times 10^5$ Kmole NO_2

$2.07 \times 10^5 \times 11/24 = 9.49 \times 10^4$ Kmole H_2O

$NaOH$ Rxn 3

1.52×10^7 Kg $NaOH \div 40.00$ Kg/Kmole $= 3.80 \times 10^5$ Kmole $NaOH$

$3.80 \times 10^5 \div 24 = 1.58 \times 10^4$ Kmole $C_{12}H_{22}O_{11}$

$3.80 \times 10^5 \times 12/24 = 1.90 \times 10^5$ Kmole O_2

$3.80 \times 10^5 \times 12/24 = 1.90 \times 10^5$ Kmole Na_2CO_3

$3.80 \times 10^5 \times 23/24 = 3.64 \times 10^5$ Kmole H_2O

Prepare summation for reactants and products for rxns 1, 2 & 3

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Summation table for reactants

Species	total moles (kmole)	molecular weight (kg/kmole)	total mass (kg)
$NaNO_3$	1.71×10^6	84.99	1.45×10^8
$NaNO_2$	2.07×10^5	69.00	1.43×10^7
NaOH	3.80×10^5	40.00	1.52×10^7
$C_{12}H_{22}O_{11}$	9.57×10^4	342.3	3.28×10^7
O_2	2.94×10^5	32.00	9.41×10^6

Summation table for products

Species	total moles (kmole)	molecular weight (kg/kmole)	total mass (kg)
Na_2CO_3	1.15×10^6	105.99	1.22×10^8
NO	9.59×10^5	30.01	2.88×10^7
NO_2	9.59×10^5	46.01	4.41×10^7
H_2O	1.24×10^5	18.02	2.23×10^6

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CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering - Calcination Alternative

ORIGINATOR Joseph Scott DATE 9-15-95

REVISION NO. 0

OBJECTIVE Calculate revised mass balance for major chemical species around calcination unit relative to replacement of glass melter for vitrification.

METHODOLOGY Consider all anticipated mass input & output from calciner in comparison to equivalent mass input & output to glass melter for Appendix A Westinghouse data package for ex situ vitrification with no separation.

ASSUMPTIONS

1) Use mass quantity data for reactants and products for reaction of sugar with $NaNO_3$, $NaNO_2$, and ~~NaOH~~ NaOH previously calculated.

2) Assume that feed to calciner is 50% weight total solids including sugar ($C_{12}H_{22}O_{11}$)

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Assumptions continued

added to feed prior to calciner.

3) Base mass of solids in feed on mass tables presented in Appendix A of Westinghouse data package for ex situ vitrification with no-separations

4) Assume the heat supplied to calcination reactor is electric or combustion of fuel external to calcination reactor, i.e. fuel combustion does not enter mass balance.

5) Assume that 0.5 lb of 50 psig saturated steam must be injected at calciner feed nozzle for each 1 lb of feed in order to atomize feed

6) Assume that off-gases produced in calcination reactor (including steam) flow up out of reactor countercurrent to flow of dry calcine salts out of bottom of reactor

7) Assume the TOC in feed is oxidized by oxygen gas added to reactor to CO_2 gas and H_2O gas. Assume TOC can be represented as n-dodecane [$C_{12}H_{26}$]

Assumptions continued

8) Assume that of solids present in feed (dissolved or suspended) only $NaNO_3$, $NaNO_2$, NaOH, and TOC undergo reactions. All other solids remain in solid form and exit reactor as dry solids.

9) For mass balance on calcination reactor off-gas only consider mass of H_2O, NO, NO_2, and CO_2. Assume all other mass quantities for off-gas from calcination reactor are the same as mass quantities given for off-gas from glass melter in Appendix A of Westinghouse data package for ex site vitrification no-separations.

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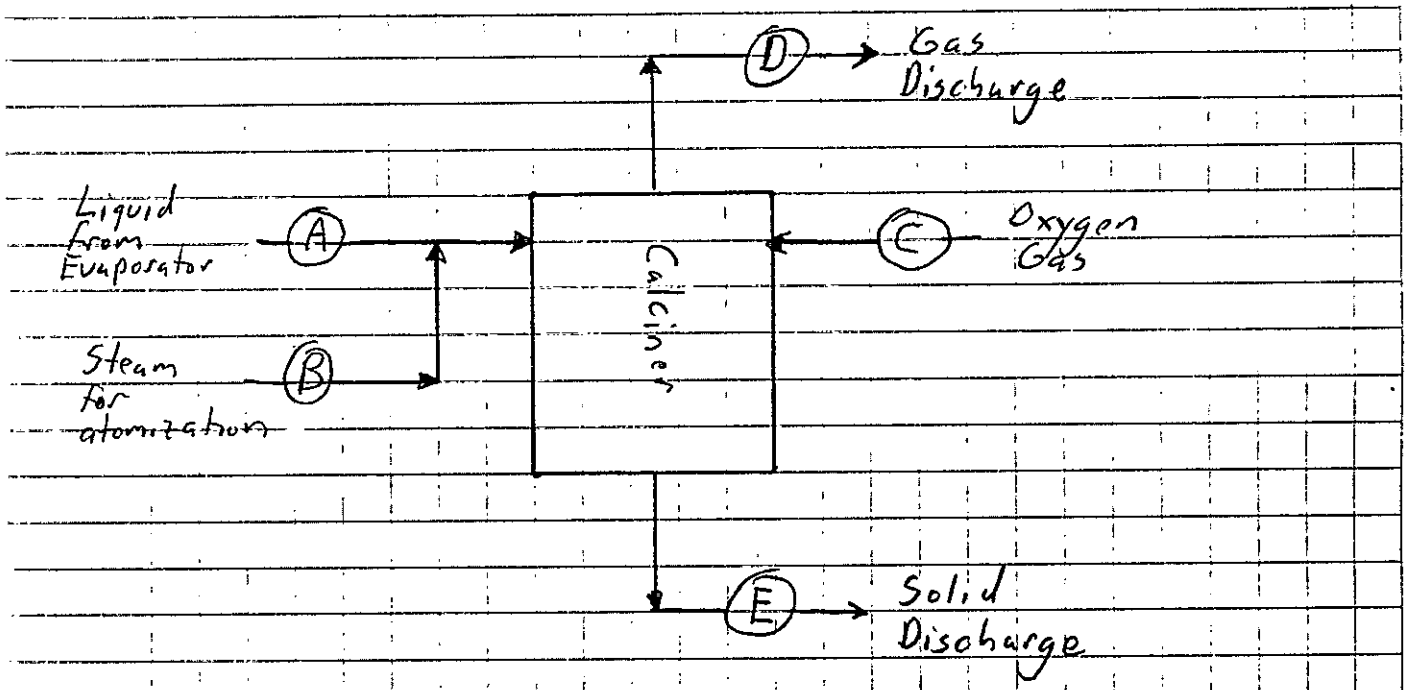
Calculate complete mass balance for spray calcination unit.

Calculations based on liquid feed to calciner containing 50% weight total solids, balance water, after evaporator. Total solids content includes sugar added to feed liquid in mixed feed adjustment tank between evaporator and calcination unit.
Steam added to liquid injection nozzle to atomize liquid feed into calciner.
Oxygen gas added as required for stoichiometry of calcination reactions.
Solids formed during calcination exit bottom of calciner unit.
Gases formed during calcination exit top of calciner unit.



Calculate mass input for Stream (A) - Liquid Feed.

By assumption stream (A) is 50% weight solids. Previous calculations to establish mass of sucrose required yield following mass for stream (A)

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Mass of sucrose [$C_{12}H_{22}O_{11}$] added to feed to calciner after feed evaporation = 3.28×10^7 kg

Feed stream mass prior to any processing from Westinghouse data package for ex situ vitrification no-separations data package Appendix A stream #1.

Liquid portion:

Total mass = 7.10×10^8 kg
Total water 5.07×10^8 kg

Total dissolved solids = 2.03×10^8 kg

Liquid dissolved solids includes:
$NaNO_3$ = 1.45×10^8 kg
$NaNO_2$ = 1.43×10^7 kg
$NaOH$ = 1.52×10^7 kg
Total organic carbon (TOC) = 1.42×10^6 kg

Solid portion:

Total mass = 1.94×10^7 kg

Solids include:
TOC = 1.16×10^5 kg

Quantity of dissolved solids and solids will not change significantly in processing steps prior to calciner except for addition of sucrose. Therefore, the total solids (dissolved and insoluble) for feed to calciner is:

2.03×10^8 kg + 1.94×10^7 kg + 3.28×10^7 kg = 2.55×10^8 kg

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By assumption the feed to the calciner is 50 % weight total solids. Therefore, total feed to calciner

$2 \times 2.55 \times 10^8$ Kg $= 5.10 \times 10^8$ Kg

Mass breakdown for stream (A)

Total mass		5.10×10^8 Kg
Liquid Portion	H_2O	2.55×10^8 Kg
	$NaNO_3$	1.45×10^8 Kg
	$NaNO_2$	1.43×10^7 Kg
	$NaOH$	1.52×10^7 Kg
	TOC	1.42×10^6 Kg
	$C_{12}H_{22}O_{11}$	3.28×10^7 Kg
	all other solids	2.70×10^7 Kg
Solid Portion	TOC	1.16×10^5 Kg
	all other solids	1.95×10^7 Kg

Calculate mass input for stream (B) – Steam
Steam feed to calciner liquid feed nozzle to assist in atomization of feed. Based on results of bench tests of calcination (Allaman and Johnson) and experience with liquid injection incinerator design will require approximately 0.5 Kg steam @ ~ 50 psig per 1 Kg of feed.

Feed Mass $= 5.10 \times 10^8$ Kg

Steam mass $= 0.5$ Kg/Kg feed $\times$ 5.10×10^8 Kg feed
$= 2.55 \times 10^8$ Kg

Stream (B) 2.55×10^8 Kg saturated 50 psig steam

Calculate mass input for stream (C) – Oxygen

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Previous calculations established a requirement for 9.41×10^6 kg O_2 as stoichometric requirement for calcination reactions for $NaNO_3$, $NaNO_2$, and NaOH. This number does not account for oxygen requirement for oxidation of TOC present in feed or any other oxygen demand.

Oxygen demand for TOC may be significant. From previous step for Stream (A) TOC in feed = 1.54×10^6 kg. No information is available on form of TOC in feed. Assume is form of hydrocarbon typical of kerosene, i.e., n-dodecane $C_{12}H_{26}$

Assume oxidize to CO_2 and H_2O

$$C_{12}H_{26} + 18\tfrac{1}{2}O_2 \rightarrow 12CO_2 + 13H_2O$$

Molecular weight n-dodecane = 170.3 kg/kmole

1.54×10^6 kg TOC ÷ 12 kg TOC/kmole TOC
= 1.30×10^5 kmole TOC

1.30×10^5 kmole TOC ÷ 12 kmole TOC / kmole $C_{12}H_{26}$
= 1.08×10^4 kmole $C_{12}H_{26}$

1.08×10^4 kmole $C_{12}H_{26}$ × 18.5 kmole O_2 / kmole $C_{12}H_{26}$
= 2.00×10^5 kmole O_2

2.00×10^5 kmole O_2 × 16.00 kg O_2 / kmole O_2
= 3.21×10^6 kg O_2

1.08×10^4 kmole $C_{12}H_{26}$ × 12 kmole CO_2 / kmole $C_{12}H_{26}$
= 1.30×10^5 kmole CO_2

1.30×10^5 kmole CO_2 × 44.01 kg / kmole = 5.72×10^6 kg CO_2

1.08×10^4 kmole $C_{12}H_{26}$ × 13 kmole H_2O / kmole $C_{12}H_{26}$
= 1.40×10^5 kmole H_2O

1.40×10^5 kmole H_2O × 18.02 kg/kmole = 2.53×10^6 kg H_2O

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So accounting for oxygen required for sodium salt calcine reactions and oxygen requirement for TOC:

7.41×10^6 kg O_2 + 3.21×10^6 kg O_2 = 1.06×10^7 kg O_2

Stream (C) 1.06×10^7 kg O_2 gas

Calculate mass output for Stream (D) - Gas Discharge

Calculations only consider species for which major changes from vitrification melter off-gas are anticipated. Limited for this calculation to NO, NO_2, H_2O, CO_2

NO previous calculations for calcination reactions balance provides 2.88×10^7 kg NO
Compares to value of 3.20×10^5 kg for stream # 410 glass melter off-gas in Appendix A of Westinghouse data package for ex situ vitrification no-separations

NO_2 previous calculations for calcination reactions balance provides 4.41×10^7 kg NO_2
Stream # 410 in Appendix A = 1.35×10^7 kg NO_2

H_2O total H_2O includes contribution from calcination reactions + atomization steam + TOC oxidation + water in feed
2.23×10^6 kg + 2.55×10^8 kg + 2.53×10^6 kg + 2.55×10^8 kg = 5.15×10^8 kg
Total H_2O for Stream # 410 in Appendix A = 3.50×10^8 kg and includes H_2O from combustion of Kerosene.

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CO_2 Previous calculations for TOC oxidation provides 5.72×10^6 kg CO_2
Stream # 410 in Appendix A = 1.72×10^8 kg CO_2

No basis available for calculation of SO_2 gas from calcination. Assume unchanged from Appendix A value = 1.36×10^6 kg

Do not consider any other gases at this time.

Calculate mass output for stream (E) - Solid Discharge

Stream (E) consists of dry solids discharged from bottom of calciner.

Solids discharged will equal solids feed adjusted for conversion of $NaNO_3$, $NaNO_2$, & $NaOH$ to carbonate salts and adjusted for oxidation of TOC.

From previous breakdown of mass in feed total solid mass excluding TOC, $NaNO_3$, $NaNO_2$, & $NaOH$, and $C_{12}H_{22}O_{11}$ is
2.70×10^7 kg + 1.93×10^7 kg = 4.63×10^7 kg
These solids will be inert and pass unchanged through calciner.

From previous calculations the total mass of Na_2CO_3 produced in calcination is: 1.22×10^8 kg

So Stream (E) breakdown

unreacted solids	=	4.63×10^7 kg
Na_2CO_3 product	=	1.22×10^8 kg
Total solids	=	1.68×10^8 kg

Summary of mass balance for calcination reactor and comparision to mass balance table in Appendix A of Westinghouse data package for the Ex Situ Vitrification No Separations Alternative

Feed to Calciner Compared to Feed to Glass Melter

Phase	Species	Calciner kg		Glass Melter Stream #406 kg	
Liquid	Total Mass	4.91E+08		4.26E+08	
	Water	2.55E+08	a	2.23E+08	
	NaNO3	1.45E+08		1.45E+08	
	NaNO2	1.43E+07		1.43E+07	
	NaOH	1.52E+07		1.52E+07	
	TOC	1.42E+06		1.42E+06	
	C12H22O11	3.28E+07	b	0.00E+00	
	Other Dissolved Solids	2.73E+07		2.71E+07	
Solid	Total Mass	1.94E+07		3.07E+07	c
	TOC	1.16E+05		1.16E+05	
	Other Solids	1.93E+07		3.06E+07	

a. Assumes 50% weight total solids fed to calciner
b. Sugar (C12H22O11) added to mix tank upstream of calciner
c. Mass includes recycle of glass fines to melter

Steam to Feed Atomizer

Calciner	50 psig saturated steam	2.55E+08	kg
Glass Melter	no direct steam feed	0.00E+00	kg

Oxygen Gas

Calciner	oxygen feed to calciner	1.06E+07	kg	a
Glass Melter	Stream #409	1.85E+08	kg	b

a. Oxygen for calcination reactions only. Does not include the oxygen required for kerosene fuel combustion. Kerosene combustion occurs outside of the calcination reactor and does not enter mass balance.
b. Includes the oxygen required for the kerosene fuel combustion.

Kerosene Liquid

Calciner	no direct feed	0.00E+00	kg	a
Glass Melter	Stream #408	5.21E+07	kg	

a. Kerosene combustions occurs outside of the calciner reactor and does not enter the mass balance

Glass Formers

Calciner	not required	0.00E+00	kg
Glass Melter	Stream #407	2.50E+08	kg

Solids Discharge for Calciner Reactor Compared to Solids Discharge for Glass Melter

Calciner	Calcined Salts	1.68E+08	kg
Glass Melter	Stream #411	3.65E+08	kg

Off-Gas for Calciner Reactor Compared to Off-Gas for Glass Melter

Only species in table considered. No estimate made for other off-gas species

Species	Calciner kg		Glass Melter Stream #410 kg
Water	5.15E+08		3.50E+08
NO2	4.41E+07		1.35E+07
NO	2.88E+07		3.20E+05
CO2	5.72E+06	a	1.72E+08

a. From oxidation of TOC in feed

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CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering – Preliminary Sizing of Calciner and Ceramic Candle Filter units.

ORIGINATOR R.D. Weed DATE 09-18-95

REVISION NO. 0

OBJECTIVE Obtain a comparative foot print sizing for the Calciner vessel and the ceramic candle filter.

METHODOLOGY Use assumed feed rate for material balance and apply laboratory data to obtain estimated size of the two vessels named in the title.

ASSUMPTIONS

1. Assumed 100 gpm feed rate to the calciner of evaporator concentrate.
2. Assumed 4 gallons/hour feed/tube in calciner (from lab report by R.T. Allemann and B.M. Johnson, J.R, HW-65806 RD.

(Continue on another sheet if necessary)

Ronald D Weed
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Calculation 3 pages

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BY _____ CHKD. _____ JOB NO. _____

ASSUMPTIONS CONTINUED.

3. ASSUMED TUBE DIAMETER OF 8 INCHES AS PER HW-65806RD by R.T. ALLEMANN and B.M. Johnson, JR.

4. ASSUMED LENGTH OF TUBE AT 10' PER HW-65806RD.

5. ASSUMED 5 FEET FOR UPPER and LOWER PLENUMS.

6. ASSUMED SPACING OF 2 INCHES BETWEEN TUBES.

7. FOR CERAMIC FILTER, ASSUMED 13 $ft^3/hr\text{-}ft^2$ gas flow PER candle unit.

8. ASSUMED 2 MICRON PORE SIZE IN FILTER UNIT.

9. ASSUMED 2-INCH OUTSIDE DIAMETER FOR CANDLE UNIT.

10. ASSUMED CANDLE UNIT AT 20 FEET IN LENGTH.

11. ASSUMED AN EQUIVALENT gas flow OF 4000 CFM which is APPROXIMATELY EQUAL TO THE VITRIFICATION OFF-gas FLOW.

12. ASSUMED a 6" CENTER LINE SPACING FOR THE CANDLES and a TRIANGULAR PITCH.

13. ASSUMED ~~1 FT TO 4 FT~~ RANGE FROM 1 FT TO 2 FEET OF INTERNAL INSULATION with THE SHROUD TO LOWER TEMPERATURE OF EXTERNAL VESSEL SHELL.

14. ASSUMED HEMISPHERICAL heads TOP and BOTTOM OF VESSEL FOR ESTIMATED HEIGHT.

Assumed 100 gpm feed rate to the calciner.

Assumed 4 gallons/hour feed per tube in calciner (from lab report by R.T. Allemann & B.M. Johnson, Jr.).

Assumed tube diameter of 8 inches as per HW-65806 RD by RT Allemann and BM Johnson, Jr.

Now, the number of calciner tubes can be calculated.

assumed feed of 100 gpm = 6000 gallons/hour
using 4 gallons/hour/tube = 1500 tubes = scale up factor.

Using 8-inch diameter tube calculate area of tube and estimate for furnace.

$$A \text{ of } 8'' \text{ dia} = \pi \frac{d^2}{4} = \frac{\pi (8)}{(4)(144)} = \frac{201}{(4)(144)} = 0.349 \text{ ft}^2$$

total tube cross sectional are $= (0.349)(1500) = 525 \text{ ft}^2$

Now then the $\sqrt{525} \cong 22.9$ ft Number of tubes $= \frac{(22.9)(12)}{8} = 34.4$ tubes

Assume tube spacing of 2 inches.

$\cong$ Length per side $= (34)(10'') + 4'' = 344'' = 28.6$ ft

~~Est~~ Estimate the furnace foot print at 30' x 30'

Heigth estimated at length of lab tube (10') + 5' for top and bottom plenums

Estimated envelope $\cong$ 30' x 30' x 15'

Assumed 13 $ft^3/hr\text{-}ft^2$ flow per candle filter unit
Assumed 2 μm pore size in filter unit
Assumed 2-inch outside diameter of candle unit
Assumed candle unit 20 ft long.

Assumed an equivalent gas flow of 4000 cfm which is approximately equal to the vitrification off-gas flow.

area per 20 ft candle $= \cancel{\left(\frac{2}{12}\right)^2 \frac{\pi}{4}} = \pi d L = \pi\left(\frac{2}{12}\right) 20' = 10.47\ ft^2/\text{candle}$.

$$\therefore ft^2 = \frac{ft^3}{hr\text{-}ft^2} = \left(\frac{hr\text{-}ft^2}{ft^3}\right)\left(\frac{ft^3}{min}\right)\left(\frac{min}{hr}\right) = \frac{(4000)(60)}{13} = 18{,}462\ ft^2$$

$\therefore$ Number of Candles 20 ft Long $= 18{,}462 \div 10.47 = 1763$ Candles

Calculate gas velocity exiting the Ceramic Candle.

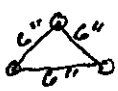
Volume of gas exiting candle $= (10.47\ ft^2)\left(\frac{13\ ft^3}{hr\text{-}ft^2}\right) = 136.11\ ft^3/hr$

area of Candle 2" in diameter.

$$A = \frac{\pi d^2}{4} = \frac{\pi 4}{(4)(144)} = \frac{\pi}{144} = 0.022\ ft^2$$

$$\text{Velocity } ft/sec = \left(\frac{ft^3}{hr}\right)\left(\frac{1}{ft^2}\right)\left(\frac{hr}{sec}\right) = \frac{(136.11)}{(0.022)(3600)} = \underline{1.72\ fps}$$

using a 6" center line spacing and a triangular pitch



The estimated vessel ID is $\cong$ 30 ft

with internal shroud and insulation vessel diameter will increase to about <u>32 to 34</u> ft outer diameter.
Assumed hemispherial heads top and bottom of vessel
for the 20-foot long ceramic candles the overall vessel heighth is estimated to be between <u>55 and 65 feet</u>.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering - Preliminary sizing of Calcination gas stream equipment and solids bin

ORIGINATOR R. D. Weed DATE 09-15-95

REVISION NO. 0

OBJECTIVE Obtain preliminary gas stream estimate for sizing filter, water quench tank, and solids bin and handling equipment.

METHODOLOGY Establish a feed flow rate to the calciner and perform material balances to obtain estimated flows based on the assumptions.

ASSUMPTIONS

1. Assumed the chemical balance of NaOH, $NaNO_3$, and $NaNO_2$ reactants with sugar, $C_{12}H_{22}O_{11}$ and O_2 react completely to the reaction products of Na_2CO_3, NO, NO_2, and H_2O.
2. Assumed 100 gallons/minute feed rate at a 1.41 specific gravity.

(Continue on another sheet if necessary)

Ronald D. Weed
SIGNATURE

CALCULATION & RESULTS ATTACHED

Calculation	7 pages
Attachment A	2 pages
Attachment B	5 pages

JACOBS\FORMS\CALCVR.SHT

ASSUMPTIONS CONTINUED

3. ASSUMED (1.41)(100) = 141 LBS/MINUTE OF FEED AT 50% SOLIDS CONTENT; THIS EQUALS 70 LBS/MIN H_2O AND 71 LBS/MIN OF TOTAL SOLIDS, DISSOLVED AND ~~[illegible]~~ RDW SUSPENDED (SUGAR WAS NEGLECTED)

4. ASSUMED THE FEED BALANCE EQUAL TO THE SOLIDS OF $NaNO_3$, $NaNO_2$, AND NaOH AND ASSUMED THE OTHER MATERIALS AS NEGLIGIBLE FOR ESTIMATING PURPOSES.

5. ASSUMED ATOMIZATION STEAM BASED ON LB MOLE OF FEED SOLIDS WITHOUT SUGAR ADDITION AND BASED ON 71 LBS OF SOLIDS IN 141 LBS/MIN OF FEED (50% SOLIDS AT 100 GPM AT 1.41 SPG FEED FROM THE EVAPORATOR.

6. ASSUMED THE FOLLOWING SOLIDS IN THE FEED PASSED THROUGH AS SOLIDS IN THE PRODUCT: Na_2SO_4, Na_2CO_3, Na_3PO_4, NaF, AND $Na_4Al(OH)_4$.

7. ASSUMED THE CALCINER PRODUCT DENSITY APPROXIMATELY 1.0 COMPARED TO WATER OR ~~[illegible]~~ RDW. (2-3 LBS/FT³.

Purpose of this calculation was to generate a mass flow rate balance with an assumed feed flow for performing an approximation of sizing process equipment.

The following initial approximations and assumptions were made.

1. Assumed the chemical balance of NaOH, $NaNO_2$, and $NaNO_3$ reactants with sugar, $C_{12}H_{22}O_{11}$ and O_2 react completely to the reaction products of Na_2CO_3, NO, NO_2, and H_2O.

2. Assumed 100 gallons per minute feed rate at a 1.41 specific gravity.

3. Assumed (1.41)(100) = 141 lbs/minute of feed at 50% solids content; this equals 70 lbs/min of water and 71 lbs/min of total solids, dissolved and suspended (sugar was neglected)

4. Assumed the feed balance equal to the solids of $NaNO_2$, $NaNO_3$, and NaOH and assumed the other materials as negligible for estimating purposes.

5. Reactions

A) $24\,NaNO_3 + C_{12}H_{22}O_{11} \longrightarrow 12\,Na_2CO_3 + 12\,NO + 12\,NO_2 + 11\,H_2O$

B) $24\,NaNO_2 + C_{12}H_{22}O_{11} + 12\,O_2 \longrightarrow 12\,Na_2CO_3 + 12\,NO + 12\,NO_2 + 11\,H_2O$

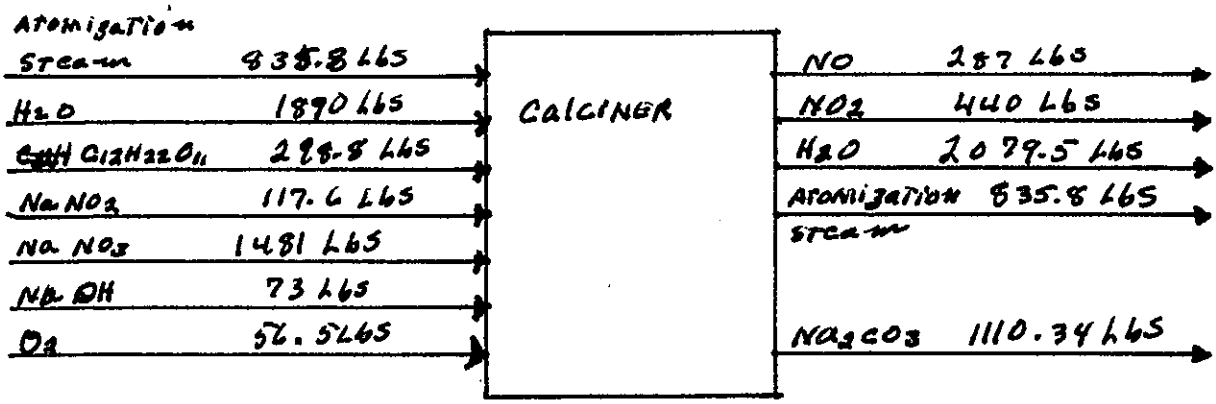
C) $24\,NaOH + C_{12}H_{22}O_{11} + 12\,O_2 \longrightarrow 12\,Na_2CO_3 + 23\,H_2O$

JACOBS ENGINEERING GROUP INC.

DATE 09-15-95 SUBJECT Preliminary sizing of calcination gas stream equipment and solids bin SHEET NO. 3 of 7

BY RAW CHKD. JOB NO. 01K 47101

Item	gm mole wt or lb mole wt	~~gm~~ %
$NaNO_3$	84.99	72.6
$C_{12}H_{22}O_{11}$	342.30	
Na_2CO_3	105.99	
NO	30.01	
NO_2	46.00	
H_2O	18.02	
$NaNO_2$	69.00	7.1
NaOH	40.00	7.6
O_2	32.00	
		87.3 %



moles of Reactants

3 moles $C_{12}H_{22}O_{11}$
24 moles $NaNO_3$
24 moles $NaNO_2$
24 moles NaOH
24 moles O_2

moles of Reactant Products.

36 moles Na_2CO_3
24 moles NO
24 moles NO_2
45 moles H_2O

FORM 81-005-1 (4/81)

Using the percentage of $NaNO_2$, $NaNO_3$ and NaOH calculate the amount of reactants entering the calciner to obtain the pounds of feed per equation relationships.

Feed

A) (24)(84.99)(0.726) = 1481 lbs $NaNO_3$ lbs = (moles)(lbs/mole)(%)

(1)(342.30)(0.726) = 248.6 lbs $C_{12}H_{22}O_{11}$

B) (24)(69.00)(0.071) = 117.576 lbs $NaNO_2$

(1)(342.30)(0.071) = 24.30 lbs $C_{12}H_{22}O_{11}$

(12)(32)(0.071) = 27.3 lbs O_2

C) (24)(40.00)(0.076) = 72.96 lbs NaOH

(1)(342.30)(0.076) = 26.02 lbs $C_{12}H_{22}O_{11}$

(12)(32)(0.076) = 29.1 lbs O_2

D) Water in feed

(lbs $NaNO_3$) + (lbs $NaNO_2$) + (lbs NaOH) ÷ (71)(0.873) = 27

[(1481) + (117.576) + (72.96)] ÷ (71)(0.873)(lbs solids)(%)

(27)(70) = 1890 lbs H_2O

E) Calciner Discharge, solids

1) (12)(105.99)(0.726) = 923.38 lbs Na_2CO_3

2) (12)(105.99)(0.071) = 90.30 lbs Na_2CO_3

3) (12)((105.99)(0.076) = 96.66 lbs Na_2CO_3

Σ = 1110.34 lbs Na_2CO_3

F) Calciner Discharge, gases

(1) (12)(30.01)(0.726) = 261.45 lbs NO

(12)(46.00)(0.726) = 400.75 lbs NO_2

(11)(18.02)(0.726) = 143.91 lbs H_2O

2) (12) (30.01) (0.071) = 25.57 lbs NO

(12) (46.00) (0.071) = 39.19 lbs NO_2

(11) (18.02) (0.071) = 14.07 lbs H_2O

3) (23) (18.02) (0.076) = 31.50 lbs H_2O

G Feed H_2O to gaseous H_2O

1890 lbs H_2O ⟶ 1890 lbs H_2O

H. atomization steam based on 1 mole of feed solids without sugar addition is based on 71 lbs of 141 lbs of feed. (50% solids at 100 gpm at 1.41 spg feed from evaporator.)

steam = [(1481 lbs $NaNO_3$) + (117.586 lbs $NaNO_2$) + (72.96 lbs NaOH)] (0.5)

~~÷ 1/0.823~~

RDW

= 835.8 lbs atomization steam

to obtain the relationship to the 100 gpm feed rate (141 lbs/min)

Σ of mole feed rate in lbs ÷ lbs/min

1. Ratio = [(1671.6) + (1890)] ÷ 141 = 25.26

Now based on 141 lbs/min of feed from the evaporator prior to sugar adjustment

Calciner Discharge Estimated Solids

1. Na_2CO_3 = (1110.34) ÷ (25.26) = 43.96 lbs/min.

Gaseous Stream from Calciner Estimated

1. NO = (287) ÷ (25.26) = (261.45 + 25.57) ÷ (25.26) = 11.36 lbs/min.
2. NO_2 = (400.75 + 39.19) ÷ (25.26) = 17.42 lbs/min
3. H_2O = (143.91 + 14.07 + ~~31.50~~ 1890 + 835.8) ÷ (25.26) = 2884 ÷ 25.26 = 114 lbs/min

NO	30.01	11.36	0.08	0.91
NO_2	46.00	17.42	0.12	5.52
H_2O	18.02	114	0.80	14.416
		Σ 143		Σ 20.8

air at 20°C and 1 atm, specdensity = 0.0808 lbs/ft³ at Molecweight = 29

$$(0.0808)\left(\frac{20.8}{29}\right)(1) = 0.06 \text{ lbs/ft}^3$$

flow = 143 lbs/min
= (143) ÷ 0.06) = 2383 ft³/min gasflow

this flow compares to the estimated flow from vitrification given as 4265 cfm.

Quench tank should handle calciner flow with no change in sizing.

assumed the following solids in the feed passed through as solids in the product.

1. Na_2SO_4 = (71)(0.015) = 1.065 lbs
2. Na_2CO_3 = (71)(0.030) = 2.13 lbs
3. Na_3PO_4 = (71)(0.022) = 1.562 lbs
4. $Na_4Al(OH)_4$ = (71)(0.048 = 3.408 lbs
5. NaF = (71)(0.012 = 0.852 lbs
   Σ 9.012 lbs

6. solids discharged = 43.96 + 9.012 = 52.92 lbs/min
= 3178.2 lbs/hr
= 76277 lbs/day
= 34.67 Metric tons/day

Assumed product density approximately 1.0 or 62.3 lbs/ft³

1. $\therefore \left[(52.92 \text{ lbs/min}) \div (62.3 \text{ lbs/ft}^3)\right] = 0.85 \text{ ft}^3/\text{min}$

Estimated tank size $= \left(\frac{ft^3}{min}\right)\left(\frac{min}{hr}\right)\left(\frac{hr}{day}\right)$

$= (0.85)(60)(24) = 3060 \text{ ft}^3/\text{day}$

Approximate size of tank (bin) with sloped bottom for a screw conveyor feeder adaptation

$\approx 15' \times 15' \times 15'$

It is also possible that atomizing nozzles are available without requiring the atomization steam. This would then reduce the steam load from the steam generator and the condensing load on the quench tank and the cooling tower water.

Attachment A
PRELIMINARY SIZING CALC.
gas STREAM Equipment
Page 1 of 2

[redacted]

Summary of mass balance for calciner and comparision to mass balance table in Appendix A of Westinghouse data package for Ex Situ Vitrification No-Separations

Feed to Calciner Compared to Feed to Glass Melter

Phase	Species	Calciner kg		Glass Melter Stream # 406 kg	
Liquid	Total Mass	4.91E+08		4.26E+08	
	Water	2.55E+08	a	2.23E+08	
	NaNO3	1.45E+08		1.45E+08	
	NaNO2	1.43E+07		1.43E+07	
	NaOH	1.52E+07		1.52E+07	
	TOC	1.42E+06		1.42E+06	
	C12H22O11	3.28E+07	b	0.00E+00	
	Other Dissolved Solids	2.69E+07		2.71E+07	
Solid	Total Mass	1.94E+07		3.07E+07	c
	TOC	1.16E+05		1.16E+05	
	Other Solids	1.93E+07		3.06E+07	

a. Assumes 50% weight total solids to calciner
b. Sugar (C12H22O11) added to mix tank prior to calciner
c. Mass includes recycle of glass fines to melter

Steam to Feed Atomizer

Calciner	50 psig saturated steam	2.55E+08	kg
Glass Melter	no direct steam feed	0.00E+00	kg

Oxygen Gas

Calciner	oxygen feed to calciner	1.04E+07	kg	a
Glass Melter	Stream # 409	1.85E+08	kg	b

a. Oxygen for calciner reactions only. Does not include oxygen required for kerosene fuel combustion which occurs outside of calciner reactor and does not enter calciner mass balance.
b. Includes oxygen required for kerosene fuel combustion.

Kerosene Liquid

Calciner	no direct feed	0.00E+00	kg	a
Glass Melter	Stream # 408	5.21E+07	kg	

a. Kerosene combustion occurs outside of calciner reactor and does not enter calciner mass balance

Attachment A
PRELimmary sizing calc
GAS STREAM Equipment
Page 1 of 2

[redacted]

Glass Formers

Calciner	Not Required	0.00E+00	kg
Glass Melter	Stream #407	2.50E+08	kg

Off-Gas for Calciner Compared to Off-Gas for Glass Melter

Note: Only species in table considered. No estimate made for another off-gas components.

Species	Calciner kg	Glass Melter Stream # 410 kg
Water	5.15E+08	~~2.23E+08~~ a 3.50E+08 kg.
NO2	4.41E+07	1.35E+07
NO	2.88E+07	3.20E+05
CO2	5.72E+06 a ~~b~~	~~2.48E+03~~ 1.72E+08
SO2	1.36E+06 b ~~c~~	1.36E+06

appendix A Stream #410

~~a. Not tabulated in Appendix A. Calculated from water content of feed to melter.~~
a ~~b.~~ From oxidation of TOC in feed.
b ~~c.~~ No estimate made of change from glass melter number.

Solids Discharge for Calciner Compared to Solids Discharge for Glass Melter

Calciner	Calcined Salts	1.68E+08	kg
Glass Melter	Stream #411	3.65E+08	kg

Attachment B
Preliminary sizing calc
gas stream equipment
Page 1 of 5

Sugar Denitrification
TWRS EIS

The term "sugar denitrification" can be used to refer to two different processing scenarios. The first refers to the use of sugar to destroy nitric acid, HNO_3. The second refers to the use of sugar during calcination to change other anions into carbonates.

Nitric Acid Destruction.

For the destruction of nitric acid, the reaction considered most likely to take place is as follows:

$$C_{12}H_{22}O_{11} + 24HNO_3 = 12CO_2 + 12NO + 12NO_2 + 23H_2O$$

Other substances such as formaldehyde have been used at Hanford to destroy nitric acid. From the dates of references it can be inferred that the reaction of nitric acid with formaldehyde was investigated from 1954 to 1963. Then in 1962 several investigators began looking at the concept of using sugar in place of formaldehyde. The laboratory and pilot plant work indicated that sugar could be successfully used to destroy the excess nitric acid in the Purex waste streams. The investigators did not indicate the point in the overall Purex process where the sugar was to be added. The reports do not indicate that sugar was ever used in place of formaldehyde, but stated that results indicated that such a substitution could be successful.

Although chemical reactions can be written for it, it is unlikely that sugar denitrification could be used to destroy the sodium nitrate which presently exists in the tank wastes as a result of neutralizing the excess nitric acid with sodium hydroxide. In neutral or basic solutions such as the Hanford tank wastes the nitrate anion is a very weak oxidizing agent. Any potential denitrification of the existing tank wastes will be hindered by the fact that one of the reaction products from adding sugar to tank wastes is sodium hydroxide, which is present in large excesses to help prevent corrosion of the steel tanks. For this reason the TPA and No Separations alternatives do not include the addition of sugar in their flowsheets and process descriptions. Where sugar denitrification can be probably used in an ex-situ alternative is that part of the Extensive Separations alternative that processes acidic solutions. In the preliminary flowsheets for Extensive Separations, sugar denitrification is used to destroy nitric acid, prior to further processing.

Sugar Calcination.

The second use of sugar, as a reactant during calcination, does not appear to have been investigated or used on a large scale. Reactions can be written for the reaction of sugar with nitrate, nitrite and hydroxide, converting these anions into carbonates. For nitrate the reaction can be written:

ATTACHMENT B
preliminary sizing calc
- gas stream equipment
page 2 of 5

$$C_{12}H_{22}O_{11} + 24NaNO_3 = 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$$

For nitrite conversion oxygen is required as shown in the following equation:

$$C_{12}H_{22}O_{11} + 24NaNO_2 + 12O_2 = 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$$

Likewise for hydroxyl conversion, oxygen is required as shown by the following equation:

$$C_{12}H_{22}O_{11} + 24NaOH + 12O_2 = 12Na_2CO_3 + 23H_2O$$

From thermodynamic considerations (Gibbs free energies) one would postulate that the above chemical reactions would very likely proceed to completion. The kinetics of these reactions would be aided by high temperatures such as those that occur during calcination processing. While it is difficult to state the exact temperature required for calcination, it would likely be in the 400-600°C range. Sodium bicarbonate melts at 851°C, sodium nitrate at 308°C, sodium nitrite at 271°C and sodium hydroxide at 328°C.

One can make an estimate of the products of calcining the tank wastes with sugar. The starting point for this estimate is the feed stream from retrieval and transfer of the tank contents. Reference to the mass balances given in the TPA (and No Separations) data package shows that over the life of the plant the total mass flow of liquid components is 710,000 metric tons (MT). The total mass flow of solid components is 19,400 MT. Of the liquid components, 507,000 MT are water and 1,420 MT are total organic carbon (TOC). The remaining dissolved solids are 99% sodium compounds and 1% other compounds, including dissolved radionuclides. Table 1 below shows the weights and percentages of the sodium compounds.

Table 1. Sodium Compounds in Feed Stream

Sodium Compound	Weight (MT)	Percent of Compounds
$NaNO_3$	145,350	72.6
$NaNO_2$	14,283	7.1
NaOH	15,160	7.6
Na_2SO_4	2,984	1.5
Na_2CO_3	5,936	3.0
Na_3PO_4	4,428	2.2
$Na_4Al(OH)_4$	9,537	4.8
NaF	2,478	1.2

The first three compounds listed are the ones for which chemical reactions have been written. Reactions were not written for the remaining compounds since they comprise a minor portion of the dissolved sodium compounds.

Based on the reactions that have been written, it is possible to calculate the weight of sugar to be added to form carbonates, and also to calculate the weight of sodium carbonate that would be formed. This assumes the reactions require no excess sugar to go to completion. Table 2, below shows the reactant compounds, the sugar required, and the sodium carbonate that would ideally be produced.

Table 2. Sugar Consumption & Na_2CO_3 Production

Reacting Compound	Sugar Required (MT)	Na_2CO_3 Formed (MT)
$NaNO_3$	24,370	90,630
$NaNO_2$	2,950	10,970
NaOH	5,400	20,090
Totals	32,720	121,690

By adding the weight of sodium carbonate that is produced to the weights of the other solid components in the feed stream (and subtracting those substances that are volatilized), one can calculate the weight of final product from the sugar calcination. Table 3 below shows a comparison of the weight of final product from sugar calcination with the weight of vitrified product shown in the data package for No Separations.

Table 3. Comparison of Final Products.

Calcination		No Pretreatment
Solid Product	Weight (MT)	Vitrified Product (MT)
Na_2CO_3	121,690	
Na_2SO_4	2,980	
Na_2CO_3(present originally)	5,940	
Na_3PO_4	4,430	
$Na_4Al(OH)_4$	9,540	
NaF	2,480	
Solid Components	19,400	
TOC (from solid comp.)	-120	
Total	166,340	357,000

The results of these preliminary calculations indicate that weight of the final product of sugar calcination is roughly 46% of the weight of final glass product from No

Separations. This would indicate that there are potential decreases in the amount of final product from the treatment of the liquid portion of the tank wastes. The solid portion of the tank wastes may also react with sugar during calcination, however this preliminary estimate did not consider any changes in the solids.

There are a number of unresolved issues that remain for sugar calcination. Among these are the following:

1. The final form of the treated wastes from sugar calcination is primarily a mixture of sodium carbonate and calcined solids. The sodium carbonate is certainly water soluble, and the calcined solids may have been rendered more soluble by high temperature reactions. Calcination is commonly used on mineral products to render them more amenable to further hydrometallurgical processing. The protection for the calcined tank wastes is then ultimately the container that they are sealed into. So while the tank wastes have been reduced in volume, the final product is immobilized to the extent that the external container remains secure. There are no NRC requirements in 10CFR60 that require a high level waste form to be a glass. A waste that is in solid form in sealed containers, that is non-combustible and with particulates consolidated to limit availability and particulate generation appears to meet the NRC waste form criteria. A Waste Form Acceptance Systems Requirements Document (WASRD) has been generated for the geologic repository, but a Waste Acceptance Criteria (WAC) is not yet available. The cesium chloride capsules represent a similar situation where a soluble product is sealed in a container. The question of repository acceptance appears to be some time in the future.
2. While the reactions of tank waste components with sugar to form sodium carbonate can be written and quantified, there is no evidence that there will not be practical problems in the calcination process that cannot be overcome. Unresolved safety issues would certainly be among the first to be resolved. The calcination process involves the heating of a fuel (sugar) with an active oxidizing agent (sodium nitrate). Under the proper circumstances the fuel and oxidizer may react with explosive violence. While this possibility would not rule out consideration of sugar calcination as a suboption in the TWRS EIS, it would place it in the category of potential but unproven technology.

One conclusion to be drawn regarding the TWRS EIS is that the exclusion or inclusion of sugar calcination as a waste processing technology should have minimal changes in the expected environmental impacts. The wastes must still be retrieved and transferred; a processing facility must still be constructed and operated; that processing facility will still emit roughly the same quantities of gaseous effluents; disturbed areas for borrow material will remain unchanged; groundwater modeling would be largely unaffected, and wastes must still be transported to the geologic repository.

Previous Calcination Studies

Appendix I of the Technical Options Report provides a preliminary analysis of a process that calcined the tank wastes. This information should be used very cautiously

since this process was not sugar calcination. Instead it was a process which calcined the plant feed directly to sodium hydroxide in fluid bed calciners, treated the gas stream for nitrogen oxides, Tc-99, and added lime to precipitate sulfur oxides in the calciner. Lime was also added later to capture C-14 as the carbonate. Since carbon could not be added in the fuel to the calciner, hydrogen and oxygen were used as the primary fuels. Calcining took place in 60 fluid bed calciners, each of which produced about one ton/day of calcined product. The use of so many small units may have been postulated to solve the problem of scaling the process up to larger calciners. It certainly solved the problem of installed spares. The final product was placed in nodular iron (not stainless steel) casks for disposal. While the filling and sealing of the casks does not depend on the material of construction, acceptance of nodular iron at the geologic repository is very questionable.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING — Calculations to support number changes in Table 8 "Operating Resource Requirements"

ORIGINATOR R. D. WEED DATE 09-29-95

REVISION NO. 0

OBJECTIVE Provide revised numbers where necessary for Calcination versus vitrification process numbers

METHODOLOGY Used material balance values for the calcination process to generate revised numbers for table 8 data.

ASSUMPTIONS

1. assumed that the sanitary water requirement would increase by the quantity of atomization steam added to the calciner process.

2. Assumed that kerosene density was the same as the density of dodecane = 0.75 g/cc at 20°C.

(Continue on another sheet if necessary)

Ronald D. Weed
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CALCULATION & RESULTS ATTACHED

Calculation	4 pages
Appendix A	8 pages
Appendix B	2 pages
Appendix C	5 pages

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Assumptions Continued

3. Assumed that the ~~Raw water~~ RDW RAW water is primarily used for cooling tower makeup for normal losses.

4. the Raw water use was assumed to be proportional to the kerosene use for the calcination versus the vitrification process.

5. Assumed the ammonia, NH_3, quantity would increase by the proportional quantity of NOx generated due to the reaction products assumed to occur during calcination which was different for the vitrification process.

6. the oxygen requirements changed because of the quantity required for chemical reactions and for external firining of calciner (obtained from the material balance).

7. Assumed the concrete requirements were proportionally reduced by the lesser quantity of solid product as compared to vitrification.

8. Assumed steel for cannisters requirements changed proportionally to the reduced number of cannisters required for the calcination process.

9. Assumed the remaining items of the table remained the same as given for the vitrification process.

Calculated data to support number changes in table 8 "Operating Resource Requirements" from paper titled "Calcination Data for the TWRSEIS". Refer also to table 6-4 of WHC-SD-WM-EV-103, Rev.0.

Assumed that the sanitary water requirement would increase by the quantity of atomization steam added to the calciner process.

1. Atomization steam from material balance = 18.2 E06 Kg steam at 50psig, saturated.
2. 1 Lb of steam = 1 Lb of H_2O ∴ = 18.2E06 Kg H_2O
3. 18.2 E06 Kg H_2O = 18.2 E03 Mg H_2O = 1.82 E04 Mg H_2O
4. Water use for vitrification process = 6.03 E04 M^3
5. 18.2 E03 Mg H_2O (at spg = 1) = 1.8 E04 M^3 H_2O
6. Total water = Σ 6.03 E04 M^3 + 1.82 E04 M^3
   = 7.85 E04 M^3 sanitary water. ←

assumed kerosene density same as dodecane = 0.75 g/cc @ 20°C

Kerosene required from material balance = 1.1 E08 Kg

1. Required units are M^3/yr for this calculation. assumed a 14-year period.
2. 1.1 E08 ÷ 14 = 7.86 E06 Kg/yr of kerosene
3. $M^3/yr = \left(\frac{Kg}{yr}\right)\left(\frac{cm^3}{g}\right)\left(\frac{g}{Kg}\right)\left(\frac{M^3}{cm^3}\right) = (7.86\,E06)\left(\frac{1}{0.75}\right)\left(\frac{1000}{1}\right)\left(\frac{1}{1E06}\right)$
4. $M^3/yr = \frac{7.86E03}{0.75} = 10.48\,E03\ M^3/yr$ ←

JACOBS ENGINEERING GROUP INC.

DATE 09-29-95 SUBJECT Calculations to support Number Changes in table 8 SHEET NO. 3 of 4

BY RDW CHKD. JOB NO. 01K47101

Less kerosene is required to externally heat the calciner unit at 700°C to 800°C than to heat the glass melter to 1300°C to 1400°C.

The raw water is primarily used for cooling tower makeup. It is assumed to be proportional to the kerosene use.

Kerosene use = 1.048 E04 m^3/yr for calciner
Kerosene use = 5.64 E04 m^3/yr for vitrification unit

1. Ratio = 1.048 ÷ 5.64 = 18.58 %

2. ∴ Raw water use = (0.1858)(4.62E05) = 8.58E04 m^3
= 8.58 E04 m^3 ←

Under the heading of materials, the glass formers are deleted from the calcining process. Sugar, $C_{12}H_{22}O_{11}$, is added as a reactant to the calciner feed.

From the material balance the amount of sugar is:

Sugar, $C_{12}H_{22}O_{11}$ = 3.3 E04 Mg ←

The ammonia, NH_3, quantity will increase by the proportional quantity of NOx generated due to the reaction products assumed to occur during calcination.

1. From the material balance, 7.29 E+07 Kg NOx from calciner.

2. From the material balance, 1.38 E+07 Kg NOx from the glass melter.

3. ∴ (7.29) ÷ (1.38) = 5.28

4 ∴ (5.28) (6.84 E03) = 3.61 E04 Mg of ammonia for NOx conversion.
NH_3 = 3.61 E04 ←

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JACOBS ENGINEERING GROUP INC.

DATE 09-29-95 SUBJECT calculations to support number changes in table 8 SHEET NO. 4 OF 4

BY RDW CHKD. JOB NO. 01K47101

the oxygen used by the calciner furnace plus the oxygen to the calciner for chemical reactions are generated by the mass balance. The amount of oxygen required for this table is as follows:

1. amount of oxygen for furnace = 1.9 E+08 Kg

2. Amount of oxygen for reactions = 1.04E+07 Kg

3. total oxygen requirement = Σ 1.9E+08Kg + 0.104 E+08 Kg

4. = 2.0 E+08 Kg

5. = 2.0 E+05 Mg ←

the concrete and the steel requirements for the shielding casks and the cannisters change because the calciner uses 52% less cannisters for the solid waste product.

1 ∴ the concrete = (22481) (0.48) (90.7) = 9.8 E+05 Mg. ←

2 ∴ the steel = (22481) (0.48) (6.5) = 7.0 E+04 Mg. ←

These calculations are based on footnotes 9 and 10 to table 6-4 in WHC-SD-WM-EV-103 Rev. 0

the following items from table 6-4 in WHC-SD-WM-EV-103 Rev. 0 remain the same as for the vitrification process.

Land surface committed permanently (M^2)	1.00E4
50% HNO_3 (M^3)	6.30E2
50% NaOH (M^3)	2.66E2
$KMnO_4$	1.70E1
Off gas treatment chemical	not defined
oxalic acid	3.2E1
trisodium phosphate	1.90E3
Electrical (GWh/yr)	4.69E3

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Appendix A
Calc for table 8
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CALCINATION DATA FOR THE TWRS EIS

The following information is requested for use in assessing the environmental impacts associated with the No Separations Calcination subalternative.

1.0 SCOPE

Calcination is one of two optional waste treatment technologies being evaluated for the No Separations subalternative in the TWRS EIS. No Separations refers to an alternative that would remove as much of the waste from the tanks as practicable (assumed to be 99%) and treat all of the retrieved waste, classified as high-level waste, for disposal at the proposed national high-level waste repository.

The retrieved waste would not separate waste into LLW and HLW streams. The single-shell tank wastes and double-shell tank wastes would be blended as necessary. Blended waste would be classified as HLW and calcined in a single treatment facility. The calcined wastes would be placed into Hanford Site canisters, which would then be placed into overpack shielding casks. The casks would be held on interim site storage pads to await shipment to a permanent HLW repository for final disposal.

The HLW calcination plant is very similar to the HLW vitrification plant described in the No Separations (Vitrification) subalternative data package.

The calcination option described in this data package provides for the following:

- Receive wastes from the waste retrieval and transfer function;
- Calcines the waste stream using sugar as a reducing agent to yield a dry waste steam that is mainly carbonates;
- Treats the off-gas stream from the calciner providing overall DFs for constituents of concern that are approximately the same as those in the vitrification option;
- Collects liquid effluents for batch transfer to the Liquid Effluent Treatment Facility;
- Produces calcined waste in Hanford Site canisters; and
- Onsite interim storage of the entire calcined waste volume pending shipment to the proposed national repository.

2.0 SOURCES OF INFORMATION

Identify information sources used in developing data.

3.0 ASSUMPTIONS USED IN DEVELOPING THE DATA

Assume the same schedule as the vitrification option
Assume the same plant operating efficiency (60%) and capacity factor (60%)
Assume the same input
Similar levels of air pollution control
Assume similar size of a canister for the calcined product as the vitrified waste (1.67 m dia x 4.57 meters high)

4.0 DISCUSSION

4.1 CONSTRUCTION

Description of the facilities that will be constructed including the required support facilities
Facility foot prints
Construction schedule- Assume the same construction schedule as the No Separations vitrification data package
Location of the facilities and siting information will be assumed to be the same as the vitrification option

4.2 OPERATION

Operating schedule assumed to be the same as vitrification:
Characteristics of material to be processed - use vitrification data package material balance stream number 1 as a plant input;
Characteristics of treated waste;
Volume of treated waste;
Size of the required interim storage facility assuming that the same 10 m3 container will be used for the calcined waste;
Process flow diagram and description;
Potential increases or decreases or changes in characteristics of secondary waste streams or incidental waste volumes from the vitrification option;

4.3 POST REMEDIATION

Assume that post remediation activities would be the same as the vitrification option.

5.0 DATA

Note: provide footnotes to tables as a means to explain data.
Provide one set of backup calculations made to develop data presented in tables.

Table 1 Waste Form Volume and Average Radionuclide Inventory

Radionuclide Inventory	Curies in Waste Form
(should be the same as vitrification)	
Total Waste Volume (m3)	

CONSTRUCTION

Table 2 Construction Personnel Requirements (FTEs)

Activity	Total	199_				

Appendix A
Calc for Table 8
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Table 3 Construction Resource Requirements

Construction Resource	Quantity
Land (hectares) Surface Committed Temporarily	
Water	
Energy Electricity (Gwh) Diesel Fuel (liters) Gasoline (liters)	
Materials Concrete (m3) Cement (m3) Sand (m3) Aggregate (m3) Steel Carbon Steel (mt) Stainless Steel (mt) Earthen Borrow Material (m3) Sand Aggregate Other (specify)	

Table 4 Nonradiological Construction Emissions

Construction Emission Pollutant	Quantity
Exhaust Particulate PM-10 (kg)	
SOx (as S02) kg	
NOx (as NO2) kg	
Hydrocarbons, kg	
Aldehydes, kg	
CO, kg	
Fugitive Dust, kg	

Note: This data should be scaled from the vitrification option based on projected facility size.

Table 5 Transportation of Earthen Borrow Construction Material

This can be calculated using the volume of borrow identified in the construction resource table and using the same assumptions as the WHC data packages. If the assumption that sand/aggregate would be taken from pit 30 would change then a proposed borrow site needs to be identified along with the location and distance.

Table 6 Transportation of Other Construction Material

This can be done using the construction resources data from table 2 above and the assumptions made in the WHC Engineering data package for No Separations.

OPERATION

Table 7 Operating Personnel Requirements (FTEs)

Operating Personnel	Total	199_	199_	___	___	___	___	___	___
Nonexempt Rad Worker Nonrad Worker									
Exempt + BU Rad Worker Nonrad Worker									
Total									

Operating personnel requirements should include startup, hot operations, and D&D. Staffing levels need to be input into socioeconomic model on an annual staffing level. Personnel requirements would be ideally shown on an annual level but showing total levels with clarification to allow the data to be broken down would be acceptable.

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calc for table 8
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Table 8 Operating Resource Requirements

Resource	Quantity
Land (hectares) committed permanently	
Water (m3) Raw Sanitary	
Energy Electrical (GWh/yr) Other (specify)	
Materials Glass formers Process Chemicals (specify) Steel 7.0E4 Concrete 9.8E5	

Note: For the alternatives in the WHC engineering data package it was assumed that the waste treatment facilities would be contaminated following treatment and the land area that they occupied would be permanently committed.

Table 9 Nonradiological Operating Emissions

Item	Quantity
Particulate (kg)	
VOC (specify)	
Toxic Air Pollutants (WAC 173-460) specify	
N0x	
S0x	
CO	

Note: These emissions are used as input to the air dispersion model. These emissions quantities are broken down into hourly and daily emission rates and divided by stack gas volumetric flow rate to develop concentrations.

Appendix A
Calc for Table 8
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Table 9 Radiological Operating Emissions (Ci)

Radionuclide	Air	Water
Specify		

Table 11 Operating Emissions Release Parameters

Item	Quantity
Stack Height Location Stack gas flow rate (std m3/sec) Stack exit area or exit velocity	
Water emissions Volume Disposition	

Table 12 Decontamination and Decommissioning of Facilities

Item	Contaminated	Non-Contaminated
Steel		
Concrete		
Soil		
Debris		

Appendix A
Calc for table 8
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Table 13 Overall Cost Component (1995 dollars)

Cost Component	Quantity
Capital	
Operating	
Monitoring and Maintenance	
Decontamination and Decommissioning	
Research and Development	
Total	

Note: Cost estimate should be made relative to the vitrification option.

APPENDIX B
calc for table 8
page 1 of 2

Summary of mass balance for calciner and comparision to mass balance table in Appendix A of Westinghouse data package for Ex Situ Vitrification No-Separations

Feed to Calciner Compared to Feed to Glass Melter

Phase	Species	Calciner kg		Glass Melter Stream # 406 kg	
Liquid	Total Mass	4.91E+08		4.26E+08	
	Water	2.55E+08	a	2.23E+08	
	NaNO3	1.45E+08		1.45E+08	
	NaNO2	1.43E+07		1.43E+07	
	NaOH	1.52E+07		1.52E+07	
	TOC	1.42E+06		1.42E+06	
	C12H22O11	3.28E+07	b	0.00E+00	
	Other Dissolved Solids	2.69E+07		2.71E+07	
Solid	Total Mass	1.94E+07		3.07E+07	c
	TOC	1.16E+05		1.16E+05	
	Other Solids	1.93E+07		3.06E+07	

a. Assumes 50% weight total solids to calciner
b. Sugar (C12H22O11) added to mix tank prior to calciner
c. Mass includes recycle of glass fines to melter

Steam to Feed Atomizer

Calciner	50 psig saturated steam	2.55E+08	kg
Glass Melter	no direct steam feed	0.00E+00	kg

Oxygen Gas

Calciner	oxygen feed to calciner	1.04E+07	kg	a
Glass Melter	Stream # 409	1.85E+08	kg	b

a. Oxygen for calciner reactions only. Does not include oxygen required for kerosene fuel combustion which occurs outside of calciner reactor and does not enter calciner mass balance.
b. Includes oxygen required for kerosene fuel combustion.

Kerosene Liquid

Calciner	no direct feed	0.00E+00	kg	a
Glass Melter	Stream # 408	5.21E+07	kg	

a. Kerosene combustion occurs outside of calciner reactor and does not enter calciner mass balance

Appendix B
Calc for table 8
page 2 of 2

[redacted]

Glass Formers

Calciner	Not Required	0.00E+00	kg
Glass Melter	Stream #407	2.50E+08	kg

Off-Gas for Calciner Compared to Off-Gas for Glass Melter

Note: Only species in table considered. No estimate made for another off-gas components.

Species	Calciner kg	Glass Melter Stream # 410 kg
Water	5.15E+08	~~2.23E+08~~ a 3.50E+08 kg.
NO2	4.41E+07	1.35E+07
NO	2.88E+07	3.20E+05
CO2	5.72E+06 a ~~b~~	~~2.48E+03~~ 1.72+08
SO2	1.36E+06 b ~~c~~	1.36E+06

Appendix A Stream #410

~~a. Not tabulated in Appendix A. Calculated from water content of feed to melter.~~
a ~~b.~~ From oxidation of TOC in feed.
b ~~c.~~ No estimate made of change from glass melter number.

Solids Discharge for Calciner Compared to Solids Discharge for Glass Melter

Calciner	Calcined Salts	1.68E+08	kg
Glass Melter	Stream #411	3.65E+08	kg

Sugar Denitrification
TWRS EIS

The term "sugar denitrification" can be used to refer to two different processing scenarios. The first refers to the use of sugar to destroy nitric acid, HNO_3. The second refers to the use of sugar during calcination to change other anions into carbonates.

Nitric Acid Destruction.
For the destruction of nitric acid, the reaction considered most likely to take place is as follows:

$$C_{12}H_{22}O_{11} + 24HNO_3 = 12CO_2 + 12NO + 12NO_2 + 23H_2O$$

Other substances such as formaldehyde have been used at Hanford to destroy nitric acid. From the dates of references it can be inferred that the reaction of nitric acid with formaldehyde was investigated from 1954 to 1963. Then in 1962 several investigators began looking at the concept of using sugar in place of formaldehyde. The laboratory and pilot plant work indicated that sugar could be successfully used to destroy the excess nitric acid in the Purex waste streams. The investigators did not indicate the point in the overall Purex process where the sugar was to be added. The reports do not indicate that sugar was ever used in place of formaldehyde, but stated that results indicated that such a substitution could be successful.

Although chemical reactions can be written for it, it is unlikely that sugar denitrification could be used to destroy the sodium nitrate which presently exists in the tank wastes as a result of neutralizing the excess nitric acid with sodium hydroxide. In neutral or basic solutions such as the Hanford tank wastes the nitrate anion is a very weak oxidizing agent. Any potential denitrification of the existing tank wastes will be hindered by the fact that one of the reaction products from adding sugar to tank wastes is sodium hydroxide, which is present in large excesses to help prevent corrosion of the steel tanks. For this reason the TPA and No Separations alternatives do not include the addition of sugar in their flowsheets and process descriptions. Where sugar denitrification can be probably used in an ex-situ alternative is that part of the Extensive Separations alternative that processes acidic solutions. In the preliminary flowsheets for Extensive Separations, sugar denitrification is used to destroy nitric acid, prior to further processing.

Sugar Calcination.
The second use of sugar, as a reactant during calcination, does not appear to have been investigated or used on a large scale. Reactions can be written for the reaction of sugar with nitrate, nitrite and hydroxide, converting these anions into carbonates. For nitrate the reaction can be written:

Appendix C
Calc for table 8
page 2 of 5

$$C_{12}H_{22}O_{11} + 24NaNO_3 = 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$$

For nitrite conversion oxygen is required as shown in the following equation:

$$C_{12}H_{22}O_{11} + 24NaNO_2 + 12O_2 = 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$$

Likewise for hydroxyl conversion, oxygen is required as shown by the following equation:

$$C_{12}H_{22}O_{11} + 24NaOH + 12O_2 = 12Na_2CO_3 + 23H_2O$$

From thermodynamic considerations (Gibbs free energies) one would postulate that the above chemical reactions would very likely proceed to completion. The kinetics of these reactions would be aided by high temperatures such as those that occur during calcination processing. While it is difficult to state the exact temperature required for calcination, it would likely be in the 400-600°C range. Sodium bicarbonate melts at 851°C, sodium nitrate at 308°C, sodium nitrite at 271°C and sodium hydroxide at 328°C.

One can make an estimate of the products of calcining the tank wastes with sugar. The starting point for this estimate is the feed stream from retrieval and transfer of the tank contents. Reference to the mass balances given in the TPA (and No Separations) data package shows that over the life of the plant the total mass flow of liquid components is 710,000 metric tons (MT). The total mass flow of solid components is 19,400 MT. Of the liquid components, 507,000 MT are water and 1,420 MT are total organic carbon (TOC). The remaining dissolved solids are 99% sodium compounds and 1% other compounds, including dissolved radionuclides. Table 1 below shows the weights and percentages of the sodium compounds.

Table 1. Sodium Compounds in Feed Stream

Sodium Compound	Weight (MT)	Percent of Compounds
$NaNO_3$	145,350	72.6
$NaNO_2$	14,283	7.1
NaOH	15,160	7.6
Na_2SO_4	2,984	1.5
Na_2CO_3	5,936	3.0
Na_3PO_4	4,428	2.2
$Na_4Al(OH)_4$	9,537	4.8
NaF	2,478	1.2

Appendix C
Calc for Table 8
Page 3 of 5

The first three compounds listed are the ones for which chemical reactions have been written. Reactions were not written for the remaining compounds since they comprise a minor portion of the dissolved sodium compounds.

Based on the reactions that have been written, it is possible to calculate the weight of sugar to be added to form carbonates, and also to calculate the weight of sodium carbonate that would be formed. This assumes the reactions require no excess sugar to go to completion. Table 2, below shows the reactant compounds, the sugar required, and the sodium carbonate that would ideally be produced.

Table 2. Sugar Consumption & Na_2CO_3 Production

Reacting Compound	Sugar Required (MT)	Na_2CO_3 Formed (MT)
$NaNO_3$	24,370	90,630
$NaNO_2$	2,950	10,970
NaOH	5,400	20,090
Totals	32,720	121,690

By adding the weight of sodium carbonate that is produced to the weights of the other solid components in the feed stream (and subtracting those substances that are volatilized), one can calculate the weight of final product from the sugar calcination. Table 3 below shows a comparison of the weight of final product from sugar calcination with the weight of vitrified product shown in the data package for No Separations.

Table 3. Comparison of Final Products.

Calcination		No Pretreatment
Solid Product	Weight (MT)	Vitrified Product (MT)
Na_2CO_3	121,690	
Na_2SO_4	2,980	
Na_2CO_3(present originally)	5,940	
Na_3PO_4	4,430	
$Na_4Al(OH)_4$	9,540	
NaF	2,480	
Solid Components	19,400	
TOC (from solid comp.)	-120	
Total	166,340	357,000

The results of these preliminary calculations indicate that weight of the final product of sugar calcination is roughly 46% of the weight of final glass product from No

Separations. This would indicate that there are potential decreases in the amount of final product from the treatment of the liquid portion of the tank wastes. The solid portion of the tank wastes may also react with sugar during calcination, however this preliminary estimate did not consider any changes in the solids.

There are a number of unresolved issues that remain for sugar calcination. Among these are the following:

1. The final form of the treated wastes from sugar calcination is primarily a mixture of sodium carbonate and calcined solids. The sodium carbonate is certainly water soluble, and the calcined solids may have been rendered more soluble by high temperature reactions. Calcination is commonly used on mineral products to render them more amenable to further hydrometallurgical processing. The protection for the calcined tank wastes is then ultimately the container that they are sealed into. So while the tank wastes have been reduced in volume, the final product is immobilized to the extent that the external container remains secure. There are no NRC requirements in 10CFR60 that require a high level waste form to be a glass. A waste that is in solid form in sealed containers, that is non-combustible and with particulates consolidated to limit availability and particulate generation appears to meet the NRC waste form criteria. A Waste Form Acceptance Systems Requirements Document (WASRD) has been generated for the geologic repository, but a Waste Acceptance Criteria (WAC) is not yet available. The cesium chloride capsules represent a similar situation where a soluble product is sealed in a container. The question of repository acceptance appears to be some time in the future.
2. While the reactions of tank waste components with sugar to form sodium carbonate can be written and quantified, there is no evidence that there will not be practical problems in the calcination process that cannot be overcome. Unresolved safety issues would certainly be among the first to be resolved. The calcination process involves the heating of a fuel (sugar) with an active oxidizing agent (sodium nitrate). Under the proper circumstances the fuel and oxidizer may react with explosive violence. While this possibility would not rule out consideration of sugar calcination as a suboption in the TWRS EIS, it would place it in the category of potential but unproven technology.

One conclusion to be drawn regarding the TWRS EIS is that the exclusion or inclusion of sugar calcination as a waste processing technology should have minimal changes in the expected environmental impacts. The wastes must still be retrieved and transferred; a processing facility must still be constructed and operated; that processing facility will still emit roughly the same quantities of gaseous effluents; disturbed areas for borrow material will remain unchanged; groundwater modeling would be largely unaffected, and wastes must still be transported to the geologic repository.

Previous Calcination Studies

Appendix I of the Technical Options Report provides a preliminary analysis of a process that calcined the tank wastes. This information should be used very cautiously

since this process was not sugar calcination. Instead it was a process which calcined the plant feed directly to sodium hydroxide in fluid bed calciners, treated the gas stream for nitrogen oxides, Tc-99, and added lime to precipitate sulfur oxides in the calciner. Lime was also added later to capture C-14 as the carbonate. Since carbon could not be added in the fuel to the calciner, hydrogen and oxygen were used as the primary fuels. Calcining took place in 60 fluid bed calciners, each of which produced about one ton/day of calcined product. The use of so many small units may have been postulated to solve the problem of scaling the process up to larger calciners. It certainly solved the problem of installed spares. The final product was placed in nodular iron (not stainless steel) casks for disposal. While the filling and sealing of the casks does not depend on the material of construction, acceptance of nodular iron at the geologic repository is very questionable.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING – Calculation to support the Changed value for NOX in Table 9 "Non Radiological Operating Emissions"

ORIGINATOR R. D. WEED DATE 09-29-95

REVISION NO. 0

OBJECTIVE Provide the Revised value for the NOX Emissions for the calcination process versus the vitrification process

METHODOLOGY Use the material balance values and assumed conversion efficiency for NOX conversion to calculate the emissions.

ASSUMPTIONS

1. Basic Reaction Products Assumed to produce only NO and NO_2 (no N_2 produced) in calciner.
2. Assumed 99% Efficiency in conversion of NO and NO_2 (NOX) to N_2 and H_2O to Reduce Amount of NO and NO_2 emitted from the stack.

(Continue on another sheet if necessary)

Ronald D. Weed
SIGNATURE

CALCULATION & RESULTS ATTACHED

Calculation	3 pages
Appendix A	8 pages
Appendix B	2 pages
Appendix C	5 pages

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JACOBS ENGINEERING GROUP INC.

DATE 09-29-95 SUBJECT Calculation to support NOX value in table 9 SHEET NO. 1 of 3

BY RAW CHKD. JOB NO. 01K47101

Assumptions continued

3. The other items were assumed to remain the same as for vitrification process in table 9.

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JACOBS ENGINEERING GROUP INC.

DATE 09-29-95 SUBJECT Calculation to support NOX value in table 9 SHEET NO. 2 of 3

BY RDW CHKD. JOB NO. 01K4710/

Calculate the NOX discharged in the calciner process gas exiting the NOX converter system.

~~NOX~~	Calciner Kg	Stream 410 Kg	Stream 627 Kg	Stream 642 Kg	Stream 643 Kg	Stream 644 Kg
		From vitrification streams				
NO_2	4.41E+07	1.35E+07	1.35E+07	1.35E+07	—	1.40E+05 ~~3.62E+07~~ RDW
NO	2.88E+07	3.20E+05	3.20E+05	3.2E+05	—	3.2E+03
N2	0	2.31E+07	2.31E+07	2.64E+07	—	3.62E+07
NH_3	0	0	0	0	6.84E+06	1.86E+04

assumed 99% conversion in the NOX converter, based on the vitrification balance.

1. NO_2 $\frac{1.35E07 - 1.4E+05}{135E07} = \frac{133.6}{135} = 99\%$

The NOX from the calciner discharged is calculated as follows.

2. $NO_2 = (4.41E07 Kg)(0.01) = 4.41E05 Kg$ ←

3. $NO = (2.88E07 Kg)(0.01) = 2.88E05 Kg$ ←

4. total NOX $= \Sigma NO_2 + NO = 4.41E05 + 2.88E05 = 7.29E02$ Mg

$= 7.29E+02$ Mg ←

5. % increase $= 7.29 \div 1.43 = 510\%$ discharged.

the other items in table 9 were assumed to remain the same as for the vitrification process.

particulate	~~NO~~
VOC	SOX
toxic air pollutants (TAP)	CO

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 09-29-95 SUBJECT Calculation to support NOX value in table 9 SHEET NO. 3 of 3

BY RDW CHKD. JOB NO. 01K4710/

The difference in the quantities of NOX (NO and NO_2) generated between the calcination and the vitrification processes is based on the reactions occurring in the different processes. With calcination all the nitrate and nitrite are assumed by reaction to form the reaction products of NO and NO_2.

From the mass balance tables for the vitrification process it was found that the reaction products assumed were NO, NO_2, and N_2. A substantial amount of N_2 was formed which accounted for the lesser quantities of NO and NOx formed.

Both processes were balanced using the same feed stream so the total nitrogen would be the same for each process.

Consequently the reaction products assumption provides the difference in the total NOX discharged to the environment over the life of the facility.

CALCINATION DATA FOR THE TWRS EIS

The following information is requested for use in assessing the environmental impacts associated with the No Separations Calcination subalternative.

1.0 SCOPE

Calcination is one of two optional waste treatment technologies being evaluated for the No Separations subalternative in the TWRS EIS. No Separations refers to an alternative that would remove as much of the waste from the tanks as practicable (assumed to be 99%) and treat all of the retrieved waste, classified as high-level waste, for disposal at the proposed national high-level waste repository.

The retrieved waste would not separate waste into LLW and HLW streams. The single-shell tank wastes and double-shell tank wastes would be blended as necessary. Blended waste would be classified as HLW and calcined in a single treatment facility. The calcined wastes would be placed into Hanford Site canisters, which would then be placed into overpack shielding casks. The casks would be held on interim site storage pads to await shipment to a permanent HLW repository for final disposal.

The HLW calcination plant is very similar to the HLW vitrification plant described in the No Separations (Vitrification) subalternative data package.

The calcination option described in this data package provides for the following:

- Receive wastes from the waste retrieval and transfer function;
- Calcines the waste stream using sugar as a reducing agent to yield a dry waste steam that is mainly carbonates;
- Treats the off-gas stream from the calciner providing overall DFs for constituents of concern that are approximately the same as those in the vitrification option;
- Collects liquid effluents for batch transfer to the Liquid Effluent Treatment Facility;
- Produces calcined waste in Hanford Site canisters; and
- Onsite interim storage of the entire calcined waste volume pending shipment to the proposed national repository.

2.0 SOURCES OF INFORMATION

Identify information sources used in developing data.

3.0 ASSUMPTIONS USED IN DEVELOPING THE DATA

Assume the same schedule as the vitrification option
Assume the same plant operating efficiency (60%) and capacity factor (60%)
Assume the same input
Similar levels of air pollution control
Assume similar size of a canister for the calcined product as the vitrified waste (1.67 m dia x 4.57 meters high)

4.0 DISCUSSION

4.1 CONSTRUCTION

Description of the facilities that will be constructed including the required support facilities
Facility foot prints
Construction schedule- Assume the same construction schedule as the No Separations vitrification data package
Location of the facilities and siting information will be assumed to be the same as the vitrification option

4.2 OPERATION

Operating schedule assumed to be the same as vitrification:
Characteristics of material to be processed - use vitrification data package material balance stream number 1 as a plant input;
Characteristics of treated waste;
Volume of treated waste;
Size of the required interim storage facility assuming that the same 10 m3 container will be used for the calcined waste;
Process flow diagram and description;
Potential increases or decreases or changes in characteristics of secondary waste streams or incidental waste volumes from the vitrification option;

4.3 POST REMEDIATION

Assume that post remediation activities would be the same as the vitrification option.

5.0 DATA

Note: provide footnotes to tables as a means to explain data.
Provide one set of backup calculations made to develop data presented in tables.

Table 1 Waste Form Volume and Average Radionuclide Inventory

Radionuclide Inventory	Curies in Waste Form
(should be the same as vitrification)	
Total Waste Volume (m3)	

CONSTRUCTION

Table 2 Construction Personnel Requirements (FTEs)

Activity	Total	199_				

Table 3 Construction Resource Requirements

Construction Resource	Quantity
Land (hectares) Surface Committed Temporarily	
Water	
Energy Electricity (Gwh) Diesel Fuel (liters) Gasoline (liters)	
Materials Concrete (m3) Cement (m3) Sand (m3) Aggregate (m3) Steel Carbon Steel (mt) Stainless Steel (mt) Earthen Borrow Material (m3) Sand Aggregate Other (specify)	

Table 4 Nonradiological Construction Emissions

Construction Emission Pollutant	Quantity
Exhaust Particulate PM-10 (kg)	
SOx (as S02) kg	
NOx (as NO2) kg	
Hydrocarbons, kg	
Aldehydes, kg	
CO, kg	
Fugitive Dust, kg	

Note: This data should be scaled from the vitrification option based on projected facility size.

Table 5 Transportation of Earthen Borrow Construction Material

This can be calculated using the volume of borrow identified in the construction resource table and using the same assumptions as the WHC data packages. If the assumption that sand/aggregate would be taken from pit 30 would change then a proposed borrow site needs to be identified along with the location and distance.

Table 6 Transportation of Other Construction Material

This can be done using the construction resources data from table 2 above and the assumptions made in the WHC Engineering data package for No Separations.

OPERATION

Table 7 Operating Personnel Requirements (FTEs)

Operating Personnel	Total	199_	199_	___	___	___	___	___	___
Nonexempt Rad Worker Nonrad Worker									
Exempt + BU Rad Worker Nonrad Worker									
Total									

Operating personnel requirements should include startup, hot operations, and D&D. Staffing levels need to be input into socioeconomic model on an annual staffing level. Personnel requirements would be ideally shown on an annual level but showing total levels with clarification to allow the data to be broken down would be acceptable.

Table 8 Operating Resource Requirements

Resource	Quantity
Land (hectares) committed permanently	
Water (m3) Raw Sanitary	
Energy Electrical (GWh/yr) Other (specify)	
Materials Glass formers Process Chemicals (specify) Steel 7.0 E 4 Concrete 9.8 E 5	

Note: For the alternatives in the WHC engineering data package it was assumed that the waste treatment facilities would be contaminated following treatment and the land area that they occupied would be permanently committed.

Table 9 Nonradiological Operating Emissions

Item	Quantity
Particulate (kg)	
VOC (specify)	
Toxic Air Pollutants (WAC 173-460) specify	
N0x	
S0x	
CO	

Note: These emissions are used as input to the air dispersion model. These emissions quantities are broken down into hourly and daily emission rates and divided by stack gas volumetric flow rate to develop concentrations.

Table 9 Radiological Operating Emissions (Ci)

Radionuclide	Air	Water
Specify		

Table 11 Operating Emissions Release Parameters

Item	Quantity
Stack Height Location Stack gas flow rate (std m3/sec) Stack exit area or exit velocity	
Water emissions Volume Disposition	

Table 12 Decontamination and Decommissioning of Facilities

Item	Contaminated	Non-Contaminated
Steel		
Concrete		
Soil		
Debris		

Table 13 Overall Cost Component (1995 dollars)

Cost Component	Quantity
Capital	
Operating	
Monitoring and Maintenance	
Decontamination and Decommissioning	
Research and Development	
Total	

Note: Cost estimate should be made relative to the vitrification option.

APPENDIX B
Calc for Table 9
page 1 of 2

[redacted]

Summary of mass balance for calciner and comparision to mass balance table in Appendix A of Westinghouse data package for Ex Situ Vitrification No-Separations

Feed to Calciner Compared to Feed to Glass Melter

Phase	Species	Calciner kg		Glass Melter Stream # 406 kg	
Liquid	Total Mass	4.91E+08		4.26E+08	
	Water	2.55E+08	a	2.23E+08	
	NaNO3	1.45E+08		1.45E+08	
	NaNO2	1.43E+07		1.43E+07	
	NaOH	1.52E+07		1.52E+07	
	TOC	1.42E+06		1.42E+06	
	C12H22O11	3.28E+07	b	0.00E+00	
	Other Dissolved Solids	2.69E+07		2.71E+07	
Solid	Total Mass	1.94E+07		3.07E+07	c
	TOC	1.16E+05		1.16E+05	
	Other Solids	1.93E+07		3.06E+07	

a. Assumes 50% weight total solids to calciner
b. Sugar (C12H22O11) added to mix tank prior to calciner
c. Mass includes recycle of glass fines to melter

Steam to Feed Atomizer

Calciner	50 psig saturated steam	2.55E+08	kg
Glass Melter	no direct steam feed	0.00E+00	kg

Oxygen Gas

Calciner	oxygen feed to calciner	1.04E+07	kg	a
Glass Melter	Stream # 409	1.85E+08	kg	b

a. Oxygen for calciner reactions only. Does not include oxygen required for kerosene fuel combustion which occurs outside of calciner reactor and does not enter calciner mass balance.
b. Includes oxygen required for kerosene fuel combustion.

Kerosene Liquid

Calciner	no direct feed	0.00E+00	kg	a
Glass Melter	Stream # 408	5.21E+07	kg	

a. Kerosene combustion occurs outside of calciner reactor and does not enter calciner mass balance

Appendix B
Calc for table 9
page 2 of 2

[redacted]

Glass Formers

Calciner	Not Required	0.00E+00	kg
Glass Melter	Stream #407	2.50E+08	kg

Off-Gas for Calciner Compared to Off-Gas for Glass Melter

Note: Only species in table considered. No estimate made for another off-gas components.

Species	Calciner kg	Glass Melter Stream # 410 kg
Water	5.15E+08	~~2.23E+08~~ a
NO2	4.41E+07	1.35E+07
NO	2.88E+07	3.20E+05
CO2	5.72E+06 a ~~b~~	~~2.48E+03~~ 1.72+08
SO2	1.36E+06 b ~~c~~	1.36E+06

3.50E+08 Kg.
appendix A
Stream #410

~~a. Not tabulated in Appendix A. Calculated from water content of feed to melter.~~
a ~~b.~~ From oxidation of TOC in feed.
b ~~c.~~ No estimate made of change from glass melter number.

Solids Discharge for Calciner Compared to Solids Discharge for Glass Melter

Calciner	Calcined Salts	1.68E+08	kg
Glass Melter	Stream #411	3.85E+08	kg

Sugar Denitrification
TWRS EIS

The term "sugar denitrification" can be used to refer to two different processing scenarios. The first refers to the use of sugar to destroy nitric acid, HNO_3. The second refers to the use of sugar during calcination to change other anions into carbonates.

Nitric Acid Destruction.

For the destruction of nitric acid, the reaction considered most likely to take place is as follows:

$$C_{12}H_{22}O_{11} + 24HNO_3 = 12CO_2 + 12NO + 12NO_2 + 23H_2O$$

Other substances such as formaldehyde have been used at Hanford to destroy nitric acid. From the dates of references it can be inferred that the reaction of nitric acid with formaldehyde was investigated from 1954 to 1963. Then in 1962 several investigators began looking at the concept of using sugar in place of formaldehyde. The laboratory and pilot plant work indicated that sugar could be successfully used to destroy the excess nitric acid in the Purex waste streams. The investigators did not indicate the point in the overall Purex process where the sugar was to be added. The reports do not indicate that sugar was ever used in place of formaldehyde, but stated that results indicated that such a substitution could be successful.

Although chemical reactions can be written for it, it is unlikely that sugar denitrification could be used to destroy the sodium nitrate which presently exists in the tank wastes as a result of neutralizing the excess nitric acid with sodium hydroxide. In neutral or basic solutions such as the Hanford tank wastes the nitrate anion is a very weak oxidizing agent. Any potential denitrification of the existing tank wastes will be hindered by the fact that one of the reaction products from adding sugar to tank wastes is sodium hydroxide, which is present in large excesses to help prevent corrosion of the steel tanks. For this reason the TPA and No Separations alternatives do not include the addition of sugar in their flowsheets and process descriptions. Where sugar denitrification can be probably used in an ex-situ alternative is that part of the Extensive Separations alternative that processes acidic solutions. In the preliminary flowsheets for Extensive Separations, sugar denitrification is used to destroy nitric acid, prior to further processing.

Sugar Calcination.

The second use of sugar, as a reactant during calcination, does not appear to have been investigated or used on a large scale. Reactions can be written for the reaction of sugar with nitrate, nitrite and hydroxide, converting these anions into carbonates. For nitrate the reaction can be written:

$$C_{12}H_{22}O_{11} + 24NaNO_3 = 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$$

For nitrite conversion oxygen is required as shown in the following equation:

$$C_{12}H_{22}O_{11} + 24NaNO_2 + 12O_2 = 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$$

Likewise for hydroxyl conversion, oxygen is required as shown by the following equation:

$$C_{12}H_{22}O_{11} + 24NaOH + 12O_2 = 12Na_2CO_3 + 23H_2O$$

From thermodynamic considerations (Gibbs free energies) one would postulate that the above chemical reactions would very likely proceed to completion. The kinetics of these reactions would be aided by high temperatures such as those that occur during calcination processing. While it is difficult to state the exact temperature required for calcination, it would likely be in the 400-600°C range. Sodium bicarbonate melts at 851°C, sodium nitrate at 308°C, sodium nitrite at 271°C and sodium hydroxide at 328°C.

One can make an estimate of the products of calcining the tank wastes with sugar. The starting point for this estimate is the feed stream from retrieval and transfer of the tank contents. Reference to the mass balances given in the TPA (and No Separations) data package shows that over the life of the plant the total mass flow of liquid components is 710,000 metric tons (MT). The total mass flow of solid components is 19,400 MT. Of the liquid components, 507,000 MT are water and 1,420 MT are total organic carbon (TOC). The remaining dissolved solids are 99% sodium compounds and 1% other compounds, including dissolved radionuclides. Table 1 below shows the weights and percentages of the sodium compounds.

Table 1. Sodium Compounds in Feed Stream

Sodium Compound	Weight (MT)	Percent of Compounds
$NaNO_3$	145,350	72.6
$NaNO_2$	14,283	7.1
NaOH	15,160	7.6
Na_2SO_4	2,984	1.5
Na_2CO_3	5,936	3.0
Na_3PO_4	4,428	2.2
$Na_4Al(OH)_4$	9,537	4.8
NaF	2,478	1.2

The first three compounds listed are the ones for which chemical reactions have been written. Reactions were not written for the remaining compounds since they comprise a minor portion of the dissolved sodium compounds.

Based on the reactions that have been written, it is possible to calculate the weight of sugar to be added to form carbonates, and also to calculate the weight of sodium carbonate that would be formed. This assumes the reactions require no excess sugar to go to completion. Table 2, below shows the reactant compounds, the sugar required, and the sodium carbonate that would ideally be produced.

Table 2. Sugar Consumption & Na_2CO_3 Production

Reacting Compound	Sugar Required (MT)	Na_2CO_3 Formed (MT)
$NaNO_3$	24,370	90,630
$NaNO_2$	2,950	10,970
NaOH	5,400	20,090
Totals	32,720	121,690

By adding the weight of sodium carbonate that is produced to the weights of the other solid components in the feed stream (and subtracting those substances that are volatilized), one can calculate the weight of final product from the sugar calcination. Table 3 below shows a comparison of the weight of final product from sugar calcination with the weight of vitrified product shown in the data package for No Separations.

Table 3. Comparison of Final Products.

Calcination		No Pretreatment
Solid Product	Weight (MT)	Vitrified Product (MT)
Na_2CO_3	121,690	
Na_2SO_4	2,980	
Na_2CO_3(present originally)	5,940	
Na_3PO_4	4,430	
$Na_4Al(OH)_4$	9,540	
NaF	2,480	
Solid Components	19,400	
TOC (from solid comp.)	-120	
Total	166,340	357,000

The results of these preliminary calculations indicate that weight of the final product of sugar calcination is roughly 46% of the weight of final glass product from No

Separations. This would indicate that there are potential decreases in the amount of final product from the treatment of the liquid portion of the tank wastes. The solid portion of the tank wastes may also react with sugar during calcination, however this preliminary estimate did not consider any changes in the solids.

There are a number of unresolved issues that remain for sugar calcination. Among these are the following:

1. The final form of the treated wastes from sugar calcination is primarily a mixture of sodium carbonate and calcined solids. The sodium carbonate is certainly water soluble, and the calcined solids may have been rendered more soluble by high temperature reactions. Calcination is commonly used on mineral products to render them more amenable to further hydrometallurgical processing. The protection for the calcined tank wastes is then ultimately the container that they are sealed into. So while the tank wastes have been reduced in volume, the final product is immobilized to the extent that the external container remains secure. There are no NRC requirements in 10CFR60 that require a high level waste form to be a glass. A waste that is in solid form in sealed containers, that is non-combustible and with particulates consolidated to limit availability and particulate generation appears to meet the NRC waste form criteria. A Waste Form Acceptance Systems Requirements Document (WASRD) has been generated for the geologic repository, but a Waste Acceptance Criteria (WAC) is not yet available. The cesium chloride capsules represent a similar situation where a soluble product is sealed in a container. The question of repository acceptance appears to be some time in the future.
2. While the reactions of tank waste components with sugar to form sodium carbonate can be written and quantified, there is no evidence that there will not be practical problems in the calcination process that cannot be overcome. Unresolved safety issues would certainly be among the first to be resolved. The calcination process involves the heating of a fuel (sugar) with an active oxidizing agent (sodium nitrate). Under the proper circumstances the fuel and oxidizer may react with explosive violence. While this possibility would not rule out consideration of sugar calcination as a suboption in the TWRS EIS, it would place it in the category of potential but unproven technology.

One conclusion to be drawn regarding the TWRS EIS is that the exclusion or inclusion of sugar calcination as a waste processing technology should have minimal changes in the expected environmental impacts. The wastes must still be retrieved and transferred; a processing facility must still be constructed and operated; that processing facility will still emit roughly the same quantities of gaseous effluents; disturbed areas for borrow material will remain unchanged; groundwater modeling would be largely unaffected, and wastes must still be transported to the geologic repository.

Previous Calcination Studies

Appendix I of the Technical Options Report provides a preliminary analysis of a process that calcined the tank wastes. This information should be used very cautiously

since this process was not sugar calcination. Instead it was a process which calcined the plant feed directly to sodium hydroxide in fluid bed calciners, treated the gas stream for nitrogen oxides, Tc-99, and added lime to precipitate sulfur oxides in the calciner. Lime was also added later to capture C-14 as the carbonate. Since carbon could not be added in the fuel to the calciner, hydrogen and oxygen were used as the primary fuels. Calcining took place in 60 fluid bed calciners, each of which produced about one ton/day of calcined product. The use of so many small units may have been postulated to solve the problem of scaling the process up to larger calciners. It certainly solved the problem of installed spares. The final product was placed in nodular iron (not stainless steel) casks for disposal. While the filling and sealing of the casks does not depend on the material of construction, acceptance of nodular iron at the geologic repository is very questionable.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering — Calculate Stack gas flow Rate estimated for table 11 - "Operating Emissions Release Parameters"

ORIGINATOR R. D. Weed DATE 09-29-95

REVISION NO. 0

OBJECTIVE Calculate the estimated stack gas flow rate for table 11 for the calcination process.

METHODOLOGY Determine from the material balance the quantity of gas to be exhausted from several sources through the stack.

ASSUMPTIONS

1. Assumed the gas stream from the calining process was composed of 12 gaseous products.
2. Assumed gas exhaust from calciner heating unit was exhausted through this same exhaust stack.

(Continue on another sheet if necessary)

Ronald D. Weed
SIGNATURE

CALCULATION & RESULTS ATTACHED

Calculation	5 pages
Appendix A	8 pages
Appendix B	2 pages
Appendix C	5 pages

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 09-29-95 SUBJECT Calculate Estimated Stack Flow Rate for Table II SHEET NO. 1 of 5

BY RDW CHKD. JOB NO. 01K4701

Assumptions continued

3. Assumed that no water vapor in heater exhaust gas was condensed.

4. assumed that the amount of Briquette cooling air was equal to the calcet drying air flow.

5. Assumed no air requirements for pneumatic transfer since calcination process does not use this method of transfer for material.

JACOBS ENGINEERING GROUP INC.

DATE 09-29-95 SUBJECT Calculated Estimated Stack Flow Rate for table 11 SHEET NO. 2 of 5

BY RDW CHKD. JOB NO. 01K4710/

Calculate the operating emissions parameters for table 11. The following parameters were assumed to remain as previously set.

Stack height	same as previously set
Stack location	same as previously set
Stack exit area or exit velocity	same as previously set.

Composition of gas stream from calciner system. Some components were assumed to be the same as that from the vitrification system.

Mol wt	mole fraction	Component	(Kg) quantity	% of total	Same as/or Calculated.
70.9	0.284	Cl_2	3.15 E+05	0.4 %	same
28	0.7	CO	2.12 E+06	2.5 %	same
44	2.95	CO_2	6.72 E+06	6.7 %	Calculated
38	0.532	F_2	1.18 E+06	1.4 %	same
18		H_2O	7.37 E+05		Calculated *
253.8	16.75	I_2	5.66 E+06	6.6 %	same
28	17.44	N_2	5.31 E+07	62.3 %	Calculated
17	0.003	NH_3	1.86 E+04	0.02 %	same
30	0.091	NO	2.26 E+05	0.27 %	Calculated
46	0.239	NO_2	4.41 E+05	0.52 %	Calculated
32	6.08	O_2	1.62 E+07	19.0 %	same
64	0.16	SO_2	2.13 E+05	0.25 %	same.
Σ	45.22		Σ 8.52 E+05 less the H_2O value		

* saturated gas - 17.3 gm/m³ @ 20 °C

Convert Mg to M³

1. $\left(\frac{45}{29}\right)\left(0.808\ \frac{lbs}{ft^3}\right)\left(\frac{1\ Kg}{2.2\ lbs}\right)\left(\frac{1\ Mg}{10^3\ Kg}\right)\left(35.3\ \frac{ft^3}{m^3}\right) = 0.0020\ Mg/m^3$

2. $8.52\ E+07\ Kg = 8.52\ E+04\ Mg$

3. $(8.52\ E+04)\left(\frac{1}{0.0020}\right) = \frac{8.52\ E+04}{2.0\ E-03} = 4.26\ E+07\ m^3$ of gas

FORM 91-005-1 (4/81)

obtain the amount of water vapor in the gas stream at 20°C

1. (4.26E+07 m^3 of gas)(17.3 gmo/m^3 of gas) = 7.37E+08 gmo water.

2. Vapor Volume 7.37E+08 gmo ÷ 18 gmo/mole = 4.09E+07 moles

3. (4.09E+07 moles)(22.4 liters/mole) = 9.24E+05 Kilo liters

= 9.24E+05 m^3

to obtain total gas flow of this stream sum the water vapor and the gas stream flows.

4. 9.24E+05 m^3 + 4.26E+07 m^3 = 4.36E+07 m^3

5. $m^3/min = (4.36E+07\ m^3)\left(\frac{1}{14\,yr}\right)\left(\frac{yr}{365\,day}\right)\left(\frac{day}{24\,hr}\right)\left(\frac{hr}{60\,min}\right) = 5.9\ m^3/min$

Obtain the kerosene exhaust to the stack estimated at 20°C and 1 atmosphere pressure.
For this calculation it was assumed that no water vapor was lost due to condensation.

From the calciner material balance

CO_2 = 3.5E+08 Kg.

H_2O = 1.5E+08 Kg.

1. $Mg/m^3 = (0.1\ lb/ft^3)\left(\frac{Kg}{2.2\,lb}\right)\left(\frac{Mg}{1000\,Kg}\right)\left(\frac{35.3\,ft^3}{m^3}\right) = 0.0016\ Mg/m^3$

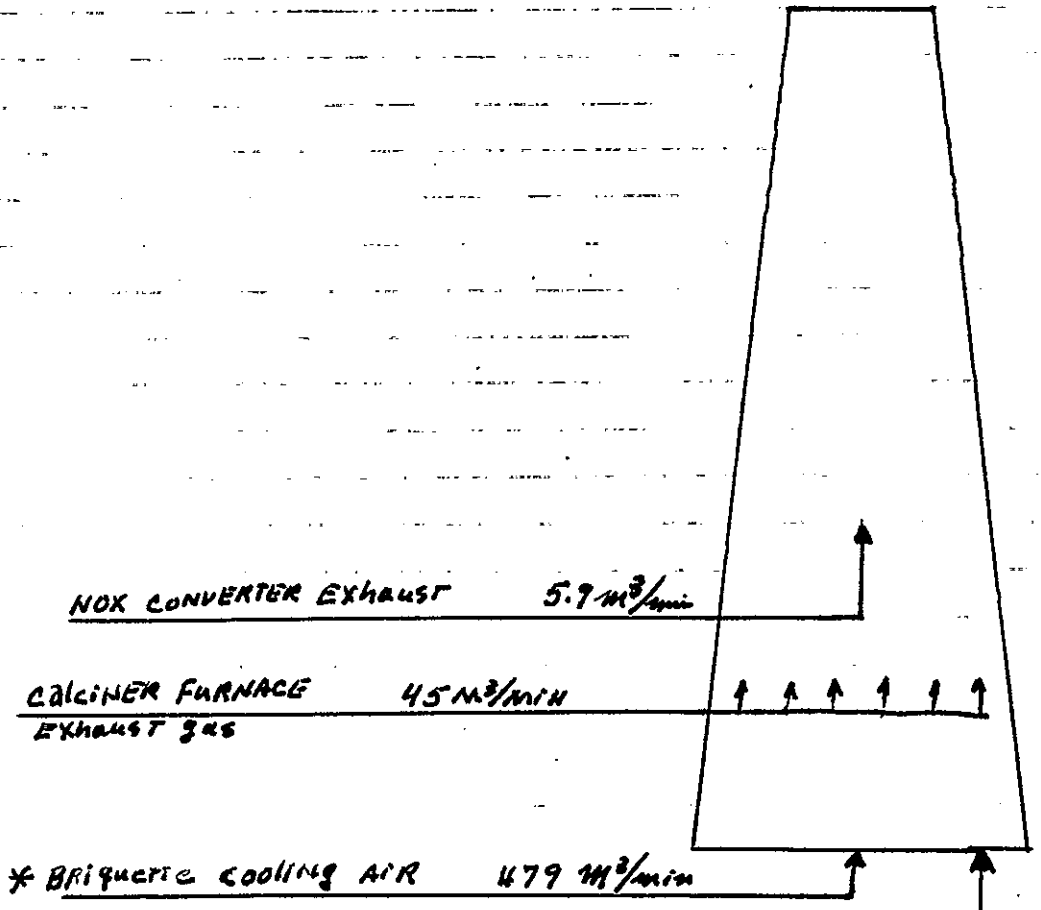
2. (3.5E+08 + 1.5E+08) ÷ (1.6E-03) = 3.125E+08 m^3

3. $m^3/min = (3.125E+08)\left(\frac{1}{14}\right)\left(\frac{1}{365}\right)\left(\frac{1}{24}\right)\left(\frac{1}{60}\right) = 45\ m^3/min$

JACOBS ENGINEERING GROUP INC.

DATE 09-29-95 SUBJECT Calculated Estimated Stack Flow Rate for table 11 SHEET NO. 4 of 6

BY ROW CHKD. JOB NO. 01K47101



* Assumed Equal to the cullet drying air flow

** Vitrification material pneumatic transfer air flow

** this is not used in the calcination process system

FORM 81-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 09-29-95 SUBJECT calculated Estimated stack Flow Rate for table 11 SHEET NO. 5 of 5

BY RDW CHKD. JOB NO. 01K4710/

From the vitrification mass balance, the drying air was given as 16,904 SCFM

$\therefore$ 16,904 ÷ 35.3 = 478.9 = 479 m^3/min @ 20°C and 1 atmosphere pressure.

Briquette cooling air = 479 m^3/min ←

CALCINATION DATA FOR THE TWRS EIS

The following information is requested for use in assessing the environmental impacts associated with the No Separations Calcination subalternative.

1.0 SCOPE

Calcination is one of two optional waste treatment technologies being evaluated for the No Separations subalternative in the TWRS EIS. No Separations refers to an alternative that would remove as much of the waste from the tanks as practicable (assumed to be 99%) and treat all of the retrieved waste, classified as high-level waste, for disposal at the proposed national high-level waste repository.

The retrieved waste would not separate waste into LLW and HLW streams. The single-shell tank wastes and double-shell tank wastes would be blended as necessary. Blended waste would be classified as HLW and calcined in a single treatment facility. The calcined wastes would be placed into Hanford Site canisters, which would then be placed into overpack shielding casks. The casks would be held on interim site storage pads to await shipment to a permanent HLW repository for final disposal.

The HLW calcination plant is very similar to the HLW vitrification plant described in the No Separations (Vitrification) subalternative data package.

The calcination option described in this data package provides for the following:

- Receive wastes from the waste retrieval and transfer function;
- Calcines the waste stream using sugar as a reducing agent to yield a dry waste steam that is mainly carbonates;
- Treats the off-gas stream from the calciner providing overall DFs for constituents of concern that are approximately the same as those in the vitrification option;
- Collects liquid effluents for batch transfer to the Liquid Effluent Treatment Facility;
- Produces calcined waste in Hanford Site canisters; and
- Onsite interim storage of the entire calcined waste volume pending shipment to the proposed national repository.

2.0 SOURCES OF INFORMATION

Identify information sources used in developing data.

3.0 ASSUMPTIONS USED IN DEVELOPING THE DATA

Assume the same schedule as the vitrification option
Assume the same plant operating efficiency (60%) and capacity factor (60%)
Assume the same input
Similar levels of air pollution control
Assume similar size of a canister for the calcined product as the vitrified waste (1.67 m dia x 4.57 meters high)

4.0 DISCUSSION

4.1 CONSTRUCTION

Description of the facilities that will be constructed including the required support facilities
Facility foot prints
Construction schedule- Assume the same construction schedule as the No Separations vitrification data package
Location of the facilities and siting information will be assumed to be the same as the vitrification option

4.2 OPERATION

Operating schedule assumed to be the same as vitrification:
Characteristics of material to be processed - use vitrification data package material balance stream number 1 as a plant input:
Characteristics of treated waste:
Volume of treated waste;
Size of the required interim storage facility assuming that the same 10 m3 container will be used for the calcined waste;
Process flow diagram and description;
Potential increases or decreases or changes in characteristics of secondary waste streams or incidental waste volumes from the vitrification option;

4.3 POST REMEDIATION

Assume that post remediation activities would be the same as the vitrification option.

5.0 DATA

Note: provide footnotes to tables as a means to explain data.
Provide one set of backup calculations made to develop data presented in tables.

Table 1 Waste Form Volume and Average Radionuclide Inventory

Radionuclide Inventory	Curies in Waste Form
(should be the same as vitrification)	
Total Waste Volume (m3)	

CONSTRUCTION

Table 2 Construction Personnel Requirements (FTEs)

Activity	Total	199_				

Table 3 Construction Resource Requirements

Construction Resource	Quantity
Land (hectares) Surface Committed Temporarily	
Water	
Energy Electricity (Gwh) Diesel Fuel (liters) Gasoline (liters)	
Materials Concrete (m3) Cement (m3) Sand (m3) Aggregate (m3) Steel Carbon Steel (mt) Stainless Steel (mt) Earthen Borrow Material (m3) Sand Aggregate Other (specify)	

Table 4 Nonradiological Construction Emissions

Construction Emission Pollutant	Quantity
Exhaust Particulate PM-10 (kg)	
SOx (as S02) kg	
NOx (as NO2) kg	
Hydrocarbons, kg	
Aldehydes, kg	
CO, kg	
Fugitive Dust, kg	

Note: This data should be scaled from the vitrification option based on projected facility size.

Table 5 Transportation of Earthen Borrow Construction Material

This can be calculated using the volume of borrow identified in the construction resource table and using the same assumptions as the WHC data packages. If the assumption that sand/aggregate would be taken from pit 30 would change then a proposed borrow site needs to be identified along with the location and distance.

Table 6 Transportation of Other Construction Material

This can be done using the construction resources data from table 2 above and the assumptions made in the WHC Engineering data package for No Separations.

OPERATION

Table 7 Operating Personnel Requirements (FTEs)

Operating Personnel	Total	199_	199_	___	___	___	___	___	___
Nonexempt Rad Worker Nonrad Worker									
Exempt + BU Rad Worker Nonrad Worker									
Total									

Operating personnel requirements should include startup, hot operations, and D&D. Staffing levels need to be input into socioeconomic model on an annual staffing level. Personnel requirements would be ideally shown on an annual level but showing total levels with clarification to allow the data to be broken down would be acceptable.

Table 8 Operating Resource Requirements

Resource	Quantity
Land (hectares) committed permanently	
Water (m3) Raw Sanitary	
Energy Electrical (GWh/yr) Other (specify)	
Materials Glass formers Process Chemicals (specify) Steel 7.0E4 Concrete 9.8E5	

Note: For the alternatives in the WHC engineering data package it was assumed that the waste treatment facilities would be contaminated following treatment and the land area that they occupied would be permanently committed.

Table 9 Nonradiological Operating Emissions

Item	Quantity
Particulate (kg)	
VOC (specify)	
Toxic Air Pollutants (WAC 173-460) specify	
N0x	
S0x	
CO	

Note: These emissions are used as input to the air dispersion model. These emissions quantities are broken down into hourly and daily emission rates and divided by stack gas volumetric flow rate to develop concentrations.

APPENDIX A
Calc for table 11
page 7 of 8

Table 9 Radiological Operating Emissions (Ci)

Radionuclide	Air	Water
Specify		

Table 11 Operating Emissions Release Parameters

Item	Quantity
Stack Height Location Stack gas flow rate (std m3/sec) Stack exit area or exit velocity	
Water emissions Volume Disposition	

Table 12 Decontamination and Decommissioning of Facilities

Item	Contaminated	Non-Contaminated
Steel		
Concrete		
Soil		
Debris		

APPENDIX A
Calc for table 11
page 8 of 8

Table 13 Overall Cost Component (1995 dollars)

Cost Component	Quantity
Capital	
Operating	
Monitoring and Maintenance	
Decontamination and Decommissioning	
Research and Development	
Total	

Note: Cost estimate should be made relative to the vitrification option.

APPENDIX B
Calc for table 11
page 1 of 2

[redacted]

Summary of mass balance for calciner and comparision to mass balance table in Appendix A of Westinghouse data package for Ex Situ Vitrification No-Separations

Feed to Calciner Compared to Feed to Glass Melter

Phase	Species	Calciner kg		Glass Melter Stream # 406 kg	
Liquid	Total Mass	4.91E+08		4.26E+08	
	Water	2.55E+08	a	2.23E+08	
	NaNO3	1.45E+08		1.45E+08	
	NaNO2	1.43E+07		1.43E+07	
	NaOH	1.52E+07		1.52E+07	
	TOC	1.42E+06		1.42E+06	
	C12H22O11	3.28E+07	b	0.00E+00	
	Other Dissolved Solids	2.69E+07		2.71E+07	
Solid	Total Mass	1.94E+07		3.07E+07	c
	TOC	1.16E+05		1.16E+05	
	Other Solids	1.93E+07		3.06E+07	

a. Assumes 50% weight total solids to calciner
b. Sugar (C12H22O11) added to mix tank prior to calciner
c. Mass includes recycle of glass fines to melter

Steam to Feed Atomizer

Calciner	50 psig saturated steam	2.55E+08	kg
Glass Melter	no direct steam feed	0.00E+00	kg

Oxygen Gas

Calciner	oxygen feed to calciner	1.04E+07	kg	a
Glass Melter	Stream # 409	1.85E+08	kg	b

a. Oxygen for calciner reactions only. Does not include oxygen required for kerosene fuel combustion which occurs outside of calciner reactor and does not enter calciner mass balance.
b. Includes oxygen required for kerosene fuel combustion.

Kerosene Liquid

Calciner	no direct feed	0.00E+00	kg	a
Glass Melter	Stream # 408	5.21E+07	kg	

a. Kerosene combustion occurs outside of calciner reactor and does not enter calciner mass balance

Appendix B
calc for table 11
page 2 of 2

[redacted]

Glass Formers

Calciner	Not Required	0.00E+00	kg
Glass Melter	Stream #407	2.50E+08	kg

Off-Gas for Calciner Compared to Off-Gas for Glass Melter

Note: Only species in table considered. No estimate made for another off-gas components.

Species	Calciner kg	Glass Melter Stream # 410 kg
Water	5.15E+08	~~2.23E+08~~ a 3.50E+08 kg.
NO2	4.41E+07	1.35E+07
NO	2.88E+07	3.20E+05
CO2	5.72E+06 a ~~b~~	~~2.48E+03~~ 1.72+08
SO2	1.36E+06 b ~~c~~	1.36E+06

appendix A
Stream #410

~~a. Not tabulated in Appendix A. Calculated from water content of feed to melter.~~
a ~~b.~~ From oxidation of TOC in feed.
b ~~c.~~ No estimate made of change from glass melter number.

Solids Discharge for Calciner Compared to Solids Discharge for Glass Melter

Calciner	Calcined Salts	1.68E+08	kg
Glass Melter	Stream #411	3.65E+08	kg

Sugar Denitrification
TWRS EIS

The term "sugar denitrification" can be used to refer to two different processing scenarios. The first refers to the use of sugar to destroy nitric acid, HNO_3. The second refers to the use of sugar during calcination to change other anions into carbonates.

Nitric Acid Destruction.

For the destruction of nitric acid, the reaction considered most likely to take place is as follows:

$$C_{12}H_{22}O_{11} + 24HNO_3 = 12CO_2 + 12NO + 12NO_2 + 23H_2O$$

Other substances such as formaldehyde have been used at Hanford to destroy nitric acid. From the dates of references it can be inferred that the reaction of nitric acid with formaldehyde was investigated from 1954 to 1963. Then in 1962 several investigators began looking at the concept of using sugar in place of formaldehyde. The laboratory and pilot plant work indicated that sugar could be successfully used to destroy the excess nitric acid in the Purex waste streams. The investigators did not indicate the point in the overall Purex process where the sugar was to be added. The reports do not indicate that sugar was ever used in place of formaldehyde, but stated that results indicated that such a substitution could be successful.

Although chemical reactions can be written for it, it is unlikely that sugar denitrification could be used to destroy the sodium nitrate which presently exists in the tank wastes as a result of neutralizing the excess nitric acid with sodium hydroxide. In neutral or basic solutions such as the Hanford tank wastes the nitrate anion is a very weak oxidizing agent. Any potential denitrification of the existing tank wastes will be hindered by the fact that one of the reaction products from adding sugar to tank wastes is sodium hydroxide, which is present in large excesses to help prevent corrosion of the steel tanks. For this reason the TPA and No Separations alternatives do not include the addition of sugar in their flowsheets and process descriptions. Where sugar denitrification can be probably used in an ex-situ alternative is that part of the Extensive Separations alternative that processes acidic solutions. In the preliminary flowsheets for Extensive Separations, sugar denitrification is used to destroy nitric acid, prior to further processing.

Sugar Calcination.

The second use of sugar, as a reactant during calcination, does not appear to have been investigated or used on a large scale. Reactions can be written for the reaction of sugar with nitrate, nitrite and hydroxide, converting these anions into carbonates. For nitrate the reaction can be written:

APPENDIX C
calc for TABLE 11
page 2 of 5

$$C_{12}H_{22}O_{11} + 24NaNO_3 = 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$$

For nitrite conversion oxygen is required as shown in the following equation:

$$C_{12}H_{22}O_{11} + 24NaNO_2 + 12O_2 = 12Na_2CO_3 + 12NO + 12NO_2 + 11H_2O$$

Likewise for hydroxyl conversion, oxygen is required as shown by the following equation:

$$C_{12}H_{22}O_{11} + 24NaOH + 12O_2 = 12Na_2CO_3 + 23H_2O$$

From thermodynamic considerations (Gibbs free energies) one would postulate that the above chemical reactions would very likely proceed to completion. The kinetics of these reactions would be aided by high temperatures such as those that occur during calcination processing. While it is difficult to state the exact temperature required for calcination, it would likely be in the 400-600°C range. Sodium bicarbonate melts at 851°C, sodium nitrate at 308°C, sodium nitrite at 271°C and sodium hydroxide at 328°C.

One can make an estimate of the products of calcining the tank wastes with sugar. The starting point for this estimate is the feed stream from retrieval and transfer of the tank contents. Reference to the mass balances given in the TPA (and No Separations) data package shows that over the life of the plant the total mass flow of liquid components is 710,000 metric tons (MT). The total mass flow of solid components is 19,400 MT. Of the liquid components, 507,000 MT are water and 1,420 MT are total organic carbon (TOC). The remaining dissolved solids are 99% sodium compounds and 1% other compounds, including dissolved radionuclides. Table 1 below shows the weights and percentages of the sodium compounds.

Table 1. Sodium Compounds in Feed Stream

Sodium Compound	Weight (MT)	Percent of Compounds
$NaNO_3$	145,350	72.6
$NaNO_2$	14,283	7.1
NaOH	15,160	7.6
Na_2SO_4	2,984	1.5
Na_2CO_3	5,936	3.0
Na_3PO_4	4,428	2.2
$Na_4Al(OH)_4$	9,537	4.8
NaF	2,478	1.2

The first three compounds listed are the ones for which chemical reactions have been written. Reactions were not written for the remaining compounds since they comprise a minor portion of the dissolved sodium compounds.

Based on the reactions that have been written, it is possible to calculate the weight of sugar to be added to form carbonates, and also to calculate the weight of sodium carbonate that would be formed. This assumes the reactions require no excess sugar to go to completion. Table 2, below shows the reactant compounds, the sugar required, and the sodium carbonate that would ideally be produced.

Table 2. Sugar Consumption & Na_2CO_3 Production

Reacting Compound	Sugar Required (MT)	Na_2CO_3 Formed (MT)
$NaNO_3$	24,370	90,630
$NaNO_2$	2,950	10,970
NaOH	5,400	20,090
Totals	32,720	121,690

By adding the weight of sodium carbonate that is produced to the weights of the other solid components in the feed stream (and subtracting those substances that are volatilized), one can calculate the weight of final product from the sugar calcination. Table 3 below shows a comparison of the weight of final product from sugar calcination with the weight of vitrified product shown in the data package for No Separations.

Table 3. Comparison of Final Products.

Calcination		No Pretreatment
Solid Product	Weight (MT)	Vitrified Product (MT)
Na_2CO_3	121,690	
Na_2SO_4	2,980	
Na_2CO_3(present originally)	5,940	
Na_3PO_4	4,430	
$Na_4Al(OH)_4$	9,540	
NaF	2,480	
Solid Components	19,400	
TOC (from solid comp.)	-120	
Total	166,340	357,000

The results of these preliminary calculations indicate that weight of the final product of sugar calcination is roughly 46% of the weight of final glass product from No

Separations. This would indicate that there are potential decreases in the amount of final product from the treatment of the liquid portion of the tank wastes. The solid portion of the tank wastes may also react with sugar during calcination, however this preliminary estimate did not consider any changes in the solids.

There are a number of unresolved issues that remain for sugar calcination. Among these are the following:

1. The final form of the treated wastes from sugar calcination is primarily a mixture of sodium carbonate and calcined solids. The sodium carbonate is certainly water soluble, and the calcined solids may have been rendered more soluble by high temperature reactions. Calcination is commonly used on mineral products to render them more amenable to further hydrometallurgical processing. The protection for the calcined tank wastes is then ultimately the container that they are sealed into. So while the tank wastes have been reduced in volume, the final product is immobilized to the extent that the external container remains secure. There are no NRC requirements in 10CFR60 that require a high level waste form to be a glass. A waste that is in solid form in sealed containers, that is non-combustible and with particulates consolidated to limit availability and particulate generation appears to meet the NRC waste form criteria. A Waste Form Acceptance Systems Requirements Document (WASRD) has been generated for the geologic repository, but a Waste Acceptance Criteria (WAC) is not yet available. The cesium chloride capsules represent a similar situation where a soluble product is sealed in a container. The question of repository acceptance appears to be some time in the future.
2. While the reactions of tank waste components with sugar to form sodium carbonate can be written and quantified, there is no evidence that there will not be practical problems in the calcination process that cannot be overcome. Unresolved safety issues would certainly be among the first to be resolved. The calcination process involves the heating of a fuel (sugar) with an active oxidizing agent (sodium nitrate). Under the proper circumstances the fuel and oxidizer may react with explosive violence. While this possibility would not rule out consideration of sugar calcination as a suboption in the TWRS EIS, it would place it in the category of potential but unproven technology.

One conclusion to be drawn regarding the TWRS EIS is that the exclusion or inclusion of sugar calcination as a waste processing technology should have minimal changes in the expected environmental impacts. The wastes must still be retrieved and transferred; a processing facility must still be constructed and operated; that processing facility will still emit roughly the same quantities of gaseous effluents; disturbed areas for borrow material will remain unchanged; groundwater modeling would be largely unaffected, and wastes must still be transported to the geologic repository.

Previous Calcination Studies

Appendix I of the Technical Options Report provides a preliminary analysis of a process that calcined the tank wastes. This information should be used very cautiously

since this process was not sugar calcination. Instead it was a process which calcined the plant feed directly to sodium hydroxide in fluid bed calciners, treated the gas stream for nitrogen oxides, Tc-99, and added lime to precipitate sulfur oxides in the calciner. Lime was also added later to capture C-14 as the carbonate. Since carbon could not be added in the fuel to the calciner, hydrogen and oxygen were used as the primary fuels. Calcining took place in 60 fluid bed calciners, each of which produced about one ton/day of calcined product. The use of so many small units may have been postulated to solve the problem of scaling the process up to larger calciners. It certainly solved the problem of installed spares. The final product was placed in nodular iron (not stainless steel) casks for disposal. While the filling and sealing of the casks does not depend on the material of construction, acceptance of nodular iron at the geologic repository is very questionable.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING – CALCINATION DATA FOR THE TWRS-EIS

ORIGINATOR DAVID STEIN DATE 9/29/95

REVISION NO. 0

OBJECTIVE PROVIDE COMPACTOR SYSTEM FLOWSHEET AND CALCULATIONS FOR CALCINATION OPTION

METHODOLOGY

ASSUMPTIONS CALCINER FLOW RATES FROM MATERIAL BALANCE AND PRODUCT CHARACTERISTICS FROM NOV 14, 1960 PAPER ON SPRAY-CALCINATION BY ALLEMANN & JOHNSON

(Continue on another sheet if necessary)

SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 9/29/95 SUBJECT HANFORD TWRS EIS SHEET NO. 1-5

BY DLS CHKD. JOB NO.

Design Basis

From material balance for the Calciner, the calciner product is 1.68E+05 MT compared to 3.65E+05 MT for Vitrification product or 46% as follows:

$$\frac{1.68E+05}{3.65E+05} \times 100\% = 46\%$$

Since both the calciner and vitrification processes will feed the same quantity of tank farm wastes and the vitrification process is designed for 200 MT/DAY product. The calcination process should be designed for:

$$200 \frac{MT}{day} \times .46 = 92 \frac{MT}{day} \text{ calcined product}$$

From "Radiant-Heat Spray-Calcination Process for the Solid Fixation of Radioactive Waste, Part I: Non-Radioactive Pilot Unit" by Allemann + Johnson, Jr., Chemical Research Hanford Lab Operation Nov. 14, 1990

upon which the calcination option is based, product from calciner is assumed to be @ 700°C and 95% less than 325 mesh loose powder at approximately 1.0 g/cc bulk density

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

Hanford EIS

DATE 9/29/95 SUBJECT SHEET NO. 2-5

BY DLS CHKD. JOB NO.

Theoretical sp.gr. of calcined product

Calciation final product composition

Soluble salts in product	Na_2CO_3	87% by wt	approx 2.57 g/cc and approx 89% by wt of calciner product
	Na_2SO_4	2%	
	Na_3PO_4	3%	
	$NaAlO_2$	6%	
	NaF	2%	
		100%	

insoluble salts in product ⟹ approx 4.5 g/cc mostly oxides, phosphates, etc of aluminum, uranium, etc and approx 11% by wt of calciner product

Above from D. Murray data pkg. on Sugar Calcination

Therefore estimated Theo. sp.gr. of product is:

$$(0.89 \times 2.57) + (0.11 \times 4.5) = 2.78 \text{ g/cc}$$

theo. density of calcined product.

Based on conversations with Richard Komarek of Komarek Inc, Elk Grove, Ill, (708) 956-0060 on 9/26/95 a calcined product as described herein (95% minus 325 mesh powder at 700°C and theo. density of 2.78 g/cc and composed mainly of Na_2CO_3) could be briquetted hot in a compactor to briquets of approx. 90% of theo density or 2.50 g/cc briquet density

FORM 91-005-1 (4/81)

These briquets could be made in various shapes and sizes with probable preferred of thumb sized briquets. For purposes of this study, we are assuming briquets of) about the same size as glass cullet for vitrification (or 1/4") so that simple comparisons to vitrification analysis can be made.

Canister calculation

Vitrification p 6-12

Hanford 10 m^3 canister + cask

- actual volume is 9.32 m^3/canister
- glass cullet density is 2.63 Mg/m^3 (g/cm^3)
- 0.7 non-void space

$$9.32\,m^3 \times 2.63\,g/cm^3 \times 10^6 \frac{cm^3}{m^3} \times \frac{1\,Kg}{10^3\,gm} \times 0.7 = 17{,}158\ Kg$$

or 17.16 MT/canister

$$\frac{3.65 \times 10^5\ MT\ glass}{17.16\ MT/canister} = 21{,}400\ \text{canisters}$$

Calcination

- 9.32 m^3 canister volume
- briquet density is 2.50 Mg/m^3 (g/cm^3)
- 0.7 non-void space

$$9.32\,m^3 \times 2.50\,g/cm^3 \times 10^6 \frac{cm^3}{m^3} \times 1 \frac{Kg}{10^3\,gm} \times 0.7 = 16{,}310\ Kg$$

or 16.31 MT/canister

$$\frac{3.65 \times 10^5\ MT/glass \times .46\ \text{as calcined product}}{16.31\ MT/canister} = 10{,}300 \text{ canisters of calcined product}$$

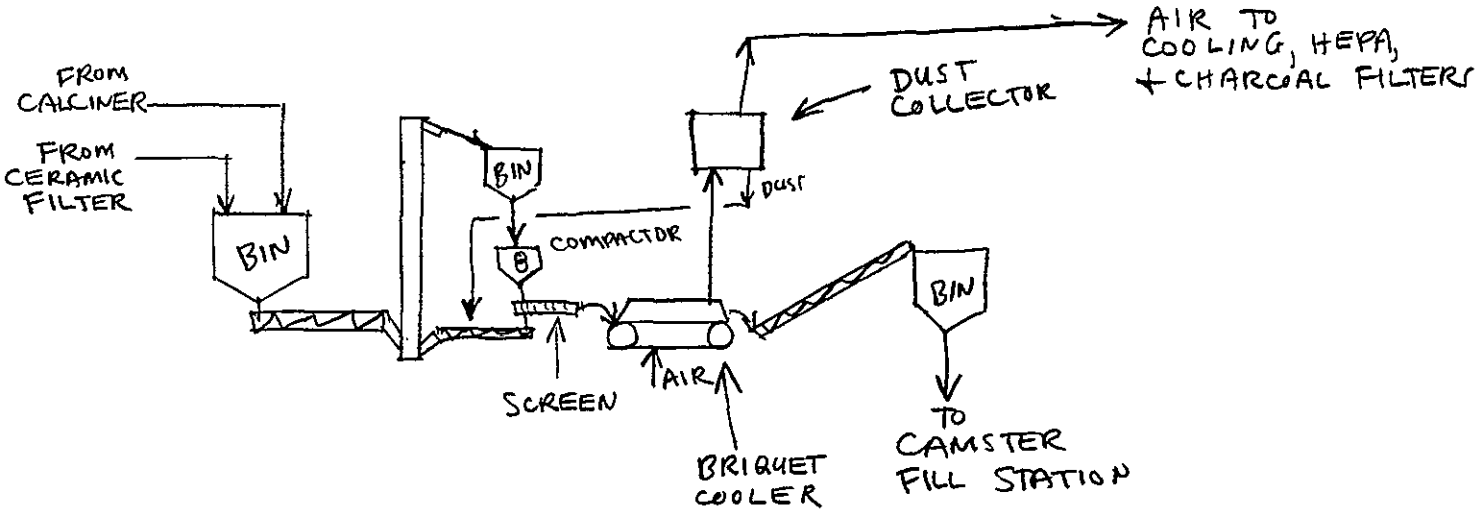
$$\frac{10{,}300\ \text{calcined canisters}}{21{,}400\ \text{vitrified canisters}} \times 100\% = 48\%\ \text{of vitrification}$$

Flowsheet for Compaction

The flowsheet for compaction will consist of the calciner product bin which will collect product from the calciner and dust from the calciner ceramic filter. From the calciner product bin, the hot powder will be conveyed up to a compactor feed bin where it will flow to the compactor with force feeder. The briquets will flow from the compactor to a screen where under sized will be removed and conveyed back to the compactor feed bin for re-compaction. The briquets will be fed to an air cooled briquet cooler and then conveyed to the product day bin for canister filling. Dust collection will be required for all solids transfer operations and for briquet cooling air. Materials of construction

for the briquetting and transfer operations will have to be designed for the hot temperatures (700°C) anticipated. Final briquets to day bin for feed to Canister to be approximately 40°C.

Conceptual Flowsheet



Machine Size

$$92\ \text{MT/DAY} \times \frac{1}{2\ \text{machines}} = 46\ \text{MT/DAY PER MACHINE}$$
$$= 1.9\ \text{MT/HR PER MACHINE}$$

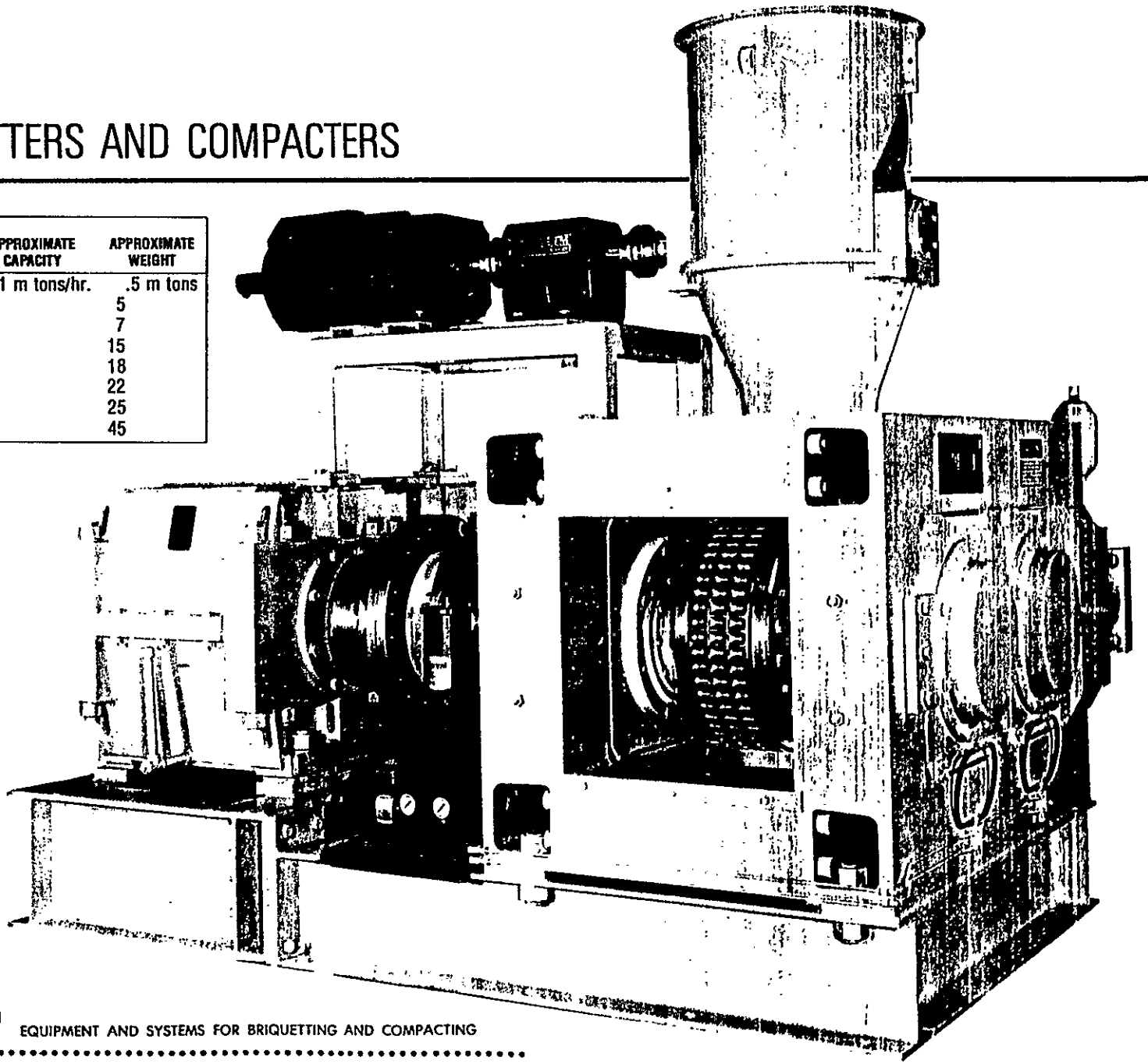
THE KOMAREK, INC MODEL NO. DH 300 WITH CAPACITY OF 3 TONS/HR (2.7 MT/HR) WHICH IS DESIGNED FOR HOT MATERIAL BRIQUETTING APPEARS TO BE SIZE REQUIRED, IT HAS A ROLL DIAM OF 330 mm, a roll separating FORCE OF 75 TONS, AND WEIGHS APPROX. 5 TONS. VENDOR SHEET ATTACHED.

MODEL DH BRIQUETTERS AND COMPACTERS

MODEL NO.	ROLL DIAMETER	ROLL SEPARATING FORCE	APPROXIMATE CAPACITY	APPROXIMATE WEIGHT
DH100	130 mm	20 m tons	.1 m tons/hr.	.5 m tons
DH300	330	75	3	5
DH300-15	380	75	4	7
DH400	520	150	9	15
DH400-28	710	150	20	18
DH400-36	920	150	40	22
DH500	710	300	20	25
DH550	920	300	40	45

MODEL DH BRIQUETTERS AND COMPACTERS

The DH machines are single purpose production machines. The rolls are supported between two bearings, so these machines are capable of greater roll separating forces. They are also specified when the roll width is greater than 1/3 of its diameter. The DH machines are used for briquetting hot materials as the rolls can be located further away from the bearings.



MODEL DH 500

K. R. KOMAREK INC.

EQUIPMENT AND SYSTEMS FOR BRIQUETTING AND COMPACTING

1825 ESTES AVENUE, ELK GROVE VILLAGE, ILLINOIS 60007

TEL. 312-956-0060

TELEX 28-0588

KOMPAK ELGR

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING - CALCINATION DATA FOR THE TWRS EIS

ORIGINATOR DAVID STEIN DATE 9/28/95

REVISION NO. 0

OBJECTIVE PROVIDE CALCINATION DATA TO COMPLETE TABLES FOR TWRS - EIS

METHODOLOGY COMPARE TO VITRIFICATION OPTION WHERE POSSIBLE AND MATERIAL BALANCE INFO FOR CALCINATION

ASSUMPTIONS SAME QUANTITY AND RATE OF BLENDED WASTE FROM TANK FARMS AS VITRIFICATION OPTION

(Continue on another sheet if necessary)

D L Stein
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

CALCINATION DATA FOR THE TWRS EIS

The following information is requested for use in assessing the environmental impacts associated with the No Separations Calcination subalternative.

1.0 SCOPE

Calcination is one of two optional waste treatment technologies being evaluated for the No Separations subalternative in the TWRS EIS. No Separations refers to an alternative that would remove as much of the waste from the tanks as practicable (assumed to be 99%) and treat all of the retrieved waste, classified as high-level waste, for disposal at the proposed national high-level waste repository.

The retrieved waste would not separate waste into LLW and HLW streams. The single-shell tank wastes and double-shell tank wastes would be blended as necessary. Blended waste would be classified as HLW and calcined in a single treatment facility. The calcined wastes would be placed into Hanford Site canisters, which would then be placed into overpack shielding casks. The casks would be held on interim site storage pads to await shipment to a permanent HLW repository for final disposal.

The HLW calcination plant is very similar to the HLW vitrification plant described in the No Separations (Vitrification) subalternative data package.

The calcination option described in this data package provides for the following:

- Receive wastes from the waste retrieval and transfer function;
- Calcines the waste stream using sugar as a reducing agent to yield a dry waste steam that is mainly carbonates;
- Treats the off-gas stream from the calciner providing overall DFs for constituents of concern that are approximately the same as those in the vitrification option;
- Collects liquid effluents for batch transfer to the Liquid Effluent Treatment Facility;
- Produces calcined waste in Hanford Site canisters; and
- Onsite interim storage of the entire calcined waste volume pending shipment to the proposed national repository.

2.0 SOURCES OF INFORMATION

Identify information sources used in developing data.

3.0 ASSUMPTIONS USED IN DEVELOPING THE DATA

Assume the same schedule as the vitrification option
Assume the same plant operating efficiency (60%) and capacity factor (60%)
Assume the same input
Similar levels of air pollution control
Assume similar size of a canister for the calcined product as the vitrified waste (1.67 m dia x 4.57 meters high)

4.0 DISCUSSION

4.1 CONSTRUCTION

Description of the facilities that will be constructed including the required support facilities
Facility foot prints
Construction schedule- Assume the same construction schedule as the No Separations vitrification data package
Location of the facilities and siting information will be assumed to be the same as the vitrification option

4.2 OPERATION

Operating schedule assumed to be the same as vitrification;
Characteristics of material to be processed - use vitrification data package material balance stream number 1 as a plant input;
Characteristics of treated waste;
Volume of treated waste;
Size of the required interim storage facility assuming that the same 10 m3 container will be used for the calcined waste;
Process flow diagram and description;
Potential increases or decreases or changes in characteristics of secondary waste streams or incidental waste volumes from the vitrification option;

4.3 POST REMEDIATION

Assume that post remediation activities would be the same as the vitrification option.

5.0 DATA

Note: provide footnotes to tables as a means to explain data.
Provide one set of backup calculations made to develop data presented in tables.

Calcination

Table 1 Waste Form Volume and Average Radionuclide Inventory

Radionuclide Inventory	Curies in Waste Form
(should be the same as vitrification)	
Total Waste Volume (m3)	6.72 E 4 ①

Notes

① $\frac{1.68E5 \text{ Mg calcined product as briquets}}{2.50 \text{ Mg/m}^3 \text{ density of briquets}} = 6.72E4 \text{ m}^3$

CONSTRUCTION

Table 2 Construction Personnel Requirements (FTEs)

Activity	Total	199_				
	Same as vitrification ①					

Notes

① It is estimated that the calcination and vitrification options would be approximately the same in size and complexity and would therefore require the same construction personnel.

Calcination

Table 3 Construction Resource Requirements

Construction Resource	Quantity
Land (hectares) Surface Committed Temporarily	Same as vitrification ①
Water	"
Energy Electricity (Gwh) Diesel Fuel (liters) Gasoline (liters)	"
Materials Concrete (m3) Cement (m3) Sand (m3) Aggregate (m3) Steel Carbon Steel (mt) Stainless Steel (mt) Earthen Borrow Material (m3) Sand Aggregate Other (specify)	" "

Notes

① It is estimated that the calcination and vitrification options would be approximately the same in size and complexity and would therefore require the same construction resources.

Table 4 Nonradiological Construction Emissions

Construction Emission Pollutant	Quantity
Exhaust Particulate PM-10 (kg)	Same as vitrification ①
SOx (as S02) kg	
NOx (as NO2) kg	
Hydrocarbons, kg	
Aldehydes, kg	
CO, kg	
Fugitive Dust, kg	

Notes

~~Note: This data should be scaled from the vitrification option based on projected facility size.~~

① It is estimated that the calcination and vitrification options would be approximately the same in size and complexity and would therefore produce the same nonradiological construction emissions.

Calcination

Table 5 Transportation of Earthen Borrow Construction Material

This can be calculated using the volume of borrow identified in the construction resource table and using the same assumptions as the WHC data packages. If the assumption that sand/aggregate would be taken from pit 30 would change then a proposed borrow site needs to be identified along with the location and distance. (same as vitrification) ①

Table 6 Transportation of Other Construction Material

This can be done using the construction resources data from table 2 above and the assumptions made in the WHC Engineering data package for No Separations. (Same as vitrification) ①

OPERATION

Table 7 Operating Personnel Requirements (FTEs)

Operating Personnel	Total	199_	199_	___	___	___	___	___	___
Nonexempt Rad Worker Nonrad Worker			Same as vitrification ①						
Exempt + BU Rad Worker Nonrad Worker									
Total									

Operating personnel requirements should include startup, hot operations, and D&D. Staffing levels need to be input into socioeconomic model on an annual staffing level. Personnel requirements would be ideally shown on an annual level but showing total levels with clarification to allow the data to be broken down would be acceptable.

Notes

① It is estimated that the calcination and vitrification options would be approximately the same in size and complexity and would therefore require the same earthen borrow construction material.

Notes

① It is estimated that the calcination and vitrification options would be approximately the same in size and complexity and would therefore require the same other construction material.

Notes

① It is estimated that the calcination and vitrification options would be approximately the same in size and complexity and would therefore have the same operating personnel requirements.

Calculation

Table 8 Operating Resource Requirements

Resource	Quantity
Land (hectares) committed permanently	
Water (m3) Raw Sanitary	
Energy Electrical (GWh/yr) Other (specify)	
Materials Glass formers Process Chemicals (specify) Steel 7.0E4 Concrete 9.8E5	

Note: For the alternatives in the WHC engineering data package it was assumed that the waste treatment facilities would be contaminated following treatment and the land area that they occupied would be permanently committed.

Table 9 Nonradiological Operating Emissions

Item	Quantity
Particulate (kg)	
VOC (specify)	
Toxic Air Pollutants (WAC 173-460) specify	
N0x	
S0x	
CO	

Note: These emissions are used as input to the air dispersion model. These emissions quantities are broken down into hourly and daily emission rates and divided by stack gas volumetric flow rate to develop concentrations.

Calcination

Table 9 Radiological Operating Emissions (Ci)

Radionuclide	Air	Water
Specify		

Table 11 Operating Emissions Release Parameters

Item	Quantity
Stack Height Location Stack gas flow rate (std m3/sec) Stack exit area or exit velocity	
Water emissions Volume (m^3) Disposition	8.03 E5 ① to retention basin ②

Table 12 Decontamination and Decommissioning of Facilities

Item	Contaminated	Non-Contaminated
Steel		
Concrete		
Soil		
Debris		

Notes

① water emissions to basin = water in feed from tank farms (same as vitrification) + water from off gases scrubber system (from mass balance) + misc filter washes + condensate streams (same as vitrification) − water in calciner feed (from mass balance)

water emissions to basin = 5.07E5 + 5.15E5 + 3.55E4 − 2.55E5 = 8.03E5 m^3

This compares to 7.30 E5 m^3 for vitrification.

② Disposition for water emissions is the same as for vitrification option.

Calcination

Table 13 Overall Cost Component (1995 dollars)

Cost Component	Quantity
Capital	$2.61 E 9 ① same as vitrification
Operating	$8.62 E 9 ②
Monitoring and Maintenance	$5.01 E 7 ① same as vitrification
Decontamination and Decommissioning	$9.77 E 8 ① same as vitrification
Research and Development	$2.80 E 8 ① same as vitrification
Total	$1.25 E10

Notes

~~Note: Cost estimate should be made relative to the vitrification option.~~

① It is estimated that the calcination and vitrification options would be approximately the same in size and complexity and would therefore have the same costs for capital, monitoring and maintenance decontamination and decommissioning, and research and development.

② Based on reduced cost of high-level waste casks/canisters and high-level waste disposal fee for calcination relative to vitrification. 10,300 canisters for calcination vs. 21,400 canisters for vitrification. Operating cost summary as follows:

Labor	$1.18E9 ⓐ
Material + Supplies	1.40 E 8 ⓐ
High-level waste casks/canisters	8.76 E 8 ⓑ
Equipment	2.10 E 8 ⓐ
High-level waste disposal fee	6.21 E 9 ⓒ
Total Operating	$8.62 E 9

Notes

ⓐ Estimated to be approximately the same as vitrification due to similar size and complexity.

ⓑ Ratioed from vitrification cost and relative number of casks/canisters required. $1.82E9 × 10,300/21,400 = $8.76 E8

ⓒ Ratioed from vitrification cost and relative number of casks/canisters for disposal. $1.29E10 × 10,300/21,400 = $6.21 E9

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING - WRITEUP FOR CALCINATION TWRS-EIS

ORIGINATOR DAVID STEIN DATE 10/5/95

REVISION NO. 0

OBJECTIVE PROVIDE DRAFT WRITEUP FOR CALCINATION FOR TWRS-EIS

METHODOLOGY MODIFY WRITEUP EXISTING TO INCLUDE NEW CALCINATION WORK.

ASSUMPTIONS

(Continue on another sheet if necessary)

SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

10/5/95
D. Stem

Calcination Process

Calcination is the process of heating precipitates or residues to a temperature that is sufficiently elevated to decompose chemical compounds such as hydroxides or nitrates. It differs from vitrification in that calcination temperatures do not necessarily cause the reacting materials to melt and form a glass. Consequently, the final product of calcination is a solid or semi-solid if certain products have been partially fused during the calcination process. Calcination techniques for solidifying radioactive wastes have been studied previously, but no recent reports of results are available. Sugar calcination refers to a process in which sugar is mixed with the tank waste prior to calcination. The calcination process consists of the evaporation of the remaining water content of the feed liquid and reaction of the sodium nitrate, nitrite and hydroxide salts with sugar and oxygen to form sodium carbonate salt, nitrogen oxide gases and water vapor. Pure oxygen would be supplied to the calciner for these reactions. The oxygen will also combust the organic materials present in the feed to produce carbon dioxide gas and water vapor. Because sodium carbonate has a sufficiently high melting point 850° C (1,562° F), it would remain as a solid in the calcining process rather than melting. Without the reaction with sugar, sodium nitrate melts at 308° C (586° F) and sodium nitrite melts at 271° C (520° F).

Feed Preparation

Because all of the tank wastes would be calcined, the waste feed to this process would be identical to the feed to the HLW vitrification melter in the Extensive Retrieval (In Situ Vitrification) alternative (Section B.3.5). Because the feed components would not be separated, all of the calcined product would be considered HLW. The primary function of the feed preparation system would be to mix measured amounts of sugar with the tank wastes prior to calcination. Each batch of tank waste would be analyzed to determine the sugar requirements. A weighed amount of bulk dry sugar would then be added, and the mixture would be agitated until the sugar was dissolved.

Calcination

The prepared feed would be pumped to the feed nozzles of a spray calciner. The calciner would be an indirectly fired vessel consisting of a number of 8 inch diameter vertical tubes. The vessel is a box design approximately 30 feet by 30 feet with an approximate height of 15 feet. This particular configuration would limit the reacting mass within the calciner as the reaction of the sugar could be very rapid and large quantities of sugar and nitrates could react violently. The calcination reactions would take place inside the tubes. The tubes would be heated by combustion of kerosene fuel with oxygen outside the tubes and the resulting hot off-gases exhausted directly to the atmosphere, probably after some indirect heat recovery operation. These gases would consist of only products from the combustion of kerosene with oxygen and should require no treatment as they would contain only very low levels of SO_x and NO_x due to the presence of small amounts of S and N in the kerosene.

The feed for the calciner would consist of a slurry containing approximately 50 percent by weight solids (dissolved and suspended). Atomizing steam at the rate of approximately one half pound per pound of feed would be added to ensure proper dispersion of the spray inside the calciner tubes. The atomized waste droplets would lose their water by evaporation and be heated to reaction temperature by the indirectly heated tubes as it falls through the length of the tube. The chemical reactions of the waste with the sugar would then take place with the release of nitrogen oxide gases and the formation of solids which are collected at the bottom of the calciner. The calciner is expected to operate at a temperature between 700 and 800° C.

The evaporated water and injected steam for atomization along with the gaseous products from calcination would be exhausted to a ceramic candle filter for the removal of as much particulate as possible from the hot gases and then processed similar to vitrification off-gas treatment. The solids

removed from the ceramic filter would be collected along with the solids from the calciner for further processing in compaction. The ceramic filter equipment envelope would be approximately 30 feet in diameter by approximately 60 feet high.

Compaction

The calcined solids would consist of a hot, fine powder which has a low bulk density and would require compaction to increase its bulk density. This fine powder would be processed hot in a roll type compactor machine to produce small pellets or briquets of high bulk density. It is estimated that the achievable bulk density of the briquets would be approximately 90 percent of the theoretical density of the solids. After compaction, the product briquets would be screened to remove fines, air cooled and transferred to the HLW cyclone bin for feeding the canisters. The fines collected from screening the briquets would be returned to the feed bin for recycle to the compactor machine.

Canister Operations

Following the transfer of the calcined product briquets to the HLW cyclone bin, the vitrification process canister filling operation flowsheet would be used. The calcine briquets would be placed in $10m^3$ canisters identical to the canisters used for glass cullet for Extensive Retrieval (Ex Situ Vitrification) alternative Section B.3.5. A major difference is the quantity of calcine briquets to be disposed. The No Separations (Calcination) subalternative would produce 92 metric tons of HLW calcine briquets/day. The number of canisters required for calcine briquets would be 10,300 or approximately 52 percent less than the 21,400 required for vitrification.

Off-Gas Treatment

Off-gas processing for calcination would be the same as used for off-gas processing for vitrification. The HLW off-gas system would receive hot gases from the HLW calciner ceramic candle filter. The gases would be cooled and scrubbed with water to remove most of the remaining particulates and water soluble materials, which would be recycled to the process feed tanks. The scrubbed off-gas would pass through a mist eliminator to remove fine water droplets and then through metal HEPA filters to remove the majority of the radionuclide particulates. The off-gas would then flow to an SO_2 adsorption process and a catalytic NO_x reactor before being discharged to the atmosphere. The amount of NO_x emissions estimated for the calcination process is approximately five times larger than estimated for the vitrification process. The difference is accounted for in the assumption that reaction products of nitrites and nitrates for the calcination process are NO_x, whereas for the vitrification process the assumption also includes a large quantity of N_2 as a reaction product.

Post Remediation

When processing of the tank wastes has been completed, the processing facilities would be decontaminated and decommissioned in the following manner:

- Processing equipment will be decontaminated sufficiently to allow onsite disposal in a LLW burial ground.
- Processing facilities will be decontaminated to the extent possible and then entombed in place. The exact materials which will be used to cover processing facilities have not been decided.

B.3.6.4 Implementability

Issues associated with implementing this subalternative include the following:

- The vitrification subalternative has the same uncertainties as those listed for the Extensive Retrieval (Ex Situ Vitrification) alternative (Section B.3.5.4). In addition, this subalternative would result in a large volume of vitrified HLW (1.4E+05 m^3). The calcination subalternative would also produce a large volume of calcined HLW (6.7E+04 m^3), but which is 52 percent less than the vitrified HLW.
- The calcination step using sugar as a reductant has had limited laboratory testing and the proposed facilities are conceptual. Calcination as a unit operation has been in use for many years on an industrial scale. No design or engineering has been completed for the process or support facilities. Consequently, the processing steps have been based on experience and engineering judgement. It is estimated that the consumption of fuel (kerosene) for calcination would be approximately 19 percent of that required for vitrification. Steam use for calcination would be higher than for vitrification due to the atomization steam required for feeding the calciner. Electrical power for calcination would be approximately the same as for vitrification.
- The process design parameters for calcining, such as feed rate, temperature, reagent addition, and mass and energy balances remain conceptual in nature. A substantial part of the flowsheet for calcination and vitrification would be the same; the remediation of the calcination and vitrification options are estimated to be approximately the same in size and complexity. As a result of this similarity between the options, the nature of most support services are estimated to be similar for calcination and vitrification. Exceptions to this are that raw water use for the calcination option is estimated to be approximately 19 percent of that for vitrification

and sanitary water use for calcination is estimated to be approximately 130 percent of that for vitrification.

- It is estimated that the calcination and vitrification options would be approximately the same in size and complexity and would therefore have approximately the same costs for capital, monitoring and maintenance, decontamination and decommissioning, and research and development. Differences in cost occur in the operating category due to reduced cost of high-level waste casks/canisters and high-level waste disposal fees for calcination relative to vitrification. The operating costs for calcination are estimated to be approximately 53 percent of that for vitrification resulting in an estimated overall cost for calcination which is approximately 62 percent of that for vitrification.
- Further laboratory and pilot plant testing are required for calcining, particularly for analyzing reaction products including the nature of the gas streams and off-gas treatment methods. The calciner and off-gas processing may require different sizes and types of equipment from the ones conceptualized herein; and
- The implementability of the calcining subalternative could be affected by the acceptability of the calcined product at the proposed national HLW repository. The acceptability issue involves the waste form. The tank wastes would be contained by canisters. As carbonates, the waste will be water soluble and will dissolve if the container is breached. The waste acceptance criteria for the proposed national HLW repository have not been finalized. While discussions are ongoing regarding the acceptability of various waste forms, current information indicates that the waste form would not meet the acceptance criteria. Current plans are for the repository to accept waste only in a borosilicate glass form.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Land Use and Habitat disturbance — Cumulative Impacts.

ORIGINATOR P. BRAMSON DATE 11/13/95

REVISION NO. 0

OBJECTIVE Provide estimate of HRA Land Use and Habitat disturbance to combine with other Hanford actions as an estimate of cumulative total impact.

METHODOLOGY Extracted preliminary estimates from HRA internal draft information.

ASSUMPTIONS Took the highest impacts for each alternative for each of 4 areas of remedial action and added them for the HRA total.

(Continue on another sheet if necessary)

P. Bramson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 11-13-95 SUBJECT Cumulative Land Use Impact SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

HRA land Disturbance

Source: PDEIS DOE/EIS-0222 5/9-26/94

Tables 5-2 thru 5-5

	TOTAL (ha)	5-5 (ha)
CR (Unrestricted)	177 (437ac) (5-2)	36 (90ac) (5-2)
Reactors on River (Unrest)	420 (1038) (5-3)	40 (101ac) (5-3)
Cent. Plateau (Exclusive use)	1246 (3064ac) (5-4)	289 (722ac) (5-4)
Other Areas. (Restricted Use)	309 (764ac) (5-5)	115 (287) (5-5)
TOTAL	2146 (5303ac)	480 (1200)

5-5 = Shrub steppe

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering / Revised LAW transportation from pumping cullet in sulfur to transporting in large disposal containers.

ORIGINATOR Colin Henderson DATE 11/15/95

REVISION NO. 0

OBJECTIVE Calculate the number of containers / the distance transported / and the frequency for transport associated with placing the LAW cullet in large 32m³ disposal containers

METHODOLOGY Using the matl. balance information calc the number of containers, using the operating schedule calculate the frequency of container transport.

ASSUMPTIONS Noted.

(Continue on another sheet if necessary)

Colin Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 9/20/95 SUBJECT Switch LLW transportation to disposal vaults. SHEET NO.

BY CH CHKD. JOB NO.

CHANGE FROM PUMPING TO LLW VAULTS TO CONTAINERS

LLW DISPOSAL.

DRAFT PROCESS FLOWSHEET.

LLW DISPOSAL CONTAINER = 32 m^3

Matrix Material = SULFUR Cement.

CALCULATE NUMBER OF CONTAINERS:

GIVEN GLASS DENSITY = 2.63 Mt / m^3

VOID FRACTION = 0.3

NO SEPARATIONS = 3.57E5 mt.

INTERMEDIATE SEP. = 3.87 E5 mt.

EXTENSIVE SEP = 3.86E5 mt.

SELECTIVE RETRIEVAL = 1.94E5 mt.

$$\text{Volume} = \frac{\text{mass}}{(\text{density})(1 - \text{void fraction})} =$$

INTERMEDIATE SEPARATIONS = 2.1E5 m^3

EXTENSIVE SEPARATIONS = 2.1E5 m^3

SELECTIVE RETRIEVAL = 1.1E5 m^3

CONTAINER COUNT:

INTERMEDIATE SEP. = 6600 CONTAINERS = 9 cont/week

EXTENSIVE SEP = 6,600 CONTAINERS = 9 containers/week

SELECTIVE RETRIEVAL = 3,400 CONTAINERS = 5 cont/week.

distance ~ 2 Km Round trip. to the disposal vaults.

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering / Capsules - Overpack & Ship Disposal Cost Estimate, Current Ops Cost for Tanks Fill & Cap & ISV alternatives

ORIGINATOR Colin Henderson DATE 11/15/95

REVISION NO. 0

OBJECTIVE Estimate the cost for disposal of the capsules under the Overpack & Ship alternative and Estimate the current operating costs for Fill & Cap and ISV.

METHODOLOGY Use Ex Situ Int Separations Cost Estimating details as a basis

ASSUMPTIONS as noted

(Continue on another sheet if necessary)

Col. Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

CAPSULE OVERPACK & SHIP DISPOSAL
COST ESTIMATE.

USING THE TPA AS A BASIS:

DISPOSAL FEE FOR TPA Calculated As follows:

TWO REPOSITORY CASE TOTAL LIFE CYCLE COST = 48,294 billion.
Defense Program Share = 15.7%
HANFORDS Share Based ON 2465
to total defense waste packages 4588 $(2465/4588) = 53.73\%$

THE TPA REPOSITORY COST IS CALCULATED
AS (48,294 billion X .157X .537) − 112 million.

= 4,072 billion − 112 million = 3,960 million

The Δ of 112 million is for the TPA case
Having 1705 packages versus 2465 from ABOVE.

∴ the savings for (2465-1705) = 760 packages = 112 million

⇒ 112/760 = $148,000 per CONTAINER.

⇒ NOTE THIS ASSUMES implementation of the TPA.

CONSERVATIVELY send 100 HMPC's to Repository

⇒ DISPOSAL Fee = 100 X 148,000 = 14.8 million

OR IF INSITU ALTERNATIVES ARE Selected for TANK wastes
Capsule Repository COSTS. would be similar to Ext. Separations

Capsule Disposal would be $3,385 [Based on the Savings for EXT Sep. (125 MPCs) -VS- 100 MPCs For Capsules]

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

Canister size (volume):

$1.6 m^3$ / canister

From Ext Sep table 9-1A

Δ Volume for Cs/Sr Capsules = $400 m^3$

$\Rightarrow$ 250 Canisters

$\Rightarrow$ 250/4 = 63 HMPC's

63 HMPC's x $148,000/mpc = 9.3 million

Δ for Ext Sep.

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

Current Ops Cost

Fill & Cap & ISV.

From TPA Rev B data Package. pg 9-25 Table 9-17 F/N

PM = 1,180
OM = 4,290 ← From T/F OPS DATA spreadsheet developed By Fredenburg
Safety = 440
Upgrades = 1720
Characterization = 933

~ 8,600

Fill & Cap goes to 2009

OM to 2009 = 2,283

Current Ops then
PM = 1,180
OM = 2,283
Safety 440
Upgrades 1,720
Char. 933

~ 6566

ISV

ISV goes to 2019 on spreadsheet

Current OPS then equals
PM = 1180
OM = 3476
Safety 440
Upgrades 1720
Charact 933

7749

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering / Modified Personnel for fill & Cap alternative for Reduction to Rad Workers following the deletion of R/F drying

ORIGINATOR Colin Henderson DATE 11/15/95

REVISION NO. 0

OBJECTIVE Remove personnel associated with the Radio frequency drying operations

METHODOLOGY Using the WSIN Rev 0 data package identify those personnel activities unique to R/F drying and delete from the existing estimates

ASSUMPTIONS None.

(Continue on another sheet if necessary)

Col Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT Modified Personnel for Fill & Cap SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

FILL & CAP.
CONSTRUCTION Personnel - NO CHANGE
OPERATING PERSONNEL -

START UP = 2 yrs Staff Spread Over 3 yrs.
D&D = "

BY UNIT PROCESS

	E	NE	BU.	
START UP	2.18E5	1.6E5	1.27E5	
DST EVAP.	5.3E5	5.4E5	0	
GRAVEL fill	3.4E5	1.0E5	5.1E5	
D&D	2.18E5	1.6E5	1.27E5	
	8.7E5	6.4E5	5.1E5	STAFF Hours.
	1.09E5	8E4	6.38E4	STAFF Hrs/yr

Schedule 2006-2013 = 8 yrs.

TOTALS	Exempt	NE	BU.	
	1.3E6	9.6E5	7.64E5	} W/o Radio Freq Dry.
WAS	1.96E6	1.2E6	2.9E6	

PERSON YEARS = 1512 ←

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering - Repository Fee per Shipping Container (HWPC)

ORIGINATOR [illegible] DATE 10-26-95

REVISION NO. 0

OBJECTIVE Compare Repository Fee for various alternative product Quantities.

METHODOLOGY use Est Hanford Fee and divide by number of Shipping Containers for Repository from each alternative

ASSUMPTIONS as given in Calculation

.43 million

(Continue on another sheet if necessary)

[illegible]
SIGNATURE

CALCULATION & RESULTS ATTACHED

Calculation 1 Page

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 10-26-95 SUBJECT SHEET NO. 10/1

BY RDW CHKD. JOB NO. 01K47101

Hanford Repository fee is given as a set percentage charge that is not affected by the number of Canisters shipped to the National Repository = $4.072 x 10^9

Calculate the fee per HMPC (shipping unit) for the several alternatives.

alternative Process	Number of HMPCs	Cost/HMPC
Extensive Separations HLW vit - 625 m³ of glass 1.3 m³/can - 4 Canis./HMPC (less base fee 679 million)	125	3.26×10^7
TPA - Partial separations HLW vit - 8866 m³ glass 1.3 m³/can - 4 Cans/HMPC	1705	2.39×10^6
No Separations - vitrification HLW vit - ≈214000 m³ glass 10 m³/can - 1 can/HMPC	21400	1.903×10^5
No separations - Calcination HLW BRIQUETTES - ≈ 103000 m³ CAL PRODUCT. 10 m³/can - 1 Can/HMPC	10,300	3.953×10^5

Selective Retrieval 853

Base fee 4.072 billion less 366 million

For Ext Sep $\frac{679}{1705-125}$ = .43 million/canister below 1705 (base case)

Sel Retrieval = (1705 - 853) = 852(.43) = 366 million

Repository fee = 4,072 - 366 = 3706 million

FORM 91-005-1 (4/81)

The cost per HMPC shipped to the repository varies as the total number of HMPCs shipped varies but does not vary as a straight line. The base line of was established as 2,645 waste packages for a ~~fee~~ proportional fee of $4.072 billion. A small decrease is observed ($112 million) if only 1705 waste packages are shipped, whereas with the no separations vitrification of all waste as HLW the fee increases by $8.8 billion for the increased number of HMPCs shipped (18,935 HMPCs) + ~~2465~~ ~~or~~ above the base line quantity of 2465 waste packages. ~~The~~ using $8.8 billion cost on a unit cost per unit increase basis gives an estimate of ~~[illegible]~~ $3.64 billion + the baseline $4.072 billion for ~~a~~ repository fee of $7.712 billion for the no separations calcination alternative.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGR. - Calculation for exposure per well drilling thru LLW vault

ORIGINATOR DAVID STEIN DATE 10/26/95

REVISION NO. 0

OBJECTIVE Estimate quantity of radionuclide which could be brought to surface if one were to drill 30cm well thru LLW vault per TPA case and extrap case.

METHODOLOGY

ASSUMPTIONS numbers for TPA are applicable to Selective retrieval, Volumes excavated include void spaces around cullet which are composed of sulfur cement.

(Continue on another sheet if necessary)

D T Stein

SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

D Stein
10/26/95

Objective:

Estimate quantity of radionuclide in "Ci" which could be brought to surface if one were to drill a 30cm diameter well thru the LLW vault per TPF case and per Extensive Sep. Case

Basis: 30 cm diam well (0.3 m)

vaults are 5300 m^3 and 37m long by 15 m deep

Tri-Party loading
calculated per Table 9-1 (p.9-3)
to be 5.73 Ci/m^3

Ext. Sep. loading
calculated per Table 9-1B (p9-5/6)
to be 2.10 Ci/m^3

Max. material to be removed by a 30cm diam. well, 15m deep is:

$$\frac{\pi D^2}{4} \times L = \frac{\pi (0.3)^2}{4} \times 15 = \underline{1.06\ m^3}$$

Tri-Party exposure

$$5.73\ Ci/m^3 \times 1.06 m^3 = \underline{6.07\ Ci}$$

Ext. Sep. exposure

$$2.10\ Ci/m^3 \times 1.06 m^3 = \underline{2.23\ Ci}$$

Low-Level Vitrification Facility

The plant would be sized to produce 200 metric tons (220 tons) of vitrified wastes per day in two production trains. It would contain seven operational areas, including feed receipt and sampling, Cs ion exchange, melter operations, cullet processing, sulfur operations, cold chemical makeup, and off-gas treatment areas.

The facility would have an overall footprint of 90 m (290 ft) wide by 75 m (250 ft) long with an overall height of 40 m (130 ft) of which 20 m (65 ft) would be below grade. In addition to the process level, which is below grade, the facility has two other levels, one at grade and the other at +9 m (30 ft). Overall, the facility would have a total area of approximately 6,800 m^2 (73,000 ft^2).

The process level would include feed receipt and sampling, Cs ion exchange, process evaporation, and cullet processing areas. Feed receipt and sampling would occur in six 200 m^3 (7,100 ft^3) tanks that would receive feed from six 400 m^3 (14,300 ft^3) tanks external to the building. The Cs ion exchange area would include a single stage of 12.5 m^3 (440 ft^3) columns and supporting tanks. The cullet processing area would consist of quench tanks below the evaporator and 18 cullet storage tanks.

The facility's other two levels would provide space for support services and additional process equipment. The grade level of the facility would provide space to support canister filling operations, instrumentation for the process equipment, melter operations, process evaporator for LLW melter feed, maintenance areas, and sulfur operations. The +9 m (30 ft) level would provide electrical services and cold chemical makeup systems.

Low-Level Waste Cullet Disposal

Under the Extensive Retrieval alternative, LLW cullet would be disposed onsite. The cullet is mixed with a molten polymer and sulfur mixture in the vitrification facility and pumped approximately 500 m (1,600 ft) in a heat-traced line to 5,300 m^3 (189,000 ft^3) storage vaults. A total of 46 vaults would be constructed. Although construction details of the vaults are not fully known at this time, each vault is estimated to be 37 m (120 ft) long by 15 m (50 ft) deep. The vaults would be engineered concrete structures designed to withstand the stresses generated by the contained volume of cullet and sulfur.

Other options may be chosen for disposal of the LLW. For example, the LLW glass may be poured directly into canisters without forming cullet. If cullet is made, the matrix may be a material other than sulfur. Furthermore, the LLW may be transferred to final storage by some alternate means such as truck transport.

When all of the LLW glass has been placed in final storage, a Hanford Barrier will be constructed over the storage site. Hanford Barrier performance objectives are discussed in Section B.6.0.

High-Level Vitrification Facility

The HLW vitrification facility would have has six operational areas that would include feed receipt and sampling, process evaporation, melter operations, maintenance areas, canister loading, cold chemical

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering / Estimated Tritium Inventory in the tanks

ORIGINATOR Colin Henderson DATE 11/15/95

REVISION NO. 0

OBJECTIVE Estimate the tritium inventory in the tanks using available published documents.

METHODOLOGY

ASSUMPTIONS noted

(Continue on another sheet if necessary)

J Colin Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

TRITIUM ESTIMATE

3300 Ci 1993. (Source DOE/RL-94-77

ADD 10% for K&N BASIN CLEAN OUT

3300 x 1.1 = 3630 OR Δ = 330 Ci

The 3300 Ci 12/31/93 decayed to 12/31/99

half life 12.4 years.

$N = N_0 e^{-\lambda t}$; $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{12.4} = 5.59E-2$

$N = 3300 e^{-(5.59E-2)(6\ yrs)}$

N = 2360 Ci. @ 12/31/99.

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering / Capsule - Onsite Disposal alternative Intrusion prevention barrier estimate / Onsite disposal details.

ORIGINATOR Colin Henderson DATE 11/15/95

REVISION NO. _____

OBJECTIVE Calculate the size & resource requirements for a conceptual intrusion prevention barrier that would be placed over the dry-wells for the Onsite disposal alternative

METHODOLOGY Design barrier as a precast concrete shape that could be set over the dry-wells, should have adequate weight to prevent removal.

ASSUMPTIONS noted

(Continue on another sheet if necessary)

Colin Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

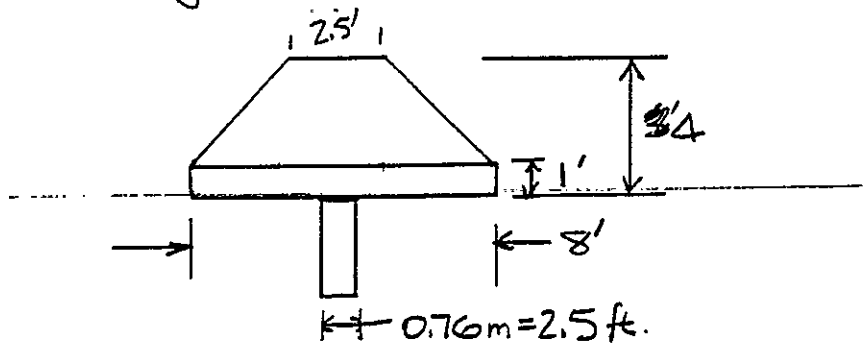
DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

CAPSULE Drywell disposal INTRUSION Barrier.

Concrete Precast piece placed over the dry-wells to prevent intrusion.

Given the drywells are spaced at 5m Center to Center.



$$\text{Volume} = 8' \times 8' \times 1' + \tfrac{1}{3}\left(64 + \sqrt{64(6.25)} + 6.25\right)$$
$$= 64\ ft^3 + 30\ ft^3 = 94\ ft^3$$

Concrete weighs 145 lb/ft³.

Cap weighs 13,600 lb.

672 drywells.

haul on Flat Bed truck @ 3 per truck.

total trips = 224.

PS 2 of 6

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 11/2 SUBJECT Info to Alex SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

CAPSULE ONSITE DISPOSAL

CANISTER 0.3m (1') dia x 3m (10' long)

ASSUMED CAPSULE LOADING / CANISTER:

3 Sr CAPSULES
4 Cs CAPSULES.

FROM PDEIS App A TABLE A.9

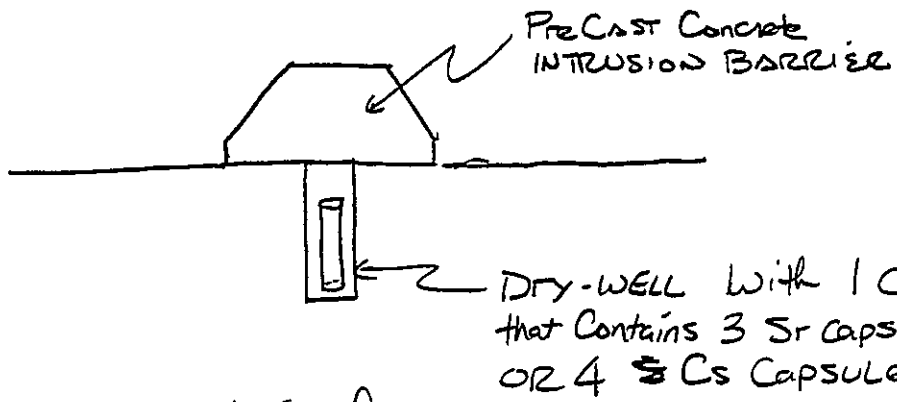
The AVE KCi loading per CAPSULE is:

Sr = 38.47 KCi @ 12/31/95
Cs = 40.1 KCi @ 12/31/95

MAX or Highest Ci LOADING per CAPSULE

Sr = 93.27 KCi (12/31/95)
Cs = 54.38 KCi (12/31/95)

CAPSULE DISPOSAL CONFIG:



The disposal SITE would be an area with ≈ 600 of these dry-wells covered with the intrusion barriers.

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

CAPSULE ONSITE DISPOSAL

CANISTER 0.3m (1') dia x 3m (10' long)

ASSUMED CAPSULE LOADING / CANISTER:

3 Sr CAPSULES
4 Cs CAPSULES.

FROM PDEIS APP A TABLE A9

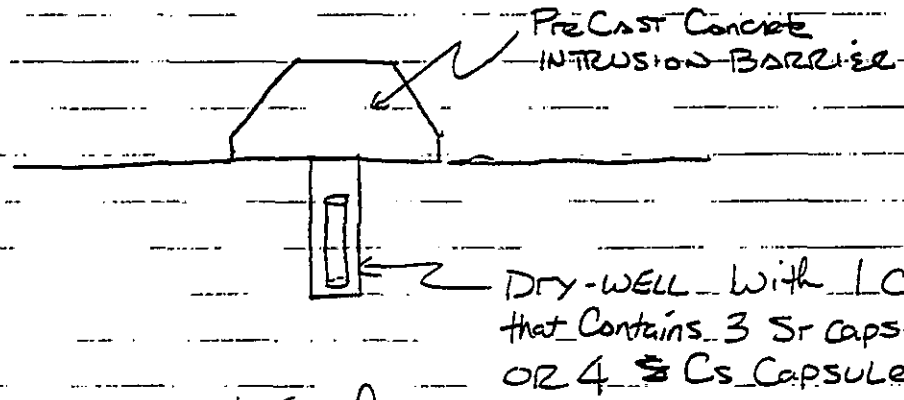
The AVE KCi loading per CAPSULE is:

Sr = 38.47 KCi @ 12/31/95
Cs = 40.1 KCi @ 12/31/95

MAX or Highest Ci LOADING per CAPSULE

Sr = 93.27 KCi (12/31/95)
Cs = 54.38 KCi (12/31/95)

CAPSULE DISPOSAL CONFIG:

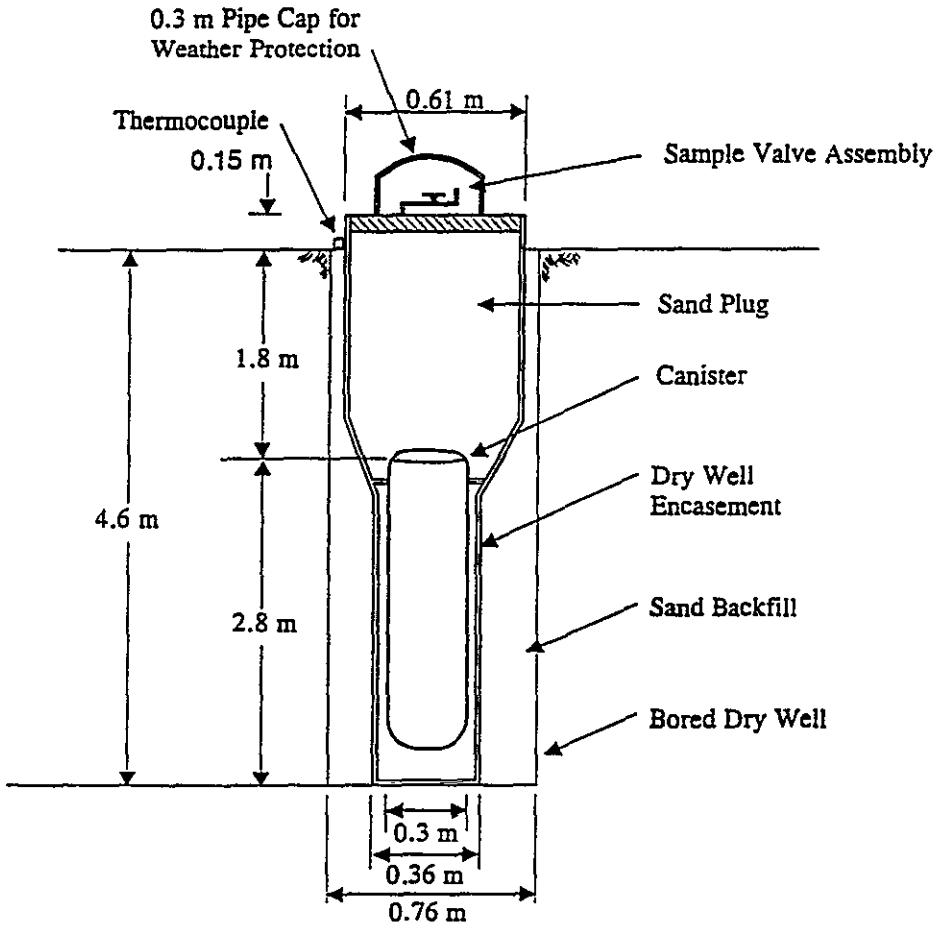


The disposal SITE would be an area with ≈ 600 of these dry-wells covered with the intrusion barriers.

pg 4 of 6

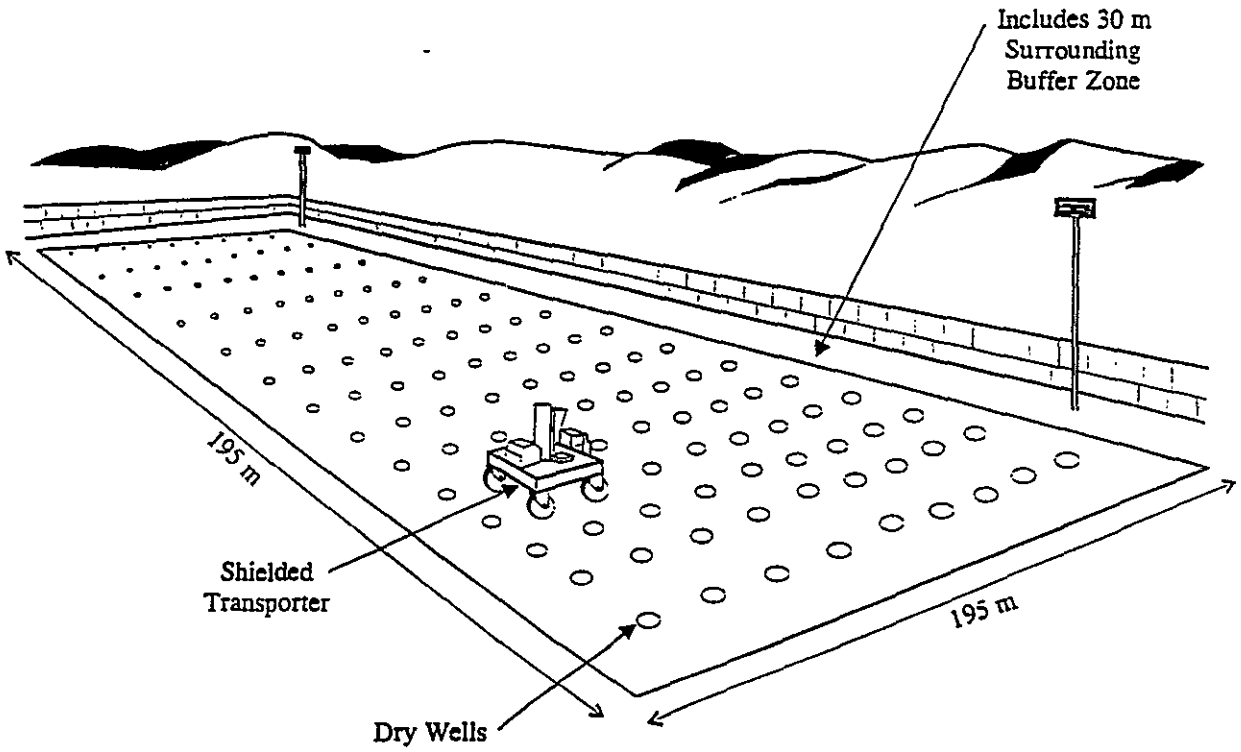
FORM 91-005-T (4/81)

Figure B.27 Capsule Dry-Well Storage Assembly



SOURCE: WHC 1995h

Figure B.28 Capsules ~~Dry Well Storage~~ Waste Disposal Arrangement



SOURCE: WHC 1995h

pg 6 of 6

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering / Resource Estimate for Capsules - Vitrify with Tank Waste Alternative

ORIGINATOR Colin Henderson DATE 11/15/95

REVISION NO. 0

OBJECTIVE Calculate the resource requirements for the Capsules Vitrify with tank waste alternative.

METHODOLOGY Using the Raytheon/BNFL preliminary capsule cell design, Estimate the requirements for Concrete, Steel, electricity, and Water

ASSUMPTIONS as noted.

(Continue on another sheet if necessary)

Col. Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 11/6 SUBJECT SHEET NO.

BY CH CHKD. JOB NO.

Calc.

Resource Estimate for Cs/Sr Capsules
Vitrify with Tank waste alternative.

Ref: Raytheon/BNFL Design & Esimate for Capsule Cut up Cell

Assumptions: ◦ Cell Required to Cut up Capsules, Crush & Drum Metalic ~~[illegible]~~ Capsule housings, house the IX Columns and feed blending equipment is Approx 50% Bigger than the required Cell size to perform overpacking

◦ Based on this resources can be scaled up 50% over overpack & ship.

Steel = 1.5 x 400 = 600 t

Concrete = 1.5 x 2300 = 3450 m^3

Electricity = 1.5 x 0.44 = 0.7 GwH

Water = 15,~~000~~ x 1.5 = 23,000,~~000~~ m^3 H_2O

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering – LR-56(H) trunk waste transfer trips T-Plant & PFP

ORIGINATOR R D Weed DATE 10-25-95

REVISION NO. 0

OBJECTIVE Estimate number of truck transfers to be made.

METHODOLOGY use waste quantities and calculate trips per 1000 gallon transfer

ASSUMPTIONS

assumed truck to be used for waste transfers.

(Continue on another sheet if necessary)

Ronald D Weed
SIGNATURE

CALCULATION & RESULTS ATTACHED

Calculations 1 page

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 10-25-95 SUBJECT SHEET NO. 1 of 1

BY RDW CHKD. JOB NO. 01K47101

Calculate the number of trips for the LR-56(H) tank truck for PFP and T-Plant wastes.

PFP plant wastes FY 1995 – 2006 estimated
total volume was 70,000 gals = 70 trips
total for the 1000 gallon Truck.

T-Plant.
Ramp up to 15,000 gals/month for waste from 1996 FY Thru 2002

$\frac{1}{7} = 0.1428$, $\frac{2}{7} = 0.2857$, $\frac{3}{7} = 0.4286$,

$\frac{4}{7} = 0.5712$, $\frac{5}{7} = 0.7140$, $\frac{6}{7} = 0.8568$ $\frac{7}{7} = 1$

	gallons/yr	# Trips
year 1996	25,704	26
1997	25,704	26
1998	51,420	52
1999	77,148	78
2000	102,816	103
2001	128,520	129
2002	154,224	155
2003	180,000	180

gallons/yr = (15,000)(12)(factor)

trip distance point of origin to Destination = 11 Km (7 miles)

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering, Phased Implementation - Disturbed Area Calculation

ORIGINATOR Colin Henderson DATE 11/15/95

REVISION NO. 1

OBJECTIVE Calculate the disturbed area for the phased Implementation Alternative.

METHODOLOGY Calculate disturbed area by scaling from the proposed layout for the phased Implementation site plan

ASSUMPTIONS 1) Assumptions of corridor width & length provided in calc.

(Continue on another sheet if necessary)

C. Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 10/18/95. SUBJECT (revised). SHEET NO. 1

BY CH CHKD. JOB NO.

PHASED IMPLEMENTATION DISTURBED AREA.

i) AREA DISTURBED DURING CONSTRUCTION — TOTAL

a) 30 ACRES/SITE (12.2 ha) — 60 Acres (24.3 ha)

b) POWER LINE (1500 m new power line)

Assumed 500 m of new Line outside existing Fence Line.

AREA = 500 m x 50 m = 25,000 m² (2.5 ha) — 6 Acres (2.5 ha)

c) Water Service 960 m of buried line

Assumed 475 m of the Line outside of existing Fence line

AREA = 475 m x 25 m = 1.18 ha = 3 Acres — 3 Acres (1.18 ha)

d) Road — 6.5 Acres (1.64 ha)

IMPROVE 1480 meters of existing Road

AREA = 1480 meters x 10 m = 3.7 acres (1.5 ha)

(10 meters width to improve road)

New Road

570 meters x 20 = 2.8 Acres (1.14 ha)

(20 meters width for new road)

e) WASTE TRANSFER PIPELINES — 0

ASSUME ALL WASTE TRANSFER PIPING IS INSTALLED WITHIN EXISTING FENCELINE IN CURRENTLY DISTURBED AREA. INCLUDES LIQUID Effluent transfer line to LERF

FORM 91-003-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 10/18 SUBJECT SHEET NO. 2

BY _____ CHKD. _____ JOB NO. _____

1. CONT.

TEMPORARY CONSTRUCTION PARKING — 5 ACRES (2 ha)

PIT 30 BORROW (Aggregate For Concrete) — 1 ACRE (0.4 ha)

TOTAL AREA DISTURBED DURING CONSTRUCTION — ~~80.5 ACRES (32 ha)~~ 81.5 ACRES (33 ha)

2. Permanently Disturbed Area = 0

ASSUME RCRA CLOSURE WITH NO PERMANENT LAND COMMITMENTS.

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING - EMISSIONS FOR PHASED IMPLEMENTATION TWRS-EIS

ORIGINATOR DAVID STEIN DATE 10/23/95

REVISION NO. 0

OBJECTIVE ESTIMATE EMISSIONS FOR PHASED IMPLEMENTATION (20 MT/D LLW VITRI. WITH SEPARATIONS, AND 1 MT/D HLW VITRIFICATION

METHODOLOGY COMPARE PROCESSING, SIZE, AND OPERATING PERIOD WITH TRI-PARTY AGREEMENT STUDY LLW VITRI., HLW VITRI. + SEPARATIONS

ASSUMPTIONS

TRI-PARTY AGREEMENT STUDY USED AS BASIS

(Continue on another sheet if necessary)

D T Stein
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

PHASED IMPLEMENTATION

Non-Radiological Operating Emissions

Hazardous Air Pollutants	SEP/LLW	SEP/LLW + HLW
Arsenic	negligible	negligible
Beryllium	negligible	negligible
Cadmium	negligible	negligible
Chromium	5.4E-03 Kg	6.0E-03 Kg
Nickel	1.5E-04 Kg	2.5E-04 Kg
Manganese	5.2E-04 Kg	2.5E-03 Kg
Mercury	negligible	negligible
Lead	negligible	negligible

Above HAPS show more detail than previously presented

D. Stein, JEG
10/25/95

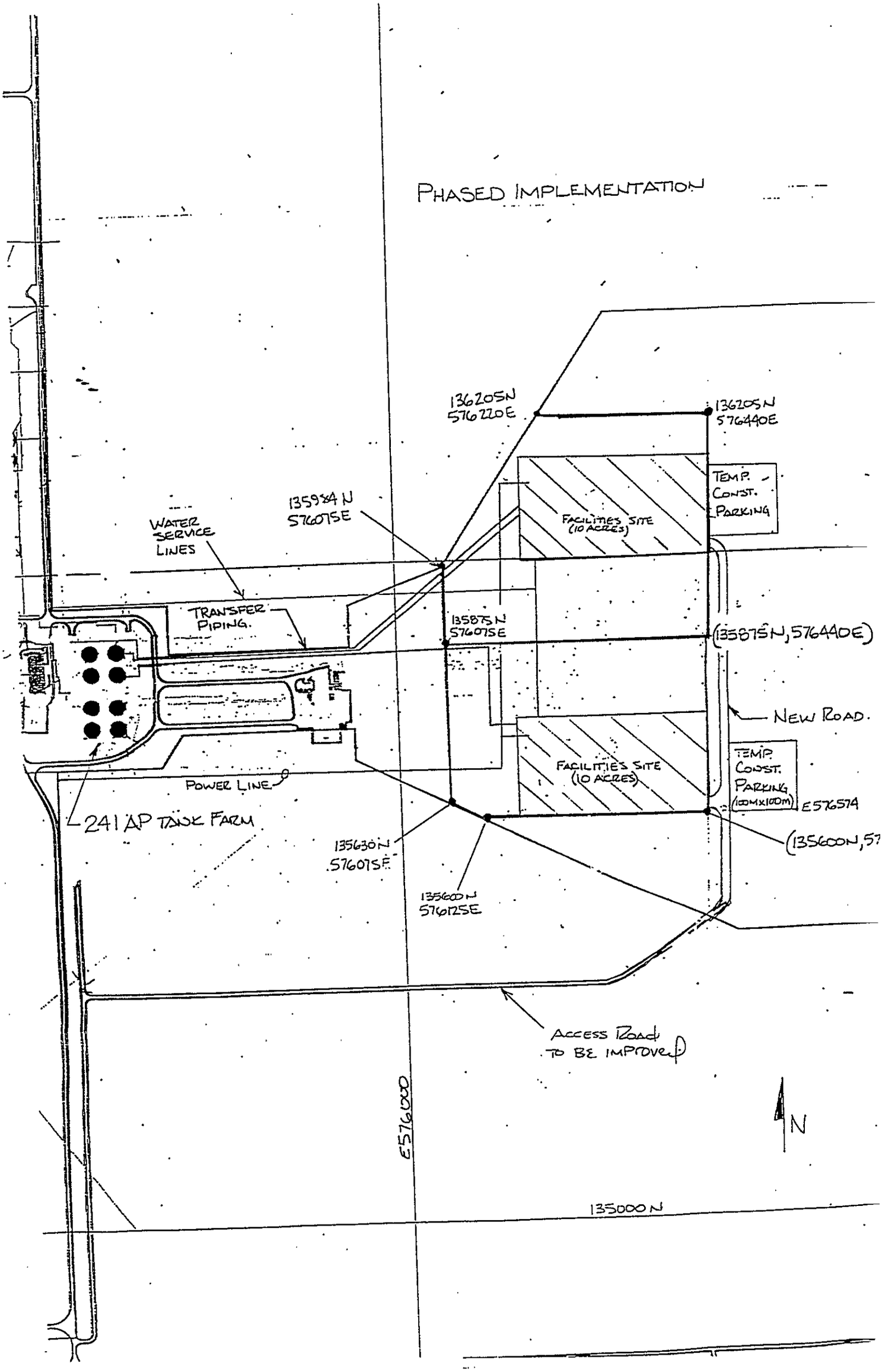
Table 9-1. Average Radionuclide Inventory in the Final Glass Form (Ci/m³).[1]

Radionuclide Inventory[2]	Tri-Party Agreement Preferred Alternative	
	Low-Level Waste Glass	High-Level Waste Glass
^{241}Am	3.9E-2	1.0E+1
^{243}Am	1.3E-5	3.2E-3
^{14}C		
^{244}Cm	4.7E-6	5.9E-3
^{135}Cs	4.8E-6	1.5E-2
$^{137}Cs^{(1)}$	1.2E+0	3.7E+3
^{129}I		
^{63}Ni	2.6E-2	2.8E+1
^{237}Np	3.2E-5	6.6E-3
^{238}Pu	3.1E-4	1.1E-1
^{239}Pu	7.6E-3	2.6E+0
^{240}Pu	1.9E-3	6.7E-1
^{241}Pu	6.7E-3	7.8E+0
^{226}Ra		
^{106}Ru	8.5E-9	3.8E-6
^{151}Sm	3.1E-2	6.6E+1
^{126}Sn	7.2E-4	5.0E-2
$^{90}Sr^{(1)}$	4.3E+0	5.6E+3
^{99}Tc	1.2E-1	6.3E-1
^{230}Th	2.3E-12	4.1E-9
^{233}U	2.8E-9	1.2E-6
^{234}U	4.9E-8	2.1E-5
^{235}U	4.8E-6	2.1E-3
^{238}U	1.1E-4	4.8E-2
^{93}Zr	1.6E-5	4.1E-1
Total (m3)[3]	2.2E+5	9.4E+3

total radionuclide inventory (Ci/m³) 5.73

Table 9-1B. Average Radionuclide Inventory in the LLW Glass and Grout Waste Forms (Ci/m³). (2 sheets)

Radionuclide Inventory	Extensive Separation Option								
	Waste Class A Upper Limits	LLW Glass Base Case (A-1A)	LLW Glassw/Cr Removal (A-2A)	LLW Glass w/Cs/Sr Capsule Blend (A-3A)	LLW Glass Without Am/La IX (A-4A)	LLW Glass With Low Temp. Limits (A-5A)	LLW Glass With Incomplete Dissolution (A-6A)	LLW GroutBase Case (A-1B)	LLW Grout w/Cr Removal (A-2B)
^{241}Am	2.66E-02	7.34E-04	7.34E-04	7.34E-04	7.34E-04	7.34E-04	7.75E-04	2.18E-04	2.18E-04
^{243}Am	2.66E-02	2.35E-07	2.35E-07	2.35E-07	2.35E-07	2.35E-07	2.48E-07	6.98E-08	6.98E-08
^{14}C	8.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
^{244}Cm	2.66E-02	4.56E-06	4.58E-06	4.56E-06	4.56E-06	4.56E-06	4.71E-06	1.36E-06	1.35E-06
^{135}Cs	no limit	9.16E-07	9.34E-07	9.16E-07	9.16E-07	9.16E-07	2.51E-06	2.72E-07	2.78E-07
^{137}Cs	1.00E+00	2.21E-01	2.25E-01	2.21E-01	2.21E-01	2.21E-01	6.04E-01	6.56E-02	6.70E-02
^{129}I	8.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
^{63}Ni	3.50E+00	1.83E+00	1.83E+00	1.83E+00	1.83E+00	1.83E+00	1.81E+00	5.42E-01	5.42E-01
^{237}Np	2.66E-02	1.87E-05	1.78E-05	1.88E-05	1.88E-05	1.88E-05	3.44E-06	5.59E-06	5.28E-06
^{238}Pu	2.66E-02	7.80E-05	7.79E-05	7.80E-05	7.80E-05	7.80E-05	8.05E-05	2.32E-05	2.32E-05
^{239}Pu	2.66E-02	1.90E-03	1.90E-03	1.90E-03	1.90E-03	1.90E-03	1.97E-03	5.65E-04	5.65E-04
^{240}Pu	2.66E-02	4.84E-04	4.83E-04	4.84E-04	4.84E-04	4.84E-04	5.00E-04	1.44E-04	1.44E-04
^{241}Pu	9.31E-01	5.41E-03	5.40E-03	5.41E-03	5.41E-03	5.41E-03	5.59E-03	1.61E-03	1.61E-03
^{226}Ra	no limit	7.20E-16	7.33E-16	7.21E-16	7.20E-16	7.21E-16	6.28E-13	2.14E-16	2.18E-16
^{106}Ru	7.00E+02	1.01E-10	1.03E-10	1.01E-10	1.01E-10	1.01E-10	8.81E-08	3.01E-11	3.06E-11
^{151}Sm	no limit	1.68E-03	1.71E-03	1.68E-03	1.68E-03	1.68E-03	1.46E+00	5.00E-04	5.08E-04
^{126}Sn	no limit	1.67E-06	1.70E-06	1.68E-06	1.67E-06	1.68E-06	1.46E-03	4.97E-07	5.06E-07


PHASED IMPLEMENTATION
136205N
576220E
136205N
576440E
TEMP. CONST. PARKING
135984 N
576075E
FACILITIES SITE (10 ACRES)
WATER SERVICE LINES
TRANSFER PIPING.
135875 N
576075E
(135875N, 576440E)
NEW ROAD.
FACILITIES SITE (10 ACRES)
TEMP. CONST. PARKING (100M x 100M)
E576574
POWER LINE
241 AP TANK FARM
135630N
576075E
(135600N, 57
135600N
576125E
ACCESS ROAD TO BE IMPROVED
E576000
N
135000 N

PHASED IMPLEMENTATION

Table . Non-Radiological Operating Emissions.
(Units as Indicated) (2 sheets)

Item	SEP/LLW	SEP/LLW + HLW
Particulates[2] (kg)	7.0E + 2	8.7E + 2
VOC[3] (kg)	215	220
Fugitive dust	n/a	n/a
TAPS[4] (state) (kg)		
HCl[5]	1.20 E + 2	1.21 E + 2
HF[5]	4.42E + 3	4.52E + 3
Ammonia[6]	1.22 E + 3	1.77E + 3
Nitric Acid[7]	1.00 E + 3	1.60 E + 3
HAPS (metals)[8]	< 100 Kg/yr	< 100 Kg/yr
NOx (as NO_2) (kg)	1.08 E + 4	1.09E + 4
SOx (as SO_2) (kg)	1.57 E + 4	1.58 E + 4
CO "	< 100,000 Kg/yr	< 100,000 Kg/yr

Note

These emissions were estimated using the same on-stream factor (60%) and average operating rate (60%) that the full scale operations used, and as such represent emissions over the operating period.

To estimate peak emissions when operating the facilities at 100% design capacity, multiply the emissions in this Table by a factor of 2.8.

D. Stein
10/23/95

Table . Non-Radiological Operating Emissions.
(Units as Indicated) (2 sheets)

Item	SEP/LLW	SEP/LLW + HLW
Particulates[2] (kg)	7.0E + 2	8.7E + 2
VOC[3] (kg)	215	220
Fugitive dust	n/a	n/a
TAPS[4] (state) (kg)		
HCl[5]	1.20 E + 2	1.21 E + 2
HF[5]	4.42E + 3	4.52E + 3
Ammonia[6]	1.22 E + 3	1.77E + 3
Nitric Acid[7]	1.00 E + 3	1.60 E + 3
HAPS (metals)[8]	< 100 Kg/yr	< 100 Kg/yr
NOx (as NO_2) (kg)	1.08E + 4	1.09E + 4
SOx (as SO_2) (kg)	1.57E + 4	1.58E + 4
CO "	< 100,000 Kg/yr	< 100,000 Kg/yr

Notes:

CO = carbon dioxide
H = hydrogen
F = fluorine
HWVP = Hanford Waste Vitrification Plant
J = joule
LLW = low-level waste
kg = kilogram
N = nitrogen
NOx = nitrogen oxide and nitrogen dioxide
S = sulfur
TAPS = Task Authorization and Planning System
VOC = volatile organic carbon

SEP/LLW → 20 MT/D glass product design
10 yrs operation

HLW → 1 MT/D glass product design
6 yrs operation

Table [illegible] Non-Radiological Operating Emissions.
(Units as Indicated) (2 sheets)

[2]Particulate emission estimate assumes cooling tower emissions are 95% of total particulate emissions (i.e. cooling tower emissions/0.95 = total emissions). Particulate emission are essentially 100% PM_{10}. Cooling tower emissions are a ratio of cooling water recirculation rates used for the alternatives. Emissions from standby power diesel engines, diesel tanks, and welding are all considered to result in emission of less than 100 kg/yr for the pollutants being analyzed.

[3]The VOC emissions shown are for kerosene handling and tankage activities assuming the use of an aboveground tank. VOC emissions from the main processes and other auxiliary sources are not currently defined. It is assumed that glycolic acid, if received, stored, and handled as a liquid, does not exhibit a significant vapor pressure, and if handled as a solid it is assumed to be controlled by filter media (i.e. baghouses, etc.) to less than 100 kg/yr.

[4]Emissions for TAP pollutants estimated to exceed 100 kg/yr are shown. Emissions from any single particulate source (silos, material handling, etc.) is considered to be controlled to a level that results in emissions below 100 kg/yr. Therefore, no particulate TAP emissions above 100 kg/yr are expected.

[5]The chlorine and fluorine emissions are expressed as HCl and HF, respectively (assumed chemical form). These emissions are based on the WHC material balances with an assumed decontamination factor of 200 for the venturi scrubber and mist eliminator.

[6]Ammonia slip from NOx control process. The ammonia emissions for Pretreatment/LLW is taken directly from the WHC material balances. The ammonia requirement for the 20 Mg/d joule-heated melter is based on assuming complete conversion of NOx precursors to NOx. The ammonia emissions for the 20 Mg/d joule-heated melter are based on a relative slip of 0.27% (in accordance with the material balance for Pretreatment/LLW).

[7]Nitric acid emissions are from decontamination activities where 100 kg/yr is estimated per melter plant.

[8]No HAPS metals will be emitted above 100 kg/yr. Appropriate NO_x abatement equipment will be installed to reduce the emission to below 40,000 kg/year.

[9]The ~~unmitigated~~ controlled NO_x emission ~~is [illegible]~~ as NO_2 is based on the ~~[illegible]~~ material balance. ~~characteristics of the melters~~

~~[10]The unmitigated SO_x emission is 9.7E+4 kg/year as SO_2.~~

[11]The unmitigated CO emission is ~~[illegible]~~ is based on the mass of CO from ~~Pretreatment/LLW~~ material balance ~~using a factor of [illegible] (to account for HEPA)~~. The flowsheets, at the present time, do not include abatement equipment for CO. Also it is assumed that the abatement equipment used for NO_x + SO_x does not effect CO, which it should. Therefore assuming less than 100,000 Kg/yr is justified.

PHASED IMPLEMENTATION

Table . Radiological Operating Emissions. (Ci)

Radionuclide[1]	SEP/LLW		SEP/LLW + HLW	
	Air[2]	Water[3]	Air[2]	Water
^{241}Am	3.26E-06	3.2E-5	1.44E-03	3.2E-5
^{14}C	4.0E+02	n/a	4.2E+02	n/a
^{137}Cs	1.87E-02	5.2E-3	1.04E+00	5.2E-3
^{129}I	1.16E+00	2.6E-5	1.18E+00	2.6E-5
$^{239,240}Pu$	7.90E-07	3.2E-5	1.58E-03	3.2E-5
^{106}Ru	n/a	n/a	n/a	n/a
^{151}Sm	n/a	n/a	n/a	n/a
^{90}Sr	7.20E-04	2.1E-4	1.60E+00	2.1E-4
^{99}Tc	9.83E-06	n/a	9.95E-05	n/a
^{93}Zr	n/a	n/a	n/a	n/a
%PM-10[5] (MT)	1.47E-02	—	1.51E-02	—

Notes:

[1]All values in Ci except for % PM-10 which is in metric tonnes

[2]Air values taken from material balances (Streams 907 and 917 in Appendix A)

[3]Water values are based on effluent streams from both Pretreatment/low-level waste (LLW) and high-level waste (HLW) flowsheets (Streams 807 and 802 respectively) and design basis for Liquid Effluent Treatment Facility (LETF) C-018. Yearly flowrates of these streams were calculated. Engineering judgement set the total amount of effluent to be processed by the LETF equal to 20% of the flow for all but one year of operation. For the last year, 100% was to be processed. The composition of the effluent was assumed to be comparable to the feed set in the design basis. Therefore the concentrations of radionuclides/chemicals in the discharge in the design sheet equals what the discharge would be for the process effluent. Ratio'd from Tri-Party Agreement (7.5% of Tri Party agreement for both cases)

	SEP/LLW	HLW	SEP/LLW + HLW
TAPs (Kg)			
Cl_2	2.33E+04	1.25E+02	
as HCl + $\frac{1}{200}$ factor	1.20E+02	6.43E−01	1.21E+02
F_2	8.40E+04	1.90E+03	
as HF + $\frac{1}{200}$ factor	4.42E+02	1.00E+01	4.52E+02
NH_3	1.22E+03	5.50E+02	1.77E+03
Nitric Acid	1.00E+03	6.00E+02	1.60E+03
NO	2.33E+02	3.00E+00	
NO_2	1.04E+04	1.30E+02	
(Kg) NO_x (as NO_2)	1.08E+04	1.35E+02	1.09E+04
(Kg) SO_x (as SO_2)	1.57E+04	1.40E+02	1.58E+04
VOC (Kg)	215	121	193 + 27 = 220
particulates (Kg)	7.0E+2	1.7E+2	8.7E+2
HAPS	<100 Kg/yr	<100 Kg/yr	<100 Kg/yr
CO	<100,000 Kg/yr	<100,000 Kg/yr	<100,000 Kg/yr
Fugitive dust	n/a	n/a	n/a
Thermal Releases (J)			

particulates LLW (1.5E+4) × $\frac{10yr}{16yr}$ × .075 = 7.0E+2

HLW (1.5E+4) × $\frac{6yr}{16yr}$ × .03 = 1.7E+2

VOC calc factors

40% WL @ 7.5% or 3% × yrs op. $\left(770\,Kg \times \frac{10yr}{16yr} \times .4\right) + \left(770 \times \frac{10}{16} \times .6 \times .075\right) = 215$ (193, 22)

40% SL @ same % × yrs op. $\left(770\,Kg \times \frac{6yr}{16yr} \times .4\right) + \left(770 \times \frac{6}{16} \times .6 \times .03\right) = 121$ (116, 5)

for Kg F_2 to Kg HF → $\frac{1}{38} \times 2 \times 20 = 1.0526$

factor for Kg Cl_2 to Kg HCl → $\frac{1}{71} \times 2 \times 36.5 = 1.0282$

	20
Cl_2	71
	36.5
NO	30
NO_2	46

Nitric Acid at 100 Kg/yr per melter plant

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Am 2.15E-14 LLW
4.35E-09
2.38E-13 HLW
4.81E-08

Total 5.24E-08 MCi or 5.24E-02 MCi

^{14}C 5.34E-03 MCi or 5.34E+03 Ci
^{129}I 1.60E-05 MCi 1.60E+01 Ci

5.3E+03 Ci for ^{14}C
1.6E+01 Ci for ^{129}I

^{14}C

for water take .075 of tri Party Agreement for both case

					Ci
LLW	Vitri	4.09E+01	MT	I_2 ⇒	1.16E+00
HLW	vitri	6.40E-01	MT	I_2 ⇒	1.81E-02
LLW+HLW					1.11E+00

Tri-Party Agreement LLW 5.45E+02 mT I_2
HLW 2.14E+01 mT I_2
→ Total 5.66E+02 mT I_2
equiv to
1.6E+01 Ci

∴ $\frac{4.09E+01 MT}{5.66E+02 MT} \times 1.6E+01 Ci = 1.16 Ci$

				C_{14}
	LLW	.075 ×	5.3E+03 Ci =	4.0E+02
LLW -	HLW	~~.03 ×~~	+5%	4.2E+0

Table 9-6. Radiological Operating Emissions. (Ci)

Radionuclide[1]	Tri-Party Agreement Preferred Alternative	
	Air[2]	Water[3]
^{241}Am	5.3E-02	4.2E-4
^{14}C	5.3E+03	n/a[4]
^{137}Cs	2.5E+01	6.9E-2
^{129}I	1.6E+01	3.5E-4
$^{239,240}Pu$	1.7E-02	4.2E-4
^{106}Ru	1.9E-08	1.0E-2
^{151}Sm	3.2E-01	NA
^{90}Sr	2.7E+01	2.8E-3
^{99}Tc	1.6E-02	n/a
^{93}Zr	1.8E-01	n/a
%PM-10[5]	2.67E-01	- -[6]

Notes:

[1]All values in Ci except for % PM-10 which is in metric tonnes

[2]Air values taken from material balances (Streams 907 and 917 in Appendix A)

[3]Water values are based on effluent streams from both Pretreatment/low-level waste (LLW) and high-level waste (HLW) flowsheets (Streams 807 and 802 respectively) and design basis for Liquid Effluent Treatment Facility (LETF) C-018. Yearly flowrates of these streams were calculated. Engineering judgement set the total amount of effluent to be processed by the LETF equal to 20% of the flow for all but one year of operation. For the last year, 100% was to be processed. The composition of the effluent was assumed to be comparable to the feed set in the design basis. Therefore the concentrations of radionuclides/chemicals in the discharge in the design sheet equals what the discharge would be for the process effluent.

Table 9-5. Non-Radiological Operating Emissions.
(Units as Indicated) (2 sheets)

Item	Tri-Party Agreement Preferred Alternative
Thermal releases[1] (J)	2.1E+16
Particulates[2] (kg)	1.5E+4
VOC[3] (kg)	770
Fugitive dust	n/a
TAPS[4] (state) (kg)	
HCl[5]	2.6E+3
HF[6]	6.1E+3
Ammonia[7]	2.4E+4
Nitric Acid[8]	1.4E+3
HAPS (metals)[9]	<100 kg/yr
NOx (as NO_2) (kg)	1.1E+4[9]
SOx (as SO_2) (kg)	1.5E+4[10]
CO	<100,000 kg/yr[11]

Notes:

CO = carbon dioxide
H = hydrogen
F = fluorine
HWVP = Hanford Waste Vitrification Plant
J = joule
LLW = low-level waste
kg = kilogram
N = nitrogen
NOx = nitrogen oxide and nitrogen dioxide
S = sulfur
TAPS = Task Authorization and Planning System
VOC = volatile organic carbon

[1]Derived from factoring the heat load.

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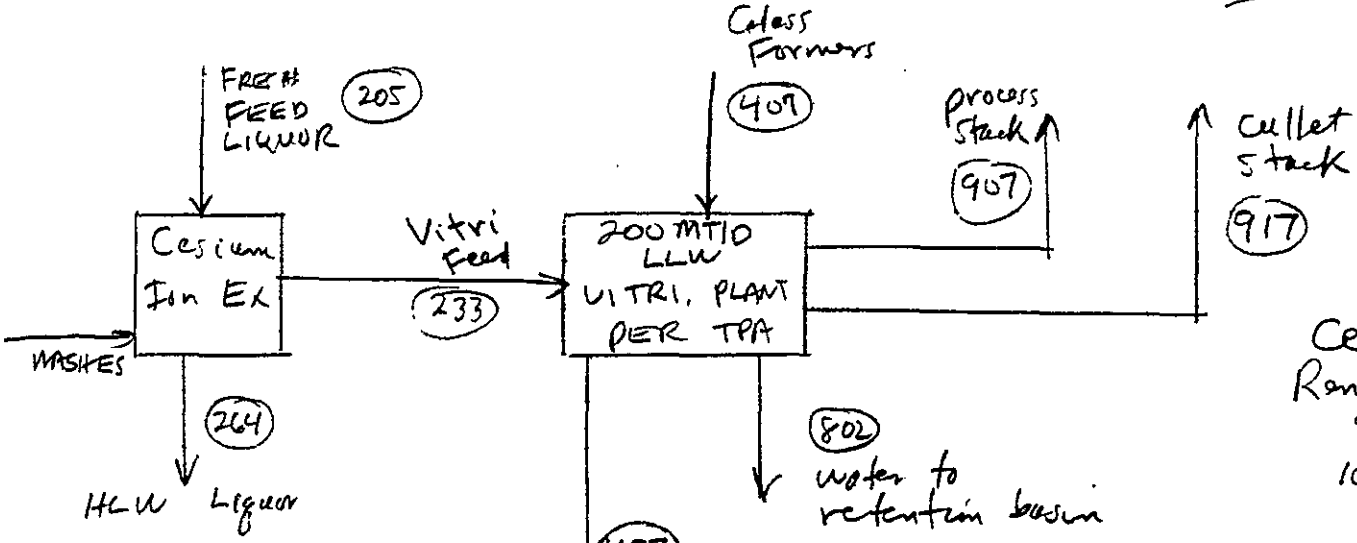
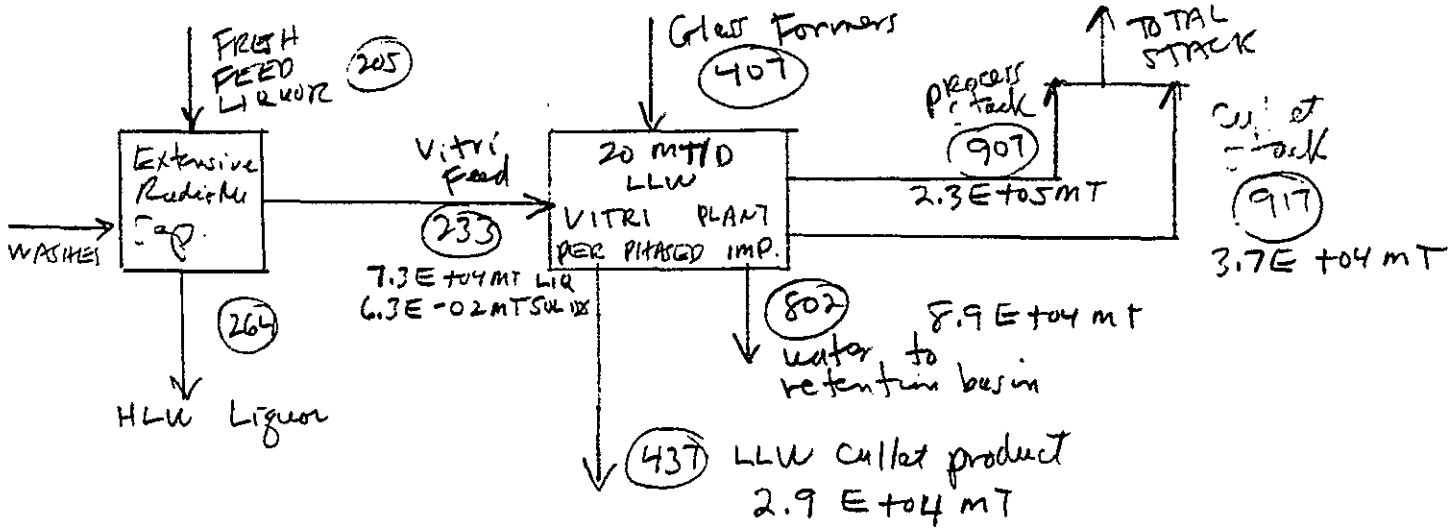


Cesium IX Removes
99% Cs + Ba
10% Sr + Y
0% other
96.3% total

LLW SEP. + Vitri per TPA
(Ex Situ Inter. Sep)



Basis

LLW Vitri PER PHASED IMP.

20 MT/D DESIGN PRODUCTION FOR 10 yrs OPERATION EQUALS 7.3E+04 MT, but assuming the same 60% capacity operation and 60% on stream yields 2.6E+04 MT which is approximately 7.5%. This 7.5% factor on flow streams will be applied to estimate emissions and material uses from 200 MT/D LLW vitri/sep. per TPA. Exceptions are extensive radionuclide removal in phased imp. In addition to 99% Cs removal in TPA, remove additionally 99% Tc, Sr, + TRU per extensive radionuclide sep. These mass numbers are shown above + in attached mass balance formes.

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If 20 MT/D for 10 yrs with no downtime or reduced capacity multiply these numbers by 2.5.

LLW VITRIFICATION (20 MT/D)

separate HLW to storage

Stream Name / Liquid Component	FEED 233	LLW CULLET 437	WATER TO BASIN 802	PROCESS STACK 907	CULLET STACK 917	TOTAL STACK EMISSIONS -	905	906	907	908	264
Cs and Ba, (MCi)	3.7E-02										
Sr and Y, (MCi)	1.4E-03										
Tc, (MCi)	2.0E-05										
Am, (MCi)	6.5E-06										
Np, (MCi)	7.7E-09										
Pu-239, (MCi)	1.3E-06										
Pu-240, (MCi)	3.1E-07										
Pu-241, (MCi)	1.1E-06										
Total TRU, (MCi)	9.2E-06										
Total MCi	1.8E-03										
Total Mass Flow, (MT)	7.3E+04	—	8.90E+04	2.3E+05	3.7E+04	2.67E+05	2.07E-01	2.07E-01	3.05E+06		3.61E+0
Total Cr, (MT)											
Total Na, (MT)											
Total Si, (MT)											
Total P, (MT)											
Total NO2-, (MT)											
Total NO3-, (MT)				1.54E+00		1.54E+00			2.05E+01		
AG+											
AL(OH)4-											
AM+3											
AS+5											
B+3											
BA+2											
BE+2											
BI+3											
C14											
CA+2											
CD+2											
CE+3											
CL-											
CL2				2.33E+01		2.33E+01			3.10E+02		
CO				1.76E+02		1.76E+02			2.35E+03		
CO2				1.42E+04		1.42E+04			1.89E+05		
CO3-2											
CR(OH)4-											
CS+											
CU+2											
DPCD											
F-											
F2				8.40E+01		8.40E+01			1.12E+03		
FE+3											
H+				2.50E-02		2.50E-02			3.33E-01		
H2											
H2O			8.90E+04	4.37E+03		4.37E+03	2.07E-01	2.07E-01	5.83E+04		
H2S											
HG											

LLW VITR (20MT/D)

Stream Name / Liquid Component	233	437	802	907	917	TOTAL STACK		906	907	908
HG+2										
I-										
I2				4.09E+01		4.09E+01			5.45E+02	
K+										
KEROSENE										
LA+3										
LI+										
MG+2										
MNO2										
MO+6										
N2				1.66E+05	2.89E+04	1.95E+05			2.21E+06	
NA+										
NH3				1.22E+00		1.22E+00			1.63E+01	
NI+3										
NO				2.33E-01		2.33E-01			3.11E+00	
NO2				1.04E+01		1.04E+01			1.39E+02	
NO2-										
NO3-				1.54E+00		1.54E+00			2.05E+01	
NP+4										
O2				4.41E+04	7.65E+03	5.22E+04			5.95E+05	
OH-										
OLIGIMER										
PB+4										
PO4-3										
POLY										
PU+4										
S										
SI+4										
SO2				1.57E+01		1.57E+01			2.09E+02	
SO4-2										
SR+2										
TCO2										
TCO4-										
TOC										
UO2+2										
V+5										
W+6										
ZN+2										
ZR+4										
ZRO2:2H2										

LLW Vitr. (20 MTD)

Stream Name / Solid Component	733	737	802	907	917	TOTAL STACK	905	906	907	908
Cs and Ba, (MCi)	-	3.70E-02		9.23E-14	1.87E-08	1.87E-08	2.47E-09	2.47E-09	1.23E-12	
Sr and Y, (MCi)		1.43E-03		3.56E-15	7.20E-10	7.20E-10	9.48E-09	9.48E-09	4.74E-12	
Tc, (MCi)		1.94E-05		4.86E-17	9.83E-12	9.83E-12	1.30E-10	1.30E-10	6.48E-13	
Am, (MCi)		6.45E-06		1.61E-17	3.26E-12	3.26E-12	4.30E-11	4.30E-11	2.15E-14	
Np, (MCi)		7.7E-09		1.94E-20	3.91E-15	3.91E-15	5.15E-14	5.16E-14	2.58E-17	
Pu-239, (MCi)		1.25E-06		3.13E-18	6.33E-13	6.33E-13	8.34E-12	8.34E-12	4.17E-15	
Pu-240, (MCi)		3.11E-07		7.73E-19	1.57E-13	1.57E-13	2.07E-12	2.07E-12	1.03E-15	
Pu-241, (MCi)		1.11E-06		2.78E-18		2.78E-18	7.42E-12	7.42E-12	3.71E-15	
Total TRU, (MCi)		9.15E-06		2.28E-17	4.06E-12	4.06E-12	6.09E-11	6.09E-11	3.04E-14	
Total MCi		3.84E-02		9.59E-14	1.94E-08	1.94E-08	1.21E-08	1.21E-08	6.07E-12	
Total Mass Flow, (MT)	6.3E-02	2.9E+04		7.88E-08	1.47E-02	1.47E-02	2.09E-03	2.09E-03	1.05E-06	
Total Cr, (MT)							7.77E-07	7.77E-07	3.89E-10	
Total Na, (MT)							3.88E-04	3.88E-04	1.94E-07	
Total Si, (MT)							5.77E-04	5.77E-04	2.89E-07	
Total P, (MT)							7.29E-06	7.29E-06	3.65E-09	
Total NO2-, (MT)										
Total NO3-, (MT)										
AG+										
AG2O							1.76E-09	1.76E-09	8.79E-13	
AL+3										
AL2O3							1.05E-04	1.05E-04	5.23E-08	
AM+3										
AM2O3							1.38E-11	1.38E-11	6.89E-15	
AS+5										
AS2O5							5.89E-09	5.89E-09	2.95E-12	
B+3										
B2O3							8.34E-09	8.34E-09	4.17E-12	
BA+2										
BAO							4.41E-09	4.41E-09	2.20E-12	
BE+2										
BEO							1.13E-09	1.13E-09	5.67E-13	
BI+3										
BI2O3							3.76E-07	3.76E-07	1.88E-10	
C14										
CA+2										
CANCRINI										
CAO							2.09E-04	2.09E-04	1.05E-07	
CD+2										
CDO							1.19E-08	1.19E-08	5.95E-12	
CE+3										
CE2O3							1.39E-08	1.39E-08	6.97E-12	
CL-										
CO3-2										
CR+3										
CR2O3				4.3E-11	7.95E-06	7.95E-06	1.14E-06	1.14E-06	5.68E-10	
CS+										

LLW Vitri (20 MT/D)

Stream Name / Solid C	233	437	802	907	917	TOTAL STACK	905	906	907	908
CS2O							3.41E-11	3.41E-11	1.71E-14	
CU										
CU+2										
CUO							1.11E-09	1.11E-09	5.53E-13	
CUSO4										
F-										
FE+3										
FE2O3							1.03E-07	1.03E-07	5.14E-11	
HG+2										
I-										
K+										
K2O							1.33E-09	1.32E-09	6.62E-13	
LA+3										
LA2O3							1.29E-09	1.29E-09	6.45E-13	
LI+										
LI2O							6.20E-11	6.20E-11	3.10E-14	
MG+2										
MGO							7.99E-09	7.99E-09	4.00E-12	
MNO2				4.1E-12	8.18E-07	8.18E-07	1.08E-07	1.08E-07	5.41E-11	
MO+6										
MOO3							3.64E-08	3.64E-08	1.82E-11	
NA+										
NA2O							5.23E-04	5.23E-04	2.62E-07	
NI+3										
NI2FECN6										
NI2O3				1.1E-12	2.17E-07	2.17E-07	2.86E-08	2.86E-08	1.43E-11	
NIO							7.48E-11	7.48E-11	3.74E-14	
NO2-										
NO3-										
NP+4										
NPO2							8.29E-11	8.29E-11	4.15E-14	
OH-										
P2O5							1.67E-05	1.67E-05	8.35E-09	
P2O5:24W										
PB+4										
PBO2							1.13E-08	1.13E-08	5.65E-12	
PO4-3										
POLY										
PU+4										
PUO2							1.63E-10	1.63E-10	8.15E-14	
S										
SI+4										
SIO2							1.24E-03	1.24E-03	6.18E-07	
SO4-2										
SR+2										
SRO							2.00E-09	2.00E-09	1.00E-12	

LLW Vitr. (20 MT/D)

Stream Name / Solid Component	233	437	802	907	917	TOTAL STACK	905	906	907	908
TC2O7							1.20E-08	1.20E-08	3.93E-12	
TCO4-										
TOC										
UO2+2										
UO3							4.51E-07	4.51E-07	2.26E-10	
V+5										
V2O5							5.52E-10	5.52E-10	2.76E-13	
WO2							1.45E-13	1.45E-13	7.27E-17	
WO3							4.70E-09	4.70E-09	2.35E-12	
ZN+2										
ZNO							2.23E-08	2.23E-08	1.12E-11	
ZR+4										
ZRO2							3.25E-09	3.25E-09	1.62E-12	
ZRO2:2H2										

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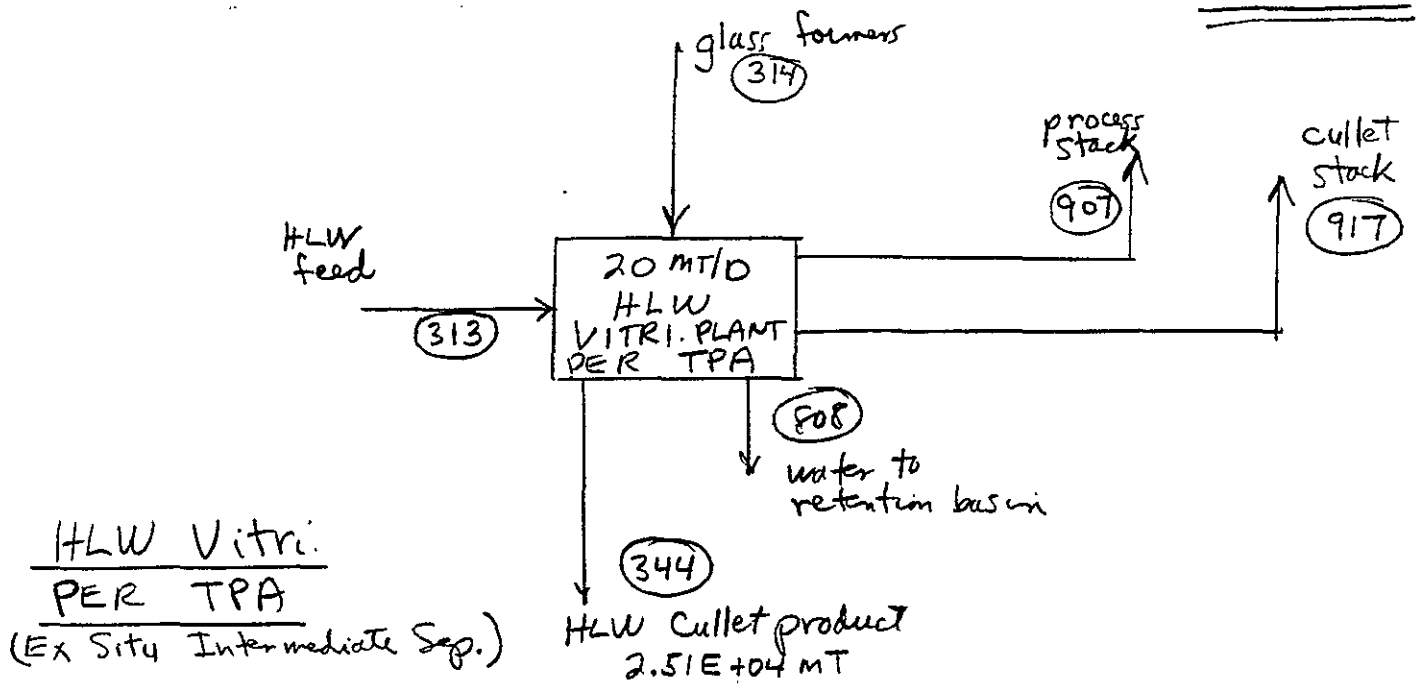

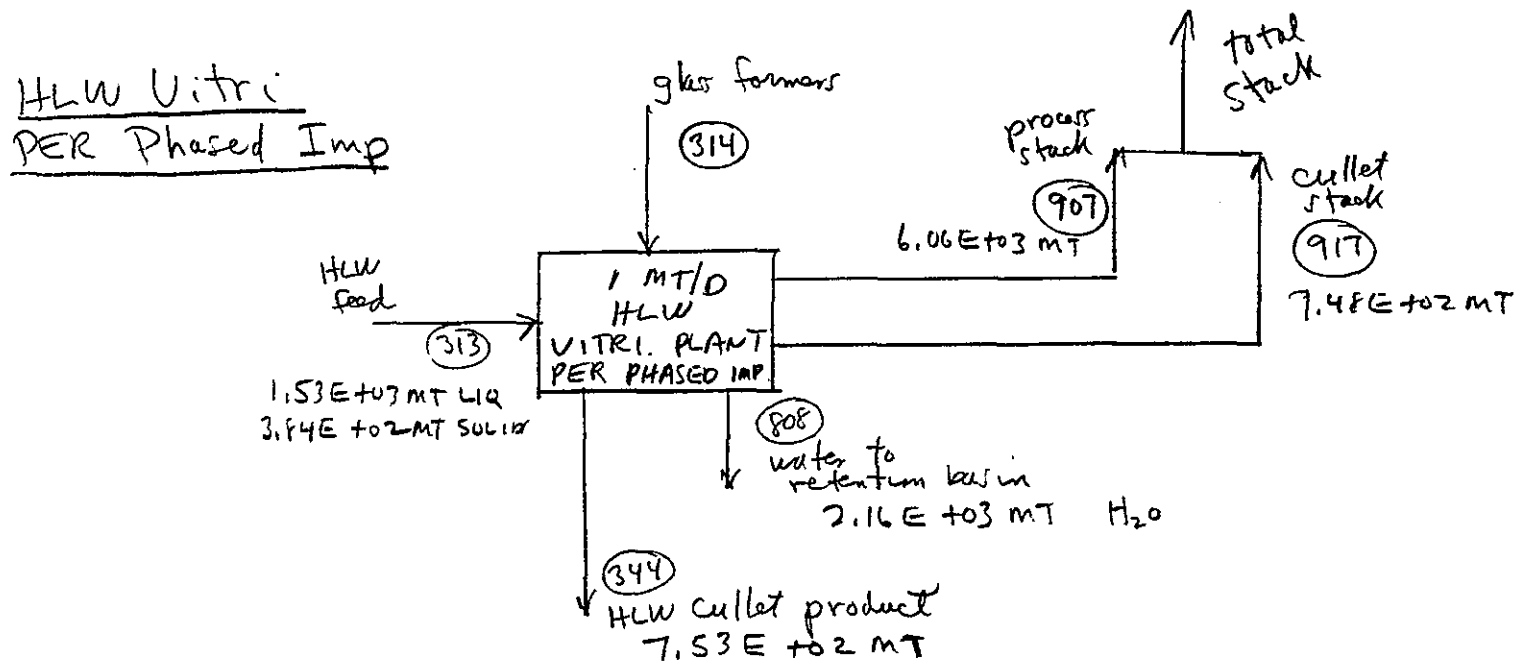

Basis 1 MT/D DESIGN PRODUCTION FOR 6 yrs OPERATION EQUALS 2.19E+03 MT, but assuming the same 60% capacity operation and 60% on stream yields 7.88E+02 MT which is approximately 3%. This 3% factor on flow streams will be applied to estimate emissions and material uses from 20 MT/D HLW VITRI per TPA. These mass numbers are shown above. and in attached mass balance forms.

If 1 MT/D for 6 yrs with no downtime or reduced capacity, multiply These numbers by 2.9.

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HLW VITRIFICATION (1 MT/D)

Stream Name / Liquid Components	FEED 313	HLW CULLET 344	WATER TO BASIN 808	PROCESS STACK 907	CULLET STACK 917	TOTAL STACK EMISSIONS	905	906	907	908
Cs and Ba, (MCi)										
Sr and Y, (MCi)										
Tc, (MCi)										
Am, (MCi)										
Np, (MCi)										
Pu-239, (MCi)										
Pu-240, (MCi)										
Pu-241, (MCi)										
Total TRU, (MCi)										
Total MCi										
Total Mass Flow, (MT)	1.53E+03		2.16E+03	6.06E+03	9.48E+02	7.00E+03	2.07E-01	2.07E-01	3.05E+06	
Total Cr, (MT)										
Total Na, (MT)										
Total Si, (MT)										
Total P, (MT)										
Total NO2-, (MT)										
Total NO3-, (MT)									2.05E+01	
AG+										
AL(OH)4-										
AM+3										
AS+5										
B+3										
BA+2										
BE+2										
BI+3										
C14										
CA+2										
CD+2										
CE+3										
CL-										
CL2				1.25E-01		1.25E-01			3.10E+02	
CO				6.09E+00		6.09E+00			2.35E+03	
CO2				5.07E+02		5.07E+02			1.89E+05	
CO3-2										
CR(OH)4-										
CS+										
CU+2										
DPCD										
F-										
F2				1.9E+00		1.90E+00			1.12E+03	
FE+3										
H+									3.33E-01	
H2										
H2O			2.16E+03	9.4E+01		9.40E+01	2.07E-01	2.07E-01	5.83E+03	
H2S										
HG										

HLW. VITR. (1 MT/D)

Stream Name Liquid Components	313	344	818	907	917	TOTAL STACK EMISSIONS		906	907	908
HG+2										
I-										
I2				6.4E-01		6.40E-01			5.45E+02	
K+										
KEROSENE										
LA+3										
LI+										
MG+2										
MNO2										
MO+6										
N2				4.3E+03	7.50E+02	5.05E+03			2.21E+06	
NA+										
NH3				5.5E-01		5.50E-01			1.63E+01	
NI+3										
NO				3.0E-03		3.00E-03			3.11E+00	
NO2				1.3E-01		1.30E-01			1.39E+02	
NO2-										
NO3-									2.05E+01	
NP+4										
O2				1.2E+03	1.99E+02	1.40E+03			5.95E+05	
OH-										
OLIGIMER										
PB+4										
PO4-3										
POLY										
PU+4										
S										
SI+4										
SO2				1.4E-01		1.40E-01			2.09E+02	
SO4-2										
SR+2										
TCO2										
TCO4-										
TOC										
UO2+2										
V+5										
W+6										
ZN+2										
ZR+4										
ZRO2:2H2										

HLW Vitr. (1 MTID)

Stream Name / Solid Component	313	344	808	907	917	TOTAL STACK EMISSIONS	905	906	907	908
CS2O				7.20E-14			3.41E-11	3.41E-11	1.71E-14	
CU										
CU+2										
CUO				7.02E-14			1.11E-09	1.11E-09	5.53E-13	
CUSO4										
F-										
FE+3										
FE2O3				9.81E-11			1.03E-07	1.03E-07	5.14E-11	
HG+2										
I-										
K+										
K2O				1.90E-12			1.33E-09	1.32E-09	6.62E-13	
LA+3										
LA2O3				1.85E-12			1.29E-09	1.29E-09	6.45E-13	
LI+										
LI2O				4.08E-11			6.20E-11	6.20E-11	3.10E-14	
MG+2										
MGO				1.41E-12			7.99E-09	7.99E-09	4.00E-12	
MNO2				1.69E-11	3.18E-06	3.18E-06	1.08E-07	1.08E-07	5.41E-11	
MO+6										
MOO3				9.12E-14			3.64E-08	3.64E-08	1.82E-11	
NA+										
NA2O				2.54E-10			5.23E-04	5.23E-04	2.62E-07	
NI+3										
NI2FECN6										
NI2O3				6.96E-13	1.41E-07	1.41E-07	2.86E-08	2.86E-08	1.43E-11	
NIO				1.84E-11			7.48E-11	7.48E-11	3.74E-14	
NO2-										
NO3-										
NP+4										
NPO2				1.12E-14			8.29E-11	8.29E-11	4.15E-14	
OH-										
P2O5				5.04E-11			1.67E-05	1.67E-05	8.35E-09	
P2O5:24W										
PB+4										
PBO2				2.84E-13			1.13E-08	1.13E-08	5.65E-12	
PO4-3										
POLY										
PU+4										
PUO2				3.63E-14			1.63E-10	1.63E-10	8.15E-14	
S										
SI+4				1.01E-09						
SIO2							1.24E-03	1.24E-03	6.18E-07	
SO4-2										
SR+2										
SRO				3.21E-12			2.00E-09	2.00E-09	1.00E-12	

HLW Vitr. (MTD)

Stream Name / Solid Component	313	314	808	907	917	Total	905	906	907	908
TC2O7				4.68E-14			1.20E-08	1.20E-08	3.98E-12	
TCO4-										
TOC										
UO2+2										
UO3				1.36E-10			4.51E-07	4.51E-07	2.26E-10	
V+5										
V2O5				2.52E-14			5.52E-10	5.52E-10	2.76E-13	
WO2				3.30E-14			1.45E-13	1.45E-13	2.27E-17	
WO3				1.55E-16			4.70E-09	4.70E-09	2.35E-12	
ZN+2										
ZNO				8.91E-14			2.23E-08	2.23E-08	1.17E-11	
ZR+4										
ZRO2				5.58E-11			3.25E-09	3.25E-09	1.62E-12	
ZRO2:2H2										

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING, Ex Situ/In Situ Combination Alternative Tank Farm Area Ratios and Inventory Estimates for Ex Situ/In Situ.

ORIGINATOR Colin Henderson DATE 11/15/95

REVISION NO. 0

OBJECTIVE Use the available tank by tank inventory & Develop the Ex Situ/In Situ inventory that would be retrieved and the inventory left behind (in situ) for the Ex Situ/In Situ alternative

METHODOLOGY Using the tanks selected for retrieval (other analysis) sum up the inventory by Aggregated Source (used for groundwater modeling). Need Inventory recovered, Retrieval leakage for SSTs, and the In Situ + Residual Inventory.

ASSUMPTIONS 1) Used Tank by Tank Chem & Radiological Data

2) Back Calculated the DST Rad Components from 12/31/99 to 12/31/95 w/o progeny.

3) Assumed that the residual (1%) from the tanks that were retrieved + the inventory in the tanks not retrieved was combined and the surface area for water infiltration was the area ratio of the tanks left for in situ filled cap to the total tank farm.

(Continue on another sheet if necessary)

Colin Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT Sel Ret Area Ratios SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

SELECTIVE RERIEVAL AREAS:

1WSS = 40 TANKS TOTAL

12 TANKS SELECTED FOR RETRIEVED

28 TANKS LEFT FOR FILL & CAP

AREA RATIO = 28/40 = 70 %

2WSS = 43 TANKS TOTAL
15 TANKS TO BE RETRIEVED
28 TANKS TO BE FILLED & CAPPED

AREA RATIO = 28/43 = 65%

1ESS = 40 TANKS TOTAL
23 TANKS RETRIEVED
17 TANKS Left for fill & CAP

AREA Ratio = 42.5%.

2ESS = 16 TANKS TOTAL
6 TANKS RETRIEVED

AREA RATIO 10/16 = 62.5%

4 ESS = 10 TANKS
4 TANKS RETRIEVED

AREA RATIO = 6/10 = 60%

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT Sel Ret Area Ratios SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

Pg 2

3WDS = 3 TANKS
2 TANKS Retrieved

Area Ratio = 1/3 = 33.3%

3EDS = 11 TANKS TOTAL
7 TANKS Retrieved

Area Ratio = 4/11 = 36%

5EDS = 14 TANKS TOTAL
1 TANK Ret

Area Ratio = 13/14 = 93%.

FORM 91 305-1 (4/81)

Table ~~A.8~~ SST Chemical Inventory by Tank Group

TABLE SST.1 pg 1

Metric tons.

COMBINED INVENTORY OF TANKS NOT RETRIEVED + 1% RESIDUALS						
Chemical	1WSS	2WSS	1ESS	2ESS	4ESS	Total
Number of Tank	4.00E+01	4.30E+01	4.00E+01	1.60E+01	1.00E+01	1.49E+02
Al(OH)4-	8.44E+01	3.89E+02	1.35E+02	5.28E+01	8.09E+00	6.69E+02
Al+3	1.32E+01	1.97E+02	1.22E+02	1.20E+01	6.41E+00	3.50E+02
Bi+3	9.90E+01	3.30E-02	3.12E+01	5.95E-01	0.00E+00	1.31E+02
CO3-2	1.59E+02	1.32E+01	1.81E+02	1.01E+01	2.19E+00	3.66E+02
Ca+2	1.98E-01	5.81E+00	4.26E+00	6.56E+01	1.49E+00	7.74E+01
Cd+2	3.61E-01	7.56E-02	5.65E-01	1.98E-02	5.40E+00	6.42E+00
Ce+3	5.31E+01	1.44E+01	1.87E+01	2.64E-01	2.65E-01	8.68E+01
Cl-	6.88E+00	1.21E+00	4.36E+00	4.01E-02	9.93E-03	1.25E+01
Cr+3	6.60E-01	4.15E+01	2.72E-01	1.27E-01	7.95E-01	4.34E+01
CrO4-2	1.64E-01	1.03E+01	6.74E-02	3.16E-02	1.97E-01	1.07E+01
F-	2.44E+01	7.83E+00	6.92E+01	8.25E+00	1.27E-01	1.10E+02
Fe+3	7.88E+01	2.82E+01	4.22E+01	1.58E+01	2.45E+01	1.90E+02
Fe(CN)6-4	1.58E-01	6.26E-01	2.97E+01	6.99E+01	5.10E-02	1.00E+02
Hg+	8.44E-02	1.78E-02	1.33E-01	4.64E-03	1.27E-02	2.53E-01
Mn+4	1.05E+01	2.85E+00	3.92E+00	1.12E+00	5.44E+00	2.38E+01
Na+	3.50E+03	9.69E+03	3.46E+03	1.09E+02	1.39E+02	1.69E+04
Ni+2	1.63E+00	1.36E+00	1.37E+01	3.31E+01	3.89E-01	5.01E+01
NO2-	2.56E+02	2.18E+02	3.95E+02	4.70E-01	5.06E+01	9.20E+02
NO3-	6.24E+03	1.96E+04	5.10E+03	1.58E+01	1.99E+02	3.11E+04
OH-	2.22E+02	1.15E+03	2.73E+02	1.75E+02	4.01E+01	1.86E+03
PO4-3	1.24E+03	3.07E+01	6.63E+02	1.45E+01	2.04E-01	1.95E+03
SiO3-	1.17E+02	1.92E+02	3.60E+01	7.02E-01	6.08E-01	3.46E+02
SO4-2	1.57E+02	3.50E+01	1.63E+02	4.67E+00	2.69E+00	3.62E+02
Sr+2	3.00E-05	4.19E-03	4.38E+00	2.48E-02	1.39E-03	4.41E+00
W+4	1.43E+00	2.85E-01	2.14E+00	7.46E-02	2.03E-01	4.13E+00
Zr+4	5.85E+00	1.71E+00	3.17E+00	6.57E+00	3.88E-02	1.73E+01

Table A.8 SST Chemical Inventory by Tank Group

TABLE SST. 2 Pg 1

SOLUBILITY OF TANKS LEFT IN PLACE + 1% RESIDUALS					
SOLUBILITY IN GRAMS/LITER					
Chemical	1WSS	2WSS	1ESS	2ESS	4ESS
Number of Tanks					
Al(OH)4-	4.87E+00	7.15E+00	9.54E+00	1.20E+03	1.46E+01
Al+3	7.64E-01	3.63E+00	8.58E+00	2.73E+02	1.16E+01
Bi+3	5.71E+00	6.08E-04	2.20E+00	1.36E+01	0.00E+00
CO3-2	9.17E+00	2.42E-01	1.28E+01	2.31E+02	3.95E+00
Ca+2	1.15E-02	1.07E-01	3.01E-01	1.50E+03	2.69E+00
Cd+2	2.08E-02	1.39E-03	3.99E-02	4.52E-01	9.76E+00
Ce+3	3.07E+00	2.66E-01	1.32E+00	6.03E+00	4.78E-01
Cl-	3.97E-01	2.23E-02	3.07E-01	9.16E-01	1.79E-02
Cr+3	3.81E-02	7.64E-01	1.92E-02	2.91E+00	1.44E+00
CrO4-2	9.45E-03	1.89E-01	4.75E-03	7.21E-01	3.56E-01
F-	1.41E+00	1.44E-01	4.88E+00	1.88E+02	2.29E-01
Fe+3	4.55E+00	5.18E-01	2.98E+00	3.60E+02	4.43E+01
Fe(CN)6-4	9.14E-03	1.15E-02	2.09E+00	1.60E+03	9.21E-02
Hg+	4.87E-03	3.27E-04	9.39E-03	1.06E-01	2.29E-02
Mn+4	6.04E-01	5.24E-02	2.76E-01	2.57E+01	9.82E+00
Na+	2.02E+02	1.78E+02	2.44E+02	2.48E+03	2.51E+02
Ni+2	9.38E-02	2.51E-02	9.64E-01	7.55E+02	7.03E-01
NO2-	1.48E+01	4.00E+00	2.79E+01	1.07E+01	9.15E+01
NO3-	3.60E+02	3.60E+02	3.60E+02	3.60E+02	3.60E+02
OH-	1.28E+01	2.11E+01	1.93E+01	4.00E+03	7.23E+01
PO4-3	7.18E+01	5.64E-01	4.68E+01	3.30E+02	3.68E-01
SiO3-	6.75E+00	3.53E+00	2.54E+00	1.60E+01	1.10E+00
SO4-2	9.08E+00	6.45E-01	1.15E+01	1.07E+02	4.85E+00
Sr+2	1.73E-06	7.72E-05	3.09E-01	5.66E-01	2.51E-03
W+4	8.25E-02	5.24E-03	1.51E-01	1.70E+00	3.66E-01
Zr+4	3.37E-01	3.15E-02	2.23E-01	1.50E+02	7.00E-02

TABLE SST.3 PG 1

~~Table A.7~~

SST Radionuclide Inventory by Tank Group

COMBINED INVENTORY OF REMAINING TANKS + 1% RESIDUALS						
Inventory in GRAMS						
SST group	1WSS	2WSS	1ESS	2ESS	4ESS	Total
Number of Tank	40	43	40	16	10	149
Ac-225	1.04E-11	2.73E-11	1.48E-11	1.06E-11	2.31E-12	6.55E-11
Ac-227	9.59E-06	6.34E-06	1.29E-05	1.99E-06	1.26E-06	3.21E-05
Am-241	5.67E+01	7.21E+02	1.02E+02	8.84E+01	1.73E+02	1.14E+03
Am-242	3.15E-05	5.41E-04	9.59E-05	6.03E-05	1.44E-04	8.72E-04
Am-242m	2.63E-02	4.50E-01	7.98E-02	5.02E-02	1.20E-01	7.26E-01
Am-243	6.50E-01	6.83E+00	2.16E+00	1.30E+00	3.27E+00	1.42E+01
At-217	3.74E-19	9.85E-19	5.35E-19	3.81E-19	8.34E-20	2.36E-18
Ba-137m	2.60E-04	8.49E-04	6.53E-04	9.79E-05	1.01E-04	1.96E-03
Bi-210	1.46E-14	3.34E-14	9.71E-15	1.00E-14	9.17E-15	7.69E-14
Bi-211	1.66E-12	1.10E-12	2.23E-12	3.45E-13	2.18E-13	5.55E-12
Bi-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bi-213	4.37E-11	1.15E-10	6.24E-11	4.44E-11	9.72E-12	2.75E-10
Bi-214	1.74E-16	4.11E-16	1.07E-16	8.43E-17	5.91E-17	8.35E-16
C-14	8.74E+00	1.03E+01	2.55E+01	2.21E+00	4.86E+00	5.17E+01
Cm-242	6.37E-05	1.09E-03	1.94E-04	1.22E-04	2.91E-04	1.76E-03
Cm-244	8.20E-03	1.68E-02	4.07E-02	1.34E-02	4.08E-02	1.20E-01
Cm-245	2.64E-04	5.71E-04	1.47E-03	4.79E-04	1.47E-03	4.26E-03
Cs-135	4.00E+03	9.71E+03	5.26E+03	6.34E+02	5.85E+02	2.02E+04
Cs-137	1.71E+03	5.58E+03	4.29E+03	6.43E+02	6.66E+02	1.29E+04
Fr-221	3.40E-15	8.96E-15	4.86E-15	3.46E-15	7.58E-16	2.14E-14
Fr-223	2.48E-13	1.64E-13	3.33E-13	5.15E-14	3.25E-14	8.29E-13
I-129	1.76E+03	2.29E+03	3.61E+03	2.08E+02	3.51E+02	8.22E+03
Nb-93m	4.45E-02	1.05E+00	8.62E-02	1.11E-01	1.55E+00	2.85E+00
Ni-59	0.00E+00	2.12E+04	4.12E+04	0.00E+00	0.00E+00	6.24E+04
Ni-63	3.55E+01	4.55E+02	9.29E+01	7.71E+01	3.28E+02	9.89E+02
Np-237	2.00E+03	2.70E+03	5.63E+03	3.77E+02	1.50E+02	1.09E+04
Np-238	6.31E-09	6.21E-08	1.56E-08	8.21E-09	3.35E-08	1.26E-07
Np-239	5.59E-07	5.86E-06	1.86E-06	1.12E-06	2.82E-06	1.22E-05
Pa-231	2.30E-02	1.71E-02	3.03E-02	5.86E-03	4.08E-03	8.04E-02
Pa-233	6.79E-05	9.17E-05	1.91E-04	1.28E-05	5.11E-06	3.69E-04
Pa-234	6.69E-07	1.14E-06	9.51E-07	6.82E-07	2.33E-07	3.68E-06
Pa-234m	1.21E-08	2.07E-08	1.72E-08	1.24E-08	4.23E-09	6.67E-08
Pb-209	1.31E-11	3.46E-11	1.88E-11	1.34E-11	2.92E-12	8.27E-11
Pb-210	2.37E-11	5.43E-11	1.58E-11	1.62E-11	1.49E-11	1.25E-10
Pb-211	2.81E-11	1.86E-11	3.78E-11	5.84E-12	3.69E-12	9.40E-11
Pb-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pb-214	2.33E-16	5.53E-16	1.43E-16	1.13E-16	7.93E-17	1.12E-15
Pd-107	3.16E+03	3.97E+03	6.44E+03	3.96E+02	7.00E+02	1.47E+04
Po-210	4.02E-13	9.22E-13	2.68E-13	2.87E-13	2.64E-13	2.14E-12
Po-211	1.63E-17	3.99E-17	2.09E-17	7.48E-18	3.06E-18	8.76E-17
Po-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE SST. 3 PG 2

~~Table A.7~~

SST Radionuclide Inventory by Tank Group

Po-213	4.69E-23	1.23E-22	6.68E-23	4.76E-23	1.04E-23	2.95E-22
Po-214	2.37E-23	5.63E-23	1.46E-23	1.16E-23	8.08E-24	1.14E-22
Po-215	2.35E-17	1.55E-17	3.16E-17	4.89E-18	3.09E-18	7.86E-17
Po-216	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-218	2.70E-17	6.41E-17	1.66E-17	1.31E-17	9.20E-18	1.30E-16
Pu-238	2.45E+00	7.39E+00	1.45E+00	1.39E+00	4.40E+00	1.71E+01
Pu-239	9.86E+03	2.33E+04	7.41E+03	7.85E+03	1.54E+04	6.38E+04
Pu-240	4.54E+02	1.39E+03	4.00E+02	5.18E+02	1.15E+03	3.92E+03
Pu-241	4.93E+00	2.35E+01	8.57E+00	9.31E+00	3.32E+01	7.94E+01
Pu-242	9.89E-04	9.79E-03	3.75E-03	2.53E-03	2.26E-03	1.93E-02
Ra-223	1.36E-08	8.96E-09	1.82E-08	2.82E-09	1.78E-09	4.53E-08
Ra-224	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-225	1.54E-11	4.05E-11	2.19E-11	1.57E-11	3.44E-12	9.69E-11
Ra-226	7.74E-09	1.84E-08	4.75E-09	3.76E-09	2.63E-09	3.72E-08
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rh-106	2.17E-15	1.72E-12	2.09E-12	3.42E-12	1.84E-11	2.57E-11
Rn-219	5.01E-14	1.18E-13	6.13E-14	1.49E-14	3.51E-15	2.48E-13
Rn-220	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rn-222	4.97E-14	1.18E-13	3.05E-14	2.41E-14	1.69E-14	2.39E-13
Ru-106	9.72E-10	2.76E-06	1.19E-06	5.99E-07	1.09E-04	1.13E-04
Sb-126	4.71E-06	1.36E-04	6.39E-06	9.22E-06	1.40E-04	2.96E-04
Sb-126m	3.58E-08	1.03E-06	4.85E-08	7.01E-08	1.06E-06	2.25E-06
Se-79	2.54E+02	3.27E+02	5.21E+02	2.94E+01	4.91E+01	1.18E+03
Sm-151	1.60E+02	3.44E+03	1.94E+02	2.81E+02	3.01E+03	7.08E+03
Sn-126	9.93E+01	2.86E+03	1.35E+02	1.94E+02	2.95E+03	6.24E+03
Sr-90	1.58E+03	5.42E+04	5.97E+03	2.17E+03	5.68E+04	1.21E+05
Tc-99	1.26E+04	1.64E+04	2.60E+04	1.47E+03	2.45E+03	5.90E+04
Th-227	2.23E-08	1.47E-08	2.99E-08	4.63E-09	2.94E-09	7.45E-08
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-229	2.84E-06	7.48E-06	4.05E-06	2.89E-06	6.38E-07	1.79E-05
Th-230	5.87E-05	1.51E-04	3.62E-05	3.44E-05	2.02E-05	3.00E-04
Th-231	6.70E-05	1.28E-04	9.59E-05	6.79E-05	2.48E-05	3.83E-04
Th-232	8.24E-09	7.46E-08	2.09E-08	6.50E-08	9.02E-08	2.59E-07
Th-234	3.60E-04	6.15E-04	5.12E-04	3.67E-04	1.26E-04	1.98E-03
Tl-207	3.64E-12	2.41E-12	4.89E-12	7.57E-13	4.79E-13	1.22E-11
Tl-208	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tl-209	1.22E-17	1.64E-17	3.36E-17	1.10E-17	4.94E-17	1.23E-16
U-233	4.07E-02	9.04E-02	6.94E-02	2.50E-02	1.14E-02	2.37E-01
U-234	1.08E+00	2.88E+00	7.18E-01	5.47E-01	1.02E+00	6.25E+00
U-235	1.64E+05	3.12E+05	2.35E+05	1.66E+05	6.09E+04	9.39E+05
U-236	1.64E-01	1.49E+00	4.16E-01	1.30E+00	1.80E+00	5.16E+00
U-237	5.78E-08	4.40E-07	1.86E-07	5.07E-07	6.28E-07	1.82E-06
U-238	2.47E+07	4.23E+07	3.52E+07	2.52E+07	8.63E+06	1.36E+08
Y-90	4.09E+01	1.41E+03	1.55E+02	5.63E+01	1.47E+03	3.14E+03
Zr-93	4.62E+03	1.70E+05	8.34E+03	1.31E+04	3.35E+05	5.31E+05

TABLE SST. 4 Pg 1

~~Table A.7~~

SST Radionuclide Inventory by Tank Group

INVENTORY IN GRAMS	IN TANKS NOT Selected for Retrieval.					
REMAINING Radionuclide INVENTORY FOLLOWING SEL RETRIEVAL						
SST group	1WSS	2WSS	1ESS	2ESS	4ESS	Total
Number of Tanks	28	28	17	10	6	89
Ac-225	1.02E-11	2.71E-11	1.39E-11	1.03E-11	1.84E-12	6.34E-11
Ac-227	8.96E-06	5.81E-06	1.18E-05	1.79E-06	1.23E-06	2.96E-05
Am-241	5.22E+01	7.00E+02	8.10E+01	6.04E+01	1.61E+02	1.05E+03
Am-242	2.84E-05	5.22E-04	7.30E-05	3.56E-05	1.34E-04	7.93E-04
Am-242m	2.37E-02	4.34E-01	6.07E-02	2.96E-02	1.12E-01	6.60E-01
Am-243	6.04E-01	6.50E+00	1.69E+00	7.19E-01	3.14E+00	1.27E+01
At-217	3.67E-19	9.77E-19	5.02E-19	3.70E-19	6.62E-20	2.28E-18
Ba-137m	2.47E-04	7.86E-04	5.92E-04	9.65E-05	9.99E-05	1.82E-03
Bi-210	1.35E-14	3.28E-14	8.71E-15	9.53E-15	9.03E-15	7.36E-14
Bi-211	1.55E-12	1.00E-12	2.04E-12	3.11E-13	2.14E-13	5.12E-12
Bi-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bi-213	4.28E-11	1.14E-10	5.85E-11	4.32E-11	7.72E-12	2.66E-10
Bi-214	1.61E-16	4.04E-16	9.56E-17	7.83E-17	5.60E-17	7.95E-16
C-14	8.18E+00	9.30E+00	2.16E+01	1.74E+00	4.49E+00	4.53E+01
Cm-242	5.75E-05	1.05E-03	1.47E-04	7.19E-05	2.72E-04	1.60E-03
Cm-244	7.88E-03	1.39E-02	3.48E-02	6.78E-03	4.03E-02	1.04E-01
Cm-245	2.54E-04	4.73E-04	1.26E-03	2.41E-04	1.45E-03	3.68E-03
Cs-135	3.86E+03	9.21E+03	4.84E+03	6.26E+02	5.72E+02	1.91E+04
Cs-137	1.63E+03	5.16E+03	3.89E+03	6.34E+02	6.56E+02	1.20E+04
Fr-221	3.34E-15	8.89E-15	4.56E-15	3.37E-15	6.02E-16	2.08E-14
Fr-223	2.31E-13	1.50E-13	3.04E-13	4.64E-14	3.18E-14	7.64E-13
I-129	1.68E+03	2.06E+03	3.12E+03	1.75E+02	3.45E+02	7.37E+03
Nb-93m	4.16E-02	1.04E+00	7.27E-02	9.68E-02	1.51E+00	2.76E+00
Ni-59	0.00E+00	2.12E+04	4.12E+04	0.00E+00	0.00E+00	6.24E+04
Ni-63	3.47E+01	4.51E+02	8.46E+01	6.77E+01	3.13E+02	9.51E+02
Np-237	1.90E+03	2.57E+03	4.97E+03	3.76E+02	1.45E+02	9.96E+03
Np-238	5.87E-09	5.91E-08	1.23E-08	4.53E-09	3.22E-08	1.14E-07
Np-239	5.20E-07	5.58E-06	1.45E-06	6.16E-07	2.71E-06	1.09E-05
Pa-231	2.12E-02	1.57E-02	2.73E-02	5.19E-03	3.99E-03	7.34E-02
Pa-233	6.45E-05	8.73E-05	1.69E-04	1.28E-05	4.94E-06	3.38E-04
Pa-234	5.34E-07	1.10E-06	8.27E-07	6.36E-07	2.22E-07	3.32E-06
Pa-234m	9.69E-09	2.00E-08	1.50E-08	1.15E-08	4.03E-09	6.02E-08
Pb-209	1.29E-11	3.43E-11	1.76E-11	1.30E-11	2.32E-12	8.01E-11
Pb-210	2.19E-11	5.33E-11	1.41E-11	1.55E-11	1.46E-11	1.19E-10
Pb-211	2.63E-11	1.70E-11	3.45E-11	5.26E-12	3.62E-12	8.66E-11
Pb-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pb-214	2.17E-16	5.43E-16	1.28E-16	1.05E-16	7.52E-17	1.07E-15
Pd-107	3.01E+03	3.55E+03	5.52E+03	3.28E+02	6.88E+02	1.31E+04
Po-210	3.72E-13	9.05E-13	2.40E-13	2.74E-13	2.61E-13	2.05E-12
Po-211	1.51E-17	3.92E-17	1.87E-17	7.14E-18	3.02E-18	8.31E-17
Po-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table SST, 4 pg 2

~~Table A.7~~

SST Radionuclide Inventory by Tank Group

Po-213	4.60E-23	1.22E-22	6.27E-23	4.63E-23	8.30E-24	2.85E-22
Po-214	2.21E-23	5.53E-23	1.31E-23	1.07E-23	7.67E-24	1.09E-22
Po-215	2.20E-17	1.42E-17	2.89E-17	4.40E-18	3.02E-18	7.25E-17
Po-216	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-218	2.51E-17	6.30E-17	1.49E-17	1.22E-17	8.73E-18	1.24E-16
Pu-238	2.35E+00	7.29E+00	1.35E+00	1.29E+00	4.31E+00	1.66E+01
Pu-239	9.62E+03	2.29E+04	7.01E+03	7.13E+03	1.48E+04	6.15E+04
Pu-240	4.40E+02	1.37E+03	3.73E+02	4.68E+02	1.11E+03	3.76E+03
Pu-241	4.59E+00	2.31E+01	7.82E+00	8.09E+00	3.24E+01	7.60E+01
Pu-242	9.65E-04	9.64E-03	3.55E-03	2.30E-03	2.18E-03	1.86E-02
Ra-223	1.27E-08	8.20E-09	1.66E-08	2.54E-09	1.74E-09	4.18E-08
Ra-224	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-225	1.51E-11	4.01E-11	2.06E-11	1.52E-11	2.73E-12	9.38E-11
Ra-226	7.19E-09	1.80E-08	4.26E-09	3.49E-09	2.50E-09	3.55E-08
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rh-106	2.01E-15	1.69E-12	1.88E-12	3.17E-12	1.75E-11	2.42E-11
Rn-219	4.65E-14	1.16E-13	5.50E-14	1.38E-14	3.33E-15	2.35E-13
Rn-220	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rn-222	4.61E-14	1.16E-13	2.73E-14	2.24E-14	1.60E-14	2.27E-13
Ru-106	7.96E-10	2.74E-06	9.46E-07	3.08E-07	1.09E-04	1.13E-04
Sb-126	3.79E-06	1.34E-04	5.64E-06	7.61E-06	1.37E-04	2.88E-04
Sb-126m	2.88E-08	1.02E-06	4.27E-08	5.79E-08	1.04E-06	2.19E-06
Se-79	2.42E+02	2.94E+02	4.50E+02	2.50E+01	4.82E+01	1.06E+03
Sm-151	1.37E+02	3.40E+03	1.75E+02	2.45E+02	2.94E+03	6.90E+03
Sn-126	7.98E+01	2.83E+03	1.19E+02	1.60E+02	2.89E+03	6.08E+03
Sr-90	1.48E+03	5.37E+04	5.42E+03	1.83E+03	5.60E+04	1.18E+05
Tc-99	1.20E+04	1.48E+04	2.25E+04	1.25E+03	2.41E+03	5.29E+04
Th-227	2.08E-08	1.35E-08	2.74E-08	4.17E-09	2.87E-09	6.87E-08
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-229	2.79E-06	7.42E-06	3.80E-06	2.81E-06	5.08E-07	1.73E-05
Th-230	5.48E-05	1.48E-04	3.28E-05	3.25E-05	1.88E-05	2.87E-04
Th-231	5.37E-05	1.23E-04	8.35E-05	6.32E-05	2.37E-05	3.47E-04
Th-232	6.61E-09	7.20E-08	1.82E-08	6.04E-08	8.62E-08	2.43E-07
Th-234	2.88E-04	5.93E-04	4.45E-04	3.42E-04	1.20E-04	1.79E-03
Tl-207	3.40E-12	2.20E-12	4.47E-12	6.81E-13	4.69E-13	1.12E-11
Tl-208	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tl-209	1.14E-17	1.50E-17	3.07E-17	9.91E-18	4.84E-17	1.15E-16
U-233	3.99E-02	8.94E-02	6.38E-02	2.44E-02	1.03E-02	2.28E-01
U-234	1.01E+00	2.84E+00	6.55E-01	5.03E-01	9.92E-01	6.00E+00
U-235	1.32E+05	3.02E+05	2.05E+05	1.55E+05	5.82E+04	8.51E+05
U-236	1.32E-01	1.44E+00	3.62E-01	1.21E+00	1.72E+00	4.86E+00
U-237	4.64E-08	4.25E-07	1.62E-07	4.72E-07	6.00E-07	1.71E-06
U-238	1.98E+07	4.08E+07	3.06E+07	2.35E+07	8.22E+06	1.23E+08
Y-90	3.84E+01	1.40E+03	1.41E+02	4.75E+01	1.45E+03	3.08E+03
Zr-93	4.48E+03	1.68E+05	7.45E+03	1.09E+04	3.29E+05	5.20E+05

~~Table A.8~~ SST Chemical Inventory by Tank Group

TABLE SST.5 pg 1

SOLUBILITY OF SSTS LEFT IN PLACE + 1% RESIDUALS					
SOLUBILITY IN GRAMS/LITER					
Chemical					
Number of Tanks					
Al(OH)4-	4.87E+00	7.15E+00	9.54E+00	1.20E+03	1.46E+01
Al+3	7.64E-01	3.63E+00	8.58E+00	2.73E+02	1.16E+01
Bi+3	5.71E+00	6.08E-04	2.20E+00	1.36E+01	0.00E+00
CO3-2	9.17E+00	2.42E-01	1.28E+01	2.31E+02	3.95E+00
Ca+2	1.15E-02	1.07E-01	3.01E-01	1.50E+03	2.69E+00
Cd+2	2.08E-02	1.39E-03	3.99E-02	4.52E-01	9.76E+00
Ce+3	3.07E+00	2.66E-01	1.32E+00	6.03E+00	4.78E-01
Cl-	3.97E-01	2.23E-02	3.07E-01	9.16E-01	1.79E-02
Cr+3	3.81E-02	7.64E-01	1.92E-02	2.91E+00	1.44E+00
CrO4-2	9.45E-03	1.89E-01	4.75E-03	7.21E-01	3.56E-01
F-	1.41E+00	1.44E-01	4.88E+00	1.88E+02	2.29E-01
Fe+3	4.55E+00	5.18E-01	2.98E+00	3.60E+02	4.43E+01
Fe(CN)6-4	9.14E-03	1.15E-02	2.09E+00	1.60E+03	9.21E-02
Hg+	4.87E-03	3.27E-04	9.39E-03	1.06E-01	2.29E-02
Mn+4	6.04E-01	5.24E-02	2.76E-01	2.57E+01	9.82E+00
Na+	2.02E+02	1.78E+02	2.44E+02	2.48E+03	2.51E+02
Ni+2	9.38E-02	2.51E-02	9.64E-01	7.55E+02	7.03E-01
NO2-	1.48E+01	4.00E+00	2.79E+01	1.07E+01	9.15E+01
NO3-	3.60E+02	3.60E+02	3.60E+02	3.60E+02	3.60E+02
OH-	1.28E+01	2.11E+01	1.93E+01	4.00E+03	7.23E+01
PO4-3	7.18E+01	5.64E-01	4.68E+01	3.30E+02	3.68E-01
SiO3-	6.75E+00	3.53E+00	2.54E+00	1.60E+01	1.10E+00
SO4-2	9.08E+00	6.45E-01	1.15E+01	1.07E+02	4.85E+00
Sr+2	1.73E-06	7.72E-05	3.09E-01	5.66E-01	2.51E-03
W+4	8.25E-02	5.24E-03	1.51E-01	1.70E+00	3.66E-01
Zr+4	3.37E-01	3.15E-02	2.23E-01	1.50E+02	7.00E-02

Table SST.6 Pg 1

~~Table A.7~~

SST Radionuclide Inventory by Tank Group

SOLUBILITY OF COMBINED INVENTORY					
COMBINED INVENTORY OF REMAINING TANKS + 1% RESIDUALS					
solubility= (mass radionuclide/mass nitrate)*360					
SST group	1WSS	2WSS	1ESS	2ESS	4ESS
Number of Tanks	40	43	40	16	10
Ac-225	5.99E-19	5.03E-19	1.05E-18	2.41E-16	4.18E-18
Ac-227	5.54E-13	1.17E-13	9.09E-13	4.55E-11	2.27E-12
Am-241	3.27E-06	1.33E-05	7.21E-06	2.02E-03	3.13E-04
Am-242	1.82E-12	9.95E-12	6.76E-12	1.38E-09	2.60E-10
Am-242m	1.52E-09	8.28E-09	5.63E-09	1.15E-06	2.16E-07
Am-243	3.75E-08	1.26E-07	1.52E-07	2.97E-05	5.91E-06
At-217	2.16E-26	1.81E-26	3.77E-26	8.69E-24	1.51E-25
Ba-137m	1.50E-11	1.56E-11	4.60E-11	2.23E-09	1.83E-10
Bi-210	8.42E-22	6.15E-22	6.85E-22	2.28E-19	1.66E-20
Bi-211	9.59E-20	2.02E-20	1.57E-19	7.88E-18	3.94E-19
Bi-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bi-213	2.52E-18	2.12E-18	4.40E-18	1.01E-15	1.76E-17
Bi-214	1.00E-23	7.57E-24	7.51E-24	1.93E-21	1.07E-22
C-14	5.05E-07	1.90E-07	1.80E-06	5.05E-05	8.77E-06
Cm-242	3.67E-12	2.01E-11	1.37E-11	2.78E-09	5.25E-10
Cm-244	4.73E-10	3.08E-10	2.87E-09	3.06E-07	7.37E-08
Cm-245	1.52E-11	1.05E-11	1.04E-10	1.09E-08	2.66E-09
Cs-135	2.31E-04	1.79E-04	3.71E-04	1.45E-02	1.06E-03
Cs-137	9.89E-05	1.03E-04	3.02E-04	1.47E-02	1.20E-03
Fr-221	1.96E-22	1.65E-22	3.43E-22	7.90E-20	1.37E-21
Fr-223	1.43E-20	3.02E-21	2.35E-20	1.18E-18	5.87E-20
I-129	1.01E-04	4.21E-05	2.55E-04	4.74E-03	6.34E-04
Nb-93m	2.57E-09	1.94E-08	6.08E-09	2.54E-06	2.81E-06
Ni-59	0.00E+00	3.89E-04	2.91E-03	0.00E+00	0.00E+00
Ni-63	2.05E-06	8.37E-06	6.55E-06	1.76E-03	5.93E-04
Np-237	1.15E-04	4.97E-05	3.97E-04	8.60E-03	2.71E-04
Np-238	3.64E-16	1.14E-15	1.10E-15	1.87E-13	6.05E-14
Np-239	3.22E-14	1.08E-13	1.31E-13	2.55E-11	5.09E-12
Pa-231	1.33E-09	3.16E-10	2.14E-09	1.34E-07	7.37E-09
Pa-233	3.92E-12	1.69E-12	1.35E-11	2.93E-10	9.23E-12
Pa-234	3.86E-14	2.10E-14	6.71E-14	1.56E-11	4.21E-13
Pa-234m	7.00E-16	3.81E-16	1.22E-15	2.82E-13	7.63E-15
Pb-209	7.58E-19	6.36E-19	1.32E-18	3.05E-16	5.28E-18
Pb-210	1.37E-18	9.99E-19	1.11E-18	3.71E-16	2.69E-17
Pb-211	1.62E-18	3.42E-19	2.66E-18	1.33E-16	6.67E-18
Pb-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pb-214	1.35E-23	1.02E-23	1.01E-23	2.59E-21	1.43E-22
Pd-107	1.82E-04	7.31E-05	4.54E-04	9.05E-03	1.26E-03
Po-210	2.32E-20	1.70E-20	1.89E-20	6.56E-18	4.77E-19
Po-211	9.43E-25	7.34E-25	1.47E-24	1.71E-22	5.53E-24
Po-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table SST.6 Pg 2

~~Table A.7~~

SST Radionuclide Inventory by Tank Group

Po-213	2.71E-30	2.27E-30	4.71E-30	1.09E-27	1.89E-29
Po-214	1.37E-30	1.04E-30	1.03E-30	2.64E-28	1.46E-29
Po-215	1.36E-24	2.86E-25	2.23E-24	1.12E-22	5.57E-24
Po-216	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-218	1.56E-24	1.18E-24	1.17E-24	3.00E-22	1.66E-23
Pu-238	1.41E-07	1.36E-07	1.02E-07	3.18E-05	7.94E-06
Pu-239	5.69E-04	4.28E-04	5.23E-04	1.79E-01	2.78E-02
Pu-240	2.62E-05	2.56E-05	2.82E-05	1.18E-02	2.08E-03
Pu-241	2.85E-07	4.32E-07	6.05E-07	2.12E-04	5.99E-05
Pu-242	5.71E-11	1.80E-10	2.65E-10	5.77E-08	4.09E-09
Ra-223	7.82E-16	1.65E-16	1.28E-15	6.43E-14	3.21E-15
Ra-224	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-225	8.88E-19	7.44E-19	1.55E-18	3.57E-16	6.21E-18
Ra-226	4.47E-16	3.38E-16	3.35E-16	8.59E-14	4.75E-15
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rh-106	1.25E-22	3.17E-20	1.48E-19	7.80E-17	3.33E-17
Rn-219	2.89E-21	2.17E-21	4.33E-21	3.40E-19	6.34E-21
Rn-220	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rn-222	2.87E-21	2.17E-21	2.15E-21	5.51E-19	3.05E-20
Ru-106	5.61E-17	5.08E-14	8.36E-14	1.37E-11	1.96E-10
Sb-126	2.72E-13	2.50E-12	4.51E-13	2.11E-10	2.53E-10
Sb-126m	2.07E-15	1.90E-14	3.42E-15	1.60E-12	1.92E-12
Se-79	1.47E-05	6.02E-06	3.68E-05	6.71E-04	8.87E-05
Sm-151	9.23E-06	6.33E-05	1.37E-05	6.43E-03	5.43E-03
Sn-126	5.73E-06	5.27E-05	9.49E-06	4.44E-03	5.33E-03
Sr-90	9.10E-05	9.97E-04	4.21E-04	4.95E-02	1.03E-01
Tc-99	7.28E-04	3.02E-04	1.84E-03	3.36E-02	4.43E-03
Th-227	1.29E-15	2.71E-16	2.11E-15	1.06E-13	5.30E-15
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-229	1.64E-13	1.38E-13	2.85E-13	6.60E-11	1.15E-12
Th-230	3.39E-12	2.77E-12	2.55E-12	7.86E-10	3.65E-11
Th-231	3.87E-12	2.35E-12	6.76E-12	1.55E-09	4.48E-11
Th-232	4.75E-16	1.37E-15	1.47E-15	1.48E-12	1.63E-13
Th-234	2.08E-11	1.13E-11	3.61E-11	8.38E-09	2.27E-10
Tl-207	2.10E-19	4.43E-20	3.45E-19	1.73E-17	8.65E-19
Tl-208	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tl-209	7.04E-25	3.01E-25	2.37E-24	2.51E-22	8.92E-23
U-233	2.35E-09	1.66E-09	4.89E-09	5.70E-07	2.06E-08
U-234	6.24E-08	5.31E-08	5.06E-08	1.25E-05	1.85E-06
U-235	9.47E-03	5.75E-03	1.66E-02	3.80E+00	1.10E-01
U-236	9.48E-09	2.74E-08	2.93E-08	2.96E-05	3.25E-06
U-237	3.34E-15	8.09E-15	1.32E-14	1.16E-11	1.13E-12
U-238	1.43E+00	7.78E-01	2.48E+00	5.76E+02	1.56E+01
Y-90	2.36E-06	2.59E-05	1.09E-05	1.29E-03	2.66E-03
Zr-93	2.67E-04	3.12E-03	5.88E-04	2.98E-01	6.05E-01

Table Leak.3 pg 1

Solubility of Radionuclides in SSTs to be retrieved					
solubility in grams per liter					
SST group	1WSS	2WSS	1ESS	2ESS	4ESS
Number of Ta	12	15	23	6	4
Ac-225	3.51E-19	3.12E-19	2.34E-18	4.21E-17	3.62E-18
Ac-227	1.13E-12	7.36E-13	2.88E-12	2.91E-11	1.99E-13
Am-241	7.96E-06	2.86E-05	5.48E-05	4.10E-03	9.10E-05
Am-242	5.47E-12	2.62E-11	5.91E-11	3.62E-09	7.25E-11
Am-242m	4.55E-09	2.18E-08	4.91E-08	3.02E-06	6.03E-08
Am-243	8.08E-08	4.55E-07	1.21E-06	8.55E-05	9.63E-07
At-217	1.26E-26	1.12E-26	8.45E-26	1.52E-24	1.30E-25
Ba-137m	2.38E-11	8.66E-11	1.56E-10	2.05E-10	1.18E-11
Bi-210	1.93E-21	8.43E-22	2.59E-21	6.98E-20	1.05E-21
Bi-211	1.95E-19	1.27E-19	4.98E-19	5.04E-18	3.45E-20
Bi-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bi-213	1.48E-18	1.31E-18	9.85E-18	1.77E-16	1.52E-17
Bi-214	2.19E-23	1.02E-23	2.82E-23	8.84E-22	2.32E-23
C-14	9.99E-07	1.40E-06	1.01E-05	6.89E-05	2.80E-06
Cm-242	1.10E-11	5.29E-11	1.19E-10	7.32E-09	1.46E-10
Cm-244	5.74E-10	3.91E-09	1.52E-08	9.68E-07	3.75E-09
Cm-245	1.71E-11	1.34E-10	5.46E-10	3.49E-08	1.35E-10
Cs-135	2.53E-04	6.91E-04	1.07E-03	1.15E-03	9.83E-05
Cs-137	1.56E-04	5.69E-04	1.03E-03	1.35E-03	7.79E-05
Fr-221	1.15E-22	1.02E-22	7.68E-22	1.38E-20	1.19E-21
Fr-223	2.91E-20	1.90E-20	7.44E-20	7.53E-19	5.15E-21
I-129	1.43E-04	3.18E-04	1.27E-03	4.76E-03	4.81E-05
Nb-93m	5.08E-09	2.13E-08	3.49E-08	2.14E-06	3.23E-07
Ni-59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-63	1.46E-06	5.21E-06	2.13E-05	1.38E-03	1.18E-04
Np-237	1.77E-04	1.81E-04	1.70E-03	1.52E-04	3.78E-05
Np-238	7.82E-16	4.14E-15	8.73E-15	5.39E-13	9.82E-15
Np-239	6.93E-14	3.90E-13	1.04E-12	7.34E-11	8.25E-13
Pa-231	3.28E-09	1.93E-09	7.71E-09	9.82E-08	7.30E-10
Pa-233	6.01E-12	6.16E-12	5.80E-11	5.13E-12	1.28E-12
Pa-234	2.39E-13	5.69E-14	3.20E-13	6.74E-12	8.48E-14
Pa-234m	4.33E-15	1.03E-15	5.80E-15	1.22E-13	1.54E-15
Pb-209	4.43E-19	3.94E-19	2.96E-18	5.32E-17	4.57E-18
Pb-210	3.14E-18	1.37E-18	4.20E-18	1.13E-16	1.70E-18
Pb-211	3.29E-18	2.16E-18	8.43E-18	8.52E-17	5.83E-19
Pb-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pb-214	2.94E-23	1.37E-23	3.80E-23	1.19E-21	3.11E-23
Pd-107	2.62E-04	5.79E-04	2.37E-03	1.01E-02	9.27E-05
Po-210	5.34E-20	2.33E-20	7.14E-20	1.91E-18	2.81E-20
Po-211	2.17E-24	1.01E-24	5.56E-24	4.97E-23	3.26E-25
Po-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE Leak.3 pg 2

RETRIEVAL LEAKAGE

Po-213	1.58E-30	1.40E-30	1.06E-29	1.89E-28	1.63E-29
Po-214	3.00E-30	1.40E-30	3.87E-30	1.21E-28	3.17E-30
Po-215	2.76E-24	1.81E-24	7.05E-24	7.14E-23	4.89E-25
Po-216	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-218	3.41E-24	1.59E-24	4.40E-24	1.38E-22	3.61E-24
Pu-238	1.78E-07	1.39E-07	2.46E-07	1.53E-05	6.74E-07
Pu-239	4.31E-04	4.87E-04	1.04E-03	1.05E-01	4.56E-03
Pu-240	2.45E-05	2.93E-05	6.99E-05	7.39E-03	3.10E-04
Pu-241	6.01E-07	5.36E-07	1.94E-06	1.77E-04	5.77E-06
Pu-242	4.32E-11	2.05E-10	5.25E-10	3.39E-08	6.72E-10
Ra-223	1.59E-15	1.04E-15	4.06E-15	4.11E-14	2.81E-16
Ra-224	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-225	5.19E-19	4.62E-19	3.47E-18	6.22E-17	5.35E-18
Ra-226	9.76E-16	4.56E-16	1.26E-15	3.95E-14	1.03E-15
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rh-106	2.73E-22	4.28E-20	5.56E-19	3.59E-17	7.24E-18
Rn-219	6.32E-21	2.93E-21	1.63E-20	1.56E-19	1.38E-21
Rn-220	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rn-222	6.26E-21	2.92E-21	8.09E-21	2.53E-19	6.63E-21
Ru-106	3.14E-16	3.25E-14	6.18E-13	4.26E-11	7.89E-13
Sb-126	1.64E-12	2.01E-12	1.95E-12	2.36E-10	2.25E-11
Sb-126m	1.25E-14	1.52E-14	1.48E-14	1.79E-12	1.71E-13
Se-79	2.07E-05	4.60E-05	1.83E-04	6.50E-04	6.79E-06
Sm-151	4.01E-05	4.99E-05	4.96E-05	5.32E-03	4.98E-04
Sn-126	3.45E-05	4.22E-05	4.10E-05	4.97E-03	4.75E-04
Sr-90	1.67E-04	6.83E-04	1.42E-03	4.95E-02	6.19E-03
Tc-99	1.03E-03	2.28E-03	9.11E-03	3.26E-02	3.37E-04
Th-227	2.61E-15	1.71E-15	6.69E-15	6.76E-14	4.62E-16
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-229	9.61E-14	8.53E-14	6.42E-13	1.15E-11	9.89E-13
Th-230	7.02E-12	3.35E-12	8.83E-12	2.82E-10	1.04E-11
Th-231	2.35E-11	5.98E-12	3.19E-11	6.93E-10	8.31E-12
Th-232	2.90E-15	3.50E-15	6.94E-15	6.62E-13	3.02E-14
Th-234	1.28E-10	3.06E-11	1.72E-10	3.63E-09	4.57E-11
Tl-207	4.27E-19	2.80E-19	1.09E-18	1.11E-17	7.56E-20
Tl-208	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tl-209	1.43E-24	1.90E-24	7.49E-24	1.61E-22	7.80E-24
U-233	1.52E-09	1.28E-09	1.43E-08	8.78E-08	8.59E-09
U-234	1.23E-07	6.27E-08	1.63E-07	6.46E-06	2.34E-07
U-235	5.77E-02	1.47E-02	7.81E-02	1.70E+00	2.03E-02
U-236	5.77E-08	6.98E-08	1.38E-07	1.32E-05	6.01E-07
U-237	2.03E-14	2.06E-14	6.20E-14	5.17E-12	2.10E-13
U-238	8.83E+00	2.11E+00	1.18E+01	2.49E+02	3.14E+00
Y-90	4.33E-06	1.77E-05	3.68E-05	1.28E-03	1.61E-04
Zr-93	2.44E-04	2.09E-03	2.31E-03	3.16E-01	4.47E-02

TABLE Leak. 4 pg 1

RETRIEVAL LEAKAGE

SST retrieval based releases in grams					
total grams released during retrieval					
SST group	1WSS	2WSS	1ESS	2ESS	4ESS
Number of Tan	12	15	23	6	4
Ac-225	6.38E-14	5.67E-14	4.26E-13	7.64E-12	6.57E-13
Ac-227	2.04E-07	1.34E-07	5.23E-07	5.29E-06	3.62E-08
Am-241	1.45E+00	5.20E+00	9.95E+00	7.46E+02	1.65E+01
Am-242	9.93E-07	4.75E-06	1.07E-05	6.58E-04	1.32E-05
Am-242m	8.26E-04	3.96E-03	8.93E-03	5.48E-01	1.10E-02
Am-243	1.47E-02	8.27E-02	2.19E-01	1.55E+01	1.75E-01
At-217	2.30E-21	2.04E-21	1.53E-20	2.75E-19	2.37E-20
Ba-137m	4.33E-06	1.57E-05	2.84E-05	3.72E-05	2.15E-06
Bi-210	3.51E-16	1.53E-16	4.70E-16	1.27E-14	1.91E-16
Bi-211	3.54E-14	2.31E-14	9.05E-14	9.15E-13	6.26E-15
Bi-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bi-213	2.68E-13	2.38E-13	1.79E-12	3.21E-11	2.76E-12
Bi-214	3.97E-18	1.85E-18	5.13E-18	1.61E-16	4.21E-18
C-14	1.82E-01	2.54E-01	1.84E+00	1.25E+01	5.08E-01
Cm-242	2.01E-06	9.61E-06	2.17E-05	1.33E-03	2.66E-05
Cm-244	1.04E-04	7.10E-04	2.77E-03	1.76E-01	6.81E-04
Cm-245	3.12E-06	2.44E-05	9.93E-05	6.33E-03	2.45E-05
Cs-135	4.60E+01	1.26E+02	1.94E+02	2.08E+02	1.79E+01
Cs-137	2.84E+01	1.03E+02	1.86E+02	2.45E+02	1.41E+01
Fr-221	2.09E-17	1.86E-17	1.40E-16	2.51E-15	2.15E-16
Fr-223	5.29E-15	3.46E-15	1.35E-14	1.37E-13	9.36E-16
I-129	2.60E+01	5.77E+01	2.31E+02	8.65E+02	8.74E+00
Nb-93m	9.23E-04	3.86E-03	6.33E-03	3.88E-01	5.87E-02
Ni-59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-63	2.66E-01	9.47E-01	3.87E+00	2.50E+02	2.15E+01
Np-237	3.21E+01	3.29E+01	3.10E+02	2.76E+01	6.86E+00
Np-238	1.42E-10	7.52E-10	1.59E-09	9.80E-08	1.78E-09
Np-239	1.26E-08	7.09E-08	1.88E-07	1.33E-05	1.50E-07
Pa-231	5.95E-04	3.52E-04	1.40E-03	1.78E-02	1.33E-04
Pa-233	1.09E-06	1.12E-06	1.05E-05	9.32E-07	2.33E-07
Pa-234	4.34E-08	1.03E-08	5.81E-08	1.22E-06	1.54E-08
Pa-234m	7.86E-10	1.87E-10	1.05E-09	2.22E-08	2.79E-10
Pb-209	8.06E-14	7.16E-14	5.38E-13	9.66E-12	8.30E-13
Pb-210	5.70E-13	2.48E-13	7.63E-13	2.06E-11	3.09E-13
Pb-211	5.98E-13	3.92E-13	1.53E-12	1.55E-11	1.06E-13
Pb-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pb-214	5.34E-18	2.49E-18	6.90E-18	2.16E-16	5.66E-18
Pd-107	4.75E+01	1.05E+02	4.30E+02	1.83E+03	1.68E+01
Po-210	9.70E-15	4.23E-15	1.30E-14	3.47E-13	5.11E-15
Po-211	3.94E-19	1.83E-19	1.01E-18	9.04E-18	5.92E-20
Po-212	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE LEAK.4 PG 2

RETRIEVAL LEAKAGE

Po-213	2.87E-25	2.55E-25	1.92E-24	3.44E-23	2.96E-24
Po-214	5.44E-25	2.54E-25	7.03E-25	2.20E-23	5.76E-25
Po-215	5.01E-19	3.28E-19	1.28E-18	1.30E-17	8.88E-20
Po-216	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-218	6.19E-19	2.89E-19	8.00E-19	2.50E-17	6.56E-19
Pu-238	3.23E-02	2.53E-02	4.48E-02	2.78E+00	1.22E-01
Pu-239	7.83E+01	8.84E+01	1.88E+02	1.91E+04	8.28E+02
Pu-240	4.44E+00	5.33E+00	1.27E+01	1.34E+03	5.64E+01
Pu-241	1.09E-01	9.75E-02	3.52E-01	3.22E+01	1.05E+00
Pu-242	7.85E-06	3.72E-05	9.54E-05	6.15E-03	1.22E-04
Ra-223	2.89E-10	1.89E-10	7.38E-10	7.47E-09	5.11E-11
Ra-224	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-225	9.43E-14	8.38E-14	6.30E-13	1.13E-11	9.72E-13
Ra-226	1.77E-10	8.28E-11	2.29E-10	7.17E-09	1.88E-10
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rh-106	4.96E-17	7.78E-15	1.01E-13	6.52E-12	1.32E-12
Rn-219	1.15E-15	5.33E-16	2.96E-15	2.84E-14	2.51E-16
Rn-220	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rn-222	1.14E-15	5.31E-16	1.47E-15	4.60E-14	1.21E-15
Ru-106	5.71E-11	5.90E-09	1.12E-07	7.75E-06	1.43E-07
Sb-126	2.98E-07	3.65E-07	3.54E-07	4.29E-05	4.09E-06
Sb-126m	2.26E-09	2.77E-09	2.69E-09	3.26E-07	3.11E-08
Se-79	3.76E+00	8.35E+00	3.33E+01	1.18E+02	1.23E+00
Sm-151	7.29E+00	9.06E+00	9.01E+00	9.67E+02	9.05E+01
Sn-126	6.28E+00	7.68E+00	7.45E+00	9.03E+02	8.63E+01
Sr-90	3.04E+01	1.24E+02	2.58E+02	8.99E+03	1.13E+03
Tc-99	1.87E+02	4.15E+02	1.65E+03	5.92E+03	6.13E+01
Th-227	4.75E-10	3.11E-10	1.21E-09	1.23E-08	8.40E-11
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-229	1.75E-08	1.55E-08	1.17E-07	2.09E-06	1.80E-07
Th-230	1.27E-06	6.08E-07	1.60E-06	5.13E-05	1.88E-06
Th-231	4.28E-06	1.09E-06	5.80E-06	1.26E-04	1.51E-06
Th-232	5.26E-10	6.36E-10	1.26E-09	1.20E-07	5.48E-09
Th-234	2.33E-05	5.56E-06	3.13E-05	6.59E-04	8.29E-06
Tl-207	7.76E-14	5.08E-14	1.98E-13	2.01E-12	1.37E-14
Tl-208	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tl-209	2.60E-19	3.45E-19	1.36E-18	2.92E-17	1.42E-18
U-233	2.76E-04	2.33E-04	2.60E-03	1.60E-02	1.56E-03
U-234	2.24E-02	1.14E-02	2.96E-02	1.17E+00	4.25E-02
U-235	1.05E+04	2.66E+03	1.42E+04	3.08E+05	3.69E+03
U-236	1.05E-02	1.27E-02	2.51E-02	2.40E+00	1.09E-01
U-237	3.69E-09	3.75E-09	1.13E-08	9.39E-07	3.81E-08
U-238	1.61E+06	3.82E+05	2.15E+06	4.53E+07	5.70E+05
Y-90	7.88E-01	3.22E+00	6.69E+00	2.33E+02	2.92E+01
Zr-93	4.44E+01	3.79E+02	4.20E+02	5.73E+04	8.12E+03

TABLE Leak.1 PS1

LEAK ESTIMATE PER TANK=15140 LITERS					
RETRIEVAL BASED LEAKAGE PER TANK GROUPING IN GRAMS					
Chemical	1WSS	2WSS	1ESS	2ESS	4ESS
Number of Tanks	12	15	23	6	4
Al(OH)4-	8.08E+05	2.26E+06	6.07E+06	4.49E+07	8.50E+04
Al+3	1.89E+05	1.66E+06	4.26E+06	7.63E+07	8.81E+04
Bi+3	2.19E+05	7.78E+02	5.72E+05	8.26E-12	0.00E+00
CO3-2	1.79E+06	4.64E+05	4.16E+06	6.97E+06	1.67E+05
Ca+2	3.12E-02	9.23E+00	4.57E+05	3.93E+04	2.42E+02
Cd+2	1.64E+03	2.98E+03	5.39E+03	7.95E+04	5.76E+04
Ce+3	2.05E+05	5.41E+04	6.31E+05	9.42E-01	6.92E+03
Cl-	4.89E+04	1.32E+04	7.50E+04	1.19E+00	2.34E+02
Cr+3	1.96E+03	1.32E+05	4.11E+03	5.09E+03	1.34E+02
CrO4-2	4.85E+02	3.27E+04	1.02E+03	1.26E+03	3.32E+01
F-	3.90E+05	6.99E+04	1.48E+06	5.27E+07	8.44E+02
Fe+3	2.97E+05	1.69E+05	9.03E+05	5.34E+06	7.14E+05
Fe(CN)6-4	6.64E+03	2.33E+03	1.98E+06	6.87E+03	9.20E+00
Hg+	3.84E+02	7.00E+02	1.27E+03	1.86E+04	1.35E+02
Mn+4	3.42E+04	2.65E+04	8.31E+04	6.73E+06	8.39E+04
Na+	3.60E+07	3.61E+07	7.36E+07	2.68E+08	1.69E+07
Ni+2	1.11E+04	6.21E+03	1.01E+06	1.47E+06	2.81E+03
NO2-	4.91E+06	1.84E+06	1.51E+07	4.75E+02	8.44E+05
NO3-	6.54E+07	8.18E+07	1.25E+08	3.27E+07	2.18E+07
OH-	7.51E+05	3.64E+06	6.96E+06	1.67E+08	6.24E+05
PO4-3	4.66E+06	2.50E+05	1.04E+07	2.06E+06	3.05E+03
SiO3-	1.45E+06	1.50E+05	3.34E+06	6.28E+02	6.89E+03
SO4-2	1.56E+06	6.72E+05	3.54E+06	1.74E+07	3.76E+05
Sr+2	2.96E+00	2.07E+02	2.86E+05	7.19E+01	2.62E+02
W+4	6.50E+03	1.12E+04	2.04E+04	2.99E+05	2.16E+03

Table Leak.2 pg 1

SOLUBILITY OF SELECTED TANK GROUP GRAMS/LITER					
SOLUBILITY=(MASS CHEM/MASS NITRATE)*360					
Chemical	1WSS	2WSS	1ESS	2ESS	4ESS
Number	12	15	23	6	4
Al(OH)4-	4.45E+00	9.96E+00	1.74E+01	4.94E+02	1.40E+00
Al+3	1.04E+00	7.31E+00	1.22E+01	8.40E+02	1.45E+00
Bi+3	1.21E+00	3.42E-03	1.64E+00	9.09E-17	0.00E+00
CO3-2	9.84E+00	2.04E+00	1.20E+01	7.67E+01	2.75E+00
Ca+2	1.72E-07	4.07E-05	1.31E+00	4.32E-01	3.99E-03
Cd+2	9.02E-03	1.31E-02	1.55E-02	8.75E-01	9.52E-01
Ce+3	1.13E+00	2.38E-01	1.81E+00	1.04E-05	1.14E-01
Cl-	2.69E-01	5.82E-02	2.15E-01	1.31E-05	3.87E-03
Cr+3	1.08E-02	5.80E-01	1.18E-02	5.61E-02	2.21E-03
CrO4-2	2.67E-03	1.44E-01	2.92E-03	1.39E-02	5.48E-04
F-	2.15E+00	3.08E-01	4.25E+00	5.80E+02	1.39E-02
Fe+3	1.64E+00	7.44E-01	2.59E+00	5.88E+01	1.18E+01
Fe(CN)6-	3.66E-02	1.03E-02	5.69E+00	7.56E-02	1.52E-04
Hg+	2.11E-03	3.08E-03	3.64E-03	2.05E-01	2.23E-03
Mn+4	1.88E-01	1.17E-01	2.39E-01	7.41E+01	1.38E+00
Na+	1.98E+02	1.59E+02	2.11E+02	2.95E+03	2.80E+02
Ni+2	6.10E-02	2.74E-02	2.90E+00	1.62E+01	4.64E-02
NO2-	2.70E+01	8.09E+00	4.33E+01	5.23E-03	1.39E+01
NO3-	3.60E+02	3.60E+02	3.60E+02	3.60E+02	3.60E+02
OH-	4.14E+00	1.60E+01	2.00E+01	1.84E+03	1.03E+01
PO4-3	2.56E+01	1.10E+00	2.99E+01	2.27E+01	5.04E-02
SiO3-	7.96E+00	6.62E-01	9.58E+00	6.91E-03	1.14E-01
SO4-2	8.56E+00	2.96E+00	1.02E+01	1.91E+02	6.20E+00
Sr+2	1.63E-05	9.10E-04	8.20E-01	7.91E-04	4.33E-03
W+4	3.58E-02	4.93E-02	5.85E-02	3.29E+00	3.57E-02

Table DST.1 p81

DST CHEM

Inventory in remaining tanks +			
1% residuals			
Chemical	metric tons		
	5EDS	3EDS	3WDS
Ag+	1.08E+00	6.98E-02	5.80E-02
Al+3	2.32E+01	1.05E+01	1.07E+01
As+5	2.28E-02	2.60E-02	2.01E-01
B+3	7.39E-01	6.64E-02	6.55E-02
Ba+2	2.01E+00	7.02E-01	6.48E-04
Be+2	2.94E-03	2.23E-02	0.00E+00
Bi+3	5.42E-02	1.04E-02	0.00E+00
Ca+2	6.98E+00	2.25E+00	1.70E+00
Cd+2	2.71E-01	6.54E-02	2.42E-01
Ce+3	2.21E+00	0.00E+00	2.64E-01
Cr+3	9.21E+00	7.84E-01	3.32E+00
Cu+2	1.09E-01	2.07E-03	3.42E-01
Fe+3	7.44E+01	2.55E+00	6.12E+00
Hg+	1.14E-03	2.80E-04	0.00E+00
K+	5.74E+00	2.02E+02	8.17E+00
La+3	1.68E+01	1.35E+00	1.97E-03
Li+	6.20E-04	0.00E+00	5.60E-03
Mg+2	9.17E+00	1.17E+00	4.58E-01
Mn+4	1.40E+01	9.93E-01	2.25E+00
Mo+6	1.11E-01	5.55E-01	4.22E-02
Na+	4.02E+02	1.97E+03	1.19E+02
Ni+2	1.82E+00	6.11E-01	1.90E-01
Pb+4	1.82E+00	1.16E-01	3.34E-01
SiO3-	1.93E+02	1.30E+01	2.46E+00
UO2+2	2.48E+00	2.63E+01	0.00E+00
V+5	1.35E-03	1.66E-01	1.37E-02
W+4	1.49E-02	0.00E+00	0.00E+00
Zn+2	3.67E-01	1.09E+00	1.45E-01
Zr+4	2.97E+00	2.58E+02	1.00E-01
Al(OH)4-2	8.84E+01	4.19E+02	3.35E+01
CO3-2	8.58E+01	8.46E+02	1.85E+01
Cl-	8.91E+00	3.06E+01	4.69E+00
CrO4-2	1.82E+00	9.89E+00	9.62E+00
F-	6.92E+00	3.20E+02	3.52E+00

Table ~~DST.2~~ PS 1

DST CHEM DST.1

SO4-2	2.87E+01	6.79E+01	5.23E+00
NO3-	3.02E+02	1.30E+03	1.31E+02
NO2-	1.05E+02	4.59E+02	2.07E+01
PO4-3	2.45E+01	6.60E+01	1.76E+01
OH-	5.36E+01	3.93E+02	2.75E+01
TOC	8.51E+01	4.90E+01	3.06E+00

TABLE DST.2 pg 1

DST CHEM

Solubility for remaining DSTs			
solubility = (mass chem/mass nitrate)*360			
solubility in grams/liter			
1% residuals + TANKS NOT Retrieved			
Chemical			
	5EDS	3EDS	3WDS
Ag+	1.29E+00	1.93E-02	1.59E-01
Al+3	2.77E+01	2.91E+00	2.94E+01
As+5	2.71E-02	7.19E-03	5.52E-01
B+3	8.81E-01	1.84E-02	1.80E-01
Ba+2	2.40E+00	1.94E-01	1.78E-03
Be+2	3.51E-03	6.19E-03	0.00E+00
Bi+3	6.46E-02	2.87E-03	0.00E+00
Ca+2	8.32E+00	6.24E-01	4.67E+00
Cd+2	3.23E-01	1.81E-02	6.65E-01
Ce+3	2.64E+00	0.00E+00	7.25E-01
Cr+3	1.10E+01	2.17E-01	9.12E+00
Cu+2	1.30E-01	5.73E-04	9.40E-01
Fe+3	8.86E+01	7.07E-01	1.68E+01
Hg+	1.36E-03	7.77E-05	0.00E+00
K+	6.85E+00	5.58E+01	2.25E+01
La+3	2.01E+01	3.74E-01	5.41E-03
Li+	7.39E-04	0.00E+00	1.54E-02
Mg+2	1.09E+01	3.24E-01	1.26E+00
Mn+4	1.67E+01	2.75E-01	6.17E+00
Mo+6	1.32E-01	1.54E-01	1.16E-01
Na+	4.79E+02	5.44E+02	3.27E+02
Ni+2	2.17E+00	1.69E-01	5.21E-01
Pb+4	2.16E+00	3.21E-02	9.18E-01
SiO3-	2.30E+02	3.61E+00	6.75E+00
UO2+2	2.95E+00	7.28E+00	0.00E+00
V+5	1.60E-03	4.60E-02	3.76E-02
W+4	1.77E-02	0.00E+00	0.00E+00
Zn+2	4.37E-01	3.01E-01	3.99E-01
Zr+4	3.54E+00	7.14E+01	2.75E-01
Al(OH)4-2	1.05E+02	1.16E+02	9.20E+01
CO3-2	1.02E+02	2.34E+02	5.09E+01
Cl-	1.06E+01	8.47E+00	1.29E+01
CrO4-2	2.17E+00	2.74E+00	2.64E+01
F-	8.25E+00	8.86E+01	9.68E+00

Table DST.2 pg2

DST CHEM

SO4-2	3.43E+01	1.88E+01	1.44E+01
NO3-	3.59E+02	3.59E+02	3.59E+02
NO2-	1.25E+02	1.27E+02	5.70E+01
PO4-3	2.92E+01	1.83E+01	4.84E+01
OH-	6.39E+01	1.09E+02	7.55E+01
TOC	1.01E+02	1.36E+01	8.42E+00

Table DST. 3 pg1
Decayed to 1995

SELECTIVE RETRIEVAL INVENTORY IN GRAMS (tanks selected for retrieval)				
DECAYED TO 12/31/95				
Radionuclides	3WDS	3EDS	5EDS	TOTAL
Na, kgs				
14C	0.00E+00	5.23E+02	3.37E-01	5.23E+02
90Sr	2.56E+02	7.01E+04	2.78E+01	7.04E+04
90Y	6.92E+00	1.89E+03	7.51E-01	1.90E+03
99Tc	2.17E+05	9.00E+05	3.63E+04	1.15E+06
137Cs	4.17E+04	2.43E+05	2.21E+04	3.07E+05
137Ba	6.37E-03	3.72E-02	3.37E-03	4.70E-02
154Eu	0.00E+00	2.78E+02	0.00E+00	2.78E+02
237Np	0.00E+00	6.40E+04	0.00E+00	6.40E+04
238Pu	0.00E+00	9.98E+00	0.00E+00	9.98E+00
239Pu	9.44E+02	3.67E+04	8.79E+02	3.86E+04
240Pu	6.44E+01	2.66E+03	5.99E+01	2.79E+03
241Pu	3.12E-01	1.12E+02	2.90E-01	1.12E+02
241Am	1.49E+02	1.46E+04	4.01E+01	1.48E+04

Table DST. 4 pg 1

SELECTIVE RETRIEVAL INVENTORY RECOVERED				
DECAYED TO 12/31/95 (IN GRAMS)				
Radionuclides	3WDS	3EDS	5EDS	TOTAL
Na, kgs				
14C	0.00E+00	5.17E+02	3.34E-01	5.18E+02
90Sr	2.53E+02	6.94E+04	2.75E+01	6.97E+04
90Y	6.85E+00	1.88E+03	7.44E-01	1.88E+03
99Tc	2.14E+05	8.91E+05	3.60E+04	1.14E+06
137Cs	4.13E+04	2.41E+05	2.18E+04	3.04E+05
137Ba	6.31E-03	3.68E-02	3.34E-03	4.65E-02
154Eu	0.00E+00	2.75E+02	0.00E+00	2.75E+02
237Np	0.00E+00	6.33E+04	0.00E+00	6.33E+04
238Pu	0.00E+00	9.88E+00	0.00E+00	9.88E+00
239Pu	9.35E+02	3.64E+04	8.70E+02	3.82E+04
240Pu	6.37E+01	2.63E+03	5.93E+01	2.76E+03
241Pu	3.09E-01	1.11E+02	2.88E-01	1.11E+02
241Am	1.48E+02	1.45E+04	3.97E+01	1.47E+04

TABLE DST.5 Pg 1

SELECTIVE RETRIEVAL RESIDUAL IN GRAMS				
DECAYED TO 12/31/95				
Radionuclides	3WDS	3EDS	5EDS	TOTAL
Na, kgs				
14C	0.00E+00	5.23E+00	3.37E-03	5.23E+00
90Sr	2.56E+00	7.01E+02	2.78E-01	7.04E+02
90Y	6.92E-02	1.89E+01	7.51E-03	1.90E+01
99Tc	2.17E+03	9.00E+03	3.63E+02	1.15E+04
137Cs	4.17E+02	2.43E+03	2.21E+02	3.07E+03
137Ba	6.37E-05	3.72E-04	3.37E-05	4.70E-04
154Eu	0.00E+00	2.78E+00	0.00E+00	2.78E+00
237Np	0.00E+00	6.40E+02	0.00E+00	6.40E+02
238Pu	0.00E+00	9.98E-02	0.00E+00	9.98E-02
239Pu	9.44E+00	3.67E+02	8.79E+00	3.86E+02
240Pu	6.44E-01	2.66E+01	5.99E-01	2.79E+01
241Pu	3.12E-03	1.12E+00	2.90E-03	1.12E+00
241Am	1.49E+00	1.46E+02	4.01E-01	1.48E+02

TABLE
DST. 6 P8'

DST Inventory for Tanks not recovered + 1% residuals			
DECAYED TO 12/31/95			
Radionuclides	3WDS	3EDS	5EDS
Grams			
14C	1.81E-01	5.23E+00	8.42E-01
90Sr	2.31E+02	1.74E+04	5.24E+02
90Y	6.25E+00	4.69E+02	1.42E+01
99Tc	2.17E+03	4.36E+04	5.87E+04
137Cs	5.26E+03	3.62E+04	2.76E+04
137Ba	1.18E-03	7.76E-03	4.61E-03
154Eu	2.24E+00	9.99E+01	2.73E+00
237Np	5.38E+02	6.57E+02	2.01E+02
238Pu	6.34E+01	3.91E-01	1.17E+01
239Pu	3.36E+04	4.34E+04	1.99E+04
240Pu	3.30E+03	2.97E+03	1.53E+03
241Pu	2.18E+02	1.59E+01	1.21E+02
241Am	3.33E+03	2.77E+03	1.06E+02

TABLE DST.7
pg 1

Solubility for DST wastes left +1% residuals			
DECAYED TO 12/31/95			
solubility=(mass radionuclide/mass nitrate)*360 g/			
Grams/liter	3WDS	3EDS	5EDS
SOLUBILITY GRAMS/LITER			
14C	5.00E-07	1.45E-06	1.00E-06
90Sr	6.37E-04	4.81E-03	6.25E-04
90Y	1.72E-05	1.30E-04	1.69E-05
99Tc	5.99E-03	1.21E-02	7.00E-02
137Cs	1.45E-02	1.00E-02	3.29E-02
137Ba	3.25E-09	2.15E-09	5.50E-09
154Eu	6.18E-06	2.77E-05	3.25E-06
237Np	1.48E-03	1.82E-04	2.40E-04
238Pu	1.75E-04	1.08E-07	1.40E-05
239Pu	9.28E-02	1.20E-02	2.37E-02
240Pu	9.11E-03	8.22E-04	1.82E-03
241Pu	6.00E-04	4.39E-06	1.45E-04
241Am	9.19E-03	7.67E-04	1.27E-04

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING - SECONDARY WASTE STREAM FROM OFF-GAS TREATMENT TWRS-EIS

ORIGINATOR DAVID STEIN DATE 10/13/95

REVISION NO. 0

OBJECTIVE DETERMINE BLEED STREAM REQUIREMENT FOR RECYCLE STREAM in OFF-GAS SYSTEM (VARIOUS SCENARIOS)

METHODOLOGY APPLY ANALYSIS FOR VITRIFICATION AND RELATE RESULTS TO OTHER ALTERNATIVES.

ASSUMPTIONS NO SEPARATIONS - VITRIFICATION MATERIAL BALANCE AND FLOW RATES USED AS BASIS.

(Continue on another sheet if necessary)

D L Stein

SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

Bleed Stream Requirement for Recycle Stream in Off-Gas System
No Separations - Vitrification

As noted in PDEIS for Tank Wastes on p. B-30 in App. B, each alternative would make extensive use of recycle streams in the process to recycle volatile radionuclide and chemical constituents captured in the off-gas systems back into the treatment process. Also noted was the need for further evaluation which may identify the need for a bleed stream that would require treatment and disposal.

Following is a conceptual analysis for vitrification to identify and characterize that bleed stream waste:

The offgas stream 410 from the melter contains the same quantity of radionuclides as is being removed in the off-gas system which is being recycled back to the evaporator feed tank from the HLW scrub filter tank in stream 692 (same as 630). Most of the radionuclides are present in solid form which make up 1% by wt of the recycle stream. Their concentration in the solid stream (recovered dust) is the same as

in the melter product stream, 411. The following assumption/analysis can then be made:

The concentration of radionuclides present in solid form in the recycle stream 692 is due to their presence in the dust from the melter and not due to volatilization in the melter and solidification in the off-gas system. Therefore their concentration should remain essentially the same in stream 410 and stream 692 with or without a bleed. This includes a very small portion of Tc as Tc_2O_7 which remains in the solid phase. The portion of Tc in the solid phase is only 1% of that in the gas/liquid phase in stream 410 and stream 692.

However, the radionuclides and chemicals present in stream 410 in a gaseous form (volatized from solid or liquid form in the melter) namely Tc I and Hg and in stream 692 in the liquid or solid form could build-up in concentration in the melter off-gas stream 410 and in the recycle stream 692 because they may have no way of

getting out of the loop. To prevent their buildup in the recycle stream, it will be necessary to bleed a portion of the recycle stream 692 and dispose of it in a second waste stream.

Technetium

From the material balance, 1/2 of the Tc in the feed to the melter is shown to exit in the melter off-gas (99% in gaseous form and 1% in solid form in dust) and 1/2 remains in the melter glass product. The Tc in the off-gas as Tc_2O_7 will solidify in the off-gas system and will dissolve in the scrubber water and be in solution in the form of the (TcO_4^-) ion which is very soluble in water. It will be recycled back with the fresh tank waste in the evaporator and then to the melter. If we assume the same 50/50 split of Tc in the feed to off-gas volatiles + to product melt, Tc will slowly build-up in the recycle stream 492 but will never exceed the amount in the new tank waste feed. Under these conditions and assumption of 50/50 split

There would be no need for a bleed stream for Tc. However, if the volatile split were greater than 50% the Tc would continue to build-up and would have to be bled from the recycle stream. The greater above 50% up to 100%, the faster the buildup and the higher the level of concentration.

Iodine

From the material balance, all of the Iodine in the feed to the melter is shown to exit in the melter off-gas. The Iodine will condense and liquefy at the temperature in the scrubber. and probably dissolve in the solution. Iodine is only slightly soluble but initially should all dissolve. It will be recycled back to the melter and will build up in the recycle stream and eventually not all dissolve but will stay in solid form. It will continue to build-up and should be bled from the recycle stream. The amount of I-129 is not given in the material balance and in fact Iodine is shown leaving in the stream 645 off gas to atmosphere. However Iodine as I_2 has a b.p. of 184°C which is well above the ambient temp (~30°C) of the offgas.

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Iodine does have an appreciable vapor pressure even at 60°C (5 mmHg) and may indeed stay with the gaseous effluent stream. It may also dissolve in water in small quantities present. For this bleed stream analysis, it is still unknown but would leave with bleed stream if present.

Mercury

From the material balance, all of the Hg is shown to exit in the melter off gas. 70% of Hg will condense and be in liquid form in the scrubber. Hg will probably collect in low points in the scrubber system or recycle system due to its high density and insolubility in water and could be removed in this manner. If it gets through and is recycled to the melter it will continue to build-up in this stream and should be bled off.

recycle stream 692 (same as 630)

liquid	Tc	3.20E-02	MCi
	Total MCi	3.20E-02	
	as TcO_4^-	3.09E+00	MT
Solid	Cs + Ba	7.01E-01	MCi
	Sr + Y	1.11E+00	MCi
	Tc	3.28E-04	MCi
	Am	1.07E-03	MCi
	Np	1.06E-06	MCi
	Pu-239	2.72E-04	MCi
	Pu-240	6.91E-05	MCi
	Pu-241	7.69E-04	MCi
	total TRU	2.18E-03	MCi
	total MCi	1.81E+00	

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BY DLS CHKD. JOB NO.

For estimating purposes, assume the case of 50% Tc in feed volatilized to off-gases in melter (same as material balance) but 100% Tc in recycle volatilized to off-gases. All Hg volatilized in feed + in recycle. All Iodine volatilized in feed + in recycle.

A bleed stream as a % of the recycle stream could then be assumed and a total volume and weight of that stream calculated. The table provides that information for a 100% bleed stream (all recycle stream bled as waste), a 10% and 1% bleed stream. It is assumed the bleed stream is representative of the recycle stream and will be 1% solids by wt. + 99% liquid by wt. The solids will be bled with the liquids to remove any buildup that may occur in this phase (unknown at this time) so that the bleed stream process will be a conservative estimate.

FORM 91-005-1 (4/81)

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DATE 10/13/95 SUBJECT BLEED STREAM TABLE SHEET NO. 7-8

BY DLS CHKD. JOB NO.

Bleed % →	100	10	1
Total Volume (m^3)	3.50E+05	3.50E+04	3.50E+03
Liquid (MT)	3.50E+05	3.50E+04	3.50E+03
Solids (MT)	3.69E+03	3.69E+03	3.69E+02
Total (MT)	3.54E+05	3.54E+04	3.54E+03
Radionuclides			
Liquids			
Tc as TcO_4^- (MCi)	3.20E-02	3.20E-02	3.20E-02
total MCi in liquid	3.20E-02	3.20E-02	3.20E-02
Solids			
Cs + Ba (MCi)	7.01E-01		
Sr + Y	1.11E+00		
Tc	3.28E-04		
Am	1.07E-03		
Np	1.06E-06		
Pu-239	2.72E-04		
Pu-240	6.91E-05		
Pu-241	7.69E-04		
total TRU	2.18E-03		
Total MCi in solid:	1.81E+00	1.81E-01	1.81E-02
Total MCi (solids + liquids)	1.84E+00	2.13E-01	5.01E-02
Other Chemicals			
Hg (MT)	2.24E+00	2.24E+00	2.24E+00
I_2 as I-129 (MT)			

amount unknown at this time. Additional calcs + modeling + pilot testing may even be required to determine. If present in recycle stream, it will be part of bleed stream.

Selected bleed rate

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For this calculation it is assumed that a 1% bleed stream will be sufficient. At the design rate of 200 MT glass per day, the total bleed volume will be approximately 500 gal/day of a waste stream for disposal. Over the life of the project, it will be approximately 3500 m^3 as shown in the table. It could be stabilized by a low temp. process (grout), concentrated by evaporation and then grouted or some other low temp. process?

Calcination

It is assumed that a similar bleed stream would be required for calcination with similar processing. Since the calcination estimates assumed the same volume of recycle stream 692, the volume and loadings would be similar.

Other Vitrification Alternatives

The bleed stream should be similar and proportional to the size (production rate) of the melter assuming the same feed composition of tank wastes.

RECYCLE STREAM
Same as 692

Stream Name Liquid Components	626	627	628	629	630	631	632	633	634	635
Volume, Kilo-Liters		2.32E+05	1.16E+03		3.50E+05	1.84E+04		2.19E-10	2.32E+05	
Specific Gravity		1.00E+00	1.00E+00		1.00E+00	1.00E+00		1.00E+00	1.00E+00	
Cs and Ba, (MCi)										
Sr and Y, (MCi)										
Tc, (MCi)			8.43E-04		3.20E-02	1.69E-03				
Am, (MCi)										
Np, (MCi)										
Pu-239, (MCi)										
Pu-240, (MCi)										
Pu-241, (MCi)										
Total TRU, (MCi)										
Total MCi			8.43E-04		3.20E-02	1.69E-03				
Total Mass Flow, (MT)		2.32E+05	1.16E+03		3.50E+05	1.84E+04		2.19E-10	2.32E+05	
Total Cr, (MT)										
Total Na, (MT)										
Total Si, (MT)										
Total P, (MT)										
Total NO2-, (MT)										
Total NO3-, (MT)										
AG+										
AL(OH)4-										
AM+3										
AS+5										
B+3										
BA+2										
BE+2										
BI+3										
C14										
CA+2										
CD+2										
CE+3										
CL-										
CL2		3.15E+02							3.15E+02	
CO		2.12E+03							2.12E+03	
CO2		1.72E+05							1.72E+05	
CO3-2										
CR(OH)4-										
CS+										
CU+2										
F-										
F2		1.18E+03							1.18E+03	
FE+3										
H2										
H2O		2.04E+02	1.16E+03		3.50E+05	1.84E+04		2.19E-10	2.04E+02	
H2S										
HG					2.24E+00	1.18E-01				

Stream Name Liquid Components	626	627	628	629	630	631	632	633	634	635
HG+2										
H+		5.66E+02							5.66E+02	
H2										
K+										
KEROSENE										
LA+3										
LI+										
MG+2										
MNO2										
MO+6										
N2		2.31E+04							2.31E+04	
NA+										
NH3										
NI+3										
NO		3.20E+02							3.20E+02	
NO2		1.35E+04							1.35E+04	
NO2-										
NO3-										
NP+4										
O2		1.68E+04							1.68E+04	
OH-										
PB+4										
PO4+3										
PU+4										
S										
SI+4										
SO2		1.36E+03							1.36E+03	
SO4+2										
SR+2										
TCO2										
TCO4-			8.13E-02		3.09E+00	1.63E-01				
TOC										
UO2+2										
V+5										
W+6										
ZN+2										
ZR+4										
ZRO2:2H2										

Stream Name Solid Components	626	627	628	629	630	631	632	633	634	635
Cs and Ba, (MCi)		5.44E-05	2.67E-03		7.01E-01	3.69E-02			2.72E-08	5.44E-05
Sr and Y, (MCi)		8.59E-05	4.21E-03		1.11E+00	5.83E-02			4.30E-08	8.59E-05
Tc, (MCi)		2.55E-08	1.25E-06		3.28E-04	1.73E-05			1.27E-11	2.55E-08
Am, (MCi)		8.31E-08	4.07E-06		1.07E-03	5.63E-05			4.15E-11	8.31E-08
Np, (MCi)		8.26E-11	4.05E-09		1.06E-06	5.60E-08			4.13E-14	8.26E-11
Pu-239, (MCi)		2.11E-08	1.03E-06		2.72E-04	1.43E-05			1.06E-11	2.11E-08
Pu-240, (MCi)		5.36E-09	2.63E-07		6.91E-05	3.64E-06			2.68E-12	5.36E-09
Pu-241, (MCi)					7.69E-04	4.05E-05				
Total TRU, (MCi)		1.10E-07	5.37E-06		2.18E-03	1.15E-04			5.48E-11	1.10E-07
Total MCi		1.41E-04	6.88E-03		1.81E+00	9.53E-02			7.02E-08	1.40E-04
Total Mass Flow, (MT)		2.86E-01	1.40E+01		3.69E+03	1.94E+02			1.43E-04	2.86E-01
Total Cr, (MT)		1.47E-04	7.21E-03		1.90E+00	9.97E-02			7.35E-08	1.47E-04
Total Na, (MT)		5.31E-02	2.60E+00		6.84E+02	3.60E+01			2.66E-05	5.31E-02
Total Si, (MT)		7.70E-02	3.77E+00		9.91E+02	5.22E+01			3.85E-05	7.69E-02
Total P, (MT)		1.30E-03	6.37E-02		1.67E+01	8.81E-01			6.50E-07	1.30E-03
Total NO2-, (MT)										
Total NO3-, (MT)										
AG+										
AG2O		1.47E-06	7.18E-05		1.89E-02	9.94E-04			7.33E-10	1.47E-06
AL+3										
AL2O3		1.43E-02	7.01E-01		1.84E+02	9.70E+00			7.16E-06	1.43E-02
AM+3										
AM2O3		2.66E-08	1.30E-06		3.43E-04	1.80E-05			1.33E-11	2.66E-08
AS+5										
AS2O5		1.56E-06	7.63E-05		2.01E-02	1.06E-03			7.79E-10	1.56E-06
B+3										
B2O3		3.90E-06	1.91E-04		5.03E-02	2.65E-03			1.95E-09	3.90E-06
BA+2										
BAO		3.47E-06	1.70E-04		4.47E-02	2.35E-03			1.74E-09	3.47E-06
BE+2										
BEO		1.99E-07	9.75E-06		2.56E-03	1.35E-04			9.95E-11	1.99E-07
BI+3										
BI2O3		2.35E-04	1.15E-02		3.03E+00	1.60E-01			1.18E-07	2.35E-04
C14										
CA+2										
CANCRINI										
CAO		2.86E-02	1.40E+00		3.69E+02	1.94E+01			1.43E-05	2.86E-02
CD+2										
CDO		9.16E-06	4.49E-04		1.18E-01	6.21E-03			4.58E-09	9.16E-06
CE+3										
CE2O3		2.23E-04	1.09E-02		2.87E+00	1.51E-01			1.12E-07	2.23E-04
CL-										
CO3-2										
CR+3										
CR2O3		2.15E-04	1.05E-02		2.77E+00	1.46E-01			1.08E-07	2.15E-04
CS-										

Stream Name / Solid Components	626	627	628	629	630	631	632	633	634	635
CS2O		7.73E-07	3.79E-05		9.95E-03	5.24E-04			3.86E-10	7.72E-07
CU										
CU+2										
CUO		9.25E-07	4.53E-05		1.19E-02	6.27E-04			4.63E-10	9.25E-07
CUSO4										
F-										
FE+3										
FE2O3		9.87E-04	4.84E-02		1.27E+01	6.69E-01			4.94E-07	9.87E-04
HG+2										
I-										
K+										
K2O			6.94E-03		2.64E-01	1.39E-02				
LA+3										
LA2O3		1.99E-05	9.77E-04		2.57E-01	1.35E-02			9.97E-09	1.99E-05
LI+										
LI2O		5.23E-08	2.56E-06		6.74E-04	3.55E-05			2.62E-11	5.23E-08
MG+2										
MGO		1.59E-05	7.79E-04		2.05E-01	1.08E-02			7.95E-09	1.59E-05
MNO2		1.85E-04	9.05E-03		2.38E+00	1.25E-01			9.24E-08	1.85E-04
MO+6										
MOO3		6.81E-06	3.34E-04		8.78E-02	4.62E-03			3.41E-09	6.81E-06
NA+										
NA2O		7.16E-02	3.51E+00		9.22E+02	4.85E+01			3.58E-05	7.15E-02
NI+3										
NI2FECN6										
NI2O3			4.07E-03		1.55E-01	8.14E-03				
NIO		1.82E-04	8.90E-03		2.34E+00	1.23E-01			9.08E-08	1.82E-04
NO2-										
NO3-										
NP+4										
NPO2		1.33E-07	6.52E-06		1.71E-03	9.02E-05			6.65E-11	1.33E-07
OH-										
P2O5		2.98E-03	1.46E-01		3.83E+01	2.02E+00			1.49E-06	2.97E-03
P2O5:24W										
PB+4										
PBO2		4.85E-06	2.37E-04		6.24E-02	3.28E-03			2.42E-09	4.84E-06
PO4-3										
PU+4										
PUO2		4.13E-07	2.02E-05		5.33E-03	2.80E-04			2.06E-10	4.13E-07
SI+4										
SIO2		1.65E-01	8.07E+00		2.12E+03	1.12E+02			8.23E-05	1.65E-01
SO4-2										
SR+2										
SRO		3.47E-05	1.70E-03		4.47E-01	2.35E-02			1.74E-08	3.47E-05
TC2O7		2.35E-06	1.15E-04		3.03E-02	1.60E-03			1.18E-09	2.35E-06
TCO4-										

Stream Name Solid Components	626	627	628	629	630	631	632	633	634	635
TOC										
UO2+2										
UO3		1.41E-03	6.92E-02		1.82E+01	9.57E-01			7.06E-07	1.41E-03
V+5										
V2O5		3.57E-07	1.75E-05		4.60E-03	2.42E-04			1.79E-10	3.57E-07
WO2		3.53E-07	1.73E-05		4.55E-03	2.40E-04			1.77E-10	3.53E-07
WO3		7.55E-07	3.70E-05		9.72E-03	5.12E-04			3.77E-10	7.54E-07
ZN+2										
ZNO		4.52E-06	2.22E-04		5.82E-02	3.07E-03			2.26E-09	4.52E-06
ZR+4										
ZRO2		5.66E-04	2.78E-02		7.30E+00	3.84E-01			2.83E-07	5.66E-04
ZRO2:2H2										

Stream Name Liquid Components	409	410	411	412	413	414	415	416	417	418
Volume, Kilo-Liters	1.85E+05	5.82E+05		7.30E+04	7.30E+04	7.23E+06	7.30E+06	4.37E+04	7.23E+03	7.34E+06
Specific Gravity	1.00E+00	1.00E+00		1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cs and Ba, (MCi)										
Sr and Y, (MCi)										
Tc, (MCi)		3.19E-02								
Am, (MCi)										
Np, (MCi)										
Pu-239, (MCi)										
Pu-240, (MCi)										
Pu-241, (MCi)										
Total TRU, (MCi)										
Total MCi		3.19E-02								
Total Mass Flow, (MT)	1.85E+05	5.82E+05		7.30E+04	7.30E+04	7.23E+06	7.30E+06	4.37E+04	7.23E+03	7.34E+06
Total Cr, (MT)										
Total Na, (MT)										
Total Si, (MT)										
Total P, (MT)										
Total NO2-, (MT)										
Total NO3-, (MT)										
AG+										
AL(OH)4-										
AM+3										
AS+5										
B+3										
BA+2										
BE+2										
BI+3										
C14										
CA+2										
CD+2										
CE+3										
CL-										
CL2		3.15E+02								
CO		2.12E+03								
CO2		1.72E+05								
CO3-2										
CR(OH)4-										
CS+										
CU+2										
F-										
F2		1.18E+03								
FE+3										
H2										
H2O		3.50E+05		7.30E+04	7.30E+04	7.23E+06	7.30E+06	4.37E+04	7.23E+03	7.34E+06
H2S										

Stream Name / Liquid Components	409	410	411	412	413	414	415	416	417	418
HG		3.20E+00								
HG+2										
I-										
I2		5.66E+02								
K+										
KEROSENE										
LA+3										
LI+										
MG+2										
MNO2										
MO+6										
N2		2.31E+04								
NA+										
NH3										
NI+3										
NO		3.20E+02								
NO2		1.35E+04								
NO2-										
NO3-										
NP+4										
O2	1.85E+05	1.68E+04								
OH-										
PB+4										
PO4-3										
PU+4										
S										
SI+4										
SO2		1.36E+03								
SO4-2										
SR+2										
TCO2		2.48E+00								
TCO4-										
TOC										
UO2+2										
V+5										
W+6										
ZN+2										
ZR+4										
ZRO2:2H2										

Stream Name: Solid Components	409	410	411	412	413	414	415	416	417	418
Cs and Ba. (MCi)		7.01E-01	6.94E+01			6.94E+01	6.94E+01		6.87E+01	6.94E-01
Sr and Y. (MCi)		1.11E+00	1.10E+02			1.10E+02	1.10E+02		1.09E+02	1.10E+00
Tc. (MCi)		3.28E-04	3.25E-02			3.25E-02	3.25E-02		3.22E-02	3.25E-04
Am. (MCi)		1.07E-03	1.06E-01			1.06E-01	1.06E-01		1.05E-01	1.06E-03
Np. (MCi)		1.06E-06	1.05E-04			1.05E-04	1.05E-04		1.04E-04	1.05E-06
Pu-239. (MCi)		2.72E-04	2.69E-02			2.69E-02	2.69E-02		2.67E-02	2.69E-04
Pu-240. (MCi)		6.91E-05	6.84E-03			6.84E-03	6.84E-03		6.77E-03	6.84E-05
Pu-241. (MCi)		7.72E-04	7.64E-02			7.64E-02	7.64E-02		7.57E-02	7.64E-04
Total TRU. (MCi)		2.18E-03	2.16E-01			2.16E-01	2.16E-01		2.14E-01	2.16E-03
Total MCi		1.81E+00	1.79E+02			1.79E+02	1.79E+02		1.77E+02	1.79E+00
Total Mass Flow. (MT)		3.69E+03	3.65E+05			3.65E+05	3.65E+05		3.61E+05	3.65E+03
Total Cr. (MT)		1.90E+00	1.88E+02			1.88E+02	1.88E+02		1.86E+02	1.88E+00
Total Na. (MT)		6.84E+02	6.77E+04			6.77E+04	6.77E+04		6.70E+04	6.77E+02
Total Si. (MT)		9.91E+02	9.81E+04			9.81E+04	9.81E+04		9.72E+04	9.81E+02
Total P. (MT)		1.67E+01	1.66E+03			1.66E+03	1.66E+03		1.64E+03	1.66E+01
Total NO2-. (MT)										
Total NO3-. (MT)										
AG+										
AG2O		1.89E-02	1.87E+00			1.87E+00	1.87E+00		1.85E+00	1.87E-02
AL+3										
AL2O3		1.84E+02	1.83E+04			1.83E+04	1.83E+04		1.81E+04	1.83E+02
AM+3										
AM2O3		3.43E-04	3.39E-02			3.39E-02	3.39E-02		3.36E-02	3.39E-04
AS+5										
AS2O5		2.01E-02	1.99E+00			1.99E+00	1.99E+00		1.97E+00	1.99E-02
B+3										
B2O3		5.03E-02	4.98E+00			4.98E+00	4.98E+00		4.93E+00	4.98E-02
BA+2										
BAO		4.47E-02	4.43E+00			4.43E+00	4.43E+00		4.38E+00	4.43E-02
BE+2										
BEO		2.56E-03	2.54E-01			2.54E-01	2.54E-01		2.51E-01	2.54E-03
BI+3										
BI2O3		3.03E+00	3.00E+02			3.00E+02	3.00E+02		2.97E+02	3.00E+00
C14										
CA+2										
CANCRINI										
CAO		3.69E+02	3.65E+04			3.65E+04	3.65E+04		3.61E+04	3.65E+02
CD+2										
CDO		1.18E-01	1.17E+01			1.17E+01	1.17E+01		1.16E+01	1.17E-01
CE+3										
CE2O3		2.87E+00	2.84E+02			2.84E+02	2.84E+02		2.81E+02	2.84E+00
CL-										
CO3-2										
CR+3										
CR2O3		2.77E+00	2.74E+02			2.74E+02	2.74E+02		2.71E+02	2.74E+00
CS+										

Stream Name / Tank Components	409	410	411	412	413	414	415	416	417	418
CS2O		9.96E-03	9.86E-01			9.86E-01	9.86E-01		9.76E-01	9.86E-03
CU										
CU+2										
CUO		1.19E-02	1.18E+00			1.18E+00	1.18E+00		1.17E+00	1.18E-02
CUSO4										
F-										
FE+3										
FE2O3		1.27E+01	1.26E+03			1.26E+03	1.26E+03		1.25E+03	1.26E+01
HG+2										
H+										
K+										
KCO		2.64E-01	2.61E+01			2.61E+01	2.61E+01		2.59E+01	2.61E-01
LA+3										
LA2O3		2.57E-01	2.54E+01			2.54E+01	2.54E+01		2.52E+01	2.54E-01
LI+										
LIO		6.74E-04	6.67E-02			6.67E-02	6.67E-02		6.60E-02	6.67E-04
MG+2										
MGO		2.05E-01	2.03E+01			2.03E+01	2.03E+01		2.01E+01	2.03E-01
MNO2		2.38E+00	2.36E+02			2.36E+02	2.36E+02		2.33E+02	2.36E+00
MO+6										
MOO3		8.78E-02	8.69E+00			8.69E+00	8.69E+00		8.60E+00	8.69E-02
NA+										
NA2O		9.22E+02	9.13E+04			9.13E+04	9.13E+04		9.04E+04	9.13E+02
NI+3										
NI2FECN6										
NI2O3		1.55E-01	1.53E+01			1.53E+01	1.53E+01		1.52E+01	1.53E-01
NIO		2.34E+00	2.32E+02			2.32E+02	2.32E+02		2.29E+02	2.32E+00
NO2-										
NO3-										
NP+4										
NPO2		1.71E-03	1.70E-01			1.70E-01	1.70E-01		1.68E-01	1.70E-03
OH-										
P2O5		3.83E+01	3.79E+03			3.79E+03	3.79E+03		3.76E+03	3.79E+01
P2O5:24W										
PB+4										
PBO2		6.24E-02	6.18E+00			6.18E+00	6.18E+00		6.12E+00	6.18E-02
PO4-3										
PU+4										
PUO2		5.33E-03	5.27E-01			5.27E-01	5.27E-01		5.22E-01	5.27E-03
SI+4										
SIO2		2.12E+03	2.10E+05			2.10E+05	2.10E+05		2.08E+05	2.10E+03
SO4-2										
SR+2										
SRO		4.47E-01	4.43E+01			4.43E+01	4.43E+01		4.38E+01	4.43E-01
TC2O7		3.03E-02	3.00E+00			3.00E+00	3.00E+00		2.97E+00	3.00E-02
TCO4-										

Stream Name Solid Components	409	410	411	412	413	414	415	416	417	418
TOC										
UO2+2										
UO3		1.82E+01	1.80E+03			1.80E+03	1.80E+03		1.78E+03	1.80E+01
V+5										
V2O5		4.60E-03	4.56E-01			4.56E-01	4.56E-01		4.51E-01	4.56E-03
WO2		4.55E-03	4.51E-01			4.51E-01	4.51E-01		4.46E-01	4.51E-03
WO3		9.72E-03	9.62E-01			9.62E-01	9.62E-01		9.53E-01	9.62E-03
ZN+2										
ZNO		5.82E-02	5.77E+00			5.77E+00	5.77E+00		5.71E+00	5.77E-02
ZR+4										
ZRO2		7.30E+00	7.22E+02			7.22E+02	7.22E+02		7.15E+02	7.22E+00
ZRO2:2H2										

Table C-2. Material Balance for Gas Streams. (4 sheets)

WHC MASS BALANCE				FLUOR MASS BALANCE										SI UNITS	
STREAM NO.	LIQUID PHASE MT	SOLID PHASE MT	TOTAL STREAM MT	PHASE	OVERALL FACTOR	TOTAL WATER MT	% DISSOLVED SOLIDS	% SUSPENDED SOLIDS	TOTAL % SOLIDS	TOTAL STREAM lb/hr	SOLN. SP. GR. (WHC)	ACTUAL SP. GR. (CALC.)	TOTAL STREAM GPM	TOTAL STREAM Kg / hr	TOTAL STREAM L / Min
SHADED NUMBERS IN BOLD ITALICS ARE BACK CALCULATED BY FLUOR AND MAY NOT AGREE WITH WHC MASS BALANCE															
651				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
652				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
653				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
654				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
655	N / A														
656	N / A														
657				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
670	N / A									N / A					
671	N / A									N / A					
672	N / A									N / A					
673	N / A									N / A					
674	N / A									N / A					
675	N / A									N / A					
676	N / A									N / A					
677	N / A									N / A					
678	N / A									N / A					
679	N / A									N / A					
680	N / A									N / A					
681	N / A									N / A					
682	N / A									N / A					
683	N / A									N / A					
684	N / A									N / A					
685	N / A									N / A					
686				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
690	4.22E+01		4.22E+01	L	4.992E-02		100.0	0.0	100.0	2	1.00	1.96	0.00	1	0.01
692	3.82E+05	3.80E+03	3.86E+05	L	4.992E-02	3.82E+05	0.0	1.0	1.0	1.9E+04	1.00	1.00	38.50	8736	146
700				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
701	2.19E-10		2.19E-10	L	4.992E-02	2.19E-10	0.0	0.0	0.0	1.1E-11	1.00	1.00	2.2E-14	5.0E-12	8.3E-14
702				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
703	N / A									N / A					
704				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
705	2.19E-10		2.19E-10	L	4.992E-02	2.19E-10	0.0	0.0	0.0	1.1E-11	1.00	1.00	2.2E-14	5.0E-12	8.3E-14
706				G		INCLUDED IN " MATERIAL BALANCE FOR GAS STREAMS "									
707	N / A									N / A					
708	N / A									N / A					
800	9.48E+05		9.48E+05	L	4.992E-02	7.53E+05	20.5	0.0	20.5	47307	1.00	1.00	94.56	21458	357.90
801	N / A									N / A					
802	9.48E+05		9.48E+05	L	4.992E-02	7.53E+05	20.5	0.0	20.5	47307	1.00	1.00	94.56	21458	357.90
803	N / A									N / A					
804	9.48E+05		9.48E+05	L	4.992E-02	7.53E+05	20.5	0.0	20.5	47307	1.00	1.00	94.56	21458	357.90
805	N / A									N / A					
906	1.97E-01	1.99E-03	1.99E-01	S/L	4.992E-02	1.97E-01	0.0	1.0	1.0	9.9E-03	1.00	1.01	2.0E-05	4.5E-03	7.5E-05
916	3.69E+04	3.72E+02	3.73E+04	L	4.992E-02	3.69E+04	0.0	1.0	1.0	1.9E+03	1.00	[illegible]	[illegible]7E+00	8.4E+02	1.4E+01

Table 7. Vapor Pressures of Inorganic Compounds, up to 1 Atm.—*(Continued)*

Compound		Pressure, mm. Hg										Melting point, °C.
Name	Formula	1	5	10	20	40	60	100	200	400	760	
		Temperature, °C.										
Deuterium cyanide	DCN	−68.9	−54.0	−46.7	−38.8	−30.1	−24.7	−17.5	−5.4	+10.0	26.2	−12
Fluorine	F_2	−223.0	−216.9	−214.1	−211.0	−207.7	−205.6	−202.7	−198.3	−193.2	−187.9	−223
oxide	F_2O	−196.1	−186.6	−182.3	−177.8	−173.0	−170.0	−165.8	−159.0	−151.9	−144.6	−223.9
Germanium bromide	$GeBr_4$	.....	43.3	56.8	71.8	88.1	98.8	113.2	135.4	161.6	189.0	26.1
chloride	$GeCl_4$	−45.0	−24.9	−15.0	−4.1	+8.0	16.2	27.5	44.4	63.8	84.0	−49.5
hydride	GeH_4	−163.0	−151.0	−145.3	−139.2	−131.6	−126.7	−120.3	−111.2	−100.2	−88.9	−165
Trichlorogermane	$GeHCl_3$	−41.3	−22.3	−13.0	−3.0	+8.8	16.2	26.5	41.6	58.3	75.0	−71.1
Tetramethylgermane	$Ge(CH_3)_4$	−73.2	−54.6	−45.2	−35.0	−23.4	−16.2	−6.3	+8.8	26.0	44.0	−88
Digermane	Ge_2H_6	−88.7	−69.8	−60.1	−49.9	−38.2	−30.7	−20.3	−4.7	+13.3	31.5	−109
Trigermane	Ge_3H_8	−36.9	−12.8	−0.9	+11.8	26.3	35.5	47.9	67.0	88.6	110.8	−105.6
Gold	Au	1869	2059	2154	2256	2363	2431	2521	2657	2807	2966	1063
Helium	He	−271.7	−271.5	−271.3	−271.1	−270.7	−270.6	−270.3	−269.8	−269.3	−268.6	
para-Hydrogen	H_2	−263.3	−261.9	−261.3	−260.4	−259.6	−258.9	−257.9	−256.3	−254.5	−252.5	−259.1
Hydrogen bromide	HBr	−138.8	−127.4	−121.8	−115.4	−108.3	−103.8	−97.7	−88.1	−78.0	−66.5	−87.0
chloride	HCl	−150.8	−140.7	−135.6	−130.0	−123.8	−119.6	−114.0	−105.2	−95.3	−84.8	−114.3
cyanide	HCN	−71.0	−55.3	−47.7	−39.7	−30.9	−25.1	−17.8	−5.3	+10.2	25.9	−13.2
fluoride	H_2F_2	.....	−74.7	−65.8	−56.0	−45.0	−37.9	−28.2	−13.2	+2.5	19.7	−83.7
iodide	HI	−123.3	−109.6	−102.3	−94.5	−85.6	−79.8	−72.1	−60.3	−48.3	−35.1	−50.9
oxide (water)	H_2O	−17.3	+1.2	11.2	22.1	34.0	41.5	51.6	66.5	83.0	100.0	0.0
sulfide	H_2S	−134.3	−122.4	−116.3	−109.7	−102.3	−97.9	−91.6	−82.3	−71.8	−60.4	−85.5
disulfide	HSSH	−43.2	−24.4	−15.2	−5.1	+6.0	12.8	22.0	35.3	49.6	64.0	−89.7
selenide	H_2Se	−115.3	−103.4	−97.9	−91.8	−84.7	−80.2	−74.2	−65.2	−53.6	−41.1	−64
telluride	H_2Te	−96.4	−82.4	−75.4	−67.8	−59.1	−53.7	−45.7	−32.4	−17.2	−2.0	−49.0
Iodine	I_2	38.7	62.2	73.2	84.7	97.5	105.4	116.5	137.3	159.8	183.0	112.9
heptafluoride	IF_7	−87.0	−70.7	−63.0	−54.5	−45.3	−39.4	−31.9	−20.7	−8.3	+4.0	5.5
Iron	Fe	1787	1957	2039	2128	2224	2283	2360	2475	2605	2735	1535
pentacarbonyl	$Fe(CO)_5$	.....	−6.5	+4.6	16.7	30.3	39.1	50.3	68.0	86.1	105.0	−21
Ferric chloride	Fe_2Cl_6	194.0	221.8	235.5	246.0	256.8	263.7	272.5	285.0	298.0	319.0	304
Ferrous chloride	$FeCl_2$	.....	.....	700	737	779	805	842	897	961	1026	
Krypton	Kr	−199.3	−191.3	−187.2	−182.9	−178.4	−175.7	−171.8	−165.9	−159.0	−152.0	−156.7
Lead	Pb	973	1099	1162	1234	1309	1358	1421	1519	1630	1744	327.5
bromide	$PbBr_2$	513	578	610	646	686	711	745	796	856	914	373
chloride	$PbCl_2$	547	615	648	684	725	750	784	833	893	954	501
fluoride	PbF_2	.....	861	904	950	1003	1036	1088	1144	1219	1293	855
iodide	PbI_2	479	540	571	605	644	668	701	750	807	872	402
oxide	PbO	943	1039	1085	1134	1189	1222	1265	1330	1402	1472	890
sulfide	PbS	852	928	975	1005	1048	1074	1108	1160	1221	1281	1114
Lithium	Li	723	828	881	940	1003	1042	1097	1178	1273	1372	186
bromide	LiBr	748	840	888	939	994	1028	1076	1147	1226	1310	547
chloride	LiCl	783	880	932	987	1045	1081	1129	1203	1290	1382	614
fluoride	LiF	1047	1156	1211	1270	1333	1372	1425	1503	1591	1681	870
iodide	LiI	723	802	841	883	927	955	993	1049	1110	1171	446
Magnesium	Mg	621	702	743	789	838	868	909	967	1034	1107	651
chloride	$MgCl_2$	778	877	930	988	1050	1088	1142	1223	1316	1418	712
Manganese	Mn	1292	1434	1505	1583	1666	1720	1792	1900	2029	2151	1260
chloride	$MnCl_2$	.....	736	778	825	879	913	960	1028	1108	1190	650
Mercury	Hg	126.2	164.8	184.0	204.6	228.8	242.0	261.7	290.7	323.0	357.0	−38.9
Mercuric bromide	$HgBr_2$	136.5	165.3	179.8	194.3	211.5	221.6	237.8	262.7	290.0	319.0	237
chloride	$HgCl_2$	136.2	166.0	180.2	195.8	212.5	222.2	237.0	256.5	275.5	304.0	277
iodide	HgI_2	157.5	189.2	204.5	220.0	238.2	249.0	261.8	291.0	324.2	354.0	259
Molybdenum	Mo	3102	3393	3535	3690	3859	3964	4109	4322	4553	4804	2622
hexafluoride	MoF_6	−65.5	−49.0	−40.8	−32.0	−22.1	−16.2	−8.0	+4.1	17.2	36.0	17
oxide	MoO_3	734	785	814	851	892	917	955	1014	1082	1151	795
Neon	Ne	−257.3	−255.5	−254.6	−253.7	−252.6	−251.9	−251.0	−249.7	−248.1	−246.0	−248.7
Nickel	Ni	1810	1979	2057	2143	2234	2289	2364	2473	2603	2732	1452
carbonyl	$Ni(CO)_4$	.....	.....	.....	.....	−23.0	−15.9	−6.0	+8.8	25.8	42.5	−25
chloride	$NiCl_2$	671	731	759	789	821	840	866	904	945	987	1001
Nitrogen	N_2	−226.1	−221.3	−219.1	−216.8	−214.0	−212.3	−209.7	−205.6	−200.9	−195.8	−210.0
Nitric oxide	NO	−184.5	−180.6	−178.2	−175.3	−171.7	−168.9	−166.0	−162.3	−156.8	−151.7	−161
Nitrogen dioxide	NO_2	−55.6	−42.7	−36.7	−30.4	−23.9	−19.9	−14.7	−5.0	+8.0	21.0	−9.3
Nitrogen pentoxide	N_2O_5	−36.8	−23.0	−16.7	−10.0	−2.9	+1.8	7.4	15.6	24.4	32.4	30
Nitrous oxide	N_2O	−143.4	−133.4	−128.7	−124.0	−118.3	−114.9	−110.3	−103.6	−96.2	−85.5	−90.9
Nitrosyl chloride	NOCl	.....	.....	.....	.....	−60.2	−54.2	−46.3	−34.0	−20.3	−6.4	−64.5
fluoride	NOF	−132.0	−120.3	−114.3	−107.8	−100.3	−95.7	−88.8	−79.2	−68.2	−56.0	−134
Osmium tetroxide (yellow)	OsO_4	3.2	22.0	31.3	41.0	51.7	59.4	71.5	89.5	109.3	130.0	56
(white)	OsO_4	−5.6	+15.6	26.0	37.4	50.5	59.4	71.5	89.5	109.3	130.0	42
Oxygen	O_2	−219.1	−213.4	−210.6	−207.5	−204.1	−201.9	−198.8	−194.0	−188.8	−183.1	−218.7
Ozone	O_3	−180.4	−168.6	−163.2	−157.2	−150.7	−146.7	−141.0	−132.6	−122.5	−111.1	−251
Phosgene	$COCl_2$	−92.9	−77.0	−69.3	−60.3	−50.3	−44.0	−35.6	−22.3	−7.6	+8.3	−104
Phosphorus (yellow)	P	76.6	111.2	128.0	146.2	166.7	179.8	197.3	222.7	251.0	280.0	44.1
(violet)	P	237	271	287	306	323	334	349	370	391	417	590
tribromide	PBr_3	7.8	34.4	47.8	62.4	79.0	89.8	103.6	125.2	149.7	175.3	−40
trichloride	PCl_3	−51.6	−31.5	−21.3	−10.2	+2.3	10.2	21.0	37.6	56.9	74.2	−111.8
pentachloride	PCl_5	55.5	74.0	83.2	92.5	102.5	108.3	117.0	131.3	147.2	162.0	
Phosphine	PH_3	.....	.....	.....	.....	−129.4	−125.0	−118.8	−109.4	−98.3	−87.5	−132.5
Phosphonium bromide	PH_4Br	−43.7	−28.5	−21.2	−13.3	−5.0	+0.3	7.4	17.6	28.0	38.3	
chloride	PH_4Cl	−91.0	−79.6	−74.0	−68.0	−61.5	−57.3	−52.0	−44.0	−35.4	−27.0	−28.5
iodide	PH_4I	−25.2	−9.0	−1.1	+7.3	16.1	21.9	29.3	39.9	51.6	62.3	
Phosphorus trioxide	P_4O_6	.....	39.7	53.0	67.8	84.0	94.2	108.3	129.0	150.3	173.1	22.5
pentoxide	P_4O_{10}	384	424	442	462	481	493	510	532	556	591	569
oxychloride	$POCl_3$	.....	.....	2.0	13.6	27.3	35.8	47.4	65.0	84.3	105.1	2
thiobromide	$PSBr_3$	50.0	72.4	83.6	95.5	108.0	116.0	126.3	141.8	157.8	175.0	38
thiochloride	$PSCl_3$	−18.3	+4.6	16.1	29.0	42.7	51.8	63.8	82.0	102.3	124.0	−36.2
Platinum	Pt	2730	3007	3146	3302	3469	3574	3714	3923	4169	4407	1755
Potassium	K	341	408	443	483	524	550	586	643	708	774	62.3
bromide	KBr	795	892	940	994	1050	1087	1137	1212	1297	1383	730
chloride	KCl	821	919	968	1020	1078	1115	1164	1239	1322	1407	790
fluoride	KF	885	988	1039	1096	1156	1193	1245	1323	1411	1502	880
hydroxide	KOH	719	814	863	918	976	1013	1064	1142	1233	1327	380
iodide	KI	745	840	887	938	995	1030	1080	1152	1238	1324	723
Radon	Rn	−144.2	−132.4	−126.3	−119.2	−111.3	−106.2	−99.0	−87.7	−75.0	−61.8	−71
Rhenium heptoxide	Re_2O_7	212.5	237.5	248.0	261.0	272.0	280.0	289.0	307.0	336.0	362.4	296

it forms a hydrate, which has the composition $Br_2 \cdot 7\frac{2}{3}\ H_2O$, according to von Stackelberg (1949–52; see p. 220). It is more soluble in many organic solvents than in water—e.g., in chloroform and carbon disulfide.

Bromine water, like chlorine water, evolves oxygen when exposed to sunlight:

$$Br_2 + H_2O = HOBr + HBr, \qquad HOBr = HBr + \tfrac{1}{2}O_2$$

Atomic bromine, which was obtained by Schwab (1934) in the same way as atomic chlorine, has a particularly high efficiency of recombination. It was found that recombination of Br-atoms, to form Br_2 molecules, took place at every collision with the wall of the container, irrespective of the material of the wall.

(*iv*) *Iodine* is much less reactive than chlorine or bromine. It combines directly and vigorously with a number of the elements (e.g., with sulfur, phosphorus, iron, and mercury), but has only a small tendency to combine with hydrogen.

At ordinary temperature, hydrogen and iodine do not combine with measurable velocity. At higher temperatures, an equilibrium is established between hydrogen iodide and its components (cf. Table 105):

$$H_2 + I_2 \rightleftharpoons 2HI.$$

Like the other halogens, iodine does not unite directly with oxygen. It forms the oxide I_2O_5, however, which may be obtained by other means, and which—unlike the oxides of chlorine and bromine—is an exothermic compound. The solubility of iodine in water is but small (1 part in 5500 at 10°). The solution has a weak brownish yellow color. Iodine is readily soluble in many organic solvents, forming *violet* solutions in carbon disulfide, chloroform and carbon tetrachloride, a *red* solution in benzene, and *brownish* solutions in many organic compounds containing oxygen, such as alcohol, ether and acetone. The violet solutions contain I_2 molecules. It is considered by some that the brown solutions contain compounds of iodine with the molecules of solvent (solvates), but others think it more likely that the differences in color of iodine solution arise from differences in the forces of interaction between I_2 molecules and solvent molecules, and the resultant perturbations of molecular energy levels, without involving the formation of any stoichiometric addition compounds (Kortüm, 1947; Rees 1951). Iodine forms deep blue adsorption complexes with starch paste and also with the gelatinous precipitates of basic lanthanum or praseodymium acetates.

The solutions of iodine in many organic solvents, such as benzophenone in which it forms a violet solution, possess electrical conductivity. It may be inferred from this that the iodine is partially dissociated into ions:

$$I_2 \rightleftharpoons I^+ + I^-.$$

The reactions undergone by such solutions also indicate that such dissociation occurs. Thus, in benzene or chloroform solution, iodine reacts with silver perchlorate:

$$I_2 + AgClO_4 = AgI + I[ClO_4].$$

The iodine(I) salt can be stabilized by addition of neutral, complex-forming substances such as pyridine, so that it may be separated as the crystalline dipyridine iodine(I) per-

produces painful wounds in contact with the skin. The vapor strongly attacks the mucous membranes, and is dangerous even in high dilution. Bromine boils at + 58.8° and freezes at —7.3° to a brown crystalline mass with a weakly metallic luster.

(*iv*) *Iodine* is solid even at ordinary temperature, forming grey-black flakes with a metallic luster (density 4.942). Although it boils only at 184.5°, it is already perceptibly volatile at ordinary temperature and has a peculiar smell. Iodine vapor is also poisonous, and produces violent catarrhal inflammations of the mucous membranes of the nose and eyes. Iodine melts at 113.7°, but vaporizes so readily below this temperature, that it often sublimes without melting if it is not too rapidly heated.

Villard (1896) and Dewar (1898) made the curious observation that the vapor pressure of bromine and iodine is higher in the presence of foreign gases (e.g., N_2, O_2, CO_2) than in a vacuum. This observation was confirmed by Braune and Strassmann (1929).

(d) Chemical Properties

(*i*) *Fluorine* [*1*, *2*] is extraordinarily reactive chemically. When mixed with hydrogen it usually ignites spontaneously* (even in the dark), and usually with a violent explosion. It also combines in the cold with bromine, iodine, sulfur, phosphorus, arsenic, antimony, boron, silicon, wood charcoal,** and with many metals, producing a flame or vigorous incandescence. Many metals, such as copper, are only superficially attacked at ordinary or slightly elevated temperatures, since the coating which is formed hinders further reaction. However, the reaction with such metals (e.g., zinc, tin, aluminum) goes to completion in some cases with lively incandescence, when they are more strongly heated. Even gold and platinum are strongly attacked by fluorine at a red heat. Most chemical compounds are also decomposed by fluorine, as also are glass and quartz, unless their surfaces are rigorously freed from adsorbed water. The reaction of fluorine with amorphous silica may be attended with incandescence; silicon tetrafluoride is formed and oxygen is displaced. In many of these reactions water exerts a strong catalytic effect, and perfectly dry fluorine can, indeed, be safely manipulated in dry glass or silica apparatus. Stopcocks and ground glass joints in such experimentation may be lubricated with suitable fluorocarbon greases. Hydrogen sulfide and ammonia inflame in fluorine, and the hydrogen halides (other than hydrogen fluoride) are also decomposed. Fluorine liberates oxygen from water, some appearing in the form of ozone.

All these reactions arise from the strong tendency of fluorine to pass into the negatively charged state, whereby fluorine is able to abstract electrons from almost all other elements. Only oxygen and nitrogen do not react directly with fluorine; chlorine does so only upon heating. However, if these elements are present in the negatively charged state, fluorine abstracts from them their excess electrons, and liberates then in the elementary state:

$$Na^+Cl^- + \tfrac{1}{2}F_2 = Na^+F^- + \tfrac{1}{2}Cl_2$$

$$Si^{4+}(O^{2-})_2 + 2F_2 = Si^{4+}(F^-)_4 + O_2$$

(*ii*) *Chlorine* is also a highly reactive element, but is much less reactive than

* See footnote 1, p. 40.

** Graphite reacts with fluorine only at a red heat, and diamond is not attacked up to 700°.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING — ESTIMATE OF RADIONUCLIDES I-129, Tc-99, Cs-137, and Sr-90, IN THE STACK EMISSIONS

ORIGINATOR R. D. WEED DATE 10-9-95

REVISION NO. 0

OBJECTIVE ESTIMATE AMOUNT OF PROJECTED RADIOACTIVITY (NUCLIDES OF I-129, Tc-99, CS-137, and SR-90) IN THE STACK EMISSIONS FOR THE CALCINATION PROCESS.

METHODOLOGY BASE THE CALCULATIONS ON THE MATERIAL BALANCE VALUES FOR "Ci" and MASS BALANCE AROUND THE VITRIFICATION PROCESS

ASSUMPTIONS

1. ASSUMED THE VITRIFICATION MASS BALANCE and TOTAL Ci VALUES WERE TYPICAL OF THE CALCINATION PROCESS.
2. ASSUMED THE SAME PARTITION VALUES FOR CALCINATION AS PRESENTED by THE VITRIFICATION MASS BALANCE FOR THE GAS STREAM and THE SOLID WASTE PRODUCT STREAM.

(Continue on another sheet if necessary)

Ronald D. Weed
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 10-9-95 SUBJECT

BY RJW CHKD.

SHEET NO. 1 of 10

JOB NO. 01K4710(

Assumptions continued:

3.0 Assumed the I-129 would combine to form the I_2 molecule in the gas phase and would show the same MP and BP characteristics.

References

1. Lange's Handbook of Chemistry

2. WHC-SD-WM-EV-103 Rev0
NO SEPARATIONS Data package for the tank waste Remediation System Environmental Impact Statement. - July 1995 by S.A. Colby of WHC.

JACOBS ENGINEERING GROUP INC.

DATE 10-9-95 SUBJECT SHEET NO. 2 of 10

BY RDW CHKD. JOB NO. 01K47101

FOR Tc $t_{1/2}$ = 2.12 YRS β^- 0.292 Mev

Feed STREAM 406 Liquid Tc = 5.82 E-02 MCi
Solid Tc = 6.89 E-03 MCi

Liquid TcO_2 = 0 —
TcO_4^- = 5.61 E+00

Solid Tc_2O_7 = 9.30 E-02
TcO_4^- = 5.68 E-01

GAS STREAM 410 Liquid Tc = 3.19 E-02 MCi
Solid Tc = 3.28 E-04 MCi

Liquid TcO_2 = 2.48 E+00
TcO_4^- = 0 —

Solid Tc_2O_7 = 3.03 E-02
TcO_4^- = 0 —

Solids STREAM 411 Liquid Tc = 0 —
Solid Tc = 3.25 E-02 MCi

Liquid TcO_2 = 0 —
TcO_4^- = 0 —

Solid Tc_2O_7 = 3.0 E+00
TcO_4^- = 0 —

TcO_2 = 130.91 gms/gm mole ; INSOLUBLE in H_2O, sublimes 1000°C
Tc_2O_7 = 309.81 gms/gm mole ; Soluble in H_2O, MP = 119.5°C, BP = 310.6°C
TcO_4^- = 98.9 + 64 = 162.9 gms/gm mole

Tc in STREAM 406 = 5.82 E-02 MCi
+ 6.89 E-03 MCi
Σ TOTAL = 6.509 E-02 MCi

FORM S1-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 10-9-95 SUBJECT SHEET NO. 3 of 10

BY RDW CHKD. JOB NO. 01K4710 1

Tc in STREAM 410 = 3.19 E-02 MCi
+ 3.28 E-04 MCi
Σ Total = 3.223 E-02 MCi

Tc in STREAM 411 = 3.25 E-02 MCi

Σ Total = 3.25 E-02 MCi

Calculate % Tc in solid material (glass)

$$\% Tc = \frac{3.25 E-02 MCi}{6.509 E-02 MCi} = 49.93\%$$

THE ASSUME Tc SPLIT FOR gas STREAM VERSUS solids STREAM was 50%/50%. THIS same split was ASSUMED FOR the Calcination PROCESS.

Gas STREAM EXIT MIST ELIMINATOR - 627
TEMP = 30°C (86°F) Liquid Tc = 0 —
Solid Tc = 2.55E-08 MCi

Solid Tc_2O_7 = 2.35 E-06

GAS STREAM EXIT double METAL HEPA FILTER - 634
TEMP = 87°C (189°F) Liquid Tc = 0 —
Solid Tc = 1.27E-11 MCi

Solid Tc_2O_7 = 1.18 E-09

% Tc TRAPPED IN THE SCRUBBER - CONDENSER - MIST ELIMINATOR SYSTEM (Condensate)

$$\% Tc = [(3.223 E-02) - (2.55 E-08)] \div (3.223 E-02)$$
$$= 99.99991$$

% Tc Remaining in gas STREAM TRAPPED IN THE double METAL HEPA FILTERS

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 10-9-95 SUBJECT SHEET NO. 4 OF 10

BY RDW CHKD. JOB NO. 01K42101

$$\%Tc = [(2.55E-08) - (1.27E-11)] \div (2.55E-08)$$

$$= (2.54893) \div (2.55) = 99.958$$

Wash STREAM from double METAL HEPA FILTERS on gas STREAM — liquid STREAM 635

Solids — Tc = 2.55 E-08 Mci

Solids Tc = 2.35 E-06

Based on the above assumptions and the physical properties for Tc_2O_7 (MP of 119.5°C) it is reasonable that Tc nuclide will be TRAPPED in the quench - Chiller - mist eliminator - double METAL HEPA portion of the gas TREATMENT PROCESS. The vitrification balances indicate that essentially 100% of the Technitium-99 is removed at this point. With the suspended solids in the condensate and wash STREAMS, a filtration of the Liquid STREAM will be needed to REMOVE this radioactive material for disposal (the third STREAM mentioned in the comments).

FOR I-129 $t_{1/2}$ = 1.7 E+07 years

β^- 0.150 MeV
e^- 0.005 MeV
e^- 0.034 MeV
γ 0.040(9) MeV

I_2 = 253.809 gms/gm mole
Sol. H_2O 0.029 gm/100gms @ 20°C
MP = 113.6°C BP = 184.4°C

Feed STREAM 406 Liquid I^- = 4.56 E+02
I_2 = 0 —
solid I^- = 2.02 E+01

gas STREAM H10 Liquid I^- = 0 —
TEMP = 2476°F (1358°C)
I_2 = 5.66 E+02
H_2O = 3.5 E+05
solid I^- = 0 —
I_2 = 0 —

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 10-9-95 SUBJECT SHEET NO. 5 of 10

BY RGW CHKD. JOB NO. 01K47101

solids STREAM 411 Liquid $I = 0$ —
solid $I = 0$ —
$I_2 = 0$ —

gas STREAM TEMPERATURE Exit Quench Tank - ENTRANCE to VENTURI SCRUBBER
temp = 167°F = 75°C

gas STREAM Exit MIST ELIMINATOR - 627
TEMP = 30°C (86°F) Liquid I_2 = 5.66 E+02
Solid I_2 = 0 —
H_2O = 2.04E+02

gas STREAM Exit double metal HEPA FILTERS - 634
TEMP = 87°C (189°F) Liquid I_2 = 5.66 E+02
solid I_2 = 0 —
H_2O = 2.04 E+02

Based on the assumption that the I-129 indeed is in the I_2 form in the gas STREAM and that it shows the same MP and BP characteristics, the following analysis is Rational.

The gas STREAM is cooled below the I_2 mp of 113.6°C in the quench tank (temp. of 75°C). The gas is further cooled to 30°C exiting the mist eliminator. This temperature should have condensed the Iodine (I_2) to a solid suspended either in the gas STREAM or in the condensate from the gas STREAM. The double metal HEPA system should remove any I_2 particulates (gas STREAM temp. 87°C) from the gas STREAM at this point.

As with the Tc it is Reasonable to assume near 100% Removal of I-129 at this point. any Remaining I-129 in the gas STREAM could be Removed by a charcoal FILTER system.

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 10-9-95 SUBJECT SHEET NO. 6 OF 10

BY RDW CHKD. JOB NO. 01K4210/

FOR Cs-137 $t_{1/2}$ = 30 years

β^- = 1.176 MeV
β^- = 0.514 MeV
e^- = 0.624 MeV
e^- = 0.656 MeV
γ = 0.662 (85) MeV

Cs = 132.91 gms/gm mole
Cs_2O = 281.81 gms/gm mole
BaO = 153.34 gms/gm mole
Ba = 137.34 gms/gm mole

BaO mp = 1920°C ; BP = ca 2000°C , 3.48 gm/100 gm H_2O @ 20°C
CS_2O mp = Decomposes 400°C Very soluble H_2O @ 20°C

Feed stream 406 Liquid CS+Ba = 6.28 E+01 MCi
Solid CS+Ba = 7.43 E+00 MCi

Liquid Cs^+ = 8.19 E+01
Ba^{+2} = 7.91 E-01

Solid Cs^+ = 9.25 E-02
Ba^{+2} = 3.09 E+00
BaO = 1.37 E-01
Cs_2O = 3.05 E-02

gas STREAM 410 Liquid CS+Ba = 0 —
Solid CS+Ba = 7.01 E-01 MCi

Liquid Cs^+ = 0 —
Solid Cs^+ = 0 —
Ba^{+2} = 0 —
BaO = 4.47 E-02
Cs_2O = 9.96 E-03

Solids STREAM 411 Liquid CS+Ba = 0 —
Solid CS+Ba = 6.94 E+01

Liquid Cs^+ = 0 —
Solid Ba^{+2} = 0 —
Cs^+ = 0 —

FORM 91-005-1 (4/81)

BaO = 4.43 E+00

Cs_2O = 9.86 E-01

gas STREAM EXIT MIST ELIMINATOR – 627

TEMP = 30°C (86°F) Liquid Cs + Ba = 0 – MCi

solid Cs & Ba = 5.44 E-05

Liquid Cs^+ = 0 –

Ba^{+2} = 0 –

solid Ba^{+2} = 0 –

Cs^+ = 0 –

BaO = 3.47 E-06

Cs_2O = 7.73 E-07

gas STREAM EXIT double METAL HEPA FILTERS – 634

TEMP = (87°C) (189°F) Liquid Cs + Ba = 0 –

solid Cs + Ba = 2.72 E-08 MCi

Liquid Ba^{+2} = 0 –

Cs^+ = 0 –

Solid Ba^{+2} = 0 –

Cs^+ = 0 –

BaO = 1.74 E-09

Cs_2O = 3.86 E-10

Cs & Ba in Feed = 6.28 E+01 MCi + 7.43 E+00 MCi

Cs & Ba Σ Total = 7.028 E+01 MCi

Calculate % Cs & Ba in gas STREAM

% Cs & Ba = 0.701 ÷ 70.28 = 0.997 %

Calculate % Cs + Ba in SOLIDS STREAM

% Cs & Ba = 6.94 ÷ 7.028 = 98.7 %

Calculate % of Cs & Ba in gas STREAM recovered in the Quench tank - MIST ELIMINATOR SECTION of PROCESS

% = [(7.01 E-01) – (5.44 E-05)] ÷ (7.01 E-01)

% = 99.992

JACOBS ENGINEERING GROUP INC.

DATE 10-9-95 SUBJECT SHEET NO. 8 of 10

BY RDW CHKD. JOB NO. 01K4710 1

Calculate % of Cs+Ba in gas stream recovered in the double metal HEPA filter bank.

% = [(5.44E-05) − (2.72E-08)] ÷ (5.44E-05)

% = ~~100%~~ 99.95%
RDW

Based on the assumptions made for the vitrification process and its mass balance and "MCi" values for several points of the gas stream, it is reasonable to believe that the Cesium/Barium nuclide will be nearly totally removed from the gas stream by this stage of the gas processing. Filtration of the recycle quench/wash stream will be required to maintain low levels of nuclide activity in the water.

FR Sr+y-90 $T_{1/2}$ = 27.7 years β^- = 0.546 Mev

γ = NONE

Sr = 87.62 gms/gm mole

SrO = 103.62 gms/gm mole

MP = 2460°C ; H_2O 0.69 gm/100 gm @ 20°C

~~Feed stream 406 Liquid Sr+y = 6.28 RDW~~

Feed stream 406 Liquid Sr+y = 2.1 E+00 MCi

Solid Sr+y = 1.09 E+02 MCi

Liquid Sr+2 = 3.75E-01

Solid Sr+2 = 3.64E+01

SrO = 1.37E+00

Gas stream 410 Liquid Sr+y = 0 —

Solid Sr+y = 1.11E+00 MCi

Liquid Sr+2 = 0 —

Solid Sr+2 = 0 —

SrO = 4.47E-01

FORM 91-005-1 (4/81)

Solids stream 411 Liquid Sr+y = 0 —
Solid Sr+y = 1.10E+02

Liquid Sr+2 = 0 —
Solid Sr+2 = 0 —
SrO = 4.48E+01

gas stream exit mist Eliminator -627
TEMP = 30°C Liquid SR+y = 0 —
Solid SR+y = 8.95E-05 MCi

Liquid Sr+2 = 0 —
Solid Sr+2 = 0 —
SrO = 3.47E-05

gas stream exit double metal HEPA FILTERS - 634
TEMP = 87°C Liquid SR+y = 0 —
Solid SR+y = 4.30E-08

Liquid Sr+2 = 0 —
Solid Sr+2 = 0 —
SRO = 1.74E-08

SR+y in FEED = 1.09E+02 MCi + 2.1E+00
Σ total = 1.11E+02 MCi

Calculate % SR+y in gas STREAM
% SR+y = (1.11E+00) ÷ (1.11E+02)
= 1%

Calculate % Sr+y in Solid STream
% Sr+y = (1.10E+02) ÷ (1.11E+02)
= 99%

Calculate % Recovery of SR+y from gas stream by scrubbing System
% = [(1.11E+00) − (8.95E-05)] ÷ (1.11E+00)
% = 99.992

JACOBS ENGINEERING GROUP INC.

DATE 10-9-95 SUBJECT SHEET NO. 10 of 10

BY RDW CHKD. JOB NO. 01K4710 1

Calculate % of Sr-90 in gas stream recovered in the double metal HEPA FILTER BANK.

$$\% = [(8.95E-05) - (4.30E-08)] \div (8.95E-05)$$

$$\% = 99.95\%$$

Based on these vitrification portions and recovery values, it is reasonable to believe that the strontium-90 will be removed from the gas stream before its emission from the stack, especially if a series of charcoal beds are installed to act as both a filter and an Iodine absorber media.

By these considerations it is reasonable to believe that the release from the stack for I-129, SR-90, CS-137 and Tc-99 will be essentially nil. However there will be a third waste stream to consider for disposal from the facility.

FORM 91-005-1 (4/81)

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING "TANK POST REMEDIATION FLUX"

ORIGINATOR COLIN HENDERSON DATE 2/2/95

REVISION NO. 0

OBJECTIVE Estimate POST REMEDIATION Emissions RESULTING FROM TANK Residuals Of 1% & 5%.

METHODOLOGY See ATTACHED

ASSUMPTIONS See Attached

(Continue on another sheet if necessary)

Colin Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

PRELIMINARY

JACOBS\FORMS\CALCVR.SHT

METHODOLOGY -

A) CALCULATE VOLUMETRIC FLOW INTO TANKS

B) CALCULATE TIME REQUIRED TO DISSOLVE NITRATE

C) CALCULATE TIME REQUIRED TO BREACH BARRIER

D CALCULATE CONCENTRATIONS IN SATURATED SOLUTIONS RELEASED FROM TANKS.

REFERENCES:

SERNE, R.J AND M.I WOOD 1990 HANFORD WASTE FORM RELEASES AND SEDIMENT INTERACTIONS, PNL 7297, BATELLE PACIFIC NORTHWEST LABORATORY, RICHLAND WA

PELTON M AND J DAVIS 1/27/95 AGGREGATE TANK FARM INVENTORIES

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 3/16

BY _____ CHKD. _____ JOB NO. _____

POST REMEDIATION RELEASE ASSUMPTIONS

1. INVENTORY 1% AND 5% OF CURRENT INVENTORY

2. SOLUBILITY OF EACH element is proportional to the SOLUBILITY of NO_3^- (360 g/l) Congruent dissolution (Serne & Wood 1990)

3. RECHARGE Rate .05 cm/yr for first 1000 yrs.
   .10 cm/yr for 1000 + yrs.
   HANFORD BARRIER FAILS AFTER 1,000 YEARS.

4 ASSUME BARRIER 5 m thick.

5. Release Point 50 ft below Surface.

6. Time for Water to Reach Waste after penetrating barrier equals 0.

7. TANK AND CONCRETE WILL HAVE FAILED AFTER 500 YEARS.

8. CONCENTRATIONS IN TANK GROUPS ARE AS SHOWN IN REFERENCE 2.

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 4/16

BY _____ CHKD. _____ JOB NO. _____

1. TANK AREAS.
GROUP

1WSS 40 tanks 36 @ 75' dia 4 @ 20' dia.

1 ft = 30.48 cm.

$$\Sigma \text{AREA} = 36\left(\pi \cdot \frac{(75(30.48))^2}{4}\right) + 4\left(\pi \frac{(20(30.48))^2}{4}\right)$$

$$= 147.8E6 + 1.167E6 \ cm^2$$

1WSS = 149.0 E6 cm^2 ←

2WSS = 43 tanks. 39 @ 75'ϕ + 4 @ 20'ϕ

$$\text{AREA} = \Sigma 39[4.1E6] + 4(.292E6) \ cm^2$$

2WSS AREA = 161.1 E6 cm^2 ←

1ESS = 40 tanks. = 36 @ 75'ϕ & 4 @ 20'ϕ

$$\text{AREA} = 36[4.1E6] + 1.167E6 \ cm^2$$

1ESS AREA = 148.8E6 cm^2 ←

2ESS. = 16 TANKS. 12 @ 75'ϕ 4 @ 20'ϕ

$$\text{AREA} = 12(4.1E6] + 1.167E6$$

2ESS = 50.4 E6 cm^2 ←

FORM 91-005-1 (4/81)

4ESS 10 TANKS. 10@ 75'φ

4ESS. AREA = 10 (4.1E6) = 41E6 cm² ←

2. VOLUMETRIC INFILTRATION.

1WSS ΔT .05 cm/yr

Q = .05 cm/yr (149E6 cm²)(1 l / 1000 cc)

Q = 7450 l/yr. ← at .05 cm/yr

ΔT .1 cm/yr

Q = 14900 l/yr ← at .10 cm/yr

2WSS

A = 161E6 cm²

@ .05 cm/yr Q = 161E6 cm² (.05 cm/yr)(1 l / 1000 cc)

Q = 8,050 l/yr ← at .05 cm/yr

@ .10 cm/yr Q = 16,100 l/yr. ← at .10 cm/yr

1ESS

A = 148.8E6 cm²

@ .05 cm/yr Q = (148.8E6 cm²)(.05 cm/yr)(1 l / 1000 cm³) = 7,440 l/yr.

Q = 7440 l/yr ← at .05 cm/yr

at .10 cm/yr Q = 14880 l/yr. ←

2ESS

$A = 50.4E6\ cm^2$

@ .05 cm/yr $Q = 50.4E6\ cm^2 (.05\ cm/yr)(1/1000) = 2520\ l/yr$

$Q = 2520\ l/yr$ — at .05 cm/yr

@ .10 cm/yr $Q = 5040\ l/yr$ —

4ESS $A = 41E6\ cm^2$

@ .05 cm/yr $Q = 41E6\ cm^2 (.05\ cm/yr)(1/1000) = 2050\ l/yr.$

$Q = 2050\ l/yr$ — at .05 cm/yr

at .10 cm/yr $Q = 4100\ l/yr.$ — at .10 cm/yr

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 7/16

BY _____ CHKD. _____ JOB NO. _____

3, POST REMEDIATION NITRATE INVENTORY. (1% Residual)

1WSS 263 MT (10^6 g)

2WSS 455 MT ($\times 10^6$ g)

1ESS 189 MT (10^6 g)

2ESS 2.59 MT (10^6 g)

4ESS. 48.9 MT (10^6 g)

SOLUBILITY = 360 g/L

4, Time Required to dissolve NITRATE.

$$\text{Time (yrs)} = \frac{\text{Inventory}}{\text{Solubility (Infiltration)}}$$

FOR 1WSS

$$\text{Time yrs} = \frac{263 \times 10^6 \text{ g}}{(360 \text{ g/L})(7450 \text{ l/yr})} = 98 \text{ years.} \leftarrow \text{at .05 cm/yr}$$

$(263E6)/(360 \times 14900) = 49$ yrs @ 0.1 cm/yr ←

2WSS.

$$\text{Time} = \frac{455 E6 \text{ g}}{360 (8050)} = 157 \text{ years.} \leftarrow \text{at .05 cm/yr}$$

$455E6/(360 \times 16100) = 78$ yrs @ 0.1 cm/yr ←

1ESS

$$\text{Time} = \frac{189 E6 \text{ g}}{360 (7440 \text{ l/yr})} = 71 \text{ years.} \leftarrow \text{at .05 cm/yr}$$

$189E6/(360 \times 14880) = 35$ yrs at 0.1 cm/yr ←

2ESS.

$$\text{Time} = 2.59E6 \text{ g}/360 (2520 \text{ l/yr}) = 3 \text{ yrs.} \leftarrow \text{at .05 cm/yr}$$

$= 2.59E6/(360 \times 5000 \text{ l/yr}) = 1.5$ yrs at 0.1 cm/yr

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4ESS

TIME = 48.9E6g/360 (2050 l/yr) = 66 years. ← at .05cm/yr.

= 48.9E6/(360 × 4100 l/yr) = 33 yrs @ 0.1 cm/yr

5. TIME REQUIRED TO Breach Barrier

First 1000 yrs. Water goes 1000(.05 cm/yr) = 50cm.

then infiltration goes to .10 cm/yr.

$$\text{Time} = \frac{500\text{ cm} - 50\text{ cm}}{.10\text{ cm/yr}} + 1000\text{ yrs.}$$

Time = 5,500 yrs.

Assume time to reach waste once barrier is breached is 0.

RESULTS FOR SSTs

AT TIME = 5,500 years. the tanks begin to release waste to VADOSE ZONE. THE Concentration of the release will be Saturated at the concentrations shown ON TABLES 1 and 2 attached. The duration OF Release will be as follows:

1WSS – 49 years	for 1% Residual	24.5 yr	for 5% residual
2WSS – 78 years		390 yr	
1ESS – 35 years		175 yr	
2ESS – 1.5 years		7.5 yr	
4ESS – 33 years.		165 yr	

NOTE: TABLE 1 & 2 ARE FROM Retrieval leakage Estimate.
NOTE FOR 5% Residual the Concentration leaking will be the Same.

PS 9/16

Table 1

Tank Release Concentration grams/ liter for Radionuclides

Decayed to 12/31/95.

Solubility Calculation — For each tank group solubility = (mass elem/mass nitrate)x360 g/l

# of Tanks	40	43	40	16	10
grams	1WSS	2WSS	1ESS	2ESS	4ESS
Ac-225	4.07E-19	3.92E-19	1.98E-18	5.38E-17	2.82E-13
Ac-227	9.80E-13	4.66E-13	2.33E-12	2.98E-11	3.03E-14
Ac-228	1.13E-07	3.65E-07	6.95E-07	6.58E-05	1.66E-06
Am-241	1.07E-08	4.47E-08	1.05E-07	8.09E-06	1.86E-07
Am-242	4.58E-12	1.91E-11	4.48E-11	3.47E-09	7.98E-11
Am-243	6.99E-08	3.11E-07	9.16E-07	8.13E-05	1.16E-06
At-217	1.47E-26	1.41E-26	7.13E-26	1.94E-24	1.30E-25
Ba-135m	1.44E-06	3.71E-06	8.37E-06	2.18E-05	1.25E-06
Ba-137m	3.83E-25	1.71E-25	4.75E-25	1.82E-23	3.86E-25
Bi-210	5.72E-16	2.72E-16	1.36E-15	1.74E-14	1.64E-16
Bi-211					
Bi-212	1.62E-19	1.56E-19	7.87E-19	2.14E-17	1.43E-18
Bi-213	6.03E-20	2.88E-20	7.18E-20	3.00E-18	8.41E-20
Bi-214	6.06E-13	6.05E-13	5.44E-12	4.66E-11	2.09E-12
C-14	6.83E-09	2.86E-08	6.68E-08	5.17E-06	1.19E-07
Cm-242	1.33E-11	5.73E-11	2.89E-10	2.25E-08	1.61E-10
Cm-244	3.52E-14	1.71E-13	9.02E-13	7.04E-11	5.02E-13
Cm-245	1.64E-06	3.12E-06	5.84E-06	1.30E-05	9.12E-07
Cs-135	1.06E+01	2.75E+01	6.20E+01	1.61E+02	9.24E+00
Cs-137	2.73E-16	2.63E-16	1.33E-15	3.61E-14	2.42E-15
Fr-221	5.53E-21	2.63E-21	1.31E-20	1.68E-19	1.59E-21
Fr-223	1.84E-15	2.74E-15	1.38E-14	6.56E-14	9.93E-16
I-129	6.64E-03	3.04E-02	4.02E-02	3.20E+00	6.29E-01
Nb-93m		5.14E-08	2.41E-07		
Ni-59	1.16E-03	4.77E-03	1.25E-02	1.01E+00	9.95E-02
Ni-63	1.92E-09	1.48E-09	1.61E-08	7.96E-09	5.61E-10
Np-237	2.49E-07	1.04E-06	2.44E-06	1.89E-04	4.34E-06
Np-238	5.37E-14	2.39E-13	7.04E-13	6.25E-11	8.88E-13
Np-239	5.67E-16	2.50E-16	1.25E-15	2.02E-14	2.02E-16
Pa-231	2.40E-06	1.84E-06	2.00E-05	9.92E-06	6.99E-07
Pa-233	1.82E-13	3.96E-14	2.40E-13	6.93E-12	9.39E-14
Pa-234	1.18E-10	2.57E-11	1.56E-10	4.51E-09	6.10E-11
Pa-234m	3.44E-23	3.32E-23	1.67E-22	4.55E-21	3.05E-22
Pb-209	4.48E-21	2.00E-21	5.56E-21	2.13E-19	4.51E-21
Pb-210	9.28E-13	4.41E-13	2.20E-12	2.82E-11	2.67E-13
Pb-211					
Pb-212	6.03E-20	2.88E-20	7.18E-20	3.00E-18	8.41E-20
Pb-214	3.77E-15	5.61E-15	2.88E-14	1.55E-13	2.19E-15
Pd-107	4.00E-13	1.79E-13	4.96E-13	1.90E-11	4.03E-13
Po-210	4.31E-17	2.05E-17	1.02E-16	1.31E-15	1.24E-17
Po-211					
Po-212	1.30E-31	1.25E-31	6.31E-31	1.72E-29	1.15E-30
Po-213	6.61E-32	3.16E-32	7.87E-32	3.29E-30	9.21E-32
Po-214	2.20E-25	1.05E-25	5.23E-25	6.70E-24	6.33E-26
Po-216					
Po-218	2.94E-24	1.40E-24	3.50E-24	1.46E-22	4.10E-24
Pu-236	5.41E-09	4.41E-09	6.63E-09	5.20E-07	3.10E-08
Pu-238	2.02E-06	2.01E-06	3.92E-06	4.77E-04	2.40E-05
Pu-239	1.08E-04	1.20E-04	2.54E-04	3.31E-02	1.65E-03
Pu-240	2.36E-04	2.22E-04	7.10E-04	8.07E-02	3.59E-03
Pu-241	1.76E-15	7.37E-15	1.72E-14	1.33E-12	3.07E-14
Pu-242	1.80E-08	8.57E-09	4.29E-08	5.49E-07	5.19E-09
Ra-223					
Ra-224	1.47E-19	1.41E-19	7.13E-19	1.94E-17	1.30E-18
Ra-225	2.12E-20	1.01E-20	2.53E-20	1.06E-18	2.96E-20
Ra-226					
Ra-228	3.08E-15	4.93E-13	5.78E-12	4.97E-10	1.07E-10

Table 1
Tank Release Concentration grams/ liter for Radionuclides

Rh-106	2.00E-20	9.49E-21	4.75E-20	6.08E-19	5.74E-21
Rn-219					
Rn-220	9.04E-25	4.32E-25	1.08E-24	4.50E-23	1.26E-24
Rn-222	5.43E-18	8.72E-16	1.02E-14	8.78E-13	1.90E-13
Ru-106	3.25E-11	5.52E-11	3.83E-11	5.80E-09	7.92E-10
Sb-126	9.29E-12	1.58E-11	1.09E-11	1.66E-09	2.26E-10
Sb-126m	1.69E-14	2.53E-14	1.27E-13	5.72E-13	8.92E-15
Se-79	1.26E-02	2.15E-02	1.54E-02	2.08E+00	2.70E-01
Sm-151	2.95E-08	5.00E-08	3.47E-08	5.26E-06	7.19E-07
Sn-126	7.32E-01	4.05E+00	5.66E+00	2.43E+02	4.99E+01
Sr-90	3.34E-07	4.98E-07	2.49E-06	1.13E-05	1.76E-07
Tc-99	4.14E-09	1.97E-09	9.83E-09	1.26E-07	1.19E-09
Th-227					
Th-228	2.88E-17	2.78E-17	1.40E-16	3.81E-15	2.55E-16
Th-229	5.81E-13	2.94E-13	6.75E-13	2.96E-11	1.08E-12
Th-231	1.87E-11	4.39E-12	2.49E-11	7.38E-10	9.71E-12
Th-232	2.30E-15	2.57E-15	5.42E-15	7.06E-13	3.53E-14
Th-233	6.50E-14	1.41E-14	8.58E-14	2.48E-12	3.36E-14
Th-234	3.06E-15	1.45E-15	7.27E-15	9.32E-14	8.80E-16
Tl-208					
Tl-209	1.25E-24	1.20E-24	6.07E-24	1.65E-22	1.10E-23
U-232	7.67E-13	6.48E-13	5.26E-12	5.24E-11	4.05E-12
U-233	6.97E-08	3.77E-08	8.51E-08	4.38E-06	1.92E-07
U-234	1.58E-05	3.72E-06	2.11E-05	6.26E-04	8.23E-06
U-235	1.37E-06	1.53E-06	3.23E-06	4.21E-04	2.10E-05
U-236	2.03E-05	1.91E-05	6.11E-05	6.95E-03	3.09E-04
U-237	2.89E-11	6.28E-12	3.81E-11	1.10E-09	1.49E-11

Table 2
Chemical Release Concentrations Nonradioactive Chemicals for Single Shell Tanks

concentration grams/liter

Chemical	1WSS	2WSS	1ESS	2ESS	4ESS
Ag	5.63E-10	5.11E-10	3.80E-09	1.24E-08	1.97E-10
Al	4.55E+00	8.75E+00	1.53E+01	5.37E+02	1.94E+00
Al+3	9.75E-01	5.73E+00	1.13E+01	8.06E+02	1.87E+00
AlO2-	6.23E+00	8.47E+00	1.37E+01	1.05E+02	1.34E+00
Ba+2	4.91E-04	1.34E-03	1.95E-03	1.52E-01	1.40E-02
Bi+3	2.28E+00	2.21E-03	1.79E+00	8.27E-01	
C2H3O3	7.28E-02	2.25E-02	6.15E-03	1.65E-01	2.19E-01
C6H5O7	7.47E+00	5.21E+00	2.33E+01	1.53E+02	1.79E+00
CO3-2	9.68E+00	1.27E+00	1.22E+01	8.62E+01	2.80E+00
Ca+2	2.72E-03	4.60E-02	1.04E+00	9.16E+01	1.13E-01
Cd+2					
Ce+3	1.59E+00	2.50E-01	1.68E+00	3.67E-01	1.29E-01
Cl-	3.00E-01	4.28E-02	2.40E-01	5.58E-02	4.44E-03
Cr+3	1.73E-02	6.59E-01	1.38E-02	2.30E-01	6.07E-02
CrO4-2	4.28E-03	1.63E-01	3.42E-03	5.69E-02	1.50E-02
EDTA	5.58E-01	1.73E-01	4.71E-02	1.27E+00	1.67E+00
F-	1.97E+00	2.38E-01	4.42E+00	5.56E+02	2.27E-02
Fe+3	2.33E+00	6.47E-01	2.70E+00	7.72E+01	1.31E+01
Fe(CN)6-4	3.00E-02	1.08E-02	4.72E+00	9.73E+01	3.90E-03
HEDTA	1.01E+00	3.14E-01	9.41E-02	2.30E+00	3.04E+00
Hg+					
K+	6.85E-02	2.00E-01	5.50E-01	2.56E-01	3.33E-02
La+	2.03E-02		7.60E-03		
Mn+4	2.87E-01	8.92E-02	2.49E-01	7.12E+01	1.73E+00
Na+	1.99E+02	1.67E+02	2.20E+02	2.92E+03	2.78E+02
Ni+2	6.88E-02	2.64E-02	2.37E+00	6.12E+01	7.31E-02
NO2-	2.41E+01	6.33E+00	3.92E+01	6.59E-01	1.71E+01
NO3-	3.60E+02	3.60E+02	3.60E+02	3.60E+02	3.60E+02
OH-	6.20E+00	1.82E+01	1.98E+01	1.97E+03	1.28E+01
PO4-3	3.66E+01	8.70E-01	3.44E+01	4.14E+01	6.34E-02
Pb	3.22E-02	3.06E-02	8.04E+00	9.48E+00	7.60E-03
SiO3-	7.67E+00	1.90E+00	7.68E+00	9.83E-01	1.54E-01
Sn			1.02E-04		
SO4-2	8.68E+00	1.96E+00	1.05E+01	1.86E+02	6.15E+00
Sr+2	1.28E-05	5.52E-04	6.82E-01	3.52E-02	4.25E-03
W+4					
Zr+4	1.92E-01	1.83E-01	1.24E-01	2.82E+02	9.41E-03

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 12/16

BY _____ CHKD. _____ JOB NO. _____

DSTs

3WDS - 3 TANKS.

3EDS = 11 TANKS

5EDS = 14 TANKS.

$$\text{AREA PER TANK} = \frac{\pi(75 \times 30.48)^2}{4} = 4.1E6 \text{ cm}^2$$

1. 3WDS · AREA = 3(4.1E6 cm²) = 12.3E6 cm²

3EDS = 11(4.1E6 cm²) = 45.1E6 cm²

5EDS = 14(4.1E6 cm²) = 57.4E6 cm²

2. VOLUMETRIC INFILTRATION at (0.1 cm/yr)

3WDS Q = 0.1 cm/yr (12.3E6 cm²)(1 l/1000 cc) = 1230 l/yr.

Q = 1230 l/yr

3EDS Q = 0.1 cm/yr (45.1E6 cm²)(1 l/1000 cc) = 4510 l/yr

Q = 4510 l/yr.

5EDS Q = 0.1 cm/yr (57.4E6 cm²)(1 l/1000 cc) = 5740 l/yr.

Q = 5740 l/yr

FORM 91-005-1 (4/81)

3. POST REMEDIATION NITRATE INVENTORY.

	INVENTORY	1%	5%
3WDS	1040 MT	10.4 MT	52 MT
3EDS	2198 MT	21.98 MT	110 MT
5EDS	4450 MT	44.5 MT (10^6 g)	222.5 MT

SOLUBILITY NO_3^- = 360 g/L

4. TIME REQ to dissolve NO_3^-

$$\text{TIME} = \frac{\text{INVENTORY}}{\text{SOLUBILITY (INFILTRATION)}}$$

FOR 3WDS.

1% → $\text{TIME} = \frac{10.4E6\ g}{360 g/L\ (1230\ l/yr)}$ = 23.5 years for 1% residual

5% TIME = 5x(1% TIME) = 118 years.

FOR 3EDS

1% → $\text{TIME} = \frac{21.98E6\ g}{360 g/L\ (4510\ l/yr)}$ = 13.5 years for 1%

5% TIME = 13.5 (5) = 67.5 or 68 years.

FOR 5EDS

1% TIME = $\frac{44.5E6\ g}{360\ (5740\ l/yr)}$ = 21.5 years for 1%.

5% TIME = 5(21.5) = 107.5 or 108 years.

RESULTS FOR DSTs

AT TIME = 5,500 years the tanks begin to release waste into the VADOSE ZONE. THE CONCENTRATION of the RELEASE WILL BE SATURATED at the CONCENTRATIONS SHOWN ON TABLES 3 and 4 for DSTs attached. THE DURATION OF THE RELEASE IS AS FOLLOWS:

	1% Residual	5% Residual
3WDS	23.5 years	118 years
3EDS	13.5 years	68 years
5EDS	21.5 years	108 years.

Table 3
DST Tank Release Concentration grams/ liter for Radionuclides

DST INVENTORY RADIONUCLIDES IN GRAMS

Decayed to 12/31/1995				
Radionuclide	ACT Ci/g	3WDS	3EDS	5EDS
grams				
C-14	4.45	1.81E-01	5.22E+02	1.18E+00
Sr-90	139	4.39E+02	7.89E+04	5.01E+02
Y-90	5140	1.19E+01	2.13E+03	1.35E+01
Tc-99	0.0169	2.17E+05	9.37E+05	9.46E+04
Cs-137	86.4	4.24E+04	2.53E+05	4.51E+04
Ba-137	537000000	6.82E-03	4.07E-02	7.25E-03
Eu-154	270	1.62E+00	2.72E+02	1.97E+00
Np-237	0.000704	5.39E+02	6.40E+04	2.02E+02
Pu-238	17.1	6.15E+01	9.98E+00	1.14E+01
Pu-239	0.0619	3.45E+04	7.99E+04	2.07E+04
Pu-240	0.227	3.36E+03	5.60E+03	1.58E+03
Pu-241	103	1.80E+02	1.05E+02	1.00E+02
Am-241	3.43	3.47E+03	1.71E+04	1.45E+02

CONCENTRATION IN GRAMS/LITER =(MASS NUCLIDE/MASS NO3)*360

Radionuclide		3WDS	3EDS	5EDS
NO3 mass g		1.04E+09	2.20E+09	4.45E+09
C-14		6.27E-08	8.56E-05	9.52E-08
Sr-90		1.52E-04	1.29E-02	4.05E-05
Y-90		4.11E-06	3.49E-04	1.10E-06
Tc-99		7.50E-02	1.54E-01	7.66E-03
Cs-137		1.47E-02	4.14E-02	3.65E-03
Ba-137		2.36E-09	6.66E-09	5.87E-10
Eu-154		5.61E-07	4.45E-05	1.60E-07
Np-237		1.86E-04	1.05E-02	1.63E-05
Pu-238		2.13E-05	1.63E-06	9.22E-07
Pu-239		1.20E-02	1.31E-02	1.67E-03
Pu-240		1.16E-03	9.17E-04	1.28E-04
Pu-241		6.23E-05	1.71E-05	8.12E-06
Am-241		1.20E-03	2.80E-03	1.17E-05

Table 4

Tank Release Concentration grams/liter for Non Rad Chemicals

CONCENTRATION GRAMS/LITER

Chemical	5EDS	3EDS	3WDS
Ag+	1.16E-01	3.43E-02	2.01E-02
Al+3	3.47E+00	1.72E+00	5.00E+00
As+5	8.42E-02	4.26E-03	6.97E-02
B+3	8.23E-02	1.09E-02	1.48E-01
Ba+2	2.52E-01	1.22E-01	1.13E-02
Be+2	5.43E-03	3.66E-03	
Bi+3	1.40E-01	8.53E-02	
Ca+2	1.06E+00	3.92E-01	2.15E+00
Cd+2	4.75E-01	1.16E-02	8.36E-02
Ce+3	2.27E-01		9.12E-02
Cr+3	7.53E-01	1.28E-01	8.32E+00
Cu+2	3.86E-02	1.71E-02	1.18E-01
Fe+3	1.09E+01	4.48E-01	4.31E+00
Hg+	4.65E-03	1.54E-04	
K+	1.21E+01	6.19E+01	1.30E+01
La+	1.60E+00	2.21E-01	3.42E-02
Li+	2.00E-03		1.94E-03
Mg+2	8.13E-01	2.28E-01	1.76E-01
Mn+4	1.69E+00	1.81E-01	1.28E+00
Mo+6	3.26E-01	1.31E-01	2.95E-01
Na+	4.91E+02	4.81E+02	7.48E+02
Nd+3	9.61E-01		4.04E-02
Ni+2	6.77E-01	1.00E-01	5.75E-01
Pb+4	2.84E-01	2.28E-01	1.16E-01
Pd	9.70E-02		
Rb	5.18E-03		
Re	2.95E-03	3.50E-02	
Rh	6.91E-03	2.41E-01	4.78E-02
Ru	2.33E-02	1.37E-01	4.70E-02
Sb	1.72E-01	2.21E-01	3.40E-02
Se	1.56E-01	4.25E-01	2.20E-01
SiO3-	1.69E+01	2.37E+00	2.10E+00
Sn	2.60E-06	6.24E-05	
Te	5.46E-03	1.85E-01	3.56E-02
Th	3.26E-02	4.18E-01	2.16E-01
Ti	2.13E-02	4.58E-02	1.34E-02
Tl	3.14E-01	4.79E+00	1.90E-01
UO2+2	2.41E-01	4.48E+00	
V+5	5.67E-03	2.72E-02	4.74E-03
W+6	6.04E-02		
Zn+2	6.23E-02	3.95E-01	4.66E-01
Zr+4	1.51E+00	4.23E+01	6.39E-02
Al(OH)4-2	1.97E+02	1.37E+02	4.13E+02
CO3-2	8.03E+01	1.38E+02	3.03E+01
Cl-	1.19E+01	8.59E+00	2.59E+01
Cr(OH)4-	3.28E+00	1.87E+00	2.08E+01
F-	2.93E+00	5.24E+01	3.11E+00
SO4-2	2.26E+01	1.18E+01	1.45E+01
NO3-	3.60E+02	3.60E+02	3.60E+02
NO2-	1.57E+02	1.46E+02	8.51E+01
PO4-3	6.91E+00	1.23E+01	2.54E+01
OH-	8.28E+01	1.24E+02	8.37E+01
TOC	7.04E+01	9.73E+00	4.46E+01

1/11

Sheet 12 (ISOTOPIC Mass fraction added)
CH 8/18/95

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Engineering - Flux From TPA LLW Vaults

ORIGINATOR D. Murray DATE 2/1/95

REVISION NO. 1

OBJECTIVE Estimate the concentration of radionuclides released from the LLW vaults, and time required for release

METHODOLOGY See p1

ASSUMPTIONS 1. Cullet/sulfur waste form is stored in vaults similar to grout vaults
2. All concrete structures fail after 500 yrs
3 Hanford Barrier fails after 1000 yrs
4 Recharge rate is 0.05 cm/yr until barrier fails, it then becomes 0.1 cm/yr

(Continue on another sheet if necessary) (cont. p3)

David J Murray
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

JACOBS ENGINEERING GROUP INC.

DATE 2/1/95 SUBJECT Flux From TPA LLW Vaults SHEET NO. 2/11

BY [illegible] CHKD. _____ JOB NO. 01K4721

Methodology

A Calculate time for water/leach solution to reach vaults

B Calculate release time of radionuclides

C Calculate feed rate of liquid into vaults

D Calculate number of vaults required

E Calculate amount leached per year, and total mass dissolved. Compare with solubility tables

F Calculate concentrations of ions in solution

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/1/95 SUBJECT SHEET NO. 3/11

BY [illegible] CHKD. _____ Flux From TPA LLW Vaults JOB NO. 01K4710/

Assumptions (cont)

5. Vitrified waste is uniform spheres, 1cm in dia. Packing fraction is 0.7
6. Glass will have composition shown in TPA Eng. Data Pkg
7. Matrix is 95% sulfur + 5% organic binders
8. The vaults are 15m below the surface of the barrier
9. Leaching commences when the recharge reaches the vaults
10. Leach products form in the same proportion as in the glass
11. Release time is approximated by $\left(\frac{\text{Particle Radius}}{\text{Corrosion Rate}}\right)$ (Ref 1)
12. Corrosion rate is 3×10^{-6} cm/yr
13. Glass density = 2.6 g/cm^3
14. Vaults are 37m × 15m × 10m deep
15. Soln resulting from dissolution of glass will contain the ions shown in the ASPEN tables in the TPA Eng Data Pkg
16. Radioactive decay is not taken into account

References

1 R.A. Kornesky, et al. Impacts of Disposal System Design Options on Low Level Glass Waste Disposal System Performance (Working Draft) July 29, 1994.

2 John A Dean ed., Langes Handbook of Chemistry McGraw-Hill, 11th Edition

FORM 01-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/1/95 SUBJECT Flux From TPA LLW Vaults SHEET NO. 4/11

BY [illegible] CHKD. _____ JOB NO. 01K7101

Calculation

① How far will recharge penetrate in the 1st thousand years?

$$.05 \frac{cm}{yr} \times 1{,}000\ yrs = 50\ cm = 0.5\ m.$$

② How long will it take for recharge to reach vaults?

$$t = d/r = \frac{14.5\ m}{0.1\ cm/yr} = \frac{1450\ cm}{0.1\ cm/yr} = 14{,}500\ yrs.$$

③ What is the release time?

$$t \cong \frac{0.5\ cm}{.3 \times 10^{-6}} = 1.7 \times 10^5\ yrs\ (\text{Assumption 11})$$

④ What is liquid feed rate on top of one vault?

$$Q = VA = \frac{.1\ cm}{yr} \times (15 \times 37)\ m^2 \times \frac{10^4\ cm^2}{m^2}$$

$$= 555{,}000 \frac{cm^3}{yr} \times \frac{liter}{1000\ cm^3} = 555 \frac{liters}{yr}$$

⑤ What is the vol of LLW spheres in one vault?

$$V = 0.7LWH = 0.7(37 \times 15 \times 10) = 3{,}885\ m^3$$

FORM 91-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/1/95 SUBJECT Flux From TPA LLW Vaults SHEET NO. 5/11

BY [illegible] CHKD. JOB NO. 01K47101

(6) How many vaults are required?

$V = LWH = 5{,}550\ m^3$ = vol of one vault

From data pkg. p 10-3, vol of LLW mix $= 2.27 \times 10^5\ m^3$

$$\text{Vaults} = 2.27 \times 10^5\ m^3 \times \frac{\text{vault}}{5{,}550\ m^3} = 40.9 \text{ vaults}$$

(7) From data pkg. p A-114, total mass of cullet = ~~4.60×10^5~~ 3.87×10^5 MT

$$\cancel{4 \times 10^5}\ 3.87 \times 10^5\ MT \times \frac{m^3}{26\ MT} = \cancel{154{,}000}\ 148{,}800\ m^3 \text{ cullet}$$

(8) Vol of cullet/sulfur mix $= \frac{\cancel{154{,}000}\ 148{,}800}{.7} = \cancel{220{,}000}\ 213{,}000\ m^3$ mix

Checks with $227{,}000\ m^3$ mix from step (6)

(9) Wt of LLW spheres in one vault

$= \cancel{4 \times 10^5}\ 3.87 \times 10^5\ MT / 40.9 = \cancel{9779.9}\ 9462$ Coll. t ~~9780~~ 9460 MT

$$\text{Total solution flow} = 555 \frac{L}{yr \cdot vault} \times 40.9 \text{ vaults} = 22{,}700\ L/yr$$

(10) Amount leached in a yr (from one vault) $= \frac{\cancel{9780}\ 9460\ MT}{170{,}000\ yrs}$

$= \cancel{.0575}\ .0556\ MT/yr$

$= \cancel{57{,}500}\ 55{,}600\ g/yr$

FORM B1-005-1 (4/81)

JACOBS ENGINEERING GROUP INC.

DATE 2/2/95 SUBJECT Flux From TPA LLW Vaults SHEET NO. 6/11

BY AJM CHKD. _____ JOB NO. 01K4701

(11) Dissolved concentration = $\frac{55{,}600 \text{ g/yr}}{555 \text{ liters/yr}}$

= ~~104~~ 100 g/L total

From p10-107 of Lange, this doesn't exceed the solubility of sodium silicate (Ref 2)

(12) From all vaults (total inventory) what fraction is leached every year?

$$\frac{1}{170{,}000} = 5.88 \times 10^{-6} \text{ yr}^{-1}$$

(13) Multiplying the glass components by this fraction will give the metric tons per year of each component, which when divided by total flow, will give the concentration in the leach product.

For total mass, for example

$$\cancel{4 \times 10^{5}}\ 3.87 \times 10^{5}\ \cancel{MT} \times \left\{ \frac{5.88 \times \cancel{10^{-6}}\ \cancel{yr^{-1}} \times \frac{\cancel{10^{6}}\ g}{\cancel{MT}}}{555 \frac{L}{\cancel{yr} \cdot \cancel{vault}} \times 40.9\ \cancel{vaults}} \right\} \rightarrow 2.59 \times 10^{-4} \text{ Combined Factor}$$

$$= \frac{\cancel{104}\ 100}{} \frac{g}{L} \text{ total solids}$$

(14) To get the concentrations of ions in soln, the metric tons of oxides must be converted to metric tons of the element

FORM 91-005-1 (4/81)

For Sm as an example, table shows 3.98×10^{-4} MT Sm_2O_3

Then 3.98×10^{-4} MT Sm_2O_3 $\times \dfrac{2 \times 150}{(2 \times 150) + (3 \times 16)} \dfrac{\text{MT Sm}}{\text{MT } Sm_2O_3}$

Subscript of Sm

At Wt of SM

Subscript of O

At of O

$= 3.43 \times 10^{-4}$ MT Sm

(15) Now multiply by conversion fraction from step (13)

$(3.43 \times 10^{-4})(2.59 \times 10^{-4}) = 8.89 \times 10^{-8} \dfrac{g}{L} Sm^{+3}$

Results

At 14,500 yrs after a barrier is emplaced, the leach vaults begin to release solution to the vadose zone.

This continues for 170,000 yrs until all of the LL glass is leached.

The total flow of leachate is 22,700 L/yr.

The concentrations of elements in the leachate are shown in the following table in the column titled "Conc. g/L".

2/11

		Estimated Vaults Release Concentrations, g/L				
Glass Component	Metric Tons	Conc. g/L	Ionic Form	Metal Subscript	Metal At Wt	Oxygen Subscript
Ag2O	3.52E-01	8.49E-05	Ag+1	2	108	1
Al2O3	1.94E+04	2.66E+00	Al+3	2	27	3
Am2O3	2.76E-03	6.51E-07	Am+3	2	243	3
As2O5	1.18E+00	1.99E-04	As+5	2	75	5
B2O3	1.67E+00	3.88E-04	B+3	2	209	3
BaO	8.81E-01	2.04E-04	Ba+2	1	137	1
BeO	2.27E-01	2.12E-05	Be+2	1	9	1
Bi2O3	7.52E+01	1.75E-02	Bi+3	2	209	3
CaO	3.87E+04	7.16E+00	Ca+2	1	40	1
CdO	2.83E+00	6.41E-04	Cd+2	1	112	1
Ce2O3	2.79E+00	6.17E-04	Ce+3	2	140	3
Cm2O3	NS	0.00E+00	Cm+3	2	247	3
Co2O3	NS	0.00E+00	Co+3	2	59	3
Cr2O3	2.11E+02	3.74E-02	Cr+3	2	52	3
Cs2O	6.83E-03	1.67E-06	Cs+1	2	133	1
CuO	2.21E-01	4.58E-05	Cu+2	1	64	1
Fe2O3	2.06E+01	3.73E-03	Fe+3	2	56	3
K2O	2.65E-01	5.70E-05	K+1	2	39	1
La2O3	2.58E-01	5.70E-05	La+3	2	139	3
Li2O	1.24E-02	1.50E-06	Li+1	2	7	1
MgO	1.60E+00	2.49E-04	Mg+2	1	24	1
MnO2	2.16E+01	3.54E-03	Mn+4	1	55	2
MoO3	7.29E+00	1.26E-03	Mo+6	1	96	3
Na2O	9.86E+04	1.89E+01	Na+1	2	23	1
Ni2O3	5.72E+00	1.05E-03	Ni+3	2	59	3
NiO	1.50E-02	3.06E-06	Ni+3	1	59	1
NpO2	1.66E-02	3.79E-06	Np+4	1	237	2
P2O5	3.09E+03	5.35E-01	PO4-3	2	31	5
PbO2	2.26E+00	5.07E-04	Pb+4	1	207	2
PuO2	3.26E-02	7.46E-06	Pu+4	1	242	2
RbO2	NA	0.00E+00	Rb+4	1	85	2
Re2O7	NA	0.00E+00	Re+7	2	186	7
Rh2O3	NA	0.00E+00	Rh+3	2	103	3
Ru2O3	NA	0.00E+00	Ru+3	2	101	3
Sb2O5	NA	0.00E+00	Sb+5	2	122	5
SeO3	NA	0.00E+00	Se+6	1	79	3
SiO2	2.29E+05	2.77E+01	Si+4	1	28	2
Sm2O3	NA	0.00E+00	Sm+3	2	150	3
SnO2	NA	0.00E+00	Sn+4	1	119	2
SrO	4.00E-01	8.77E-05	Sr+2	1	88	1
Tc2O7	2.39E+00	3.25E-04	TcO4-1	2	99	7
TeO3	NA	0.00E+00	Te+6	1	128	3
ThO2	NA	0.00E+00	Th+4	1	232	2
TiO2	NA	0.00E+00	Ti+4	1	48	2
Tl2O3	NA	0.00E+00	Tl+3	2	204	3
UO3	9.02E+01	2.21E-02	UO2+2	1	238	3
V2O5	1.11E-01	1.61E-05	V+5	2	51	5
WO2	2.91E-05	8.65E-09	WO4-2	1	184	2
WO3	9.40E-01	2.60E-04	WO4-2	1	184	3
ZnO	4.46E+00	9.27E-04	Zn+2	1	65	1
ZrO2	6.49E-01	1.46E-04	ZrO+2	1	91	2
VAULTCON.WKS			Rev. B			

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Stream Name Solid Components	435	436	437	438	439	440	441	442	443	444
Cs and Ba, (MCi)	4.93E-06	4.93E-06	4.93E-01	4.93E-05	4.93E-01	4.93E-01	4.93E-01		4.93E-05	4.93E-05
Sr and Y, (MCi)	1.90E-05	1.90E-05	1.90E+00	1.90E-04	1.90E+00	1.90E+00	1.90E+00		1.90E-04	1.90E-04
Tc, (MCi)	2.59E-07	2.59E-07	2.59E-02	2.59E-06	2.59E-02	2.59E-02	2.59E-02		2.59E-06	2.59E-06
Am, (MCi)	8.60E-08	8.60E-08	8.60E-03	8.60E-07	8.60E-03	8.60E-03	8.60E-03		8.60E-07	8.60E-07
Np, (MCi)	1.03E-10	1.03E-10	1.03E-05	1.03E-09	1.03E-05	1.03E-05	1.03E-05		1.03E-09	1.03E-09
Pu-239, (MCi)	1.67E-08	1.67E-08	1.67E-03	1.67E-07	1.67E-03	1.67E-03	1.67E-03		1.67E-07	1.67E-07
Pu-240, (MCi)	4.13E-09	4.13E-09	4.14E-04	4.14E-08	4.14E-04	4.14E-04	4.14E-04		4.14E-08	4.14E-08
Pu-241, (MCi)	1.48E-08	1.48E-08	1.48E-03	1.48E-07	1.48E-03	1.48E-03	1.48E-03		1.48E-07	1.48E-07
Total TRU, (MCi)	1.22E-07	1.22E-07	1.22E-02	1.22E-06	1.22E-02	1.22E-02	1.22E-02		1.22E-06	1.22E-06
Total MCi	2.43E-05	2.43E-05	2.43E+00	2.43E-04	2.43E+00	2.43E+00	2.43E+00		2.43E-04	2.43E-04
Total Mass Flow, (MT)	3.87E+00	3.87E+00	3.87E+05	3.87E+01	3.87E+05	3.87E+05	5.15E+05		3.87E+01	3.87E+01
Total Cr, (MT)	1.44E-03	1.44E-03	1.44E+02	1.44E-02	1.44E+02	1.44E+02	1.44E+02		1.44E-02	1.44E-02
Total Na, (MT)	7.18E-01	7.18E-01	7.18E+04	7.18E+00	7.18E+04	7.18E+04	7.18E+04		7.18E+00	7.18E+00
Total Si, (MT)	1.07E+00	1.07E+00	1.07E+05	1.07E+01	1.07E+05	1.07E+05	1.07E+05		1.07E+01	1.07E+01
Total P, (MT)	1.35E-02	1.35E-02	1.35E+03	1.35E-01	1.35E+03	1.35E+03	1.35E+03		1.35E-01	1.35E-01
Total NO2-, (MT)										
Total NO3-, (MT)										
AG+										
AG2O	3.52E-06	3.52E-06	3.52E-01	3.52E-05	3.52E-01	3.52E-01	3.52E-01		3.52E-05	3.52E-05
AL+3										
AL2O3	1.94E-01	1.94E-01	1.94E+04	1.94E+00	1.94E+04	1.94E+04	1.94E+04		1.94E+00	1.94E+00
AM+3										
AM2O3	2.75E-08	2.75E-08	2.76E-03	2.76E-07	2.76E-03	2.76E-03	2.76E-03		2.76E-07	2.76E-07
AS+5										
AS2O5	1.18E-05	1.18E-05	1.18E+00	1.18E-04	1.18E+00	1.18E+00	1.18E+00		1.18E-04	1.18E-04
B+3										
B2O3	1.67E-05	1.67E-05	1.67E+00	1.67E-04	1.67E+00	1.67E+00	1.67E+00		1.67E-04	1.67E-04
BA+2										
BAO	8.81E-06	8.81E-06	8.81E-01	8.82E-05	8.82E-01	8.82E-01	8.81E-01		8.82E-05	8.82E-05
BE+2										
BEO	2.27E-06	2.27E-06	2.27E-01	2.27E-05	2.27E-01	2.27E-01	2.27E-01		2.27E-05	2.27E-05
BI+3										
BI2O3	7.52E-04	7.52E-04	7.52E+01	7.52E-03	7.52E+01	7.52E+01	7.52E+01		7.52E-03	7.52E-03
C14										
CA+2										
CANCRIN1										
CAO	3.87E-01	3.87E-01	3.87E+04	3.87E+00	3.87E+04	3.87E+04	3.87E+04		3.87E+00	3.87E+00
CD+2										
CDO	2.38E-05	2.38E-05	2.38E+00	2.38E-04	2.38E+00	2.38E+00	2.38E+00		2.38E-04	2.38E-04
CE+3										
CE2O3	2.79E-05	2.79E-05	2.79E+00	2.79E-04	2.79E+00	2.79E+00	2.79E+00		2.79E-04	2.79E-04
CL-										
CO3-2										
CR+3										
CR2O3	2.10E-03	2.10E-03	2.11E+02	2.11E-02	2.11E+02	2.11E+02	2.11E+02		2.11E-02	2.11E-02
CS+										

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Stream Name Solid Components	435	436	437	438	439	440	441	442	443	444
CS2O	6.82E-08	6.82E-08	6.83E-03	6.83E-07	6.83E-03	6.83E-03	6.83E-03		6.83E-07	6.83E-07
CU										
CU+2										
CUO	2.21E-06	2.21E-06	2.21E-01	2.21E-05	2.21E-01	2.21E-01	2.21E-01		2.21E-05	2.21E-05
CUSO4										
F-										
FE+3										
FE2O3	2.06E-04	2.06E-04	2.06E+01	2.06E-03	2.06E+01	2.06E+01	2.06E+01		2.06E-03	2.06E-03
HG+2										
I-										
K+										
K2O	2.65E-06	2.65E-06	2.65E-01	2.65E-05	2.65E-01	2.65E-01	2.65E-01		2.65E-05	2.65E-05
LA+3										
LA2O3	2.58E-06	2.58E-06	2.58E-01	2.58E-05	2.58E-01	2.58E-01	2.58E-01		2.58E-05	2.58E-05
LI+										
LI2O	1.24E-07	1.24E-07	1.24E-02	1.24E-06	1.24E-02	1.24E-02	1.24E-02		1.24E-06	1.24E-06
MG+2										
MGO	1.60E-05	1.60E-05	1.60E+00	1.60E-04	1.60E+00	1.60E+00	1.60E+00		1.60E-04	1.60E-04
MNO2	2.16E-04	2.16E-04	2.16E+01	2.16E-03	2.16E+01	2.16E+01	2.16E+01		2.16E-03	2.16E-03
MO+6										
MOO3	7.29E-05	7.29E-05	7.29E+00	7.29E-04	7.29E+00	7.29E+00	7.29E+00		7.29E-04	7.29E-04
NA+										
NA2O	9.68E-01	9.68E-01	9.68E+04	9.68E+00	9.68E+04	9.68E+04	9.68E+04		9.68E+00	9.68E+00
NI+3										
NI2FECN6										
NI2O3	5.72E-05	5.72E-05	5.72E+00	5.72E-04	5.72E+00	5.72E+00	5.72E+00		5.72E-04	5.72E-04
NIO	1.50E-07	1.50E-07	1.50E-02	1.50E-06	1.50E-02	1.50E-02	1.50E-02		1.50E-06	1.50E-06
NO2-										
NO3-										
NP+4										
NPO2	1.66E-07	1.66E-07	1.66E-02	1.66E-06	1.66E-02	1.66E-02	1.66E-02		1.66E-06	1.66E-06
OH-										
P2O5	3.09E-02	3.09E-02	3.09E+03	3.09E-01	3.09E+03	3.09E+03	3.09E+03		3.09E-01	3.09E-01
P2O5:24W										
PB+4										
PBO2	2.26E-05	2.26E-05	2.26E+00	2.26E-04	2.26E+00	2.26E+00	2.26E+00		2.26E-04	2.26E-04
PO4-3										
POLY										
PU+4										
PUO2	3.26E-07	3.26E-07	3.26E-02	3.26E-06	3.26E-02	3.26E-02	3.26E-02		3.26E-06	3.26E-06
S							1.28E+05			
SI+4										
SIO2	2.29E+00	2.29E+00	2.29E+05	2.29E+01	2.29E+05	2.29E+05	2.29E+05		2.29E+01	2.29E+01
SO4-2										
SR+2										
SRO	4.00E-06	4.00E-06	4.00E-01	4.00E-05	4.00E-01	4.00E-01	4.00E-01		4.00E-05	4.00E-05

Stream Name Solid Components	435	436	437	438	439	440	441	442	443	444
TC2O7	2.39E-05	2.39E-05	2.39E+00	2.39E-04	2.39E+00	2.39E+00	2.39E+00		2.39E-04	2.39E-04
TCO4-										
TOC										
UO2+2										
UO3	9.01E-04	9.01E-04	9.02E+01	9.02E-03	9.02E+01	9.02E+01	9.02E+01		9.02E-03	9.02E-03
V+5										
V2O5	1.10E-06	1.10E-06	1.11E-01	1.11E-05	1.11E-01	1.11E-01	1.11E-01		1.11E-05	1.11E-05
WO2	2.91E-10	2.91E-10	2.91E-05	2.91E-09	2.91E-05	2.91E-05	2.91E-05		2.91E-09	2.91E-09
WO3	9.40E-06	9.40E-06	9.40E-01	9.40E-05	9.40E-01	9.40E-01	9.40E-01		9.40E-05	9.40E-05
ZN+2										
ZNO	4.46E-05	4.46E-05	4.46E+00	4.46E-04	4.46E+00	4.46E+00	4.46E+00		4.46E-04	4.46E-04
ZR+4										
ZRO2	6.49E-06	6.49E-06	6.49E-01	6.49E-05	6.49E-01	6.49E-01	6.49E-01		6.49E-05	6.49E-05
ZRO2:2H2										

Comparison of LLW glass from TPA material balance Rev A versus Rev B

LLW glass is material balance Stream 437

Consitutents of Concern

		stream 437	sream 437		stream 437
		Inventory	Inventory		inventory in grams
		Rev A	Rev B		
		MT	MT		
	Tc2O7	2.81	2.39	Tc	1526516
	UO3	9.74E+01	9.02E+01	U	75061538
	PuO2	9.46E-03	3.26E-02	Pu	28820.29
	NpO2	5.35E-03	1.66E-02	Np	14625.28

Inventory in LLW glass based on mass fraction in feed		
	grams	metric tons
Tc99	1526516	1.526516
Pu238	9.346429	9.35E-06
Pu239	26896.57	0.026897
Pu240	1863.687	0.001864
Pu241	50.68281	5.07E-05
Pu242	0.005495	5.49E-09
U233	0.058661	5.87E-08
U234	1.61748	1.62E-06
U235	496835.2	0.496835
U236	1.832832	1.83E-06
U237	6.73E-07	6.73E-13
U238	74564700	74.5647
Np237	14625.28	0.014625
Np238	1.14E-07	1.14E-13
Np239	1.28E-05	1.28E-11

FROM THE INVENTORY DATA

MASS OF RADIONUCLIDES (grams)

from inventory by tank grouping

	SSTs	DSTs	TOTAL	Fraction
Pu238	65.1	82.88	147.98	0.000324
Pu239	290791.6	135056	425847.6	0.933251
Pu240	18960.35	10547	29507.35	0.064666
Pu241	417.5	384.95	802.45	0.001759
Pu242	0.087		0.087	1.91E-07
total Pu			456305.5	
U233	1.125		1.125	7.82E-10
U234	31.02		31.02	2.15E-08
U235	9528294		9528294	0.006619
U236	35.15		35.15	2.44E-08
U237	1.29E-05		1.29E-05	8.96E-15
U238	1.43E+09		1.43E+09	0.993381
total Np			1.44E+09	
Np237	98913	64729	163642	1
Np238	1.28E-06		1.28E-06	7.82E-12
Np239	1.43E-04		0.000143	8.74E-10
total Np			163642	

The material balance is based on WHC inventory which is 12/31/99

The breakdown by isotope using tank by tank grouping data is decayed to 12/31/95\

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TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE ENGINEERING ; FLUX FROM TANKS DURING RETRIEVAL

ORIGINATOR COLIN HENDERSON DATE

REVISION NO. ~~4~~ 1 2/27/95

OBJECTIVE DETERMINE FLUX and Concentration of leakage ASSOCIATED WITH Retrieval of SSTs.

METHODOLOGY See ATTACHED

ASSUMPTIONS SEE ATTACHED

(Continue on another sheet if necessary)

Colin Henderson
SIGNATURE

CALCULATION & RESULTS ATTACHED

PRELIMINARY

JACOBS ENGINEERING GROUP INC.

DATE _____ SUBJECT _____ SHEET NO. 2 of ~~16~~ 16

BY _____ CHKD. _____ JOB NO. _____

METHOD:

— CALCULATE THE SOLUBILITY OF TANK CONSTITUENTS BASED ON THE RATIO OF THE MASS OF EACH CONSTITUENT TO THE MASS OF NITRATE MULTIPLIED BY SOLUBILITY OF NO_3

— SOLUBILITY NO_3 = 360 g/L (Serne & Wood 1990)

— CONVERT RADIONUCLIDES from Ci to grams using SPECIFIC ACTIVITY CHART FROM ASI. (ATTACHED) AND FROM WHC-EP-0063-4 Appendix C

— THE TANK INVENTORY provided ON DISK BY ASI.

ASSUMPTIONS

1. LEAKAGE VOLUME PER TANK = 15140 l (4,000 gal)

   BASED ON Waste Retrieval and transfer data package WHICH USED 1/10 of LEAKAGE VOL estimated for TANK 106C

2. RETRIEVAL DURATION IS 15 YR (2003/2018)

3. SOLUBILITIES are proportional to mass Ratio of Each CONSTITUENT TO NITRATE.

4. LEAKAGE IS saturated WITH CONTAMINANTS.

5. NO LEAKAGE FROM DSTs

6. RADIONUCLIDES Decayed to 1995 USED AS INVENTORY DOES NOT CORRESPOND TO RETRIEVAL DATE.

RESULTS.

FOR EACH TANK GROUP THE Release Concentration is taken from TABLE 1 FOR RADIONUCLIDES AND TABLE 2 for CHEMICALS. BOTH TABLES ARE IN grams/liter, THE ANNUAL LEAKAGE FROM EACH TANK GROUP IS FROM TABLE 3.

TABLE 1A Provided for Reference and is the inventory in grams, Specific Activity Shown IN left hand Column.

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		Radionucli	Decayed to 12/31/1995				
	Specific Act	# of Tanks	40	43	40	16	10
	Ci/g.	Ci	1WSS	2WSS	1ESS	2ESS	4ESS
	5.80E+04	Ac-225	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	72.3	Ac-227	0.005179	0.004258	0.008844	0.001552	0.000277
	3.43	Am-241	2261.046	12602.86	9961.252	12927.14	6139.114
	8040	Am-242	2.676083	19.36104	18.82025	19.97412	8.668311
	9.71	Am-242m	2.688882	19.45364	18.91026	20.06965	8.70977
	0.199	Am-243	1.015628	7.824369	9.568559	11.64296	3.122778
	1.61E+12	At-217	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	5.37E+08	Ba-137m	844480.3	3775456	3538440	126183.6	136522.7
	1.24E+05	Bi-210	1.5E-08	1.16E-08	1.34E-08	7.03E-09	2.81E-09
	4.18E+08	Bi-211	0.005179	0.004258	0.008844	0.001552	0.000277
	1.46E+05	Bi-212	0	0	0	0	0
	1.38E+04	Bi-213	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	4.41E+07	Bi-214	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08
	4.45	C-14	1952.428	3373.591	12587.81	1479.091	1250.91
	3300	Cm-242	2.219645	16.05879	15.61023	16.5673	7.189828
	80.8	Cm-244	3.216887	23.89107	50.0855	53.42385	7.202217
	0.172	Cm-245	0.000208	0.001744	0.003826	0.004092	0.000551
	1.15E-03	Cs-135	20.65955	67.89432	52.72478	1.611265	2.130069
	86.4	Cs-137	892685.3	3990968	3740423	133386.4	144315.7
	1.77E+08	Fr-221	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	3.86E+07	Fr-223	7.15E-05	5.88E-05	0.000122	2.14E-05	3.82E-06
	1.76E-04	I-129	5.189401	13.39034	27.88373	1.821797	0.520811
	2.63E+02	Nb-93m	85.37654	675.9455	371.1179	404.9119	1504.691
	0.0807	Ni-59	0	1707.296	3325.23	0	0
	58.8	Ni-63	6834.228	48601.69	53030.59	58729.78	109051.8
	7.04E-04	Np-237	8.264374	11.00118	49.58412	0.3368	0.448371
	2.59E+05	Np-238	0.012799	0.092599	0.090013	0.095532	0.041459
	2.32E+05	Np-239	1.015628	7.824369	9.568559	11.64296	3.122778
	4.72E-02	Pa-231	0.009613	0.007326	0.01526	0.003377	0.000637
	2.07E+04	Pa-233	8.264374	11.00118	49.58412	0.3368	0.448371
	1.99E+04	Pa-234	0.275063	0.103494	0.260803	0.103241	0.026397
	6.86E+08	Pa-234m	171.9143	64.68359	163.0022	64.52547	16.49811
	4.59E+04	Pb-209	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06
	76.4	Pb-210	1.5E-08	1.16E-08	1.34E-08	7.03E-09	2.81E-09
	2.47E+07	Pb-211	0.005179	0.004258	0.008844	0.001552	0.000277
	1.38E+04	Pb-212	0	0	0	0	0
	3.28E+07	Pb-214	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08
	5.14E-04	Pd-107	9.0336	23.27601	49.54251	3.664392	0.974433
	4.49E+03	Po-210	1.5E-08	1.16E-08	1.34E-08	7.03E-09	2.81E-09
	1.04E+11	Po-211	1.41E-05	1.16E-05	2.41E-05	4.24E-06	7.56E-07
	2.95E+13	Po-212	0	0	0	0	0
	1.26E+16	Po-213	1.69E-06	2.81E-06	5.9E-06	2.2E-06	2.78E-06
	3.22E+14	Po-214	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08
	2.95E+13	Po-215	0.005179	0.004258	0.008844	0.001552	0.000277
	3.57E+11	Po-216	0	0	0	0	0
	2.83E+08	Po-218	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08

CONT FROM PG 1

	17.1	Pu-238	209.6931	296.1764	184.9489	198.7904	223.7023	
	0.0619	Pu-239	2522.875	4350.621	3522.892	5871.238	5570.596	
	0.227	Pu-240	486.5172	940.262	825.2579	1472.858	1389.286	
	103	Pu-241	3917.129	6358.175	8460.234	13183.46	11080.7	
	3.93E-03	Pu-242	1.33E-05	9.59E-05	9.32E-05	9.89E-05	4.29E-05	
	5.12E+04	Ra-223	0.005179	0.004258	0.008844	0.001552	0.000277	
	1.61E+05	Ra-224	0	0	0	0	0	
	3.92E+04	Ra-225	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06	
	0.988	Ra-226	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08	
	272	Ra-228	0	0	0	0	0	
	3.55E+09	Rh-106	6.11E-05	0.016964	0.082485	0.097283	0.396806	
	1.30E+10	Rn-219	0.005179	0.004258	0.008844	0.001552	0.000277	
	9.21E+08	Rn-220	0	0	0	0	0	
	1.54E+05	Rn-222	6.08E-08	5.03E-08	5.2E-08	2.98E-08	1.58E-08	
	3.34E+03	Ru-106	6.11E-05	0.016964	0.082485	0.097283	0.396806	
	8.35E+04	Sb-126	7.936369	23.28679	6.712138	13.94531	35.94768	
	7.85E+07	Sb-126m	56.68835	166.3342	47.94384	99.60934	256.7691	
	6.96E-02	Se-79	97.05961	251.0777	521.4021	32.2847	9.509629	
	26.3	Sm-151	64317.33	189324.1	56333.67	104150.4	255351.4	
	0.0283	Sn-126	56.68835	166.3342	47.94384	99.60934	256.7691	
	139	Sr-90	1513650	14476169	8411675	4949226	19174943	
	0.0169	Tc-99	3387.614	8743.647	18136.74	1132.886	331.8042	
	3.07E+04	Th-227	0.005107	0.004199	0.008722	0.001531	0.000273	
	819	Th-228	0	0	0	0	0	
	0.212	Th-229	1.72E-06	2.88E-06	6.03E-06	2.25E-06	2.84E-06	
	2.02E-02	Th-230	9E-06	7.86E-06	7.51E-06	4.51E-06	3.11E-06	
	5.29E+03	Th-231	7.217891	2.933397	6.922466	2.809554	0.697812	
	1.10E-07	Th-232	1.85E-14	3.57E-14	3.13E-14	5.59E-14	5.27E-14	
	2.31E+04	Th-234	171.9143	64.68359	163.0022	64.52547	16.49811	
	1.90E+08	Tl-207	0.005164	0.004247	0.008819	0.001548	0.000276	
	2.96E+08	Tl-208	0	0	0	0	0	
	4.09E+08	Tl-209	3.73E-08	6.21E-08	1.3E-07	4.85E-08	6.13E-08	
	9.64E-03	U-233	0.001199	0.001753	0.00591	0.000807	0.001178	
	6.24E-03	U-234	0.04907	0.045905	0.043094	0.030365	0.025199	
	2.16E-06	U-235	7.217891	2.933397	6.922466	2.809554	0.697812	
	6.46E-05	U-236	0.000216	0.000418	0.000367	0.000654	0.000617	
	8.15E+04	U-237	0.09597	0.155775	0.207276	0.322995	0.271477	
	3.36E-07	U-238	171.9143	64.68359	163.0022	64.52547	16.49811	
	5.41E+03	Y-90	1513650	14476169	8411675	4949226	19174943	
	2.51E-03	Zr-93	45.38102	800.02	241.6636	562.6344	2286.793	

tank contents in grams				
40	43	40	16	10
1WSS	2WSS	1ESS	2ESS	4ESS
2.97E-11	4.96E-11	1.04E-10	3.87E-11	4.89E-11
7.16E-05	5.89E-05	0.000122	2.15E-05	3.83E-06
659.197	3674.302	2904.155	3768.847	1789.829
0.000333	0.002408	0.002341	0.002484	0.001078
0.276919	2.003464	1.947504	2.066906	0.89699
5.10366	39.31844	48.08321	58.50734	15.69235
1.07E-18	1.79E-18	3.75E-18	1.39E-18	1.76E-18
0.001573	0.007031	0.006589	0.000235	0.000254
1.21E-13	9.36E-14	1.08E-13	5.67E-14	2.27E-14
1.24E-11	1.02E-11	2.12E-11	3.71E-12	6.62E-13
0	0	0	0	0
1.25E-10	2.08E-10	4.37E-10	1.63E-10	2.06E-10
1.38E-15	1.14E-15	1.18E-15	6.76E-16	3.58E-16
438.7478	758.1104	2828.721	332.38	281.1035
0.000673	0.004866	0.00473	0.00502	0.002179
0.039813	0.295682	0.61987	0.661186	0.089136
0.001209	0.010138	0.022243	0.023793	0.003206
17964.83	59038.54	45847.63	1401.1	1852.234
10332.01	46191.76	43291.93	1543.824	1670.321
9.75E-15	1.63E-14	3.41E-14	1.27E-14	1.6E-14
1.85E-12	1.52E-12	3.16E-12	5.55E-13	9.9E-14
29485.23	76081.49	158430.3	10351.12	2959.154
0.324626	2.570135	1.411095	1.539589	5.721258
0	21156.09	41204.83	0	0
116.2284	826.5593	901.8807	998.8058	1854.622
11739.17	15626.67	70431.98	478.4089	636.8901
4.94E-08	3.58E-07	3.48E-07	3.69E-07	1.6E-07
4.38E-06	3.37E-05	4.12E-05	5.02E-05	1.35E-05
0.203666	0.155203	0.323304	0.071551	0.013501
0.000399	0.000531	0.002395	1.63E-05	2.17E-05
1.38E-05	5.2E-06	1.31E-05	5.19E-06	1.33E-06
2.51E-07	9.43E-08	2.38E-07	9.41E-08	2.4E-08
3.76E-11	6.27E-11	1.31E-10	4.89E-11	6.19E-11
1.97E-10	1.52E-10	1.75E-10	9.2E-11	3.68E-11
2.1E-10	1.72E-10	3.58E-10	6.28E-11	1.12E-11
0	0	0	0	0
1.85E-15	1.53E-15	1.59E-15	9.09E-16	4.81E-16
17575.1	45284.06	96386.22	7129.167	1895.785
3.34E-12	2.58E-12	2.98E-12	1.57E-12	6.27E-13
1.36E-16	1.12E-16	2.32E-16	4.07E-17	7.27E-18
0	0	0	0	0
1.34E-22	2.23E-22	4.68E-22	1.74E-22	2.2E-22
1.89E-22	1.56E-22	1.62E-22	9.26E-23	4.9E-23
1.76E-16	1.44E-16	3E-16	5.26E-17	9.39E-18
0	0	0	0	0
2.15E-16	1.78E-16	1.84E-16	1.05E-16	5.57E-17

12.26275	17.32026	10.81573	11.62517	13.082
40757.26	70284.68	56912.63	94850.37	89993.48
2143.248	4142.124	3635.497	6488.36	6120.203
38.03038	61.72985	82.13819	127.9948	107.5796
0.003372	0.024397	0.023715	0.025169	0.010923
1.01E-07	8.32E-08	1.73E-07	3.03E-08	5.41E-09
0	0	0	0	0
4.4E-11	7.34E-11	1.54E-10	5.73E-11	7.24E-11
6.15E-08	5.09E-08	5.27E-08	3.02E-08	1.6E-08
0	0	0	0	0
1.72E-14	4.78E-12	2.32E-11	2.74E-11	1.12E-10
3.98E-13	3.28E-13	6.8E-13	1.19E-13	2.13E-14
0	0	0	0	0
3.95E-13	3.26E-13	3.38E-13	1.94E-13	1.02E-13
1.83E-08	5.08E-06	2.47E-05	2.91E-05	0.000119
9.5E-05	0.000279	8.04E-05	0.000167	0.000431
7.22E-07	2.12E-06	6.11E-07	1.27E-06	3.27E-06
1394.535	3607.438	7491.41	463.8606	136.6326
2445.526	7198.636	2141.965	3960.091	9709.18
2003.122	5877.533	1694.129	3519.765	9073.114
10889.57	104145.1	60515.65	35605.95	137949.2
200450.5	517375.5	1073180	67034.7	19633.39
1.66E-07	1.37E-07	2.84E-07	4.99E-08	8.89E-09
0	0	0	0	0
8.14E-06	1.36E-05	2.84E-05	1.06E-05	1.34E-05
0.000445	0.000389	0.000372	0.000223	0.000154
0.001364	0.000555	0.001309	0.000531	0.000132
1.68E-07	3.24E-07	2.85E-07	5.08E-07	4.79E-07
0.007442	0.0028	0.007056	0.002793	0.000714
2.72E-11	2.24E-11	4.64E-11	8.15E-12	1.45E-12
0	0	0	0	0
9.11E-17	1.52E-16	3.18E-16	1.19E-16	1.5E-16
0.124419	0.181847	0.61306	0.083734	0.122188
7.863758	7.356635	6.906132	4.866185	4.038277
3341616	1358054	3204845	1300719	323060.9
3.345725	6.465961	5.674911	10.12839	9.553981
1.18E-06	1.91E-06	2.54E-06	3.96E-06	3.33E-06
5.12E+08	1.93E+08	4.85E+08	1.92E+08	49101503
279.7875	2675.817	1554.838	914.8293	3544.352
18080.09	318733.1	96280.32	224157.1	911072.8

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Table 1 Rev A

Tank Release Concentration grams/liter for radionuclides

	release concentration grams/liter				
	1WSS	2WSS	1ESS	2ESS	4ESS
Ac-225	4.07E-19	3.92E-19	1.98E-18	5.4E-17	3.6E-18
Ac-227	9.8E-13	4.66E-13	2.33E-12	3E-11	2.82E-13
Am-241	9.02E-06	2.91E-05	5.53E-05	0.005259	0.000132
Am-242	4.56E-12	1.91E-11	4.46E-11	3.47E-09	7.94E-11
Am-242m	3.79E-09	1.59E-08	3.71E-08	2.88E-06	6.6E-08
Am-243	6.99E-08	3.11E-07	9.16E-07	8.16E-05	1.16E-06
At-217	1.47E-26	1.41E-26	7.13E-26	1.95E-24	1.3E-25
Ba-137m	2.15E-11	5.56E-11	1.26E-10	3.28E-10	1.87E-11
Bi-210	1.66E-21	7.4E-22	2.06E-21	7.91E-20	1.67E-21
Bi-211	1.7E-19	8.06E-20	4.03E-19	5.18E-18	4.88E-20
Bi-212	0	0	0	0	0
Bi-213	1.71E-18	1.65E-18	8.32E-18	2.27E-16	1.51E-17
Bi-214	1.89E-23	9.02E-24	2.25E-23	9.43E-22	2.63E-23
C-14	6.01E-06	6E-06	5.39E-05	0.000464	2.07E-05
Cm-242	9.21E-12	3.85E-11	9.01E-11	7.01E-09	1.6E-10
Cm-244	5.45E-10	2.34E-09	1.18E-08	9.23E-07	6.56E-09
Cm-245	1.65E-11	8.02E-11	4.24E-10	3.32E-08	2.36E-10
Cs-135	0.000246	0.000467	0.000873	0.001955	0.000136
Cs-137	0.000141	0.000365	0.000825	0.002154	0.000123
Fr-221	1.33E-22	1.29E-22	6.49E-22	1.77E-20	1.18E-21
Fr-223	2.53E-20	1.2E-20	6.02E-20	7.74E-19	7.29E-21
I-129	0.000404	0.000602	0.003018	0.014443	0.000218
Nb-93m	4.44E-09	2.03E-08	2.69E-08	2.15E-06	4.21E-07
Ni-59	0	0.000167	0.000785	0	0
Ni-63	1.59E-06	6.54E-06	1.72E-05	0.001394	0.000137
Np-237	0.000161	0.000124	0.001342	0.000668	4.69E-05
Np-238	6.76E-16	2.83E-15	6.62E-15	5.15E-13	1.18E-14
Np-239	5.99E-14	2.67E-13	7.86E-13	7E-11	9.91E-13
Pa-231	2.79E-09	1.23E-09	6.16E-09	9.98E-08	9.94E-10
Pa-233	5.46E-12	4.2E-12	4.56E-11	2.27E-11	1.59E-12
Pa-234	1.89E-13	4.11E-14	2.5E-13	7.24E-12	9.77E-14
Pa-234m	3.43E-15	7.46E-16	4.53E-15	1.31E-13	1.77E-15
Pb-209	5.14E-19	4.96E-19	2.5E-18	6.83E-17	4.55E-18
Pb-210	2.69E-18	1.2E-18	3.34E-18	1.28E-16	2.71E-18
Pb-211	2.87E-18	1.36E-18	6.82E-18	8.77E-17	8.25E-19
Pb-212	0	0	0	0	0
Pb-214	2.54E-23	1.21E-23	3.02E-23	1.27E-21	3.54E-23
Pd-107	0.000241	0.000358	0.001836	0.009948	0.00014
Po-210	4.58E-20	2.04E-20	5.68E-20	2.18E-18	4.61E-20
Po-211	1.86E-24	8.84E-25	4.42E-24	5.69E-23	5.35E-25
Po-212	0	0	0	0	0
Po-213	1.83E-30	1.77E-30	8.92E-30	2.43E-28	1.62E-29
Po-214	2.58E-30	1.23E-30	3.08E-30	1.29E-28	3.61E-30
Po-215	2.4E-24	1.14E-24	5.71E-24	7.34E-23	6.91E-25
Po-216	0	0	0	0	0
Po-218	2.94E-24	1.4E-24	3.5E-24	1.47E-22	4.1E-24

$$\text{Conc} = \left(\frac{\text{mass isotope}}{\text{mass } NO_3 \text{ in tank group}}\right) X3$$

in grams/liter

2/27/95

Table 1 Rev A

Tank Release Concentration grams/liter for radionuclides

Pu-238	1.68E-07	1.37E-07	2.06E-07	1.62E-05	9.63E-07
Pu-239	0.000558	0.000556	0.001084	0.132349	0.006625
Pu-240	2.93E-05	3.28E-05	6.92E-05	0.009054	0.000451
Pu-241	5.21E-07	4.88E-07	1.56E-06	0.000179	7.92E-06
Pu-242	4.62E-11	1.93E-10	4.52E-10	3.51E-08	8.04E-10
Ra-223	1.38E-15	6.58E-16	3.29E-15	4.23E-14	3.98E-16
Ra-224	0	0	0	0	0
Ra-225	6.02E-19	5.81E-19	2.93E-18	7.99E-17	5.33E-18
Ra-226	8.42E-16	4.02E-16	1E-15	4.21E-14	1.18E-15
Ra-228	0	0	0	0	0
Rh-106	2.36E-22	3.78E-20	4.43E-19	3.82E-17	8.23E-18
Rn-219	5.45E-21	2.59E-21	1.3E-20	1.67E-19	1.57E-21
Rn-220	0	0	0	0	0
Rn-222	5.4E-21	2.58E-21	6.44E-21	2.7E-19	7.54E-21
Ru-106	2.51E-16	4.02E-14	4.7E-13	4.06E-11	8.75E-12
Sb-126	1.3E-12	2.21E-12	1.53E-12	2.33E-10	3.17E-11
Sb-126m	9.88E-15	1.68E-14	1.16E-14	1.77E-12	2.41E-13
Se-79	1.91E-05	2.85E-05	0.000143	0.000647	1.01E-05
Sm-151	3.35E-05	5.7E-05	4.08E-05	0.005526	0.000715
Sn-126	2.74E-05	4.65E-05	3.23E-05	0.004911	0.000668
Sr-90	0.000149	0.000824	0.001153	0.049683	0.010156
Tc-99	0.002744	0.004094	0.020442	0.093537	0.001445
Th-227	2.28E-15	1.08E-15	5.41E-15	6.96E-14	6.55E-16
Th-228	0	0	0	0	0
Th-229	1.11E-13	1.07E-13	5.42E-13	1.48E-11	9.86E-13
Th-230	6.1E-12	3.08E-12	7.08E-12	3.12E-10	1.13E-11
Th-231	1.87E-11	4.39E-12	2.49E-11	7.41E-10	9.71E-12
Th-232	2.3E-15	2.57E-15	5.42E-15	7.09E-13	3.53E-14
Th-234	1.02E-10	2.22E-11	1.34E-10	3.9E-09	5.26E-11
Tl-207	3.72E-19	1.77E-19	8.84E-19	1.14E-17	1.07E-19
Tl-208	0	0	0	0	0
Tl-209	1.25E-24	1.2E-24	6.07E-24	1.65E-22	1.1E-23
U-233	1.7E-09	1.44E-09	1.17E-08	1.17E-07	9E-09
U-234	1.08E-07	5.82E-08	1.32E-07	6.79E-06	2.97E-07
U-235	0.045741	0.010745	0.061045	1.814957	0.023784
U-236	4.58E-08	5.12E-08	1.08E-07	1.41E-05	7.03E-07
U-237	1.61E-14	1.51E-14	4.84E-14	5.53E-12	2.45E-13
U-238	7.003571	1.523161	9.240486	267.9629	3.614835
Y-90	3.83E-06	2.12E-05	2.96E-05	0.001277	0.000261
Zr-93	0.000247	0.002522	0.001834	0.312777	0.067073

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Table 2
Chemical Release Concentrations Nonradioactive Chemicals for Single Shell Tanks

solubility grams/liter

Chemical	1WSS	2WSS	1ESS	2ESS	4ESS
Ag (1)	5.63E-10	5.11E-10	3.80E-09	1.24E-08	1.97E-10
Al (1)	4.55E+00	8.75E+00	1.53E+01	5.37E+02	1.94E+00
Al+3	9.75E-01	5.73E+00	1.13E+01	8.06E+02	1.87E+00
AlO2-	6.23E+00	8.47E+00	1.37E+01	1.05E+02	1.34E+00
Ba+2 (1)	4.91E-04	1.34E-03	1.95E-03	1.52E-01	1.40E-02
Bi+3	2.28E+00	2.21E-03	1.79E+00	8.27E-01	
C2H3O3 (1)	7.28E-02	2.25E-02	6.15E-03	1.65E-01	2.19E-01
C6H5O7 (1)	7.47E+00	5.21E+00	2.33E+01	1.53E+02	1.79E+00
CO3-2	9.68E+00	1.27E+00	1.22E+01	8.62E+01	2.80E+00
Ca+2	2.72E-03	4.60E-02	1.04E+00	9.16E+01	1.13E-01
Cd+2 (2)					
Ce+3	1.59E+00	2.50E-01	1.68E+00	3.67E-01	1.29E-01
Cl-	3.00E-01	4.28E-02	2.40E-01	5.58E-02	4.44E-03
Cr+3	1.73E-02	6.59E-01	1.38E-02	2.30E-01	6.07E-02
CrO4-2	4.28E-03	1.63E-01	3.42E-03	5.69E-02	1.50E-02
EDTA (1)	5.58E-01	1.73E-01	4.71E-02	1.27E+00	1.67E+00
F-	1.97E+00	2.38E-01	4.42E+00	5.56E+02	2.27E-02
Fe+3	2.33E+00	6.47E-01	2.70E+00	7.72E+01	1.31E+01
Fe(CN)6-4	3.00E-02	1.08E-02	4.72E+00	9.73E+01	3.90E-03
HEDTA (1)	1.01E+00	3.14E-01	9.41E-02	2.30E+00	3.04E+00
Hg+ (2)					
K+ (1)	6.85E-02	2.00E-01	5.50E-01	2.56E-01	3.33E-02
La+ (1)	2.03E-02		7.60E-03		
Mn+4	2.87E-01	8.92E-02	2.49E-01	7.12E+01	1.73E+00
Na+	1.99E+02	1.67E+02	2.20E+02	2.92E+03	2.78E+02
Ni+2	6.88E-02	2.64E-02	2.37E+00	6.12E+01	7.31E-02
NO2-	2.41E+01	6.33E+00	3.92E+01	6.59E-01	1.71E+01
NO3-	3.60E+02	3.60E+02	3.60E+02	3.60E+02	3.60E+02
OH-	6.20E+00	1.82E+01	1.98E+01	1.97E+03	1.28E+01
PO4-3	3.66E+01	8.70E-01	3.44E+01	4.14E+01	6.34E-02
Pb (1)	3.22E-02	3.06E-02	8.04E+00	9.48E+00	7.60E-03
SiO3-	7.67E+00	1.90E+00	7.68E+00	9.83E-01	1.54E-01
Sn (1)			1.02E-04		
SO4-2	8.68E+00	1.96E+00	1.05E+01	1.86E+02	6.15E+00
Sr+2	1.28E-05	5.52E-04	6.82E-01	3.52E-02	4.25E-03
W+4 (2)					
Zr+4	1.92E-01	1.83E-01	1.24E-01	2.82E+02	9.41E-03

TABLE 3

SST RETRIEVAL LEAK ESTIMATES

TANK GROUP	1WSS	2WSS	1ESS	2ESS	4ESS
NO. TANKS	40	43	40	16	10
RETRIEVAL LEAK VOLUME (LITERS)	605600	651020	605600	242240	151400
RETRIEVAL LEAK RATE (LITERS/YR)	40373	43401	40373	16149	10093
SST RETRIEVAL OPERATIONS =15 YRS MIN PRETREAT AND TPA					
SST RETRIEVAL PERIOD 2003/2018					

SHEET ~~9 of 14~~ 11/16

SHEET ~~12 of 14~~ 12/16

(DK-ADJ.XLW)Radnuclide Data

Atomic Weight (A)	Isotope	Half-Life (T)	Units	Specific Activity (TBq/g)	Specific Activity (Ci/g)	Decay Constant (per day)
3	H-3	1.24E+01	y	3.57E+02	9.64E+03	1.54E-04
7	Be-7	53.440	d	1.29E+04	3.49E+05	1.30E-02
11	C-11	20.380	m	3.10E+07	8.38E+08	4.90E+01
13	N-13	9.970	m	5.36E+07	1.45E+09	1.00E+02
14	C-14	5.73E+03	y	1.65E-01	4.45E+00	3.31E-07
16	N-16	7.20E+00	s	3.62E+09	9.78E+10	8.32E+03
18	F-18	1.829	h	3.50E+04	9.47E+05	9.10E+00
22	Na-22	2.60E+00	y	2.31E+02	6.24E+03	7.29E-04
24	Na-24	15.000	h	3.20E+03	8.66E+04	1.11E+00
32	P-32	14.290	d	1.06E+04	2.85E+05	4.85E-02
35	S-35	87.440	d	1.58E+03	4.26E+04	7.93E-03
36	Cl-36	3.01E+05	y	1.22E-03	3.30E-02	6.30E-09
41	Ar-41	1.827	h	1.54E+04	4.16E+05	9.11E+00
42	K-42	51.500	d	2.23E+03	6.03E+04	1.35E-02
45	Ca-45	163.000	d	6.58E+02	1.78E+04	4.25E-03
46	Sc-46	83.830	d	1.25E+03	3.38E+04	8.27E-03
51	Cr-51	27.704	d	3.42E+03	9.23E+04	2.50E-02
54	Mn-54	312.500	d	2.86E+02	7.73E+03	2.22E-03
55	Fe-55	2.70E+00	y	8.90E+01	2.41E+03	7.03E-04
56	Mn-56	2.579	h	7.99E+03	2.16E+05	6.45E+00
57	Co-57	270.900	d	3.13E+02	8.45E+03	2.56E-03
59	Ni-59	7.50E+04	y	2.99E-03	8.07E-02	2.53E-08
59	Fe-59	44.529	d	1.84E+03	4.97E+04	1.56E-02
60	Co-60	5.27E+00	y	4.18E+01	1.13E+03	3.60E-04
63	Ni-63	1.00E+02	y	2.10E+00	5.66E+01	1.90E-05
64	Cu-64	12.701	h	1.42E+03	3.84E+04	1.31E+00
65	Zn-65	243.900	d	3.04E+02	8.23E+03	2.84E-03
65	Ni-65	2.520	h	7.04E+03	1.90E+05	6.60E+00
72	Ga-72	14.100	h	1.14E+03	3.07E+04	1.18E+00
76	As-76	26.320	h	5.77E+02	1.56E+04	6.32E-01
79	Se-79	6.50E+04	y	2.57E-03	6.96E-02	2.92E-08
82	Br-82	35.300	h	3.99E+02	1.08E+04	4.71E-01
86	Rb-86	18.660	d	3.01E+03	8.13E+04	3.71E-02
89	Sr-89	50.500	d	1.07E+03	2.90E+04	1.37E-02
90	Sr-90	2.86E+01	y	5.13E+00	1.39E+02	6.64E-05
90	Y-90	64.100	h	2.00E+02	5.41E+03	2.60E-01
92	Y-92	3.540	h	3.54E+03	9.58E+04	4.70E+00
92	Sr-92	2.710	h	4.63E+03	1.25E+05	6.14E+00
93	Nb-93m	1.46E+01	y	9.73E+00	2.63E+02	1.30E-04
93	Zr-93	1.53E+06	y	9.29E-05	2.51E-03	1.24E-09
95	Zr-95	63.960	d	7.94E+02	2.15E+04	1.08E-02
95	Nb-95	35.150	d	1.45E+03	3.91E+04	1.97E-02
99	Mo-99	66.000	h	1.77E+02	4.77E+03	2.52E-01
99	Tc-99m	6.020	h	1.94E+03	5.23E+04	2.76E+00
99	Tc-99	2.13E+05	y	6.27E-04	1.69E-02	8.91E-09
103	Ru-103	39.280	d	1.19E+03	3.22E+04	1.76E-02
106	Ru-106	368.200	d	1.24E+02	3.34E+03	1.88E-03

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(DK-ADJ.XLW)Radnuclide Data

Atomic Wieght (A)	Isotope	Half-Life (T)	Units	Specific Activity (TBq/g)	Specific Activity (Ci/g)	Decay Constant (per day)
106	Rh-106	2.99E+01	s	1.31E+08	3.55E+09	2.00E+03
107	Pd-107	6.50E+06	y	1.90E-05	5.14E-04	2.92E-10
110	Ag-110m	249.900	d	1.76E+02	4.75E+03	2.77E-03
110	Ag-110	2.46E+01	s	1.54E+08	4.17E+09	2.49E+03
123	I-123	13.200	h	7.11E+02	1.92E+04	1.26E+00
125	I-125	60.140	d	6.42E+02	1.74E+04	1.15E-02
126	Sb-126	12.400	d	3.09E+03	8.35E+04	5.59E-02
126	Sb-126m	19.000	m	2.90E+06	7.85E+07	5.25E+01
126	Sn-126	1.00E+05	y	1.05E-03	2.83E-02	1.90E-08
129	I-129	1.57E+07	y	6.52E-06	1.76E-04	1.21E-10
131	I-131	8.040	d	4.58E+03	1.24E+05	8.62E-02
132	Te-132	76.200	h	1.12E+02	3.02E+03	2.13E-01
132	I-132	2.300	h	3.80E+03	1.03E+05	7.23E+00
133	Ba-133	1.05E+01	y	9.46E+00	2.56E+02	1.81E-04
133	Xe-133	5.245	d	6.92E+03	1.87E+05	1.32E-01
133	I-133	20.800	h	4.17E+02	1.13E+04	8.00E-01
133	Te-133	12.450	m	4.20E+06	1.13E+08	8.02E+01
134	Cs-134	2.06E+00	y	4.78E+01	1.29E+03	9.20E-04
135	I-135	6.610	h	1.29E+03	3.49E+04	2.52E+00
135	Ba-135m	28.700	h	2.98E+02	8.05E+03	5.80E-01
135	Cs-135	2.30E+06	y	4.26E-05	1.15E-03	8.25E-10
136	Cs-136	13.100	d	2.71E+03	7.32E+04	5.29E-02
137	Cs-137	3.02E+01	y	3.20E+00	8.64E+01	6.29E-05
137	Ba-137m	2.552	m	1.99E+07	5.37E+08	3.91E+02
140	Ba-140	12.740	d	2.71E+03	7.31E+04	5.44E-02
140	La-140	40.272	h	2.05E+02	5.53E+03	4.13E-01
141	Ce-141	32.501	d	1.05E+03	2.85E+04	2.13E-02
143	Ce-144	284.800	d	1.19E+02	3.21E+03	2.44E-03
143	Pr-143	13.580	d	2.49E+03	6.73E+04	5.11E-02
143	Ce-143	33.000	h	2.44E+02	6.61E+03	5.04E-01
144	Pr-144	17.280	m	2.79E+06	7.55E+07	5.78E+01
147	Pm-147	2.62E+00	y	3.43E+01	9.26E+02	7.23E-04
151	Sm-151	9.00E+01	y	9.72E-01	2.63E+01	2.11E-05
154	Eu-154	8.590	y	9.99E+00	2.70E+02	2.21E-04
181	Ta-181	121.200	d	2.20E+02	5.95E+03	5.72E-03
182	Ta-182	115.000	d	2.31E+02	6.23E+03	6.03E-03
185	W-185	75.100	d	3.47E+02	9.39E+03	9.23E-03
192	Ir-192	74.020	d	3.40E+02	9.18E+03	9.36E-03
198	Au-198	2.696	d	9.04E+03	2.44E+05	2.57E-01
199	Au-199	3.139	d	7.73E+03	2.09E+05	2.21E-01
203	Hg-203	46.600	d	5.10E+02	1.38E+04	1.49E-02
204	Tl-204	3.78E+00	y	1.71E+01	4.63E+02	5.02E-04
207	Tl-207	4.770	m	7.04E+06	1.90E+08	2.09E+02
208	Tl-208	3.053	m	1.09E+07	2.96E+08	3.27E+02
209	Pb-209	3.253	h	1.70E+03	4.59E+04	5.11E+00
209	Tl-209	2.200	m	1.51E+07	4.09E+08	4.54E+02
210	Pb-210	2.23E+01	y	2.83E+00	7.64E+01	8.53E-05

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(DK-ADJ.XLW)Radnuclide Data

Atomic Weight (A)	Isotope	Half-Life (T)	Units	Specific Activity (TBq/g)	Specific Activity (Ci/g)	Decay Constant (per day)
210	Bi-210	5.012	d	4.59E+03	1.24E+05	1.38E-01
210	Po-210	138.378	d	1.66E+02	4.49E+03	5.01E-03
211	Bi-211	2.130	m	1.55E+07	4.18E+08	4.69E+02
211	Pb-211	36.100	m	9.12E+05	2.47E+07	2.78E+01
211	Po-211	5.16E-01	s	3.83E+09	1.04E+11	1.16E+05
212	Po-212	2.99E-07	s	6.60E+15	1.78E+17	2.01E+11
212	Bi-212	1.009	h	5.39E+03	1.46E+05	1.65E+01
212	Pb-212	10.643	h	5.11E+02	1.38E+04	1.56E+00
213	Bi-213	45.650	m	7.15E+05	1.93E+07	2.19E+01
213	Po-213	4.20E-06	s	4.66E+14	1.26E+16	1.43E+10
214	Bi-214	19.900	m	1.63E+06	4.41E+07	5.02E+01
214	Pb-214	26.800	m	1.21E+06	3.28E+07	3.72E+01
214	Po-214	1.64E-04	s	1.19E+13	3.22E+14	3.66E+08
215	Po-215	1.78E-03	s	1.09E+12	2.95E+13	3.37E+07
216	Po-216	1.46E-01	s	1.32E+10	3.57E+11	4.10E+05
217	At-217	3.23E-02	s	5.95E+10	1.61E+12	1.85E+06
218	Po-218	3.050	m	1.05E+07	2.83E+08	3.27E+02
219	Rn-219	3.96E+00	s	4.81E+08	1.30E+10	1.51E+04
220	Rn-220	5.56E+01	s	3.41E+07	9.21E+08	1.08E+03
221	Fr-221	4.800	m	6.55E+06	1.77E+08	2.08E+02
222	Rn-222	3.824	d	5.69E+03	1.54E+05	1.81E-01
223	Fr-223	21.800	m	1.43E+06	3.86E+07	4.58E+01
223	Ra-223	11.434	d	1.89E+03	5.12E+04	6.06E-02
224	Ra-224	3.620	d	5.95E+03	1.61E+05	1.91E-01
225	Ac-225	10.000	d	2.15E+03	5.80E+04	6.93E-02
225	Ra-225	14.800	d	1.45E+03	3.92E+04	4.68E-02
226	Ra-226	1.60E+03	y	3.65E-02	9.88E-01	1.19E-06
227	Th-227	18.718	d	1.14E+03	3.07E+04	3.70E-02
227	Ac-227	2.18E+01	y	2.67E+00	7.23E+01	8.72E-05
228	Ra-228	5.75E+00	y	1.01E+01	2.72E+02	3.30E-04
228	Th-228	1.91E+00	y	3.03E+01	8.19E+02	9.92E-04
228	Ac-228	6.130	h	8.25E+02	2.23E+04	2.71E+00
229	Th-229	7.34E+03	y	7.86E-03	2.12E-01	2.59E-07
230	Th-230	7.70E+04	y	7.46E-04	2.02E-02	2.46E-08
231	Th-231	25.520	h	1.96E+02	5.29E+03	6.52E-01
231	Pa-231	3.28E+04	y	1.75E-03	4.72E-02	5.79E-08
232	Th-232	1.41E+10	y	4.05E-09	1.10E-07	1.35E-13
232	U-232	7.20E+01	y	7.81E-01	2.14E+01	2.64E-05
233	U-233	1.59E+05	y	3.57E-04	9.64E-03	1.19E-08
233	Pa-233	27.000	d	7.67E+02	2.07E+04	2.57E-02
233	Th-233	22.300	m	1.34E+06	3.62E+07	4.46E+01
234	U-234	2.45E+05	y	2.31E-04	6.24E-03	7.76E-09
234	Th-234	24.100	d	8.56E+02	2.31E+04	2.88E-02
234	Pa-234	6.700	h	7.36E+02	1.99E+04	2.48E+00
234	Pa-234m	1.170	m	2.54E+07	6.86E+08	8.53E+02
235	U-235	7.04E+08	y	7.99E-08	2.16E-06	2.70E-12
236	U-236	2.34E+07	y	2.39E-06	6.46E-05	8.10E-11

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(DK-ADJ.XLW)Radnuclide Data

Atomic Weight (A)	Isotope	Half-Life (T)	Units	Specific Activity (TBq/g)	Specific Activity (Ci/g)	Decay Constant (per day)
236	Pu-236	2.85E+00	y	1.96E+01	5.31E+02	6.66E-04
237	U-237	6.750	d	3.02E+03	8.15E+04	1.03E-01
237	Np-237	2.14E+06	y	2.61E-05	7.04E-04	8.67E-10
238	U-238	4.47E+09	y	1.24E-08	3.36E-07	4.25E-13
238	Pu-238	8.77E+01	y	6.33E-01	1.71E+01	2.16E-05
238	Np-238	2.117	d	9.58E+03	2.59E+05	3.27E-01
239	Pu-239	2.41E+04	y	2.29E-03	6.19E-02	7.86E-08
239	Np-239	2.355	d	8.57E+03	2.32E+05	2.94E-01
240	Pu-240	6.57E+03	y	8.38E-03	2.27E-01	2.89E-07
241	Am-241	4.32E+02	y	1.27E-01	3.43E+00	4.39E-06
241	Pu-241	1.44E+01	y	3.81E+00	1.03E+02	1.32E-04
242	Am-242	16.020	h	2.98E+02	8.04E+03	1.04E+00
242	Am-242m	1.52E+02	y	3.59E-01	9.71E+00	1.25E-05
242	Cm-242	163.200	d	1.22E+02	3.30E+03	4.25E-03
242	Pu-242	3.76E+05	y	1.45E-04	3.93E-03	5.05E-09
243	Am-243	7.38E+03	y	7.37E-03	1.99E-01	2.57E-07
244	Cm-244	1.81E+01	y	2.99E+00	8.08E+01	1.05E-04
245	Cm-245	8.50E+03	y	6.35E-03	1.72E-01	2.23E-07
252	Cf-252	2.64E+00	y	1.99E+01	5.37E+02	7.19E-04

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WASTE RETRIEVAL AND TRANSFER DATA PACKAGE EA FREDENBURG, WHC-SD-WM-EV-097 REVA Draft RECVD 11/8/94.

TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE & TITLE Hydrogeology

ORIGINATOR Phil Rogers DATE 11/12/95

REVISION NO. 0

OBJECTIVE Estimate potential impact of the LETF facility on groundwater

METHODOLOGY Review draft report for sufficiency

ASSUMPTIONS Data in report are adequate and accurate

(Continue on another sheet if necessary)

Phil Rogers
SIGNATURE

CALCULATION & RESULTS ATTACHED

JACOBS\FORMS\CALCVR.SHT

J. Davis comment

Received 10/12/95

GROUNDWATER MONITORING PLAN for (DISPOSAL OF TREATED EFFLUENT) from

200 AREAS EFFLUENT ~~DISPOSAL~~ TREATMENT FACILITY

(PROJECT C-018H)

10/11/95

DRAFT

NOT RELEASED

WILL BE RELEASED IN DECEMBER

for Disposal of Treated Effluent from the

Document Title: Groundwater Monitoring Plan - 200 Areas ~~ETF~~ Effluent ~~Disposal~~ Treatment Facility (Project C-018H)

Prepared by: _____ _____
J. D. Davis Date

Reviewed by: _____ _____
XXXX Date
Program

Approved by: _____ _____
D. L. Flyckt, Manager Date
PSS/LES

10/11/95

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ABSTRACT

This report provides information that supports the U.S. Department of Energy Discharge Permit No. ST-4500 from the State of Washington issued under the auspices of Washington Administrative Code 173-216. The report has two functions: (1) summarize the results of a multi-year characterization of the hydrogeology, sediment properties, and groundwater quality of the discharge site and (2) provide plans for evaluating the effects of the facility's operation on groundwater quality and document its compliance with applicable groundwater quality standards.

This report consists of the pre-operational groundwater monitoring report and the groundwater monitoring plan. The groundwater monitoring plan includes a tritium tracking plan and a plan for updating and maintaining computer-encoded numerical models for predicting groundwater flow and tritium transport. A separate submittal will be prepared to comply with the effluent sampling requirements of permit Sections S5 and S6 for the Liquid Effluent Retention Facility.

Four boreholes were drilled to define the stratigraphy, evaluate sediment characteristics, and establish a groundwater monitoring network for the discharge facility. Three of these boreholes were completed as groundwater monitoring wells and are being used to monitor groundwater quality in the uppermost aquifer upgradient and downgradient from the discharge facility. This report contains plans for continuing the monitoring of groundwater quality and water levels after treated wastewater discharges to the facility begin.

DRAFT

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ACRONYMS

AFPM	Aquifer Porous Media
CRBG	Columbia River Basalt Group
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EII	environmental investigations instructions
EPA	U.S. Environmental Protection Agency
ETF	Effluent Treatment Facility
HEIS	Hanford Environmental Information System
LERF	Liquid Effluent Retention Facility
LLWBG	Low-Level Waste Burial Ground
LLWMA	Low-Level Waste Management Area
NTU	nephelometric turbidity units
PCB	polychlorinated biphenyl
PQL	practical quantitation limit
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	U.S. Department of Energy, Richland Operations Office
SC	specific conductance
SOLTR	Solute Transport
TC	total carbon
TDS	total dissolved solids
~~TEDF~~	~~Treated Effluent Disposal Facility~~
TIC	total inorganic carbon
TOC	total organic carbon
TOX	total organic halides
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company

1.0 INTRODUCTION

This groundwater monitoring plan provides information supporting the U.S. Department of Energy's (DOE), Richland Operations Office (RL) state wastewater Discharge Permit No. ST-4500 issued by the Washington State Department of Ecology (Ecology) in accordance with RCW 90.48. With permission from Ecology, RL will operate a facility designed to discharge wastewater from the 200 Areas Effluent Treatment Facility (ETF) to the soil column north of the 200 West Area (Figure 1-1). The site for ~~the~~ treated effluent ~~disposal facility (TEDF)~~ was chosen based on a selection process described by Koegler (1990).

This report has two functions: (1) summarize results of a multi-year study to characterize the hydrogeology, sediment properties, and groundwater quality beneath the proposed ~~TEDF~~ site and (2) provide plans to evaluate the effects of ~~the~~ facility's operation on groundwater quality to confirm compliance with the groundwater quality standards of Washington Administrative Code (WAC) 173-200-080(2).

This report consists of the pre-operational groundwater monitoring report and the groundwater monitoring plan. The groundwater monitoring plan includes a tritium tracking plan and a plan for updating and maintaining computer-encoded models for predicting groundwater flow and tritium transport. A separate submittal was prepared to comply with the effluent sampling requirements of permit Sections S5 and S6 for the Liquid Effluent Retention Facility (LERF).

1.1 DESCRIPTION OF CONTENTS

Chapter 1.0 describes the purpose of the report. The information in Chapter 2.0 establishes a water-quality baseline for the facility and is the pre-operational groundwater monitoring report. Chapter 2.0 also includes summaries of the results of predictive modeling of the groundwater flow environment (Golder Associates 1990, 1991; Connelly et al. 1992; Lu et al. 1993), and summarizes information previously reported by Delaney and Harris (1991), Reidel and Thorton (1993), and Swanson (1994b). The following information is included in Chapter 2.0:

- Facility description
- Well locations, construction, and development data
- Geologic and hydrologic description of the site and affected area
- Ambient groundwater quality and current use
- Water balance information
- Hydrologic parameters
- Potentiometric map, hydraulic gradients, and flow velocities
- Results of hydraulic tests
- Groundwater and sediment sampling and chemical analysis data
- Statistical evaluation of background values for groundwater chemistry
- Projected effects of facility operation on groundwater flow and water quality.

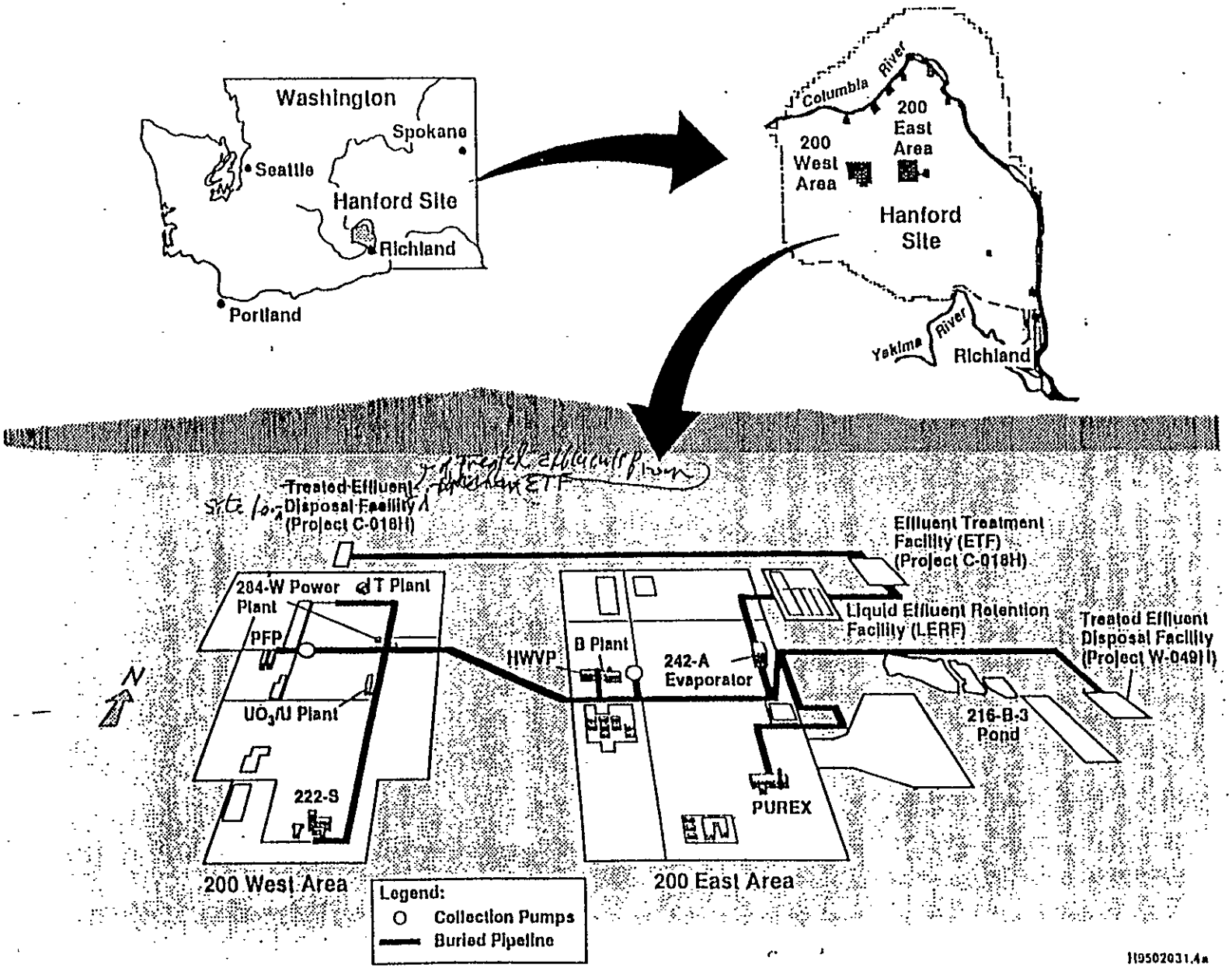


Figure 1-1. 200 Areas Effluent Treatment Facility and Related Infrastructure.

Chapter 3.0 defines, based on the information in Chapter 2.0, how environmental effects of disposal facility operation ~~on the environment~~ will be evaluated and how compliance with groundwater quality standards will be documented in accordance with the terms and conditions of the permit. Chapter 3.0 provides information needed to demonstrate that the monitoring wells were properly located and constructed, and that representative groundwater samples will be collected to document the status of facility compliance with groundwater quality laws and the operating permit conditions. Chapter 3.0 contains the following information:

- Media to be monitored
- Wells monitored for compliance in the uppermost aquifer
- Basis for monitoring well network and evidence of monitoring adequacy
- Specification of constituents to be sampled and analyzed
- Specification of groundwater sampling and analysis procedures that will be used
- Tritium tracking plan
- Plans for updating and maintaining numerical models to predict groundwater flow and tritium transport.

Chapter 4.0 provides information on how the monitoring results will be reported and the monitoring and reporting schedules. Chapter 5.0 lists all references cited in this monitoring plan. These references should be consulted for additional or more detailed information. Appendices A through D consist of water-level measurements, logs, and background soils and groundwater chemistry data from the three site characterization/monitoring wells drilled adjacent to the disposal facility. Appendix E provides well logs for the Tritium-Tracking Network.

1.2 OBJECTIVES OF FACILITY

The ~~TEDF~~ disposal facility was located, designed, and constructed to provide a means to dispose of treated wastewater from the ETF and water drawn from the ETF cooling tower (i.e., "blowdown" water) to maintain a consistent chemistry of cooling tower water. Because no viable means have yet been found to remove tritium from water, the ~~treated wastewater~~ discharge~~d to the TEDF~~ will contain tritium.

Assuming a 72% operating efficiency for the ETF (Crane 1993), tritium is projected to be present in treated effluent at an average annualized concentration of 5.6E+06 pCi/L. Expected concentration at a 90% confidence interval will be 6.3E+06 pCi/L; maximum concentration will be 2.4E+07 pCi/L (DOE-RL 1993). The maximum concentration would occur only if liquids from a relatively small number of double-shell tanks (DST) with high tritium concentrations were immediately processed through the 242-A Evaporator and the ETF without simultaneous throughput from other tanks.

these numbers will likely change

At the expected effluent volumes, concentrations, and operating efficiency, maximum annual discharge of tritium from the ETF is projected to be ~1,200 Ci/yr. At the 90% confidence interval, maximum annual discharge of tritium would be ~1,350 Ci/yr. During the expected 30-yr operating

life of the facility (Crane 1993), as much as 3,000 to 3,300 Ci of tritium may be discharged to the soil column.

The location and design of the ~~TEDF~~ disposal facility were based on a selection process and criteria originally described by Koegler (1990) and subsequently summarized by Brown (1993). The major factor in selecting ~~the location of the TEDF~~ the disposal site was to maximize the travel time of tritium (half-life 12.3 yr) to the Columbia River. A covered design was chosen to protect wildlife and minimize evaporation. Unlike past wastewater disposal facilities at the Hanford Site, the ~~TEDF~~ this disposal facility will receive no untreated effluents or sanitary system water; all wastewater routed to the facility for disposal will have been processed by the ETF as needed to comply with water quality standards.

1.3 SCOPE OF FACILITY

The ~~TEDF~~ disposal facility consists of (1) a pipeline and transfer pumps that will transport treated wastewater from effluent quality-verification tanks at the ETF and (2) a "crib" that facilitates infiltration of the treated effluent into the soil (Figure 1-1). (A crib is defined for purposes of this report as a covered drain field constructed below grade).

2.0 BACKGROUND INFORMATION

This chapter outlines the relationship of the ~~TEDF~~ disposal site to related facilities, describes the ~~TEDF~~ disposal site, and summarizes hydrogeologic information from Swanson (1994b) and Reidel and Thorton (1993). Chapter 2.0 also provides a brief synopsis of the predicted effects of ~~TEDF operation~~ the discharge on groundwater flow in the vadose zone and the uppermost aquifer (Golder Associates 1990, 1991; Lu et al. 1993), and water quality in the uppermost aquifer. The information in Chapter 2.0 corresponds to that required by permit Section S7.A. This information is used to assess current groundwater quality and is the basis for the groundwater monitoring plan in Chapter 3.0.

2.1 RELATIONSHIP OF FACILITIES

All wastewater discharged to the ~~TEDF~~ disposal facility will be from the ETF. Effluent to be treated by the ETF will consist of vapor condensate from DST liquids piped to the 242-A Evaporator (Figure 1-1) for volume reduction. If other aqueous wastes from the 200 Areas require treatment by the ETF to comply with discharge limits assigned by Ecology, future permission may be sought for discharge of those treated wastewaters ~~to the TEDF~~.

As part of current 242-A Evaporator operations, the vapor condensate is filtered to remove particulates and is then passed through an ion-exchange column to remove radionuclides before being transferred to the LERF for temporary storage in covered impoundments (Figure 1-1). The process concentrate from the 242-A Evaporator is in the form of a slurry. The slurry is designated an extremely hazardous mixed waste and is returned to the DSTs for storage pending further treatment.

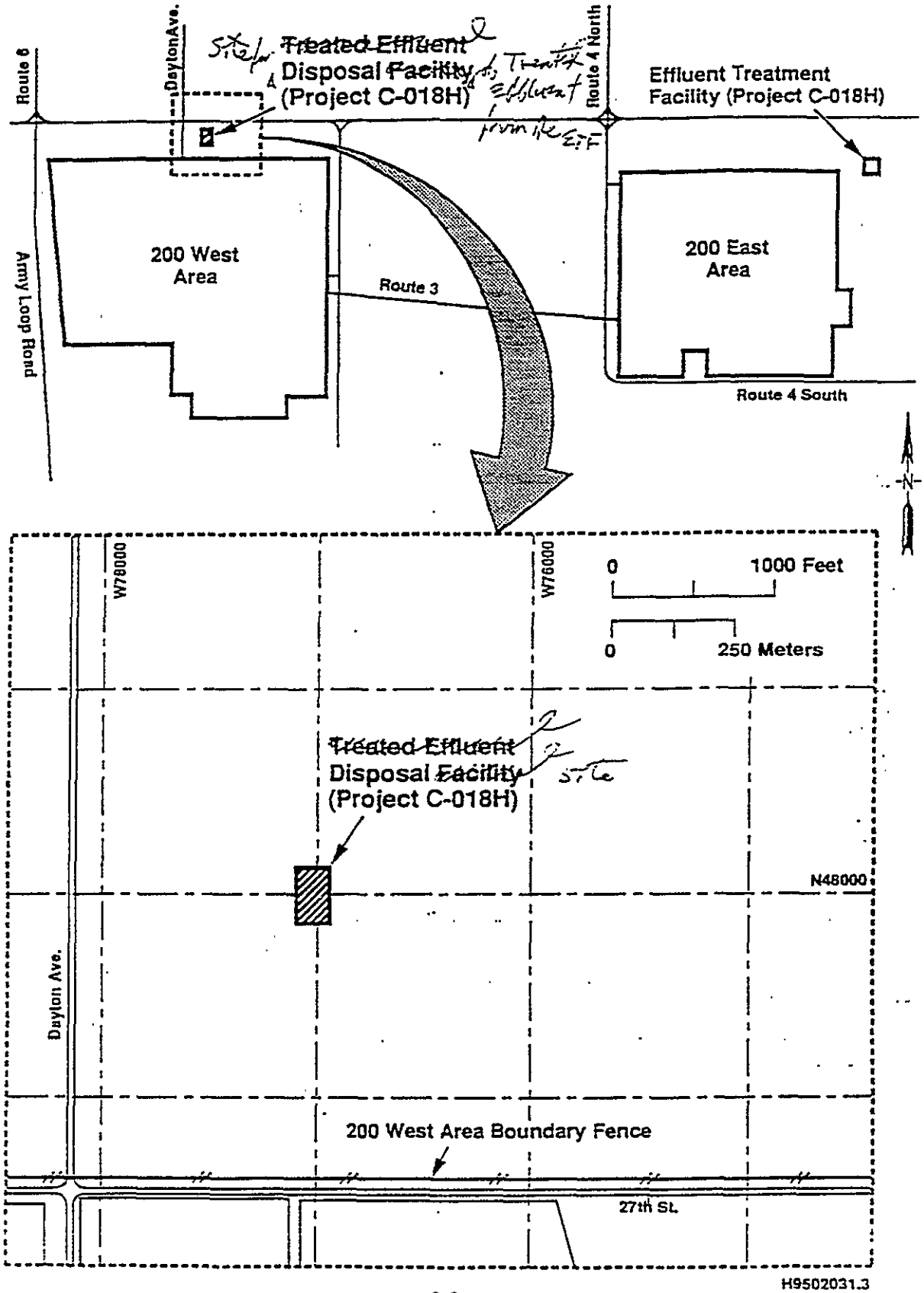
The ETF receives vapor condensates containing radionuclides and organic and inorganic constituents either directly from the 242-A Evaporator or from LERF storage. Because the ETF design incorporates a large ion-exchange unit, the ion-exchange column of the 242-A Evaporator is bypassed when the process condensates are being pumped directly to the ETF, to allow more rapid processing of the DST feed streams.

Wastewater discharged from the ETF to the ~~TEDF~~ disposal facility has been subjected to the best available treatment, considering all known, available, and reasonable methods of prevention, control, and treatment. ETF operations employ, as appropriate for the specific waste streams, coarse filtration, ultraviolet/hydrogen peroxide oxidation, pH adjustment, hydrogen peroxide decomposition, fine filtration, degasification, reverse osmosis, ion exchange, additional pH adjustment, analytical verification, and cooling of the treated wastewater (DOE-RL 1993).

2.2 FACILITY DESCRIPTION

The ~~TEDF~~ disposal facility is designed to infiltrate wastewater treated by the ETF into the soil column. The ~~TEDF~~ disposal facility is located ~183 m (600 ft) north of the 200 West Area boundary, and is ~3.7 km (5.9 mi) west of the ETF (Figure 2-1). A 6-in. pipeline and transfer pumps transport the treated effluent and cooling tower blowdown from the ETF to the ~~TEDF~~ disposal facility.

Figure 2-1. Location of Disposal Facility.



At the design capacity of the ETF (Crane 1993), 568 L/min (150 gal/min) of treated water and 83 L/min (22 gal/min) of cooling tower blowdown may be discharged to the soil column at the ~~TEDF~~. The design capacity of the ~~TEDF~~ was based on these projected discharge rates and an estimated infiltration capacity of 400 L/d/m² (10 gal/d/ft²) (Westinghouse Hanford Company [WHC]) (WHC 1990). Based on these design parameters, 2,000 m² (22,000 ft²) of infiltration surface was deemed to be needed.

As shown in Figure 2-2, the ~~TEDF~~ is approximately 35 m (116 ft) wide by 61 m (200 ft) long. Treated effluent is delivered to the crib via a 20-cm- (8-in.-) diameter distribution header. The treated effluent is evenly spread over the surface of the crib via 66 perforated distribution laterals made of 10-cm (4-in) diameter pipes buried 15 cm (6 in) below grade and spaced 1.8 m (6 ft) apart.

The distribution laterals drain into a 1.8-m- (6-ft-) deep bed of washed cobbles that, in turn, drain into the soil column. The distribution header, laterals, and drain rock are covered by an impermeable membrane protected on its top and bottom sides by geotextile fabric (Figure 2-3). The rock-filled drainage basin was constructed entirely below grade. The ground surface was mounded slightly to promote surface runoff.

2.3 RESULTS FROM SUBSURFACE BASELINE CHARACTERIZATION

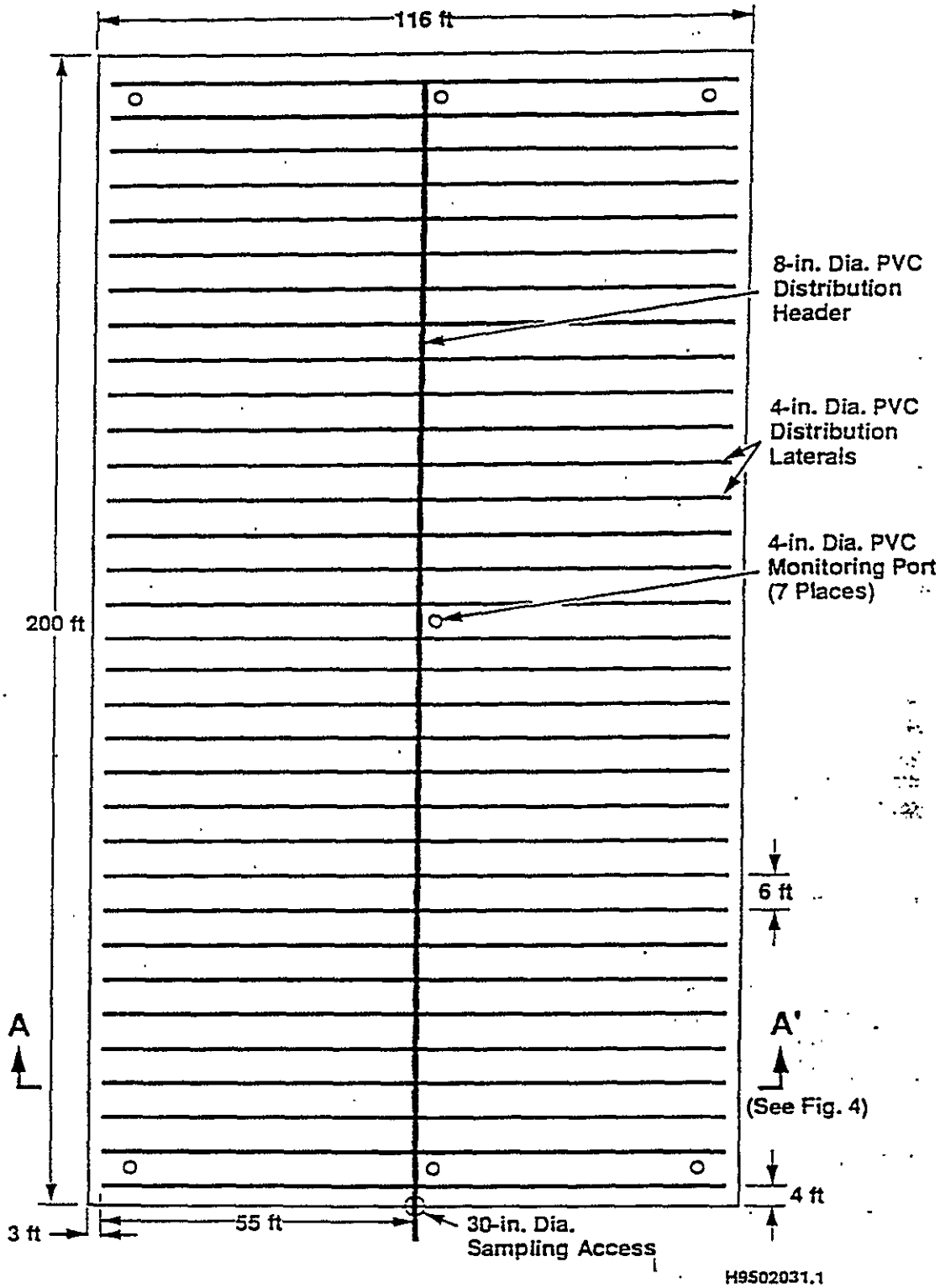
Section 2.3 summarizes current knowledge of the geology, soil chemistry, hydrology, and current groundwater quality at the ~~TEDF~~ site (Swanson 1994b; Reidel and Thorton 1993). Section 2.3 also summarizes hydrogeologic modeling of the 200 West Area and vicinity (Connelly et al. 1992), an analysis of treated effluent movement through the vadose zone beneath the ~~TEDF~~ (Lu et al. 1993), and prediction of tritium migration in the uppermost aquifer that will result from discharges to the facility (Golder Associates 1991).

Information is provided on the location, use, and construction of all known wells within 1.6 km (1 mi) of the ~~TEDF~~. Details of the drilling, construction, development, and aquifer testing for the three wells adjacent to the facility that will be used for permit-compliance monitoring are provided by Sweeney (1993). Finally, this section summarizes ~~the~~ results of chemical analyses of ~~subsurface~~ sediments from the three wells that were reported in detail ~~in~~ WHC (1993).

2.3.1 Groundwater Monitoring/Site Characterization Wells

To determine ~~TEDF site~~ stratigraphy, evaluate sediment characteristics, and establish a groundwater monitoring network, four new boreholes were drilled (Figure 2-4). Borehole 699-48-77B was drilled to a depth of 18 m (~60 ft) and abandoned because of its substantial deviation from plumb. The three remaining boreholes are being used as groundwater monitoring wells for the ~~discharge~~ facility. Information on the locations of the three wells is provided in Table 2-1. Details of well construction and development are provided by Sweeney (1993). Wells 699-48-77A, 699-48-77C, and 699-48-77D were constructed and completed in compliance with requirements of the *Resource Conservation and Recovery Act of 1976* (RCRA) to monitor the upper part of the uppermost aquifer. The basis for the well locations and construction specifications is discussed in Chapter 3.0.

Figure 2-2. Plan View of Disposal Facility Design.
(simplified from as-built engineering drawing No. H-2088755)



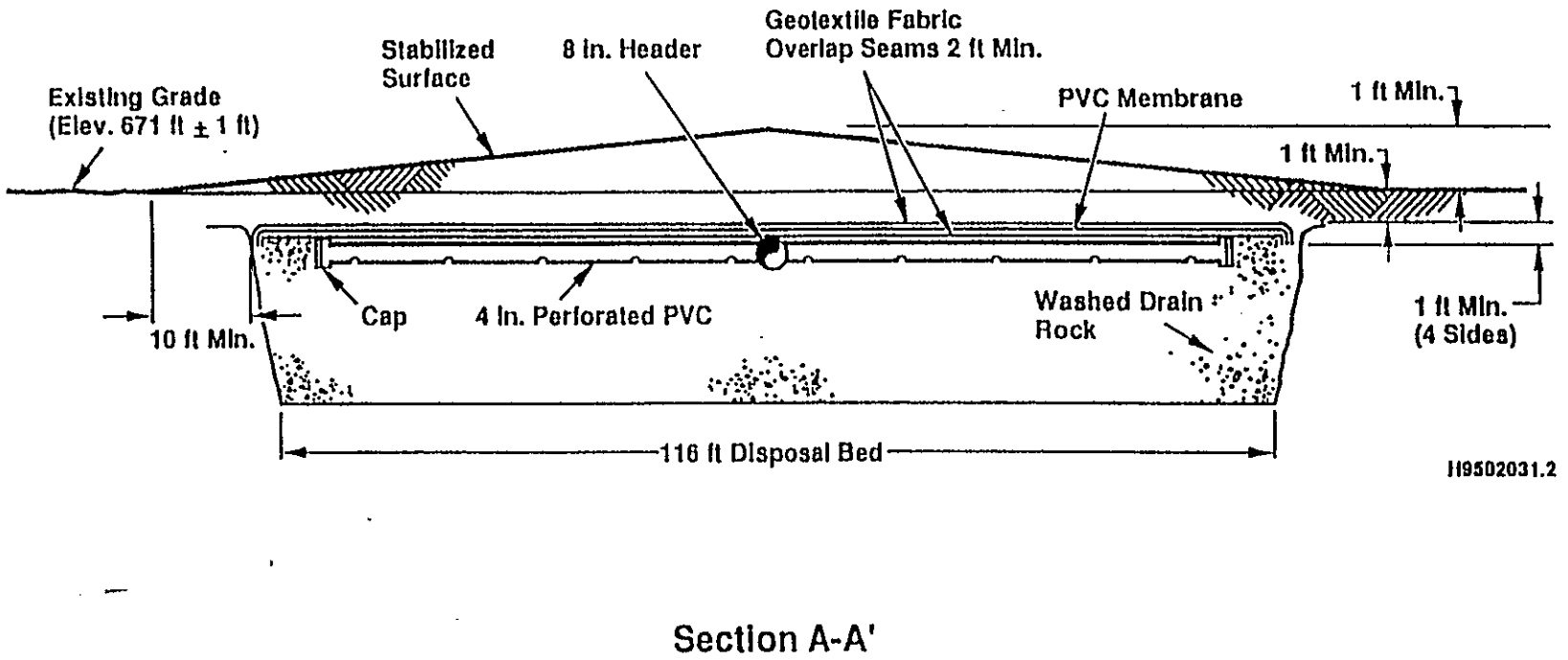


Figure 2-3. Elevation View of Disposal Facility Design.
(simplified from as-built engineering drawing No. H-2-88755.)

Figure 2-4. Site Characterization/Monitoring Wells for the Disposal Facility.

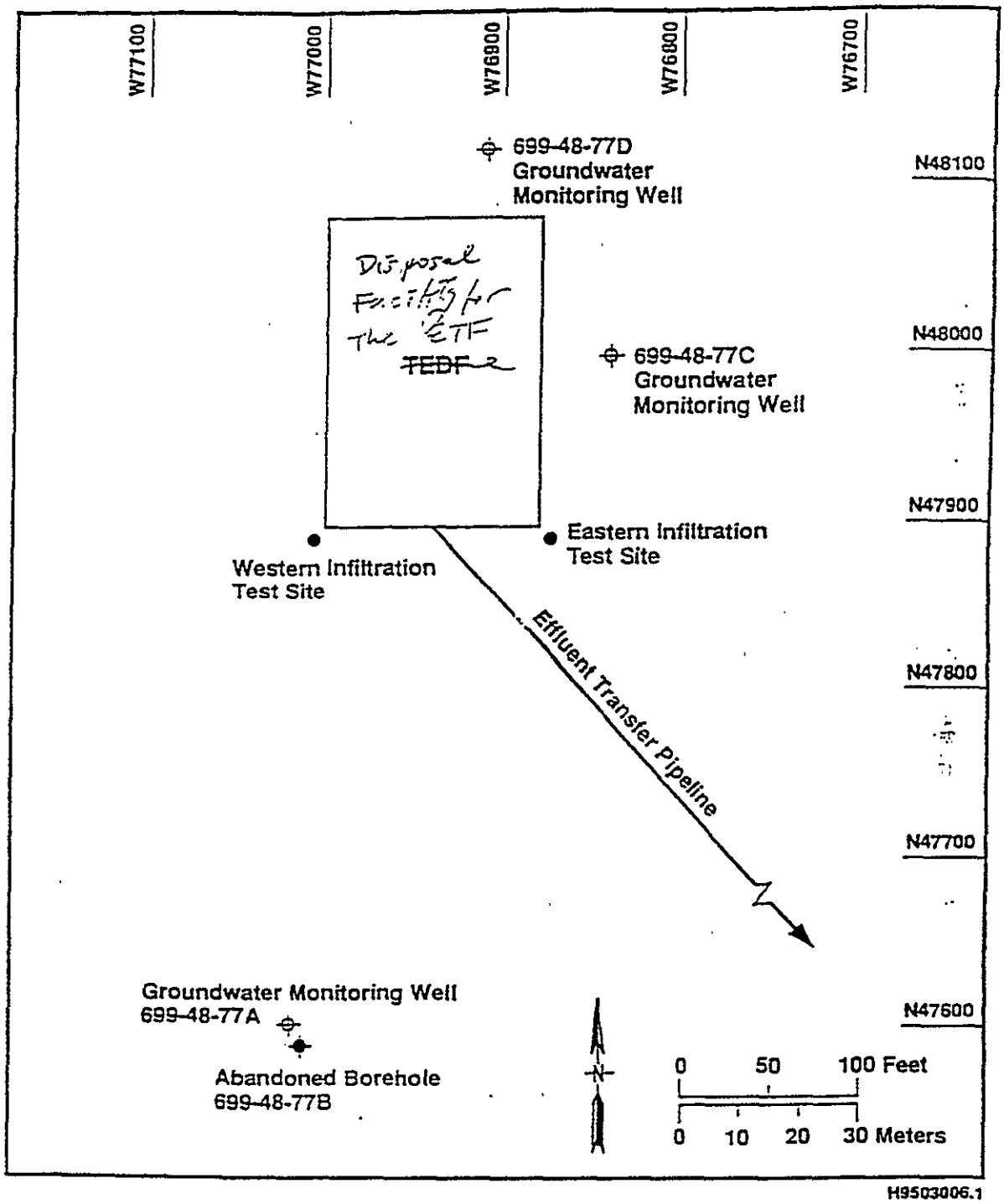


Table 2-1. Location Data for Site Characterization/Groundwater Monitoring Wells.

Borehole	Coordinates		Elevations		
	200 W (ft)	Lambert NAD '83(m)	Top of brass cap	Hydrostar[a] plate	Top of outer casing[b]
699-48-77A	N:47602.7 W:77020.0	N:137969.02 E:566413.57	672.25	674.74	674.72
699-48-77B	N:47590.0 W:77013.3	N:137965.15 E:566415.60	671.73	N/A	N/A
699-48-77C	N:47989.32 W:76836.16	N:138086.801 E:566468.954	671.91	N/A	674.28
699-48-77D	N:48096.14 W:76952.88	N:138119.268 E:566433.302	671.37	N/A	673.87

[a]Trademark of Instrumentation Northwest, Inc., Redmond, Washington.
[b]Measured on north side.
NAD = North American Datum.

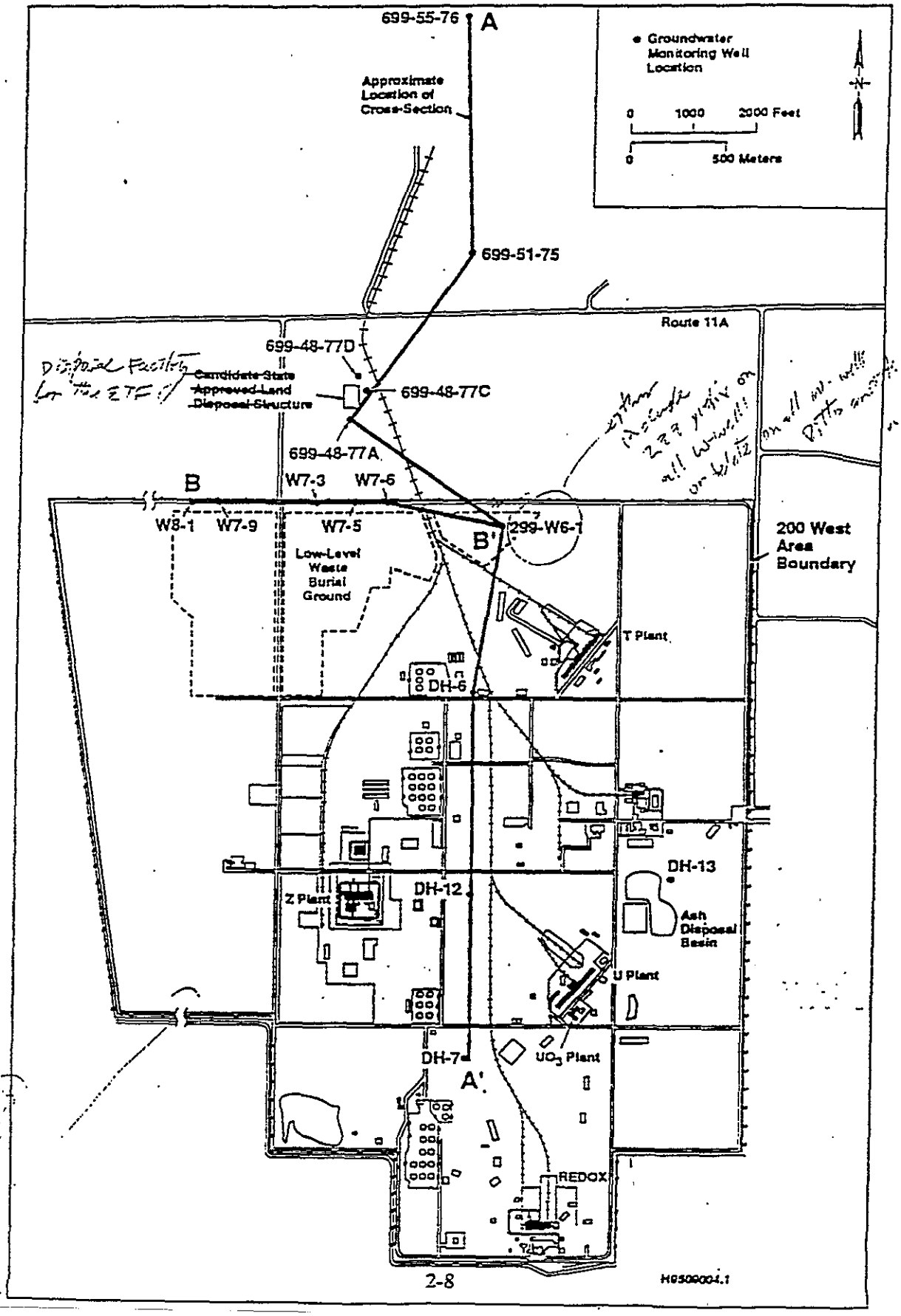
Lithologic and hydrologic data from other nearby wells were used to complement the information acquired from the three new groundwater monitoring wells at the ~~TEDF~~. These wells include 20 wells upgradient from the ~~TEDF~~ at the Low-Level Waste Burial Grounds in the 200 West Area (Figure 2-5). Wells south of the facility are sampled quarterly as part of the RCRA groundwater monitoring program for the Hanford Site and are <600 m (<2,000 ft) south of the ~~TEDF~~. Information from these wells was used to help interpret the stratigraphy, geologic structure, and groundwater hydrology in the vicinity of the TEDF site.

2.3.2 Geology

This section describes the geologic and stratigraphic setting of the disposal facility, with emphasis on the sediments overlying basalt.

The geology of the Hanford Site and the Pasco Basin has been characterized by Myers et al. (1979), DOE (1988), Delaney et al. (1991), and Reidel et al. (1992). Lindsey et al. (1992) discussed the origin of the sediments overlying basalt bedrock and provided a detailed description of their stratigraphic relationships. More recently, Lindsey's stratigraphic nomenclature was modified by Thorne et al. (1994), based on the hydraulic characteristics of the sediments. The geology of the disposal facility and vicinity ~~is~~ described by Lindsey and Reidel (1992), Reidel and Thornton (1993), and Reidel (1993). Subsequent drilling of two additional characterization/groundwater-monitoring wells at the facility allowed refinement by Swanson (1994b) of earlier hydrogeologic interpretations. The following sections summarize pertinent information from these reports.

Figure 2-5. Locations of Geologic Cross Sections, Other Boreholes, and Monitoring Wells Near the Disposal Facility.



2.3.2.1 **Hanford Site Geology.** The Hanford Site lies within the Columbia Plateau. The Columbia Plateau consists of a thick sequence of Miocene-age tholeiitic basalt flows called the Columbia River Basalt Group (CRBG). These flows have been folded and faulted during the past 17 million years, creating broad structural and topographic basins separated by asymmetric anticlinal ridges. Sediments up to 518 m (1,700 ft) thick have accumulated over the CRBG in some of these basins. These sediments are of late Miocene, Pliocene, and Pleistocene age. The Hanford Site is located within one of the larger basins, the Pasco Basin. The Pasco Basin is bounded on the north by the Saddle Mountains and on the south by Rattlesnake Mountain and the Rattlesnake Hills.

Principal stratigraphic units underlying the Hanford Site include, in ascending order, the CRBG (Miocene), Ringold Formation (Miocene-Pliocene), Plio-Pleistocene unit and early "Palouse" soil, and the Hanford formation (Pleistocene). A regionally-discontinuous veneer of recent alluvium, colluvium, and/or eolian sediments overlies the principal geologic units. Figure 2-6 shows the general stratigraphy of the Hanford Site. Figure 2-7 depicts stratigraphic relationships and provides the nomenclature ~~of the~~ for sediments overlying basalt.

Sediments overlying the basalt at the disposal facility are the late Miocene-to-Pliocene Ringold Formation, relatively thin and discontinuous sediments of Pliocene-Pleistocene age (which occur in the western part of the Hanford Site), the Pleistocene-age Hanford formation, and surficial alluvium and dune sand of Holocene age.

Sediments of the Ringold Formation are fluvio-lacustrine in origin and have been grouped into units based on facies (Figure 2-7). The Ringold Formation is absent from portions of the northeastern part of the Hanford Site, but is up to 185 m (~600 ft) thick in the west-central part (Reidel et al. 1992). The dominant facies of the Ringold Formation are fluvial sand and gravel, fine-grained sand, and silt and clay of stream overbank and lacustrine origin. Variable amounts of $CaCO_3$ cementation occur in the Ringold Formation.

The Hanford formation consists of cataclysmic flood deposits of sand, gravel, and interbedded silt which, in aggregate, are up to 110 m (~350 ft) thick. Hanford formation sediments typically are less consolidated than Ringold Formation sediments and open-framework gravels are common (Reidel et al. 1992). The Hanford formation is informally subdivided into three principal facies: gravel-dominated (pebble to boulder clast sizes), sand-dominated, and silty.

2.3.2.2 **Geology of the Disposal Facility Site.** Interpretation of the geology ~~at~~ of the disposal site is based on data gathered from the four ~~three~~ site-characterization/monitoring boreholes ~~wells~~, nearby wells drilled for the RCRA and Operations groundwater monitoring networks, and older wells used for sitewide monitoring. These data were evaluated in conjunction with published stratigraphic correlations (e.g., Lindsey and Reidel 1992) to refine ~~current knowledge of the geology of the unconfined aquifer system in the vicinity of the facility~~ the hydrogeology of the disposal facility site.

Cross sections A-A' and B-B' (Figures 2-8 and 2-9) show stratigraphic relationships across the 200 West Area and vicinity in north-south and east-west directions, respectively. The locations of these cross sections ~~are~~ were shown in Figure 2-5.

The stratigraphy in the immediate vicinity of the facility is illustrated by the lithologic log from well 699-48-77A (Appendix A) and the cross section C-C' of Figure 2-10. The locations of wells used to construct the cross sections ~~are~~ were shown in Figure 2-4.

Figure 2-6. Generalized Stratigraphy of the Hanford Site.

Period	Epoch	Group	Formation	Isotopic Age Dates Years x 10^6	Member (Formal and Informal)	Sediment Stratigraphy or Basalt Flows	
QUATERNARY	Holocene				Surficial Units	Loess, Sand Dunes, Alluvium and Alluvial Fans, Land Slides, Talus, Colluvium	
	Pleisto-cene		Han-ford		Touchet beds / Pasco gravels		
						Plio-Pleistocene unit	
TERTIARY	Plio-cene						
	Miocene		Ringold Formation				
		Columbia River Basalt Group	Saddle Mountains Basalt	8.5	Ice Harbor Member	basalt of Goose Island	Ellensburg Formation
						basalt of Martindale	
						basalt of Basin City	
						Levey interbed	
				10.5	Elephant Mountain Member	basalt of Ward Gap	
						basalt of Elephant Mountain	
						Rattlesnake Ridge interbed	
				12.0	Pomona Member	basalt of Pomona	
						Selah interbed	
					Esquatzel Member	basalt of Gable Mountain	
						Cold Creek interbed	
				13.5	Ascotin Member	basalt of Huntzinger	
					Wilbur Creek Member	basalt of Lapwai	
						basalt of Wahluke	
					Umatilla Member	basalt of Sillusi	
						basalt of Umatilla	
				14.5		Mabton interbed	
			Wanapum Basalt		Priest Rapids Member	basalt of Lolo	
						basalt of Rosalia	
						Quincy interbed	
					Roza Member	basalt of Roza	
						Squaw Creek interbed	
					Frenchman Springs Member	basalt of Lyons Ferry	
						basalt of Sentinel Gap	
						basalt of Sand Hollow	
						basalt of Silver Falls	
						basalt of Ginkgo	
						basalt of Palouse Falls	
				15.6		Vantage interbed	
			Grande Ronde Basalt*		N_2 Sentinel Bluffs Unit	basalt of Museum	
						basalt of Rocky Coulee	
						basalt of Levering	
						basalt of Conassett	
						basalt of Birkett	
						basalt of McCoy Canyon	
				16.5	Umtanum Unit	basalt of Umtanum	
					Slack Canyon Unit		
					Ortley Unit	basalt of Benson Ranch	
					R_2 Grouse Creek Unit		
					Wapshilla Ridge Unit		
					Mt. Horrible Unit		
					N_1 China Creek Unit		
					R_1 Teepee Butte Unit		
					Buckhorn Springs Unit		
			Imnaha	17.5	Rock Creek Unit		
					American Bar Unit		

*The Grande Ronde Basalt consists of at least 120 major basalt flows. Only a few flows have been named. N_2, R_2, N_1 and R_1 are magnetostratigraphic units.

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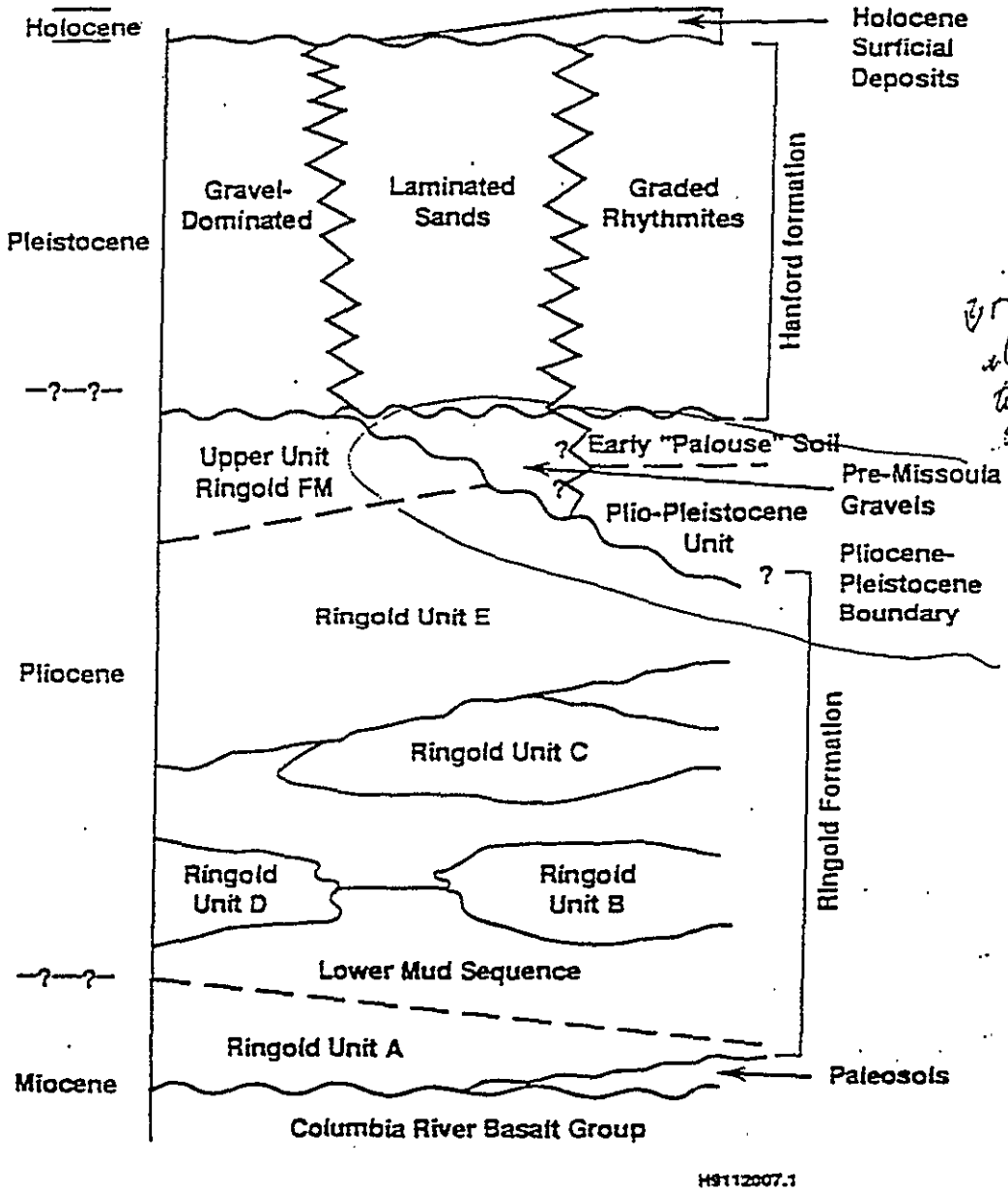
Figure 2-7. Stratigraphic Relationships of Sediments Above Basalt at the Hanford Site. (After Lindsey et al. 1992)



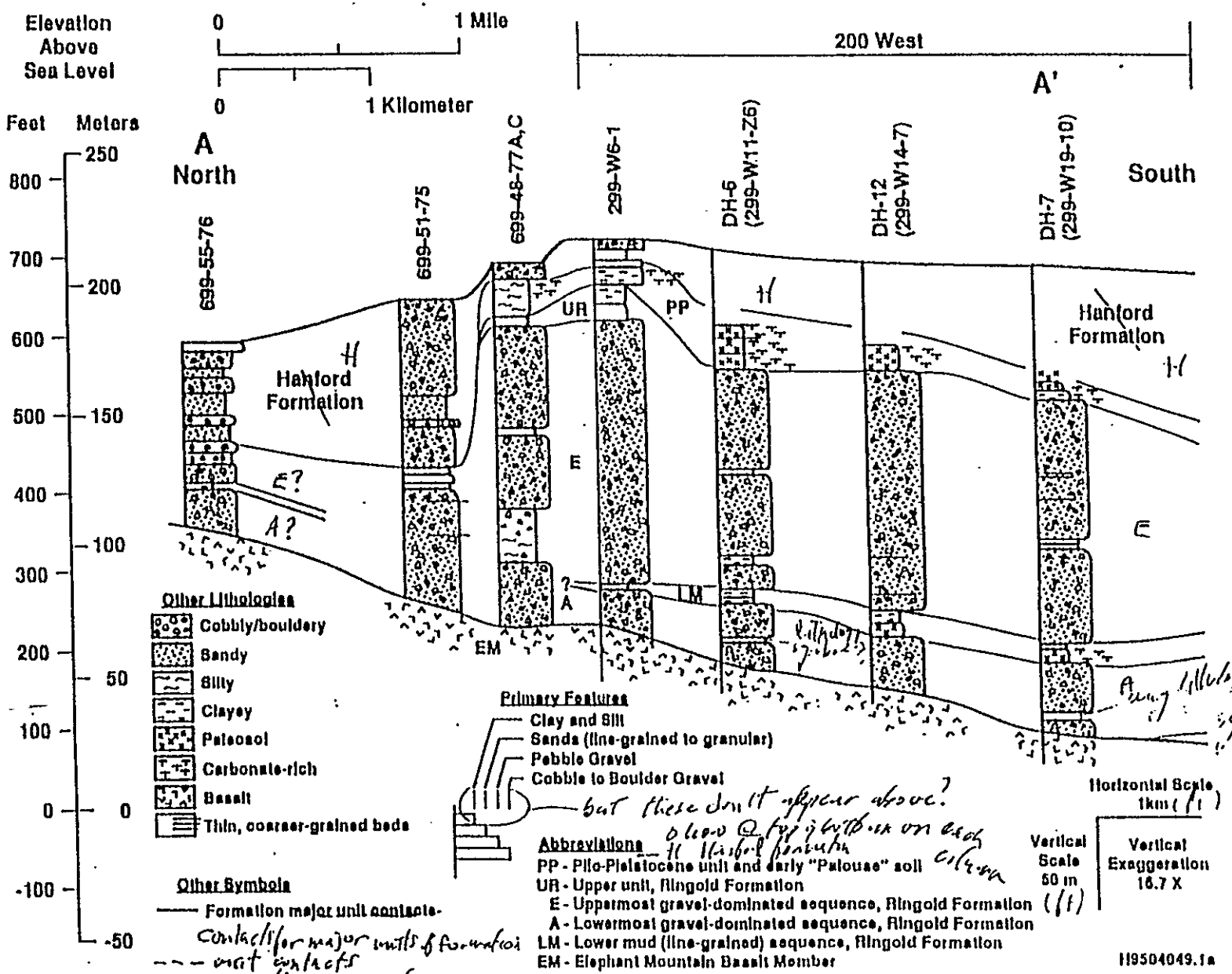


Figure 2-8. Cross Section A-A'. (modified from Lindsey and Reidel 1992)

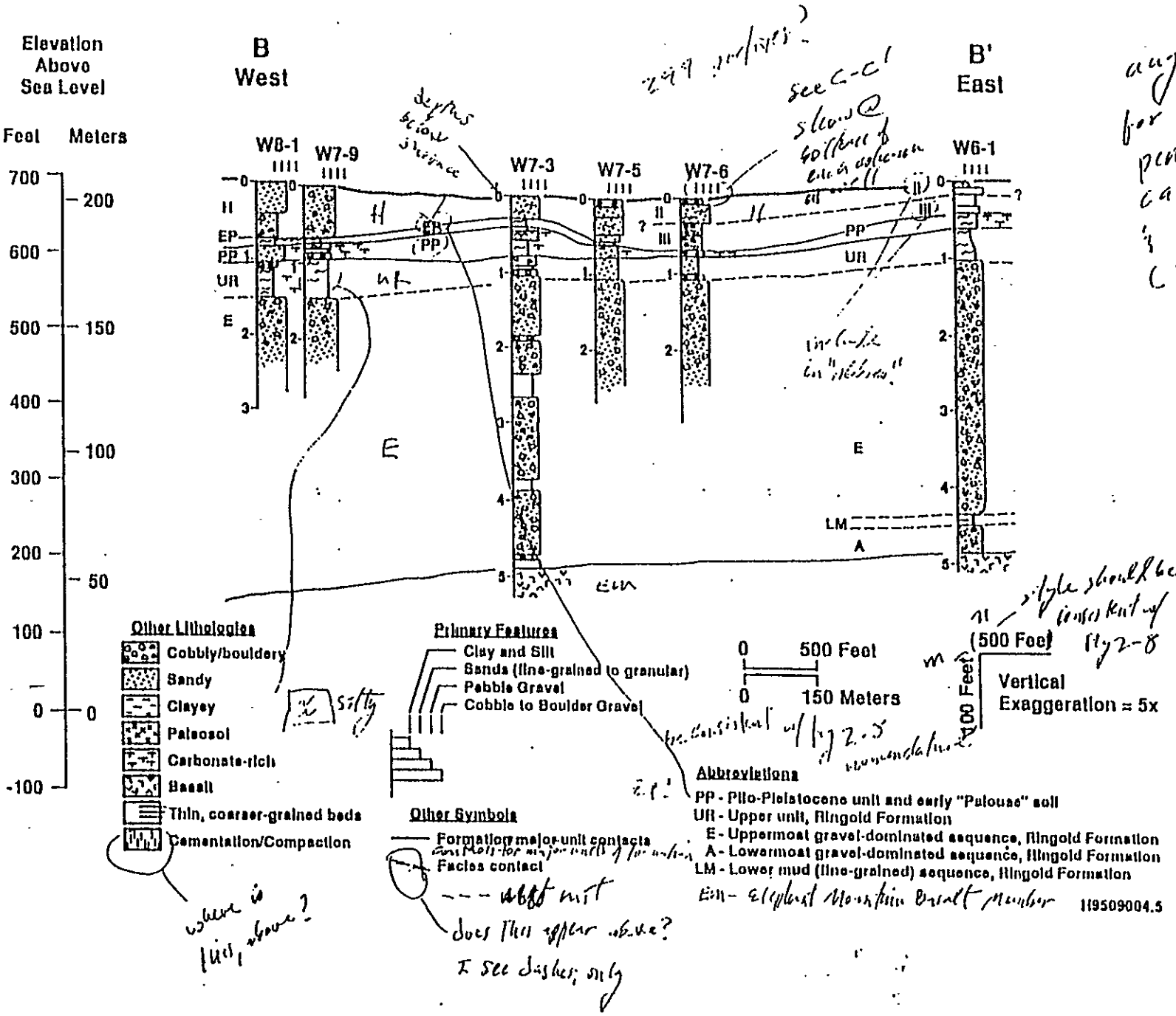


Figure 2-9. Cross Section B-B'. (modified from Lindsey and Reidel 1992)

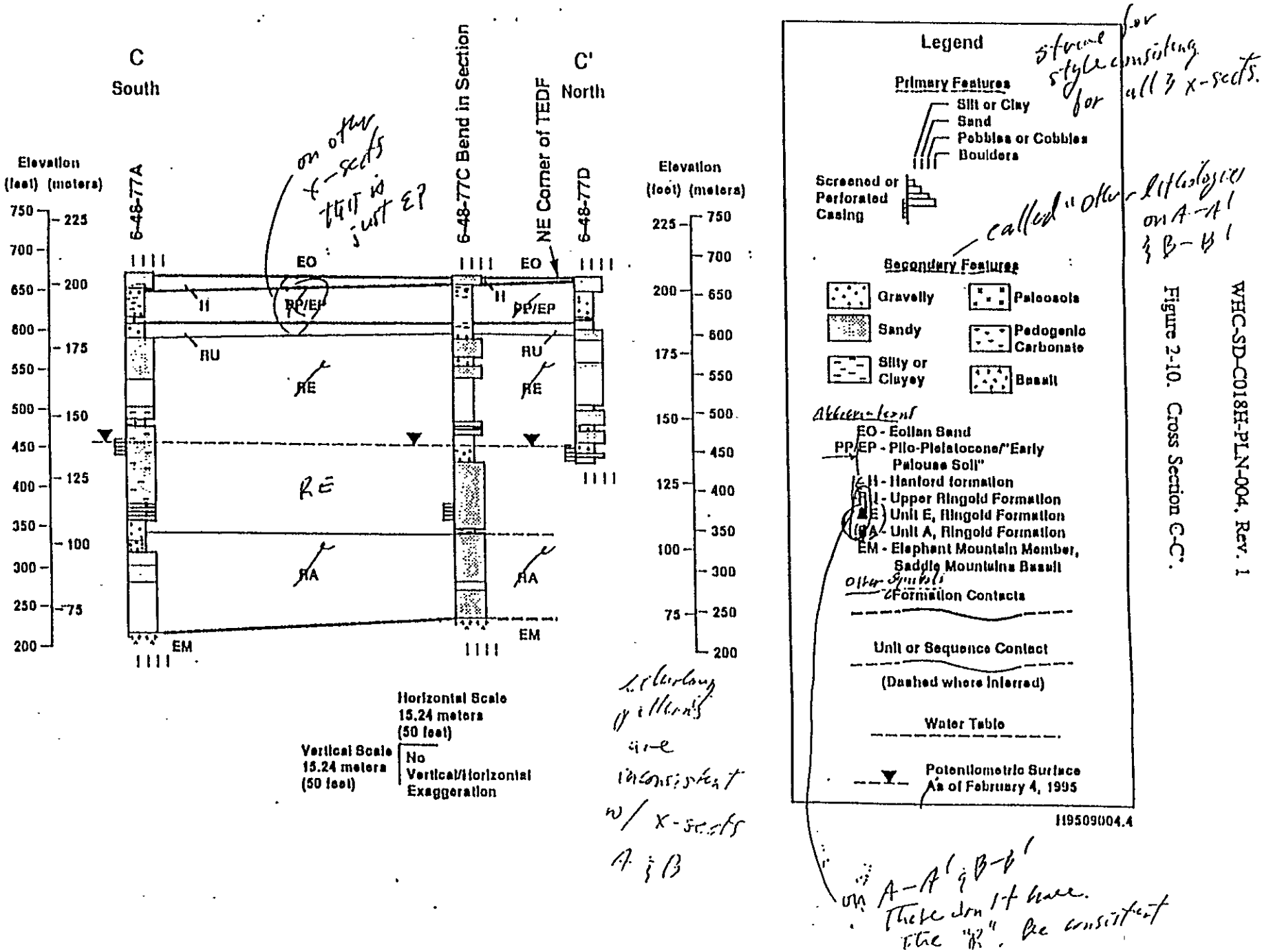


Figure 2-10. Cross Section C-C'.

The surface of the uppermost flow of the CRBG beneath the facility, the Elephant Mountain Member of the Saddle Mountains Formation, is present at approximately 132 m (433 ft) below ground surface, and is at a depth of approximately 139 m (455 ft) in well 699-48-77A. Hence, the surface of the basalt beneath the facility slopes to the south at approximately 3°.

The Ringold Formation sediments beneath the facility are those of unit A and unit E gravels, and the sands/gravelly sands of the "upper Ringold" unit. The overall thickness of the Ringold Formation at the facility is approximately 119 m (390 ft). Of this thickness, unit A comprises approximately 40 m (130 ft); unit E approximately 74 m (242 ft); and the upper Ringold approximately 5 m (17 ft). The location of the contact between units A and E is inferred by projection from a well (299-W6-1) south of the facility (see Figure 2-3). The Ringold lower mud sequence usually provides a reference horizon for separating units A and E, but is absent in the vicinity of the disposal facility. Moreover, Ringold sediments identified as lower unit E may include sediments designated elsewhere as unit C. Because of the similarities between units E and C and the type of drilling employed, the two units were not differentiated at the facility site.

The Plio-Pleistocene and early Palouse soil collectively are approximately 16 m (51 ft) thick beneath the facility, and are encountered at ~~depths~~ below the surface ~~of~~ 2 m (6 ft) in well 699-48-77D and ~~to~~ 7 m (22.5 ft) below the surface immediately south of the disposal facility in well 699-48-77A. The Plio-Pleistocene unit is noteworthy for its thin horizons of pedogenic ~~carbonate~~ and cementitious carbonate separated by carbonate-poor silt and sand. Lindsey and Reidel (1992) describe the Plio-Pleistocene and early Palouse soil as occurring discontinuously throughout much of the 200 West Area, but the degree of lateral continuity of carbonate-cemented horizons in the immediate vicinity of the facility is problematic. All three site characterization/monitoring wells intercepted carbonate-cemented horizons in the Plio-Pleistocene/early Palouse soil.

The Hanford formation is from 1.4 m (4.5 ft) to 6.4 m (21 ft) thick in the vicinity of the disposal facility ~~TEDF~~, but was largely removed from beneath the facility during drain field construction. This thin occurrence of Hanford formation is dominated by sandy, silty gravel. Minor amounts of cementation by unidentified minerals occur near the bottom of the unit. The Hanford formation is covered by 0.5 m (1.5 ft) of eolian sand.

Most relatively small-scale structures in the basalt bedrock and Ringold Formation trend roughly east-west, in accordance with the major structural features, such as the Gable Butte/Gable Mountain anticline, the Cold Creek syncline, and the Yakima Ridge anticline. In the vicinity of the facility, both the basalt and overlying Ringold sediments dip gently to the south.

2.3.3 Groundwater Hydrology

This section summarizes current knowledge ~~the results of investigations into~~ of the factors controlling groundwater occurrence and movement within the uppermost aquifer beneath the disposal facility ~~ETF~~. The summary includes information from earlier hydrologic investigations at the facility (Ballantyne 1993; Reidel 1993; Swanson 1994a). The hydrogeologic setting of the 200 West Area (immediately south of the facility) is described by Connelly et al. (1992) and Ford and Trent (1994).

Groundwater levels are currently measured quarterly in all three wells at the facility. Quarterly measurements have been made since May 1994 in wells 699-48-77C and 699-48-77D, and since June 1992 in well 699-48-77A. Water levels are measured annually in wells north, northwest, and northeast of the facility as part of the side-wide groundwater surveillance program. Water levels in wells monitored for RCRA and Operational programs in the 200 West Area (immediately south of the facility) are measured at monthly to annual frequencies. Figures 2-5 and 3-4 show wells in the vicinity of the facility that currently monitor groundwater for these programs or that are available for use in ~~addition to~~ monitoring ~~networks~~.

2.3.3.1 **Precipitation and Groundwater Recharge.** Average annual precipitation at the Hanford Site from 1961 to 1990 was 159 mm (6.26 in.) (Hoitink and Burk 1994). Of this total, only 5 to 10 mm (0.2 to 0.04 in.) are estimated to contribute to groundwater recharge in the vicinity of the disposal facility ~~EFF~~ (Fayer and Walters 1995).

2.3.3.2 **Uppermost Aquifer.** Data gathered from drilling and testing of the three site characterization and monitoring wells show that groundwater moves primarily within Ringold units A and E. The water table currently is at a depth of ~66 m (~217 ft) below ground surface at the disposal facility. This depth coincides with a level approximately halfway through the Ringold unit E. No identifiable confining layers occur at this location.

Hydrographs of the three wells (Figure 2-11) indicate that groundwater levels beneath the facility have fallen gradually since monitoring began (June 1992). Between June 1992 and April 1995 the water level in well 699-48-77A fell 0.56 m (1.84 ft). The most recently available water-level data for the vicinity of the disposal facility are illustrated in the potentiometric surface map. Groundwater flow directions at the facility are generally north to northeast (see Section 2.3.3.4). Appendix A lists water levels measured in the three wells since their monitoring began.

2.3.3.3 **Results of Aquifer Testing.** Results of aquifer testing in the three site-characterization/monitoring wells are described in detail by Swanson (1994a). A summary of that work is presented here.

Well 699-48-77C was used as the pumping well in all tests. Three constant-rate pumping tests (with recovery data) and three slug tests were conducted in three depth intervals of the well. These intervals were; 74.53 to 78.81 m (244.37 to 258.40 ft), 91.41 to 96.18 m (299.70 to 315.36 ft), and 117.24 to 122.01 m (384.40 to 400.02 ft). Wells 699-48-77A, 699-48-77D, and two wells in the 200 West Area were used as observation wells, but only well 699-48-77D and the stressed well, 699-48-77C, measurably responded to the tests. The tests were conducted from March 4 to March 31, 1994. Baseline conditions and barometric efficiencies were determined in all three wells prior to testing. Barometric efficiencies are: 699-48-77A - 60%; 699-48-77C - 59%; and 699-48-77D - 55%. Table 2-2 lists significant results of the aquifer tests for each tested interval.

Estimated Hydraulic conductivity ~~estimates~~ derived from the testing range from 3 m/d (10 ft/d) in the upper part of the aquifer (test interval 1) to 37 m/d (120 ft/d) at intermediate depth in the aquifer (test interval 2).

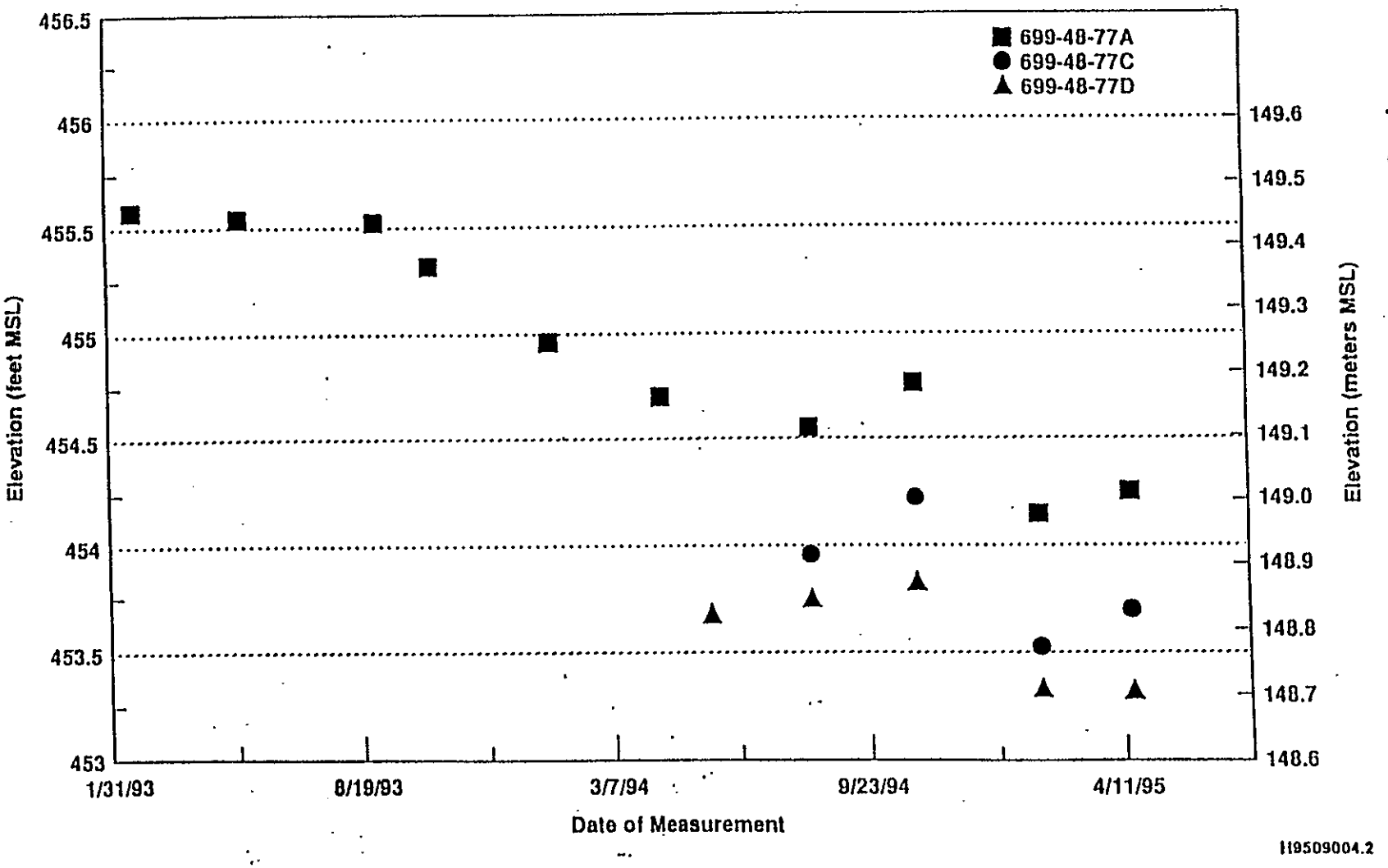


Figure 2-11. Hydrographs of the Three Site Characterization/Groundwater Monitoring Wells.

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Table 2-2. Aquifer Test Results.

Test interval[a]	Test type	Discharge rate (gal/min)	K (ft/d)	T[b] (ft²/d)
75.53 to 78.81 m (244.37 to 258.40 ft)	Slug[c]	—	11	35
	Constant-rate pumping	21	10	530
91.41 to 96.18 m (299.70 to 315.36 ft)	Slug[c]	—	115	—
	Constant-rate pumping	203	120	6,500
117.24 to 122.01 m (384.40 to 400.02 ft)	Slug[c]	—	58	—
	Constant-rate pumping	157.8	32	drawdown = 1,290 recovery = 4,350

[a]Depth below land surface; all tests were performed in well 699-48-77C.
[b]Assumes aquifer thickness of ~16 m (~53 ft) for test intervals 1 and 2, and ~4.6 m (~15 ft) for interval 3.
[c]Slug rod volume = 2.404 ft³.

A storativity of 0.0016 was derived from observation well 699-46-77D during the recovery phase for test interval 1. This value is for the upper, less permeable, part of the aquifer. However, Swanson (1994a) notes that some of the data plot irregularly for this particular test and, therefore, may be spurious. A storativity of 0.0005 was assumed to develop type curves for analysis of data from test interval 2. This value is thought to be a reasonable estimate of the storage coefficient for a confined aquifer in the Ringold formation. The values for both the derived storativity and the barometric efficiencies indicate confined conditions in the uppermost aquifer beneath the facility.

2.3.3.4 Groundwater Flow Direction and Rate. Groundwater flow direction and rate beneath the facility can be calculated using hydraulic conductivities derived from constant-rate aquifer tests, estimated effective porosities, and hydraulic gradient calculated from water-level measurements. Average linear groundwater velocity is estimated in this manner by the relationship:

$$\bar{v} = \frac{KI}{n_e}$$

where $\bar{v}$ is average linear groundwater velocity, K is hydraulic conductivity, I is hydraulic gradient, and n_e is effective porosity. Effective porosity is estimated based on values thought to be typical of the Ringold Formation and is typically assigned a value of 0.1 to 0.2.

As discussed in Section 2.3.3.3, calculated hydraulic conductivities range from 3 m/d (10 ft/d) in the upper part of the aquifer (test interval 1) to 37 m/d (120 ft/d) at intermediate depth in the aquifer (test interval 2). The calculated hydraulic gradient is 0.003, and the direction of slope of the water table is 35° west of north, using April 1995 water-level measurements from the three facility monitoring wells. Based on these parameter values, the average linear velocity of groundwater beneath the facility ranges from 0.05 to 1.1 m/d (0.15 to 3.6 ft/d), flowing 35° west of north.

2.3.4 Groundwater Chemistry and Related Parameters

This section describes the results of chemical analyses of groundwater sampled in three ~~TEDF~~ site characterization/monitoring wells and is organized in parallel with Section 3.4 to aid in comparing pre-operation (baseline) monitoring data with monitoring data collected after initiation of disposal. The baseline results cover the period from June 1992 to October 1994. Appendix C contains all groundwater chemistry data reported for that time period. These results were also reported in RCRA quarterly groundwater monitoring reports (e.g., Barnett 1994).

Various methods used to evaluate data from the ~~TEDF~~ wells indicate that the data are of acceptable quality. Nevertheless, groundwater sample collections and analyses are subject to actual and potential anomalies and errors. The following paragraphs discuss the analy~~tical results~~ses in the context of several factors that may affect ~~them.~~

Groundwater in well 699-48-77A was sampled during each of 11 quarters since well completion in 1992. Wells 699-48-77C and 699-48-77D were sampled during each of four quarters since well completion in 1994. The results of these samplings were used to determine baseline water quality. Table 2-3 lists the sampling dates and corresponding purge rates.

Table 2-3. Sampling Dates and Corresponding Purge Rates for Monitoring Wells.

Sampling dates in well 699-48-77A	Purge rates (gal/min)	Sampling dates in well 699-48-77C	Purge rates (gal/min)	Sampling dates in well 699-48-77D	Purge rates (gal/min)
06/19/92	2.0		12.5 ?		11.1 ?
09/02/92	4.0				
11/02/92	3.7				
02/22/93	5.0				
05/17/93	4.6				
09/02/93	4.6				
10/15/93	3.33				
01/17/94	4.0				
04/15/94	3.7	05/28/94	5		
08/10/94	4.0	08/10/94	4		
10/31/94		10/31/94		10/31/94	

any data? any data? any data?

As noted in Table 2-3, the purge rates for all sampling dates generally were reasonably consistent. However, when purge rates exceed sampling rates, analytical results for some sample constituents may not be representative of the aquifer. Potential anomalies introduced by variable purging and sampling rates were taken into consideration during evaluation of the data and are discussed later in this section. Future collections of groundwater samples from these wells (see Section 3.6.1) will use purge and sampling rates that are consistent and less than or equal to the rate of pumping used for well development.

2.3.4.1 **Turbidity and Other Field Parameters.** Measurements of turbidity are used to determine the relative amount of particulate matter in water. Water samples with high particulate content interfere with analytical methods and may cause analytical results to be erroneously high or low, depending on the analyte and the analytical method used. Consequently, groundwater samples with low turbidity are sought. Turbidity is known to be influenced by pumping rates during purging and sampling. For groundwater samples collected from the three monitoring wells between October 1993 and May 1994, turbidity was measured in the laboratory, rather than at the well site. For all other collection dates, turbidity was not analyzed. Hence, samples were collected without prior knowledge of the turbidity of the water. The advantage of measuring turbidity prior to sample collection is that the pumping rate can be reduced as needed to achieve lower turbidity, thus helping eliminate potential interferences to laboratory analyses.

The measured turbidities were all within an acceptable range of < 10 nephelometric turbidity units (NTU). The corresponding pumping rates were consistent. Consequently, the analytical results have most likely not been significantly affected by turbidity.

Other field parameters for which measurements were made in the three wells are specific conductance (SC), pH, temperature, and water level. Water level was measured monthly and is discussed in Section 2.3.3. The other field parameters were measured during quarterly groundwater sample collection. The consistency of values for the field parameters measured at each well indicate that they provide a reliable baseline for groundwater quality.

2.3.4.2 **Cations and Anions.** Ammonia/nitrogen was detected in well 699-48-77A on October 15, 1993 and January 17, 1994. Ammonia/nitrogen was also found in the field quality-control blank. Coliform bacteria were detected twice in well 699-48-77A on June 19, 1992 and September 2, 1992. Coliform bacteria were not detected in wells 699-48-77C and 699-48-77D. Sulfide was not detected in wells 699-48-77C or 699-48-77D, and was not analyzed in well 699-48-77A. Hydrazine was not detected in well 699-48-77A and was not analyzed in wells 699-48-77C or 699-48-77D. All detections were in the low-level range and are considered to be baseline values for the disposal facility.

Samples were collected for analysis of cations, anions, alkalinity, total carbon (TC), total dissolved solids (TDS), and SC to provide information for evaluating water quality parameters and charge-balance equations. Because charge balance can be used to verify sampling and laboratory analysis precision and accuracy, attempts were made to assess the relationships of charge balance to TDS and SC. However, these attempts did not consistently indicate correlations.

The relationship of TDS to major cations and anions is as follows:

$$TDS\ (\mu g/L) = \Sigma(cations + alkalinity\ (0.6) + anion)\mu g/L.$$

If alkalinity analyses are not available, then TC and total organic carbon (TOC) may be used to calculate alkalinity indirectly by the relationship:

$$(TC - TOC) \times 4 = Alkalinity.$$

This relationship is based on the assumption that total inorganic carbon (TIC) is equal to TC minus TOC. TIC is expressed as an equivalent concentration of calcium carbonate ($CaCO_3$).

The relationship of TDS to SC is as follows:

$$TDS\ (\mu g/L) = SC\ (\mu mohs/cm) \div 1.7.$$

Charge balance, the calculated percent deviation between the observed total cations and anions (each measured in milliequivalent (meq)/L), can be determined by using the following equation:

$$Charge\ balance = \frac{total\ cations - total\ anions}{total\ cations + total\ anions} \times 100\%$$

where:

$$Total\ cations\ (meq/L) = \frac{[NA^{+}]}{22.9898} + \frac{[K^{+}]}{39.102} + \frac{[Ca^{+2}]}{20.04} + \frac{[Mg^{+2}]}{12.156}$$

and

$$Total\ anions\ (meq/L) = \frac{alkalinity}{50} + \frac{[Cl^{-}]}{35.453} + \frac{[F^{-}]}{18.9984} + \frac{[NO^{-3}]}{62.0049} + \frac{[SO^{-4}]}{48.0308}.$$

Concentration units in these equations are milligrams per liter; the divisors are the equivalent weights of the respective species. A charge balance can be computed provided that data for all of the key components are available. Key components include sodium, potassium, calcium, magnesium, alkalinity, chloride, fluoride, nitrate, and sulfate. If results for nitrate are available, they are included in the charge-balance calculation but are not believed to be quantitatively significant. Consequently, a charge balance typically is determined whether nitrate analyses are available or not.

Alkalinity was not measured nor was it calculable from TC because TC was not analyzed. Based on evaluation of the relationship of SC to TDS, a $< \pm 21\%$ difference was observed between analyzed and calculated TDS. Hence, there is a relationship between SC and TDS: laboratory measured TDS values were consistently higher than the TDS estimated from field-measured SC.

Evaluation of the chemical analysis data based on cation and anion information indicates that the analyses are of acceptable quality; no anomalous values were noted, and the groundwater in all three monitoring wells currently complies with all primary drinking water standards.

2.3.4.3 **Metals and Cyanide.** Evaluation of metals analyses was also in terms of the comparability of results for filtered and unfiltered samples. If the results for filtered vs. unfiltered samples agreed within 20%, the data were considered to be good. If the results did not agree within the limits of this criterion, the disagreement was attributable to high turbidity resulting from well construction or sampling techniques.

Only two outlying analyses were observed for samples from well 699-48-77A. On May 17, 1993, copper in the filtered sample was twice as high as that in the unfiltered sample. On September 2, 1993, potassium in the unfiltered sample was twice as high as that in the filtered sample.

Data from well 699-48-77A showed no correlation between aluminum, chromium, iron, manganese, vanadium, and zinc values for filtered versus unfiltered samples. This same lack of correlation is seen for groundwater samples from throughout the Hanford Site and can be attributed to

well construction, and to sampling and analytical errors. Consequently, analytical data from both filtered and unfiltered samples will be used to evaluate future analytical data for metals.

In wells 699-48-77C and 699-48-77D, only filtered samples were collected for metals analysis. Analytical results from the wells were compared to historical values from other monitoring wells on the Hanford Site. The analytical results were very consistent for filtered samples, except for three outlying values. Well 699-48-77C had two outlying results for manganese and zinc in a sample collected on August 10, 1994. Well 699-48-77D had one outlying result for manganese in a sample collected on August 10, 1994.

Analyses were made for cyanide in well 699-48-77A until October 1993; thereafter, samples were not analyzed for cyanide in any of the three wells. Cyanide was not detected in any of the samples.

2.3.4.4 **Organic Compounds.** Analyses of organic compounds focused on both specific constituents and broad-based indicators. Analyses were made of total organic halides (TOX), TOC, volatile organic compounds, semivolatile organic compounds, phenols, pesticides, polychlorinated biphenyls (PCB), herbicides, dioxin/dibenzofurans and organophosphates. The relationships between the detection of specific constituents, TOC, and/or TOX were reviewed. Audits of laboratory analyses and reporting suggest that the results of TOX analyses from December 1992 to December 1993 should be treated as suspect. After December 1993, TOX was analyzed by a different laboratory for which audit results have been more satisfactory.

For all sampling dates and wells, all detections of specific organic compounds were below the laboratory contractual reporting limits. The following are the only detections of organic compounds. The number or other entry in parentheses after the name of the organic compound indicates the number of detections (if more than one) or the type of laboratory error.

- Well 699-48-77A: acetone (blank contaminated) and cis-1,2-dichloroethylene were detected
- Well 699-48-77C: methylene chloride (2, blank contaminated), 4,4'-DDE, aldrin, carbon tetrachloride (2), chloroform (2) and di-n-butylphthalate were detected
- Well 699-48-77D: 1,1,1-trichloroethane, methylene chloride (2, blank contaminated), carbon tetrachloride (2), chloroform (2), and di-n-butylphthalate were detected.

2.3.4.5 **Radionuclides.** Radionuclides are being monitored in groundwater at the three ~~TEDF~~ monitoring wells to establish baseline values. All detections have been at very low levels. Iodine-129, among the most mobile of radionuclides found in groundwater elsewhere beneath the Hanford Site, was detected once in well 699-48-77A and was not analyzed for wells 699-48-77C or 699-48-77D. Tritium was detected twice in each of wells 699-48-77C and 699-48-77D, but was absent from well 699-48-77A. Gross alpha and gross beta are being monitored in all wells and the results are very consistent except for two outlying values for gross beta. The two outlying values were detected for samples collected in well 699-48-77C (25 times higher than historical results) and well 699-48-77D (10 times higher than historical results) on August 10, 1994. Radium was analyzed only for samples from wells 699-48-77C and 699-48-77D, with one detection at each well.

2.3.5 Statistical Evaluation of Groundwater Background Data

Eleven quarters of monitoring data from well 699-48-77A and four quarters of monitoring data from wells 699-48-77C and 699-48-77D were statistically evaluated to derive background values representative of pre-operational groundwater quality for the three monitoring wells at the ~~discharge~~ disposal facility. Background concentrations in groundwater are statistically defined as the 95% upper tolerance interval, with 95% confidence. These background concentrations represent conditions present in the uppermost aquifer prior to the onset of discharges to the ~~TEDF~~ facility. The assumptions, objectives, and approach used for the statistical evaluation are described in the following sections.

2.3.5.1 **Assumptions.** Assumptions related to the statistical model or methods are required to properly determine and interpret background values for constituents of interest in groundwater at the disposal site ~~TEDF~~. These assumptions are:

- Groundwater monitoring data are representative of actual groundwater conditions in the uppermost aquifer beneath the facility.

- Groundwater chemistry data, except for pH and SC, are log-normally distributed. The use of a log-normal distribution as a default statistical model is justified because (1) most groundwater monitoring data are positively skewed and are restricted to positive values, (2) all available statistical tests for distributional assumptions are inadequate when the sample size is small, and (3) the U.S. Environmental Protection Agency's (EPA) experience with contaminant concentration and groundwater monitoring data suggest that a log-normal distribution is generally more appropriate as a default statistical model than a normal distribution (EPA 1992). For field-measured pH and SC data, normal distributions are assumed because each data point is the average of quadruplicate measurements (i.e., the central limit theorem applies in this case).

- Seasonal or temporal variations are insignificant. The test for seasonality generally requires a minimum of 2 yr of monitoring data. The data from the two downgradient wells are insufficient to test and/or to adjust for seasonal variation.

2.3.5.2 **Objectives.** Objectives of the statistical evaluation were to (1) establish baseline values for constituents of potential concern at each of the three monitoring wells and (2) provide information to enable Ecology to determine enforcement limits for specific constituents in groundwater. Enforcement limits are established for specific constituents of concern to delineate groundwater contamination. Enforcement limits are determined on a site-specific basis and are based in part on background concentrations of these constituents in groundwater.

2.3.5.3 **Statistical Approach.** In general, background groundwater data were statistically evaluated following procedures outlined by the EPA (1989, 1992).

Groundwater chemistry data from the three monitoring wells (699-48-77A, 699-48-77C, and 699-48-77D) were obtained from the Geosciences Data Analysis Toolkit (GeoDAT) and Liquid Effluent Monitoring Information System (LEMIS) databases. Analytical results were reviewed under the aegis of the RCRA quality control (QC) program. The QC program that supports the sampling and analysis of groundwater from the ~~TEDF~~ is described in quarterly RCRA groundwater monitoring reports (e.g., DOE-RL 1994a). Data flagged with 'B' (contaminated blank) or 'H' (holding time exceeded) qualifiers were eliminated from further statistical evaluation because the validity of such

data is doubtful. However, the usefulness of data flagged with a 'Q' qualifier (suspect QC data) was evaluated based on consistency with the historical trend.

Groundwater chemistry data from each monitoring well were visually screened and tested at the 5% level of significance for outlying values using Box-and-Whisker plots and the Grubbs method, respectively (EPA 1989). The data were not used to calculate background concentrations if they were determined to be outlying values.

Groundwater monitoring data are often reported as "not detected." In these instances, a value such as the appropriate method-detection limit is given. Statistical treatment of "nondetects" depends on the percentage of nondetects in the database. When the percentage of nondetects was small (<15%), a replacement value of 1/2 the detection limit was used for the nondetected data point. When the percentage of nondetects was between 15 and 50%, Cohen's method was applied to the log-transformed data values to calculate estimates of the true mean and standard deviation (EPA 1989). For example, Cohen's method was used for chromium (wells 699-40-36 and 699-48-77C) and nitrate data. When the percentage of nondetects was larger than 50%, summary statistics (sample mean and standard deviation) were not calculated.

A 95% upper tolerance limit and a confidence level of 95% based on log-normal distribution were used to calculate background concentrations. For pH, a two-sided tolerance limit based on normal distribution was calculated. For SC, a one-sided tolerance limit, based on normal distribution, was calculated. These tolerance limits are of the form:

$$\bar{x} + ks \quad \text{(one-sided)}$$

$$\bar{x} \pm ks \quad \text{(two-sided)},$$

where $\bar{x}$ is the sample mean, s is the sample standard deviation, and k is a multiplier whose value is based on the coverage, the confidence level, and sample size. Values of k can be obtained from the EPA (1989).

The tolerance interval is designed to cover only a specific proportion (e.g., 95%) of the population of interest. Therefore, 1 of 20 samples could be expected to exceed the upper tolerance limit, even when no contamination has occurred (EPA 1992). In such cases, a well would be resampled to verify the presence or absence of contamination.

2.3.5.4 Results of ~~Groundwater~~ Statistical Evaluation. Background groundwater characteristics were evaluated for each well using data collected from June 1992 through October 1994. A summary of the status of all constituents of potential concern is provided in Appendix D. Additional statistics and conditional statements associated with computation of the tolerance limits listed in Appendix D.1 are provided in Appendix D.2.

2.3.6 Sediment Characterization

Physical and chemical properties of sediments at the ~~TEDF~~ were first described by Reidel and Thornton (1993). Reidel and Thornton (1993) describe the results of physical tests on sediments, sediment chemistries, and leach tests. The results, except for grain size analyses, are for samples collected during the drilling of wells 699-48-77A and 699-48-77B.

Swanson (1994a) reported the results of analyses of split-spoon and grab samples collected from two subsequently drilled wells, 699-48-77C and 699-48-77D. These samples were analyzed only for moisture and $CaCO_3$ contents. In addition, in-situ infiltration was determined at two locations immediately south of the TEDF to measure infiltration capacity and hydraulic conductivities of near-surface sediments (Swanson 1994c). These tests were conducted in two shallow boreholes to determine whether $CaCO_3$-cemented horizons in the sediments beneath the TEDF would hinder facility operation.

The discussions that follow summarize results in the characterization work identified previously. Detailed descriptions of the sediments can be found in borehole data package WHC (1995).

2.3.6.1 Physical Properties of Sediments. Grain-size distributions within Ringold units A and E, the units that collectively comprise most of the sediments beneath the TEDF, were measured in samples from well 699-48-77A. However, because of the diminution of grain sizes caused by the cable-tool method used to drill this well, the results may not be representative. For purposes of comparison, grain-size distributions were also determined for sediment cores taken from three rotary-drilled boreholes south of the TEDF (DH-6, DH-12, and DH-13; see Figure 2-5 for locations). These samples were from Ringold units A and E, and interbeds of silt and sand within the Ringold Formation. Sampling results from all four wells were expressed by Reidel and Thornton (1993) in terms of the Wentworth grain-size classification system (Krumbein and Pettijohn 1938).

Grain-size distributions were measured for 18 samples from well 699-48-77A. A sample of the Hanford formation taken from this well at a depth of 1.4 to 1.5 m (4.5 to 5.5 ft) indicates that 48 wt% of the formation is comprised of pebble-sized grains. In contrast, medium to very coarse-grained sand comprises an average 49% of strata identified as the Plio-Pleistocene unit and/or early Palouse soil. This average is based on grain-size measurements for 12 samples from depths of 8.1 to 16.6 m (26.5 to 54.4 ft). Because 21% of these samples is silt, the average grain-size distribution in the Plio-Pleistocene unit and/or early Palouse soils appears to be bimodal.

The only sample analyzed from the upper unit of the Ringold Formation is dominated by medium to very coarse-grained sand. This sample was taken at depths of 20.6 to 20.7 m (67.5 to 68.0 ft). Based on the average of four samples analyzed from the Ringold unit E, the dominant grain size of this unit is pebble-to-granule (56.5%). Grain-size distributions in the Ringold unit A were not measured for samples from this well. Clay-sized particles are reported as being present only in 'trace' amounts for all units.

Grain-size distributions were measured in 47 samples from wells DH-6, DH-12, and DH-13, all south of the TEDF in the 200 West Area (Figure 2-5). The average grain-size distribution for 26 of these samples from the Ringold unit E indicates that 75% of the particles comprising the sediment are of pebble size. Most of the remaining samples from Ringold unit E are classified as medium to very coarse-grained sand. The average for 10 samples from Ringold unit A indicates that 71% of the particles comprising this unit are of pebble size; 11% are medium-grained sand. Twelve samples from sand and silt interbeds within the gravels indicate that the dominant grain sizes in these lithologies are fine to medium-grained sand (63%), and that an average of only 3.8% silt is present. As was the case in well 699-48-77A, only a trace of clay is noted, on average, for samples from these three wells.

$CaCO_3$ content was analyzed for 1.5-m (5-ft) sample intervals in wells 699-48-77A and 699-48-77D (WHC 1995). The results of most analyses indicated that $CaCO_3$ is present in amounts

less than 0.5%, except within the Plio-Pleistocene unit and/or early Palouse soil. In well 699-48-77A, as much as 7.8% $CaCO_3$ is estimated to be present within these two strata. In well 699-48-77D, 8.5% $CaCO_3$ is present near the contact separating the Hanford formation from the Plio-Pleistocene unit and/or early Palouse soil; 8.7% $CaCO_3$ is present in these strata near their contact with the Ringold Formation.

2.3.6.2 Results of Infiltration Tests. Geologic logging of monitoring well 699-48-77A revealed a substantial thickness of relatively impermeable sediments, now recognized as the Plio-Pleistocene unit and/or early Palouse soil. These strata occur ~6 to 20 m (~20 to 65 ft) below ~~land~~ the surface at the disposal facility ~~TEDF~~. The presence of these fine-grained, $CaCO_3$-cemented sediments was a cause of potential concern for the infiltration of treated effluent because these sediments have relatively low hydraulic conductivities. Consequently, in June 1994, two shallow boreholes were drilled near the southern end of the facility ~~TEDF~~ to test the infiltration rate (Figure 2-4). Falling-head and constant-head tests were conducted in each borehole.

Tests in the eastern borehole yielded a hydraulic conductivity (constant-head test) of 1.0×10^{-3} cm/sec (3 ft/d) and an infiltration rate (falling-head test) of 0.9 ~~lb~~ liters/d/m^2 (2.5 gal/d/ft^2). The hydraulic conductivity derived from the constant-head test in this borehole is not consistent with the infiltration rate derived from the falling-head test. The value ~~derived~~ from the constant-head test was interpreted to be suspect because of a possible leak in the casing shoe at the bottom of the borehole.

Two falling-head tests were conducted in the western borehole. These tests yielded infiltration rates from 17.6 to 66.8 ~~lb~~ liters/d/m^2 (50 to 190 gal/d/ft^2). The single constant-head test in the western borehole produced a hydraulic conductivity of 2.7×10^{-3} cm/sec (7.4 ft/d).

Swanson (1994c) attributed the discrepancies in results from the two boreholes to lateral and vertical discontinuities in the distribution of calcrete in the Plio-Pleistocene unit and/or early Palouse soil. Swanson (1994b) also noted that the much 'softer' calcrete encountered in the western borehole suggests significant lateral variability in the degree of induration and $CaCO_3$ content.

2.3.6.3 Sediment Chemistry. Seven samples of sediments from two boreholes were chemically analyzed; four from well 699-48-77A and three from abandoned borehole 699-48-77B (see Section 2.3.1) (Reidel and Thornton 1993). Each sample was analyzed for metals, anions, pH, radionuclides, volatile organic compounds, semivolatile organic compounds, pesticides and PCBs, and hexavalent chromium. Eight additional ~~sediment~~ samples from well 699-48-77A were the subject of column leach tests. Four samples of leachate were analyzed from each of the eight samples.

Results of the ~~chemical~~ analyses indicated ~~that~~ the sediments contain none of the analytes identified in the preceding paragraph at levels ~~considered to~~ indicative contamination. The results of most analyses of nonmetals were at or below detection limits of the analytical method. Relatively high values for pH (9.0 to 9.4) result from the calcareous nature of the sediments. Trace amounts of two volatile organic compounds: 2-butanone and 4-methyl-2-pentanone were found in the analyses for volatile organic compounds. Similarly, traces of three semivolatile compounds, benzoic acid, carboxylic acids, and phthalates were identified in the sediments.

Column leach tests were conducted to determine if potentially pre-existing contaminants in the sediments could be leached by treated effluent, thus affecting groundwater quality. The tests consisted of draining deionized water through core samples of sediments. The resulting leachate was analyzed for nonorganic constituents. All analytes of potential concern were at or below detection limits. Nitrate in one sample was elevated (42.7 mg/L) but still below drinking water standards. Calcium content and pH were also slightly elevated because of $CaCO_3$ in the sediments.

In summation, no constituents of concern were detected at significant levels, either from chemical analyses of the sediments or ~~column leach tests~~. Elevated alkalinity is thought to result from the $CaCO_3$ in the sediments.

2.4 PROJECTED EFFECTS OF FACILITY OPERATION ON GROUNDWATER FLOW AND SOLUTE TRANSPORT

Groundwater flow characteristics in the vicinity of the ~~TEDF~~ and the fate of tritium discharges were evaluated by using computer-encoded numerical models. These models were used to simulate infiltration of the discharge into the vadose zone and its subsequent movement in the uppermost aquifer. This section summarizes results of the following analyses:

- Hydrogeologic modeling of hydraulic properties and water quality in the uppermost aquifer underlying the 200 West Area and vicinity (Connelly et al. 1992)
- Numerical analysis of treated effluent flow and tritium transport in the vadose zone beneath the ~~TEDF~~ (Lu et al. 1993)
- Numerical analysis of groundwater flow and tritium transport in the uppermost aquifer between the ~~TEDF~~ and the Columbia River (Golder Associates 1990, 1991).

Connelly et al. (1992) ~~provided a~~ comprehensive ~~overview of~~ groundwater flow characteristics in the 200 West Area and selected adjacent areas. They also compiled information on the extent and nature of existing groundwater contamination associated with past operations in the 200 West Area. The numerical simulations by Lu et al. (1993) evaluated the potential for preferential lateral movement of treated effluent ~~from the TEDF~~ in the partially saturated zone above the uppermost aquifer, and predicted the ~~concentration~~ distribution of tritium in the immediate vicinity of the discharge. Numerical modeling by Golder Associates focused on (1) prediction of movement through the uppermost aquifer to the Columbia River of tritium discharged to the ~~TEDF~~ and (2) estimation of future tritium concentrations in groundwater entering the river.

2.4.1 Modeling of Hydraulic Properties and Known Groundwater Contamination in the 200 West Area and Vicinity

This section summarizes the work by Connelly et al. (1992) that is pertinent to evaluation of baseline water quality and hydrology in the vicinity of the ~~TEDF~~: (1) distribution of groundwater contaminated by past operations in the 200 West Area and (2) the movement of groundwater through the uppermost aquifer in the northern portion of the 200 West Area.

2.4.1.1 Areas of Known Groundwater Contamination Near the ~~TEDF~~ Pond Facility. Contaminant plume geometries and distributions associated with past operations in the 200 West Area were compiled and plotted by Connelly et al. (1992) based on data in the Hanford Environmental Information System (HEIS) database through the first half of 1990. As used by Connelly et al. (1992), the term "contaminant" refers to any constituent listed in:

- WAC 173-200-040, *Model Toxics Control Act*
- 40 CFR 141 and 143, *Primary and Secondary Drinking Water Regulations*
- FR 54 22062, *Proposed Drinking Water Maximum Concentration Limits*
- 40 CRF 264, Appendix IV, the RCRA "Long List"
- DOE Order 5400.5, *Derived Concentration Guides for Radionuclides*.

Data on contaminant concentrations that exceeded the limits stated in the above regulations were compiled and their distributions were contoured by computer to indicate the approximate extent of the contamination. A composite distribution map of hazardous chemicals, for concentrations in groundwater that exceed regulatory limits, is shown in Figure 2-12. This map shows the areas of the uppermost aquifer in the 200 West Area that are contaminated by past discharges of arsenic, chromium, fluoride, carbon tetrachloride, chloroform, trichloroethylene, and nitrate. Figure 2-13 is a map of the areas of the uppermost aquifer with radionuclide contamination from ^{129}I, $^{239/240}Pu$, ^{99}Tc, tritium, and uranium.

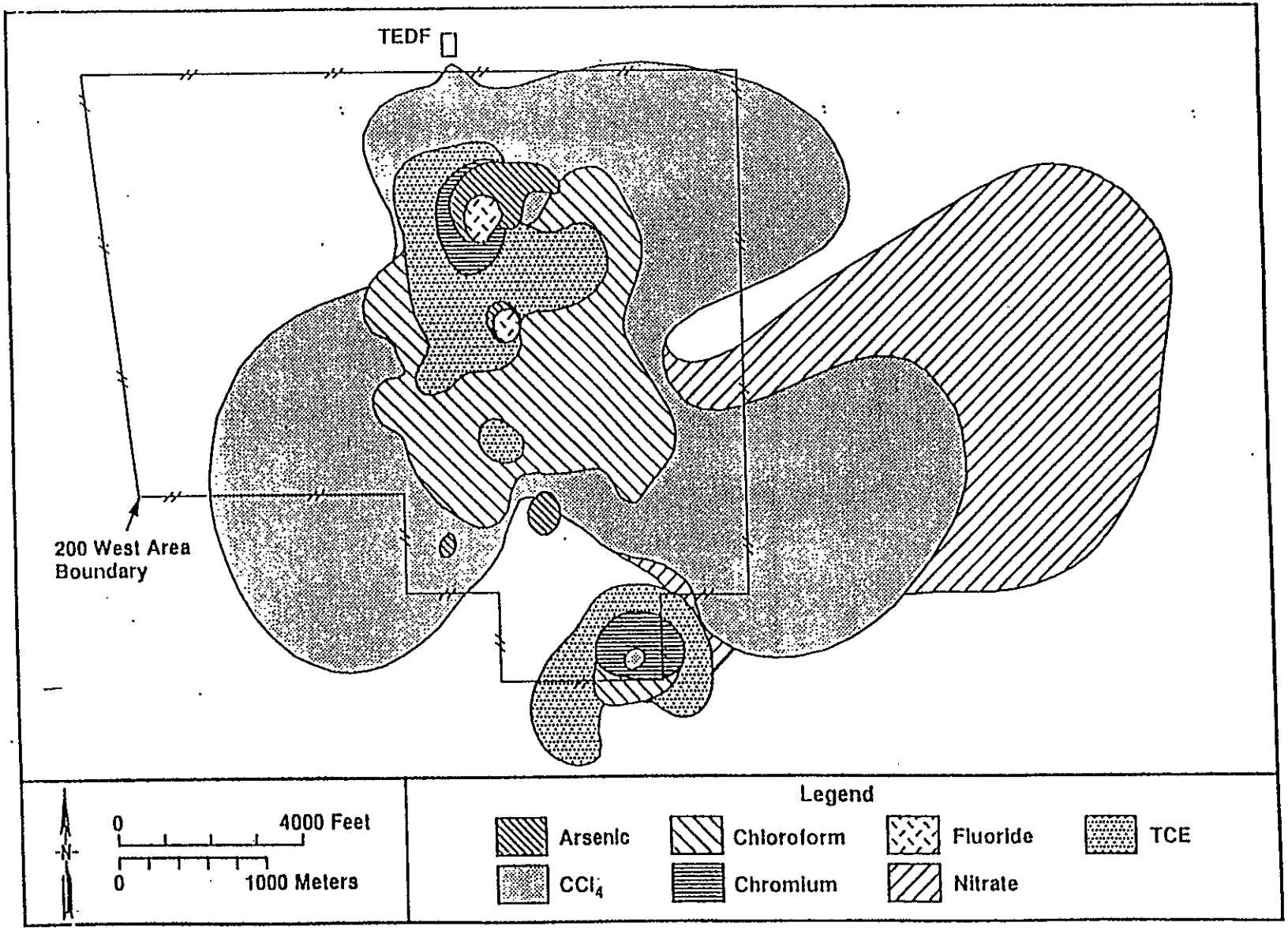
The discharge facility currently is downgradient from some of these areas of aquifer contamination. However, the gradual, progressive decay of a mound in the water table resulting from past discharges of wastewater to U Pond in the 200 West Area is resulting in a gradual shift of groundwater flow from a northerly to a more easterly direction in the vicinity of the TEDF. As that occurs, the facility will no longer be downgradient from areas of known contamination in the uppermost aquifer.

2.4.1.2 Pre-Operational Movement of Water through the Uppermost Aquifer in the 200 West Area and Vicinity. The uppermost, regionally unconfined aquifer beneath the TEDF and most of the 200 West Area is in Ringold Formation gravel units A and E. As shown in Figure 2-14, hydraulic properties of this aquifer vary widely. However, the northern part of the 200 West Area, including the vicinity of the TEDF, is distinguished by a zone of relatively high hydraulic conductivity (>30 m/d [>100 ft/d]). This high-conductivity zone is believed to trend north-south between the area immediately to the west of the TEDF and the low-level waste burial ground.

The potential movement of contaminants in the uppermost aquifer (Connelly et al. (1992) is illustrated by the streamlines in Figure 2-14. The simulated rate of groundwater movement varies among areas of the aquifer with differing hydraulic conductivities. The time markers shown on the streamlines in the figure illustrate the relative differences in the rates of groundwater movement for areas with differing hydraulic conductivities. For 1992 head conditions in the high hydraulic conductivity zone shown in Figure 2-14, groundwater would travel ~610 m (~2,000 ft) in 3 yr.

2.4.2 Numerical Analysis of the Effects of Facility Operation on the Vadose Zone

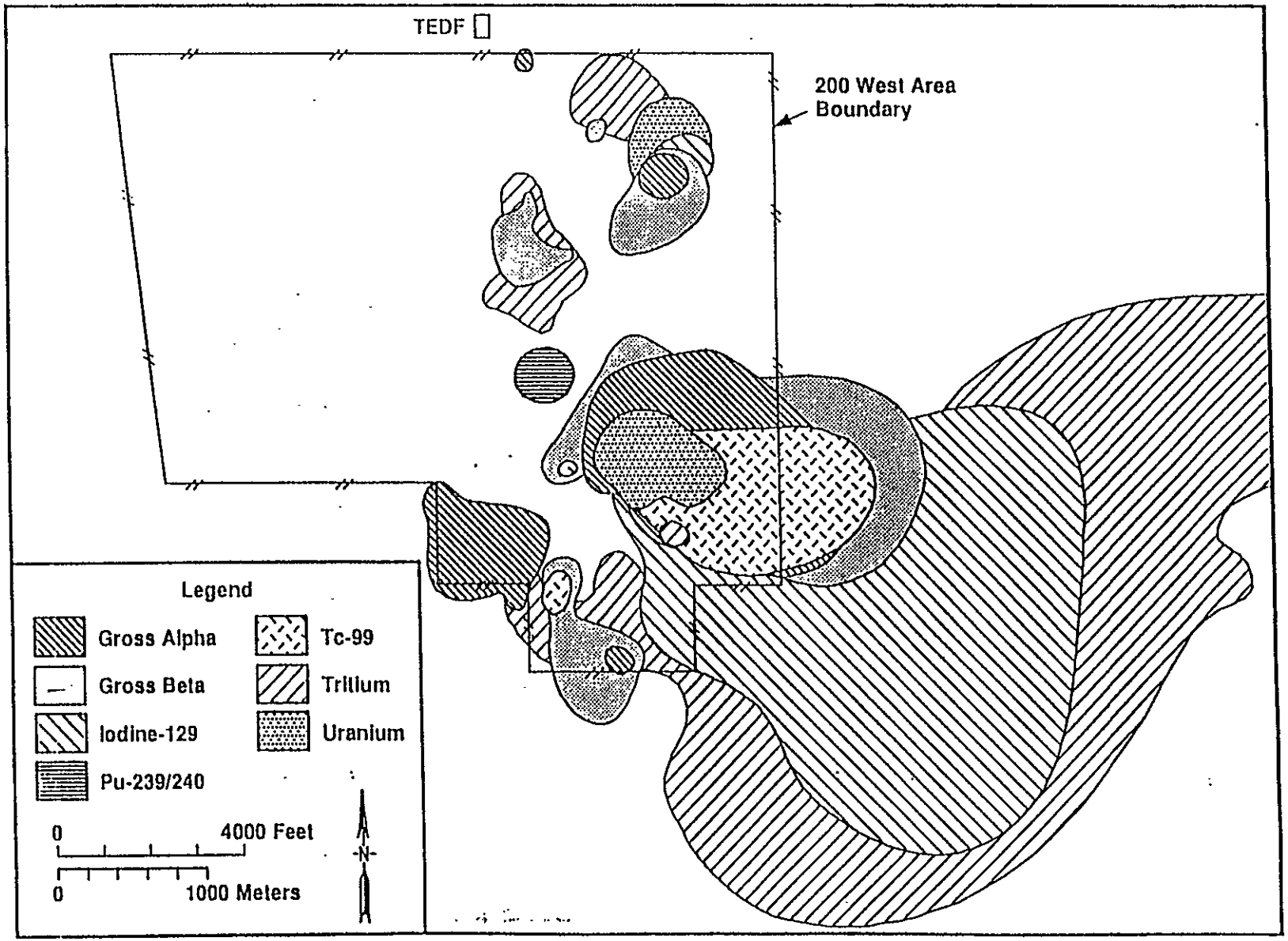
This section summarizes work by Lu et al. (1993) to simulate the movement of discharges from the TEDF through the vadose zone to the water table. The simulation was made using the VAM3D-CG numerical model (Huyakorn and Panday 1991).



119503006.0

Figure 2-12. Hazardous Contaminant Distributions in the Uppermost Aquifer.

43



H9503006.9

Figure 2-13. Radioactive Contaminant Distributions in the Uppermost Aquifer.

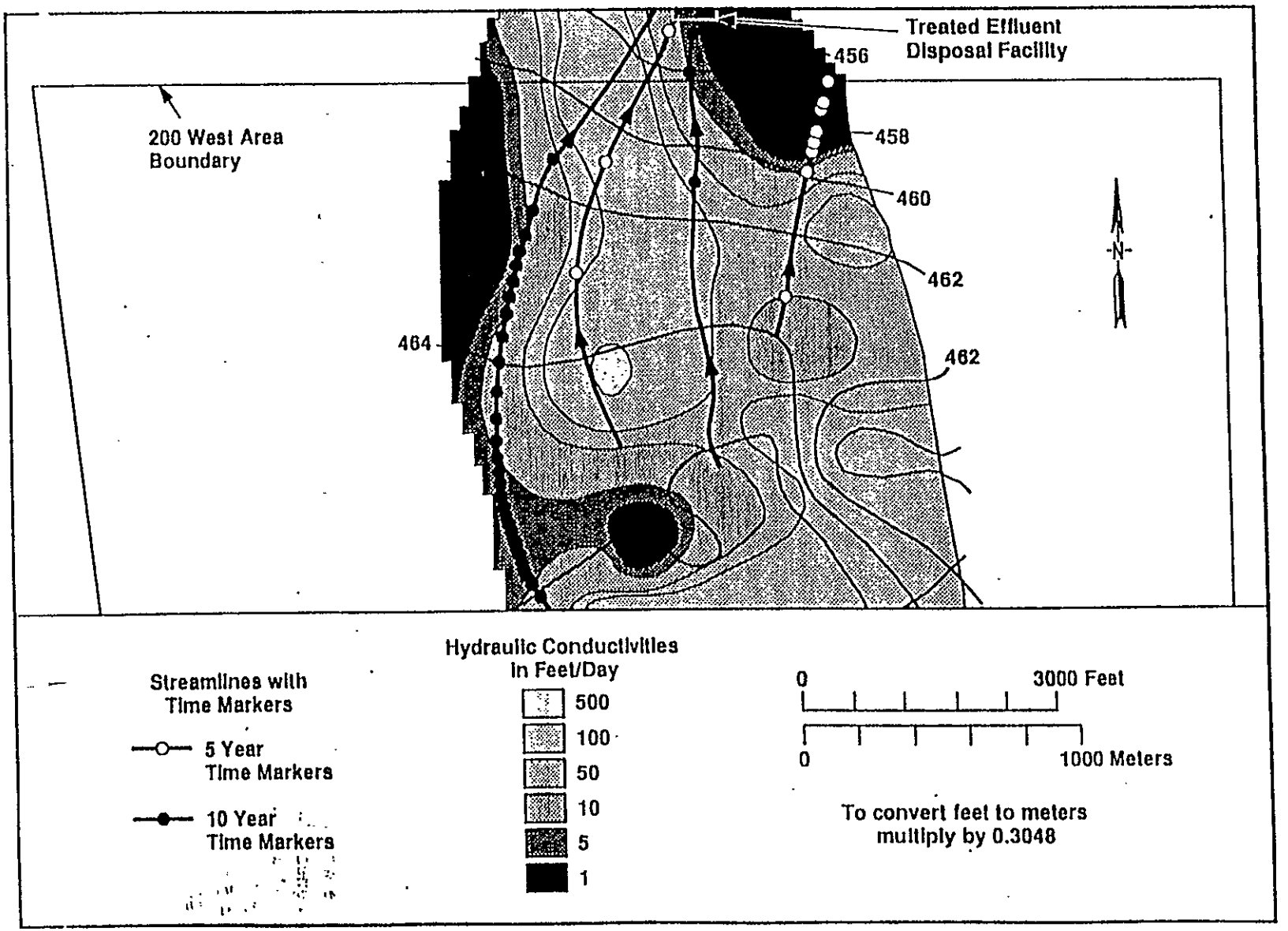


Figure 2-14. Hydraulic Conductivities, Water Table Elevations, and Streamlines with Time Markers.

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2.4.2.1 Conceptual Model. The conceptual model of Lu et al. (1993) assumed that infiltration of treated wastewater into the soil would occur through a surface area of 2,000 m^2 (21,600 ft^2) at a rate of ~ 150 $m^3/yr/m^2$ (400 $L/d/m^2$ [10 $gal/d/ft^2$), that half the tritium would decay by the end of each 12.3 yr, and that tritium concentrations would be unaffected by sorption.

Lu et al. (1993) assumed that 568 L/min (150 gal/min) of wastewater would continue to be discharged for 125 yr and that the water would contain tritium with an average concentration of 1.62E+07 pCi/L. Subsequent to that analysis, the estimated discharge rate was increased by 8 L/min (22 gal/min) and the expected concentration of tritium was revised substantially downward to 6.2E+06 pCi/L. The actual design life of the facility is 30 yr.

The VAM3D-CG numerical model simulated advection, hydrodynamic dispersion, and radioactive decay in a two-dimensional vertical cross section, from the surface to a depth of 120 m (395 ft) across the center of the infiltration surface. The discharge to the TEDF was represented in the conceptual model by applying the treated effluent as a constant flux along a 32 m (105 ft) length of the cross section. Beyond the 32-m (105-ft) influx length, the model domain extended 50 m (165 ft) upgradient along the plane of the cross section and 100 m (328 ft) downgradient, for an overall length of 182 m (600 ft).

Based on the stratigraphy in the upgradient monitoring well (699-48-77A), Lu et al. (1993) depicted lithologies in the conceptual model by six zones which correspond to the Hanford formation, Pliocene-Pleistocene unit, upper part of the Ringold Formation, and portions of the middle and lower parts of the Ringold Formation. The hydraulic properties assigned to these zones were based on laboratory analyses of six split-spoon samples of sediments from the well.

Moisture characteristic curves were developed for each of the six samples by using laboratory measurements of matric potential at different moisture contents and fitting a moisture retention curve using the RETC computer program (van Genuchten et al. 1991) that embodies the van Genuchten-Mualem model for moisture retention (Mualem 1976; van Genuchten 1978). RETC was also used to estimate unsaturated hydraulic conductivity values from the moisture retention data and laboratory-measured saturated hydraulic conductivities.

Initial conditions in the vadose zone were assumed by Lu et al. (1993) to be controlled by steady-state infiltration of meteoric water at a rate of 5 cm/yr. An initial unit-gradient pressure head was assigned to the vadose zone, thus equating the initial infiltration rate to the unsaturated hydraulic conductivity.

The left and right boundaries of the model domain within the vadose zone above the water table were assigned zero fluid and solute concentration fluxes. Zero flux conditions were also assigned to the bottom boundary. The boundary condition of the saturated portion of the conceptual model was defined by applying a hydrostatic pressure distribution along boundary nodes below the current 70 m (230 ft) depth of the water table. A lateral hydraulic gradient of 2.75 m/km (14.5 ft/mi) was assigned to the uppermost aquifer by applying slightly higher pressures on the upgradient side of the model domain.

2.4.2.2 Input Parameters. The following values were used as model input parameters:

- Aquifer storativity: 0.2
- Longitudinal dispersivity: 1.0 m (3.3 ft)
- Transverse dispersivity: 0.1 m (0.33 ft)
- Molecular diffusion coefficient: 1.4×10^{-6} cm^2/s
- Sorption coefficient for tritium: 0.0
- Retardation factor for tritium: 1.0

2.4.2.3 Results. The results of Lu et al. (1993) confirm that the relatively low hydraulic conductivity of the fine-grained Plio-Pleistocene unit and early "Palouse" soil would result in lateral spreading of the treated effluent in the sediments above the water table. Lu et al. (1993) predicted that the maximum transverse flow would occur at a depth of ~10 m (~33 ft), but that lateral flow would not necessarily result in extensive migration of the treated effluent in the vadose zone to areas of high hydraulic conductivity. One such area of higher hydraulic conductivity occurs to the north of the TEDF where the Hanford formation has been deposited in a Pleistocene paleochannel eroded into the Ringold Formation. Another area may occur immediately west of the TEDF (see Figure 2-14).

By about 1 yr after operation of the TEDF begins, Lu et al. (1993) predicted that the water table beneath the TEDF would reach its maximum elevation at ~5 m (16 ft) above the pre-TEDF operation level. The model predicted that a new steady-state condition would become established by ~14 yr after operation of the facility begins. After 14 yr, no additional lateral spreading of the treated effluent in the vadose zone was predicted. When discharges end, ~5 yr would be required for the water table to revert to its natural state and for the mound in the water table beneath the TEDF to dissipate.

Lu et al. (1993) estimated that the treated effluent would reach the water table ~1 yr after discharges began and would require ~9 yr from the onset of treated effluent disposal to arrive at a hypothetical well 100 yd (328 ft) downgradient. Hence, maximum predicted activity of tritium in the uppermost aquifer would be equal to the discharge activity minus the radioactive decay of tritium occurring in 1 yr. For the tritium discharge used by Lu et al. (1993) (16.2 μCi/L [1.62E+07 pCi/L]), this would correspond to a maximum activity of ~14 μCi/L. After ~19 yr of TEDF operation, the forecast maximum activity would arrive at a steady-state location in the uppermost aquifer, ~20 m (65 ft) laterally from the location of treated effluent entry into the aquifer. However, more extensive lateral spreading may occur in preferred directions if hydraulic conductivity is appreciably anisotropic.

2.4.3 Numerical Analysis of the Effects of Facility Operation on the Uppermost Aquifer

Golder Associates (1991, 1990) assessed the movement of treated effluent in the uppermost aquifer between the TEDF and the Columbia River. The analysis had two principal objectives. The first was to predict the direction and rate of movement through the uppermost aquifer of tritium discharged to the TEDF. The second was to estimate resulting future concentrations of tritium in groundwater entering the Columbia River.

2.4.3.1 Conceptual and Numerical Models. Golder Associates used their proprietary two-dimensional Aquifer Porous Media (AFPM) and Solute Transport (SOLTR) software modules for the analysis. Detailed descriptions of the conceptual and numerical models, and discussions of the calibration procedures, assumptions, and model limitations can be found in Golder Associates (1990.

1991). The major assumptions, simplifications, uncertainties, and limitations of the AFPM and SOLTR transport models were:

- Vertical flow and solute transport within the aquifer were not accounted for
- Assumed isotropic flow characteristics for the aquifer
- Vertically averaged hydraulic conductivities
- Deterministically approximated flow parameters
- Used a single dispersivity value characteristic of long-distance flow
- Assumed the size and geometry of the effluent influx area at the water table
- Assumed steady-state influx from flow sources for the duration simulated
- Accuracy was reduced by numerical dispersion and oscillations
- Neglected the effects of transient changes in river elevation
- Solute transport portion of the model was uncalibrated.

Fixed-head conditions were applied to the portion of the model boundary defined by the Columbia and Yakima rivers (Figure 2-15). A no-flow condition was imposed at the bottom of the uppermost aquifer (i.e, at the bottom of the model domain). Where basalt bedrock occurs above the water table, the model boundary was assigned an extremely low hydraulic conductivity (i.e., 8 orders of magnitude less than the aquifer). A non-zero, fixed-flux condition was applied at the segment of the model boundary defined by the Dry Creek and Cold Creek valleys (Figure 2-15).

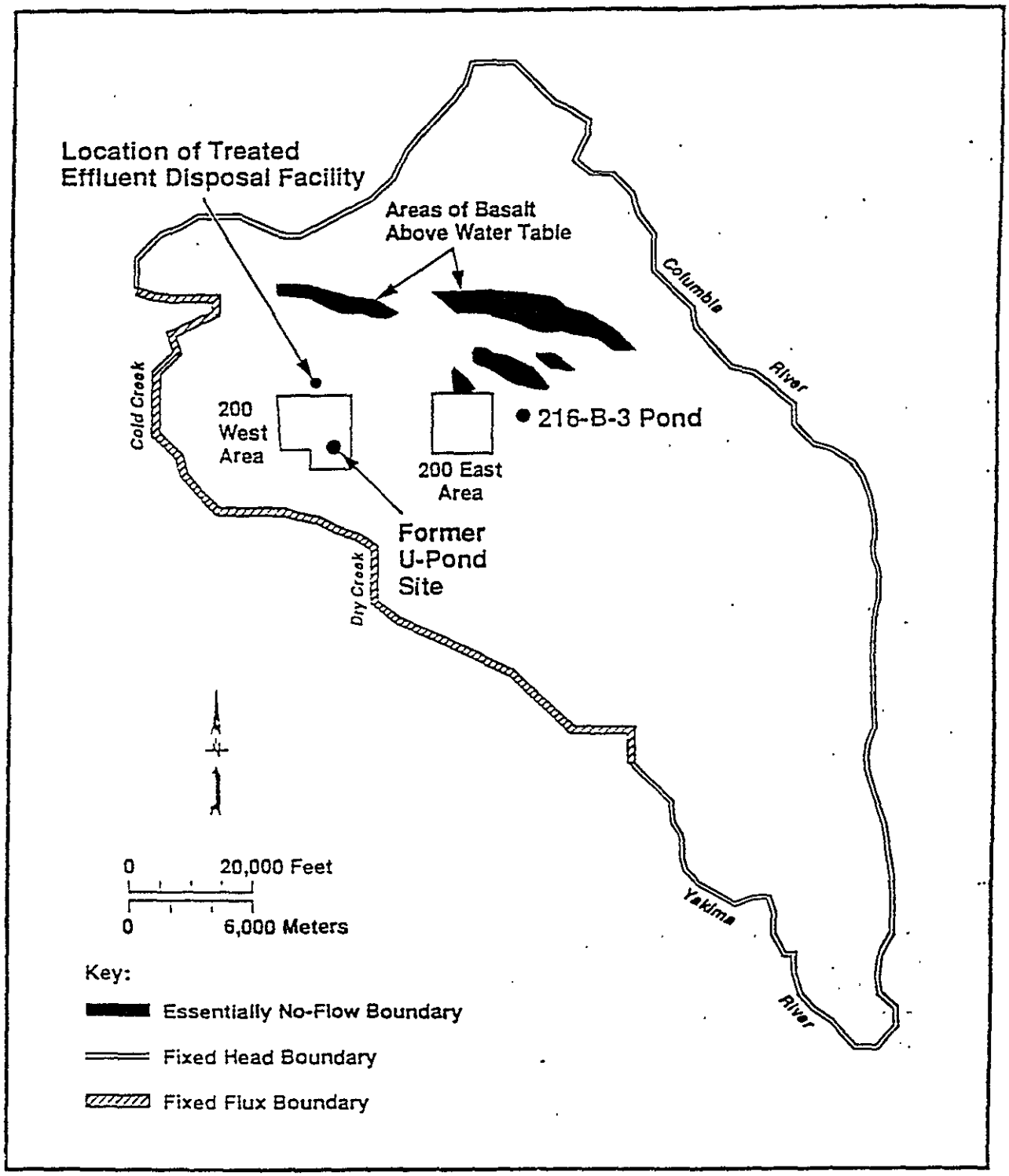
The modeled area was subdivided into 27 pieces. Each piece was assigned a set of values for hydraulic properties based on current hydrogeologic knowledge. The groundwater flow portion of the model was then calibrated using water table maps for 1944 and 1976. Hydraulic conductivities and boundary fluxes for Dry Creek and Cold Creek were adjusted in the model until water table elevation contours produced by the simulations closely approximated those of the 1944 and 1976 maps.

To help reduce numerical oscillation and dispersion, the downgradient portion of the numerical grid was refined by relatively small-scale discretization. The resulting grid for the overall model domain contained 4,639 elements and 4,773 nodes. Each square element in the north (downgradient) part of the model domain had sides 333 m (1,092 ft) long. Numerical effects near the TEDF resulted in a simulated acceleration of solute transport near the TEDF, resulting in prediction of decreased travel time and increased tritium concentration at the river.

2.4.3.2 **Input Parameters.** For purposes of simulating advective flow through the aquifer, a continuous effluent flux rate of 568 L/min (150 gal/min) was assigned to the TEDF location in the calibrated model. Subsequent to the analysis, estimates of the average annualized discharge rate increased by 83 L/min (22 gal/min). The planar area of the aquifer through which this influx was simulated was estimated by accounting for the effects of lateral spreading of the treated effluent in the vadose zone above the water table. This estimation assumed isotropic conditions for horizontal hydraulic conductivity and resulted in an estimated area of 8,350 m^2 (90,000 ft^2) through which treated effluent entered the top of the uppermost aquifer.

Because the model was two-dimensional and oriented in a horizontal plane, it did not account for vertical gradients within the aquifer. The effect on hydraulic gradients of past and current discharges of treated effluent to the 216-B-3 Pond complex (Figure 2-15) was accounted for by assuming a flux of 62.5 million L/d (16.4 million gal/d) at that location. The flux was assumed to be distributed uniformly at the edges of a square element. Each edge of the element representing the 216-B-3 Pond complex was 998 m (3,275 ft) long.

Figure 2-15. Model Domain for Numerical Simulation of Tritium Transport in the Uppermost Aquifer.



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In addition to hydraulic head distributions generated by the groundwater flow model, simulation of tritium movement through the aquifer required input for dispersivities, retardation factors, decay rates, source concentrations, and effective porosities. Values for longitudinal and transverse dispersivities were obtained from a combination of Hanford Site data and data from similar alluvial and glaciofluvial sediments elsewhere.

Because dispersivity is a scale-dependent parameter, the dispersivities chosen for model input were selected to conservatively underestimate the size of the tritium plume and thereby overestimate the concentration of tritium where it is predicted to intercept the Columbia River. A longitudinal dispersivity of ~36.5 m (120 ft) and a transverse dispersivity of ~12.2 m (40 ft) were used (Golder Associates 1991).

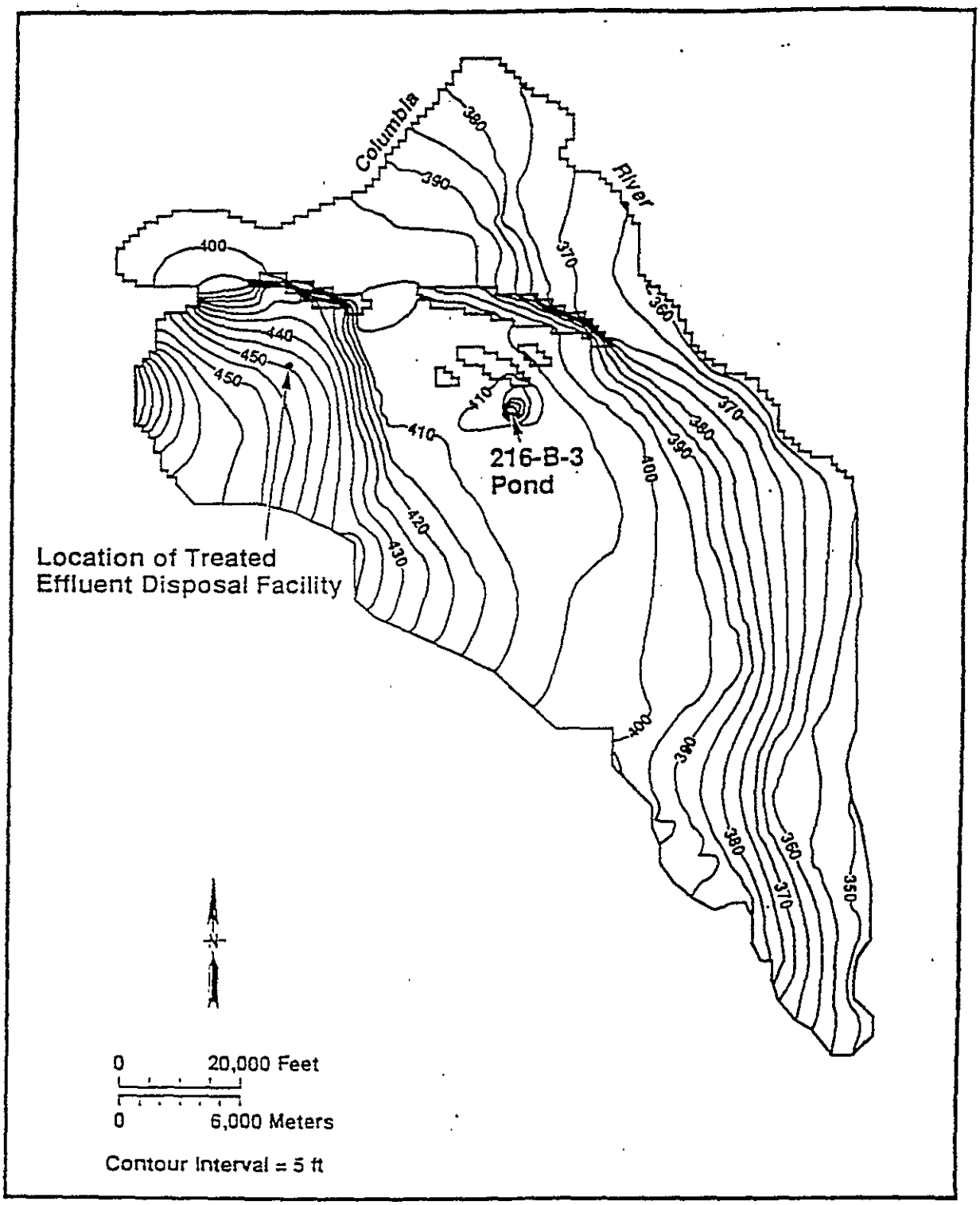
Tritium was assumed to decay in accordance with its half-life of 12.3 yr (corresponding to a first-order decay rate of 0.056 yr^{-1}. Based on its known behavior, tritium was assumed to move inseparably with the groundwater in the uppermost aquifer. Consequently, a retardation factor of 1.0 was used. The modeled volumetric flux of treated effluent entering the aquifer was 568 L/min (150 gal/min). The concentration of tritium in treated effluent entering the aquifer was assumed for purposes of the analysis to be 21 μCi/L, distributed evenly over model elements representing the entry area. Subsequent to the analysis, the expected concentration of tritium in the discharged effluent was revised substantially downward to 6.3E+06 pCi/L. Effective porosity values were assumed to be correlated with hydraulic conductivity and were estimated to range from 0.15 to 0.25 (Golder Associates 1991).

2.4.3.3 Interpretation of Two-Dimensional Solute Concentrations. Because the two-dimensional nature of the model portrayed the treated effluent as being instantaneously mixed throughout the entire modeled aquifer thickness of ~30 m (100 ft), the model depicted tritium concentrations in the aquifer as being proportional to the aquifer thickness. To compensate for this distortion the simulated concentration was scaled by a factor which reflected the likelihood that the treated effluent will not mix vertically throughout the aquifer thickness. Golder Associates (1991) assumed an arbitrary 6 m (20 ft) mixing depth, corresponding to the typical screened interval for Hanford Site monitoring wells in the uppermost aquifer.

2.4.3.4 Results. Contours of simulated hydraulic head after operation of the TEDF are shown in Figure 2-16. The results indicate that the proposed disposal of treated effluent at the projected rate will have relatively little effect on the local direction of groundwater movement. Reversal of the regional hydraulic gradient will extend only ~150 m (500 ft) to the southwest of the TEDF. Groundwater flow directions will remain essentially unchanged ~300 m (1,000 ft) from the TEDF (i.e., within 20° of the northeasterly regional flow direction).

Tritium transport simulations were run until steady-state conditions were achieved. A travel time from the TEDF to the Columbia River of at least 100 yr was indicated by the simulation results. Consequently, tritium's residence period in the uppermost aquifer would reduce its concentration at the Columbia River to less than 1/300 the level at the TEDF because of radioactive decay.

Figure 2-16. Simulated Hydraulic Head Contours for Time After Startup of Facility Operation. Assuming Steady-State Conditions.

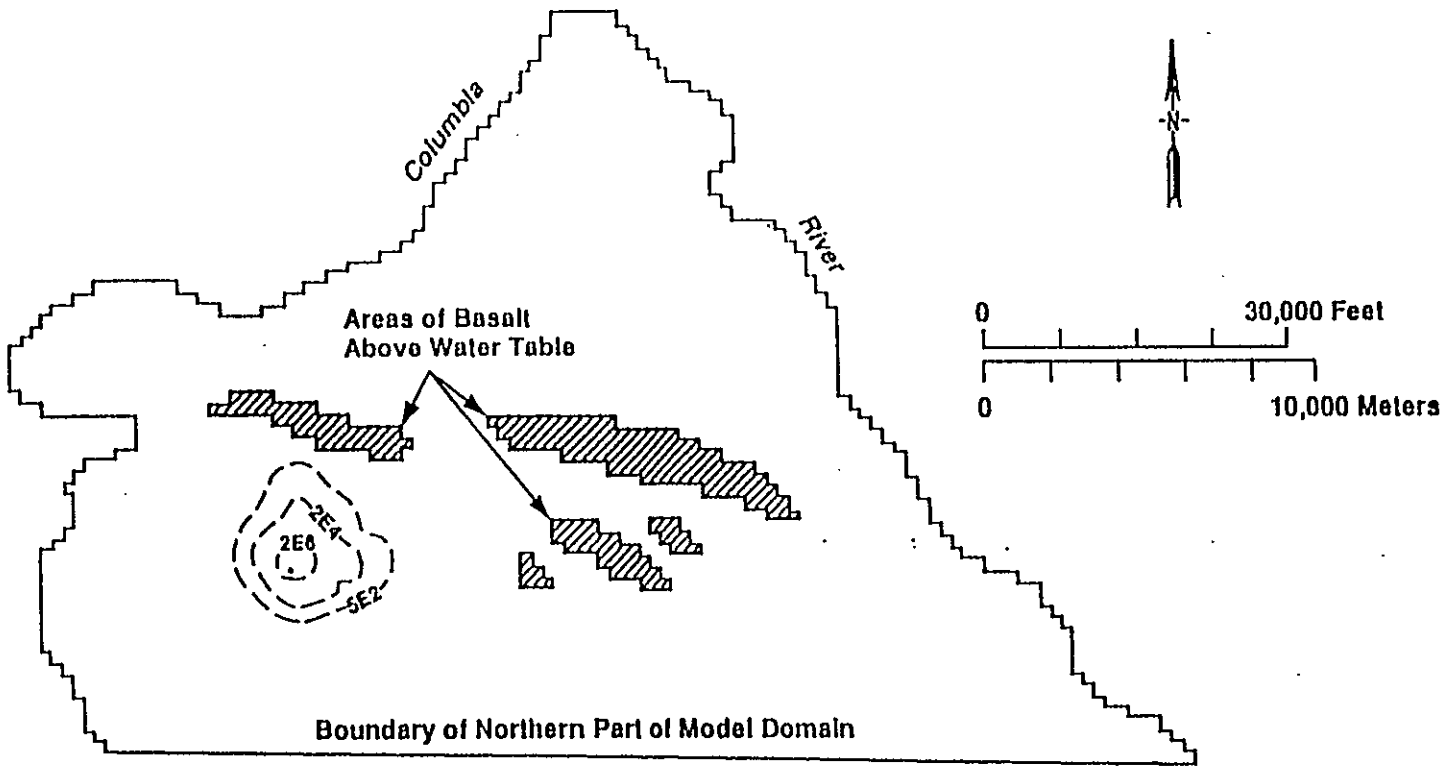


Because of the use of dispersivity values appropriate for the distance from the TEDF to the Columbia River throughout the model domain, tritium isoconcentration contours closer than several thousand feet from the TEDF are considered to have high uncertainty. Contours of simulated concentration were plotted for several intervals between the time of TEDF startup and the reestablishment of steady-state conditions ~205 yr later. These results are shown in Figures 2-17 through 2-21. As can be seen by comparing the figures, near steady-state conditions occur after 105 yr. Simulation results suggest that treated effluent initially migrates relatively slowly in the uppermost aquifer because of the comparatively low hydraulic conductivity of Ringold unit E in the vicinity of the TEDF, and accelerates as it passes through the Hanford formation gravels in the gap between Gable Mountain and Gable Butte.

Figures 2-22 through 2-25 show profiles of simulated tritium concentration in groundwater entering the Columbia River at the locations shown in Figure 2-26. The concentrations simulated at any given location along the river are subject to large uncertainties because a small change in direction of tritium migration due to high-permeability channels (USGS 1987) could have large effects on concentrations at the edge of the treated effluent plume. However, the estimated maximum concentrations of tritium entering along this reach of the river at the times shown are judged by Golder Associates (1991) to be considerably more accurate.

Profiles are shown for simulated tritium concentrations at 105, 125, 165 and 205 yr after initiation of TEDF operation. For steady-state conditions (205 yr), maximum tritium concentrations at the riverbank resulting from TEDF operations are predicted to be 0.14 μCi/L (14,000 pCi/L). This value is below the federal criterion of 0.02 μCi/L (20,000 pCi/L). Mixing and dilution are expected to reduce tritium levels in the Columbia River to a small fraction of the drinking water criterion within a short distance downstream of the riverbank discharge area.

Figure 2-17. Simulated Tritium Concentrations After 5 Years.



- Model assumed an effluent tritium concentration level of 21 µCi/L.

Legend:

5E2 Tritium Concentration in pCi/L

5E2 = 5×10^2

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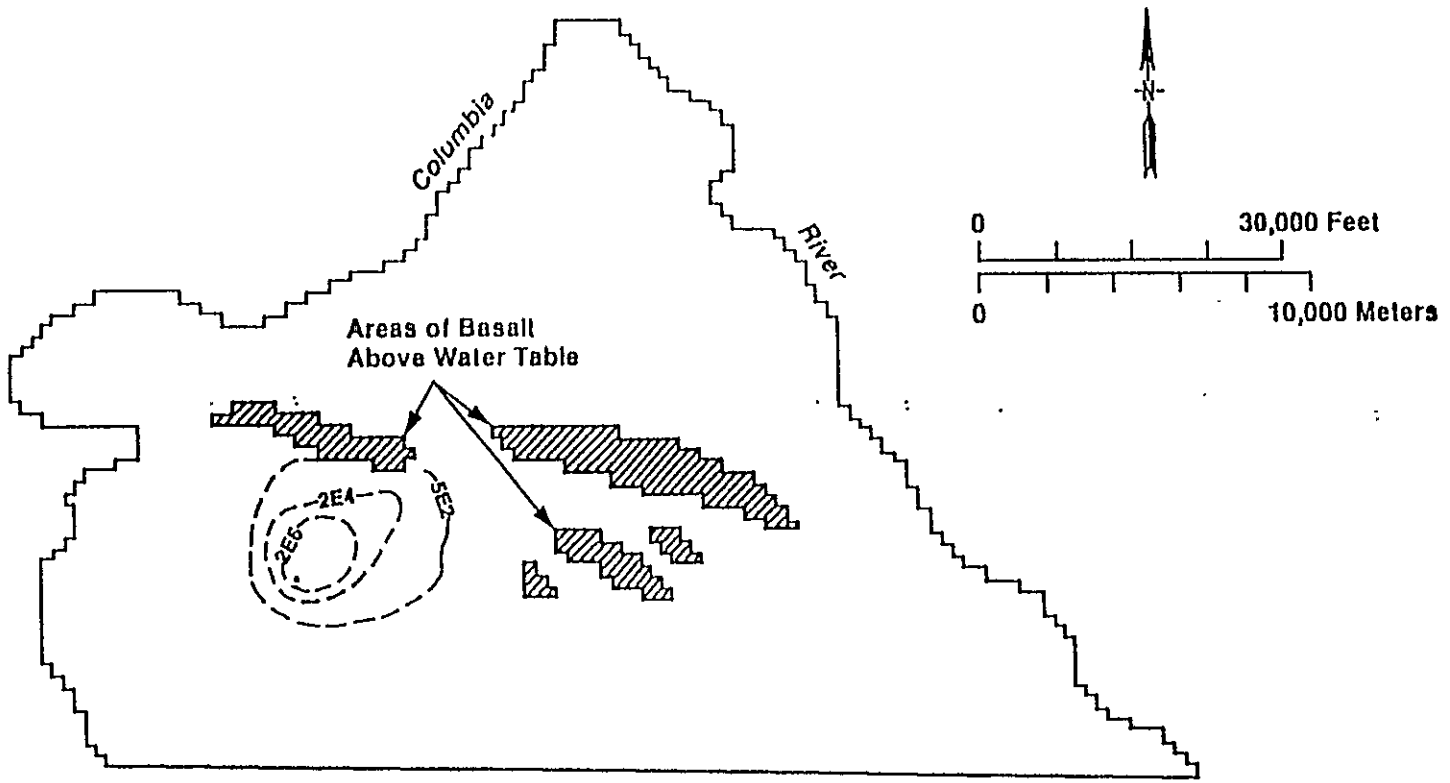
53

Figure 2-18. Simulated Tritium Concentrations After 55 Years.



- Model assumed an effluent tritium concentration level of 21 µCi/L.

Legend:

5E2 Tritium Concentration in pCi/L

5E2 = 5 x 10^2

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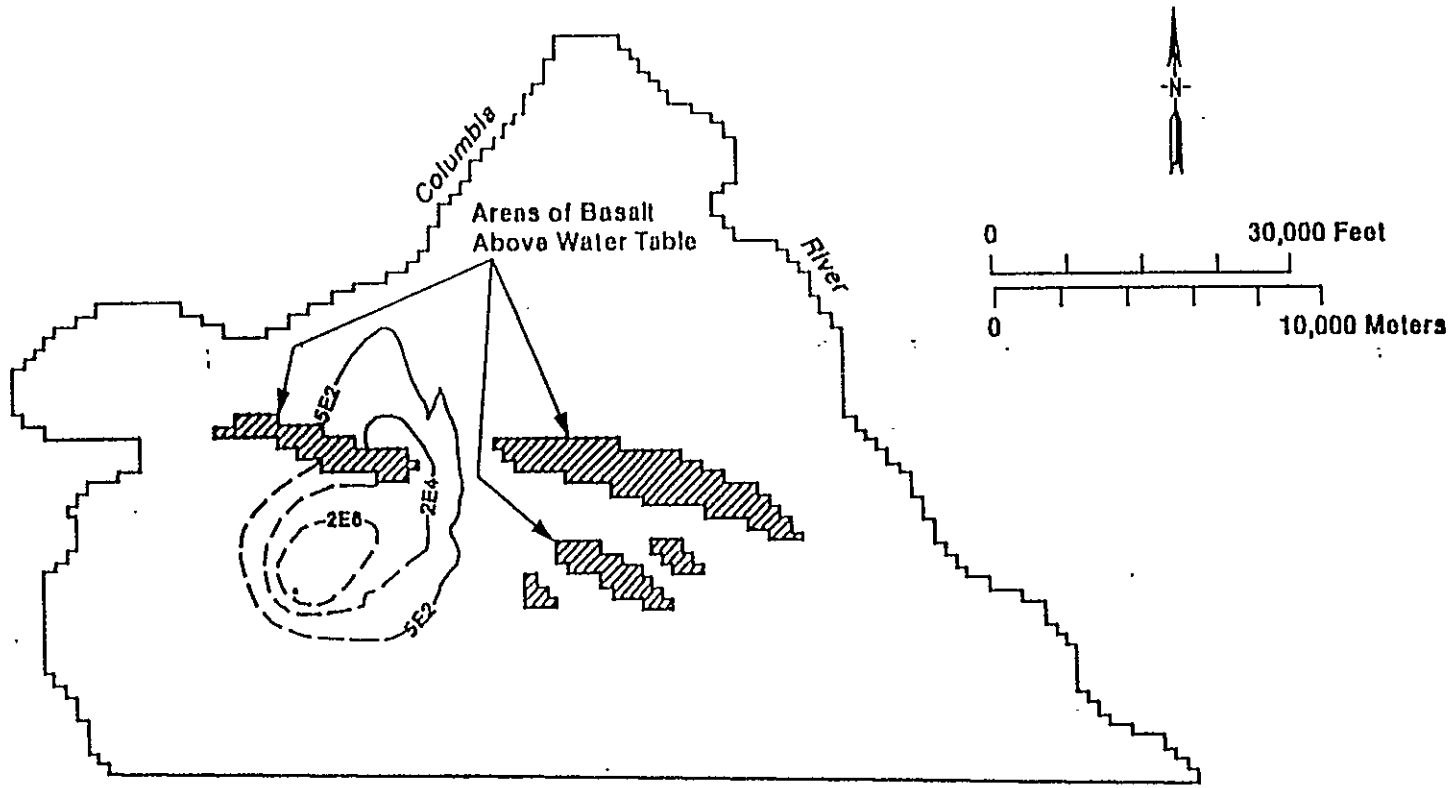
Figure 2-19. Simulated Tritium Concentrations After 85 Years.



- Model assumed an effluent tritium concentration level of 21 µCi/L.

Legend:

5E2 Tritium Concentration in pCi/L

5E2 = 5×10^2

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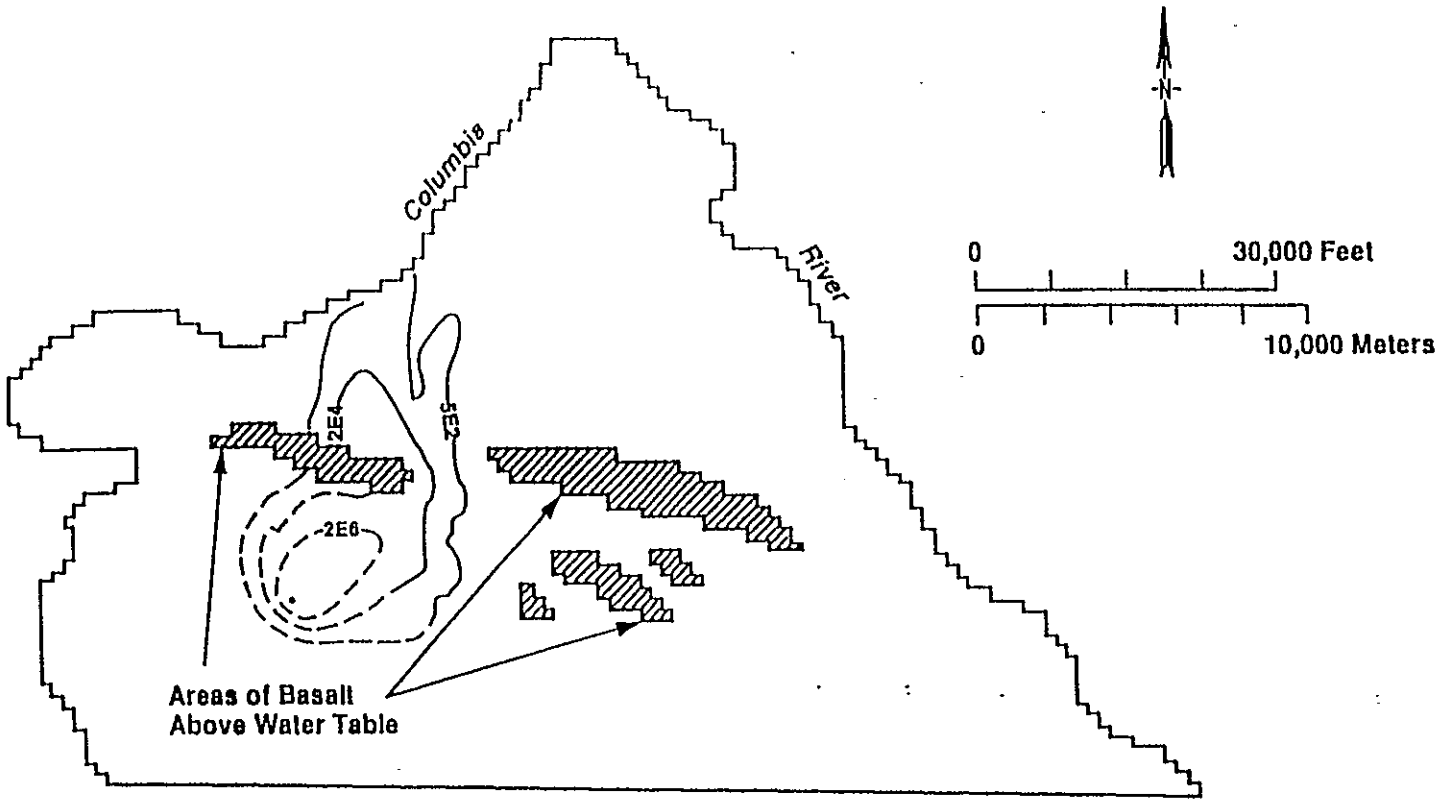
55

Figure 2-20. Simulated Tritium Concentrations After 150 Years.



- Model assumed an effluent tritium concentration level of 21 µCi/L.

Legend:

5E2 Tritium Concentration in pCi/L

5E2 = 5×10^2

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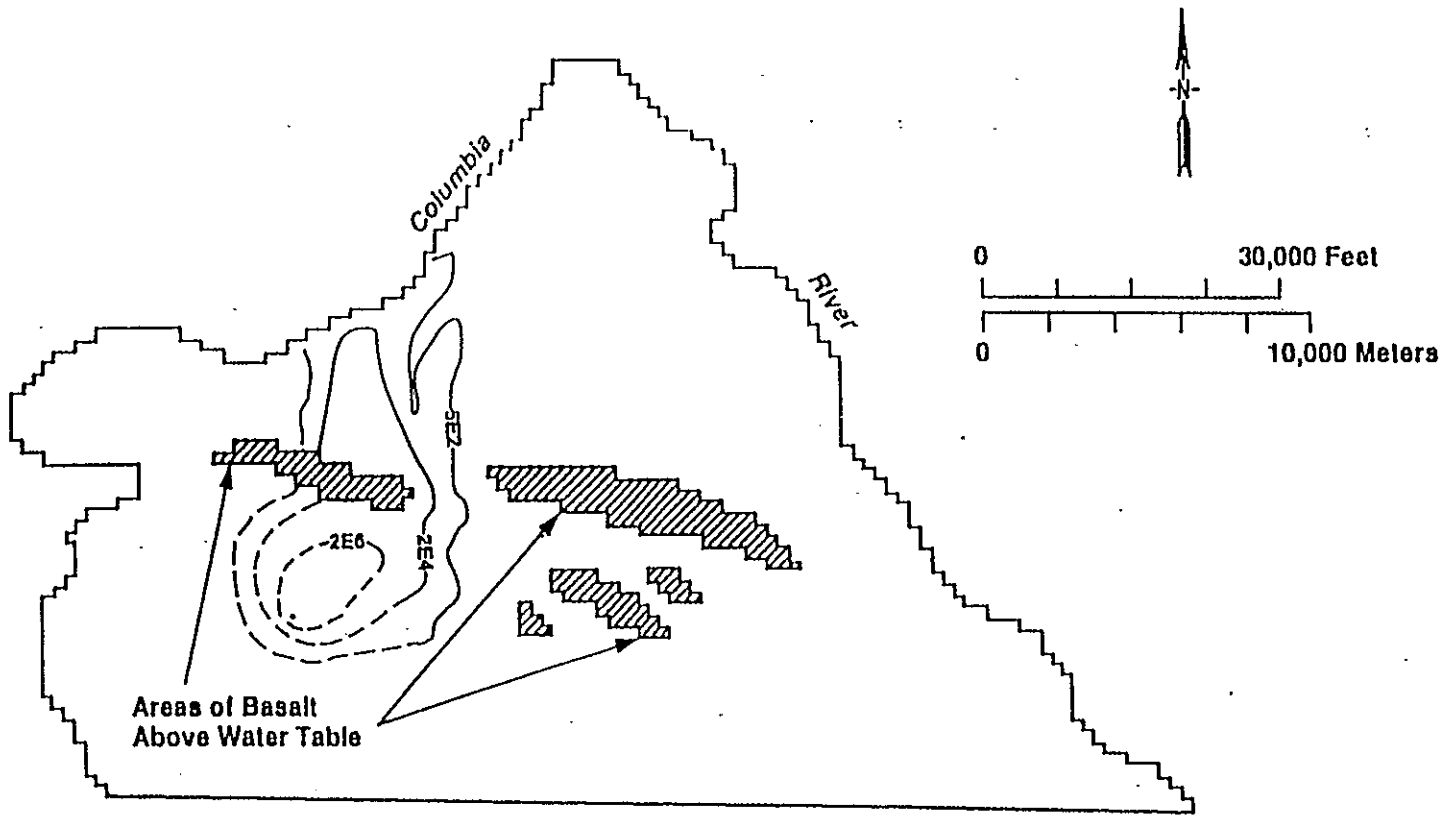
Figure 2-21. Simulated Tritium Concentrations After 205 Years.



- Model assumed an effluent tritium concentration level of 21 µCi/L.

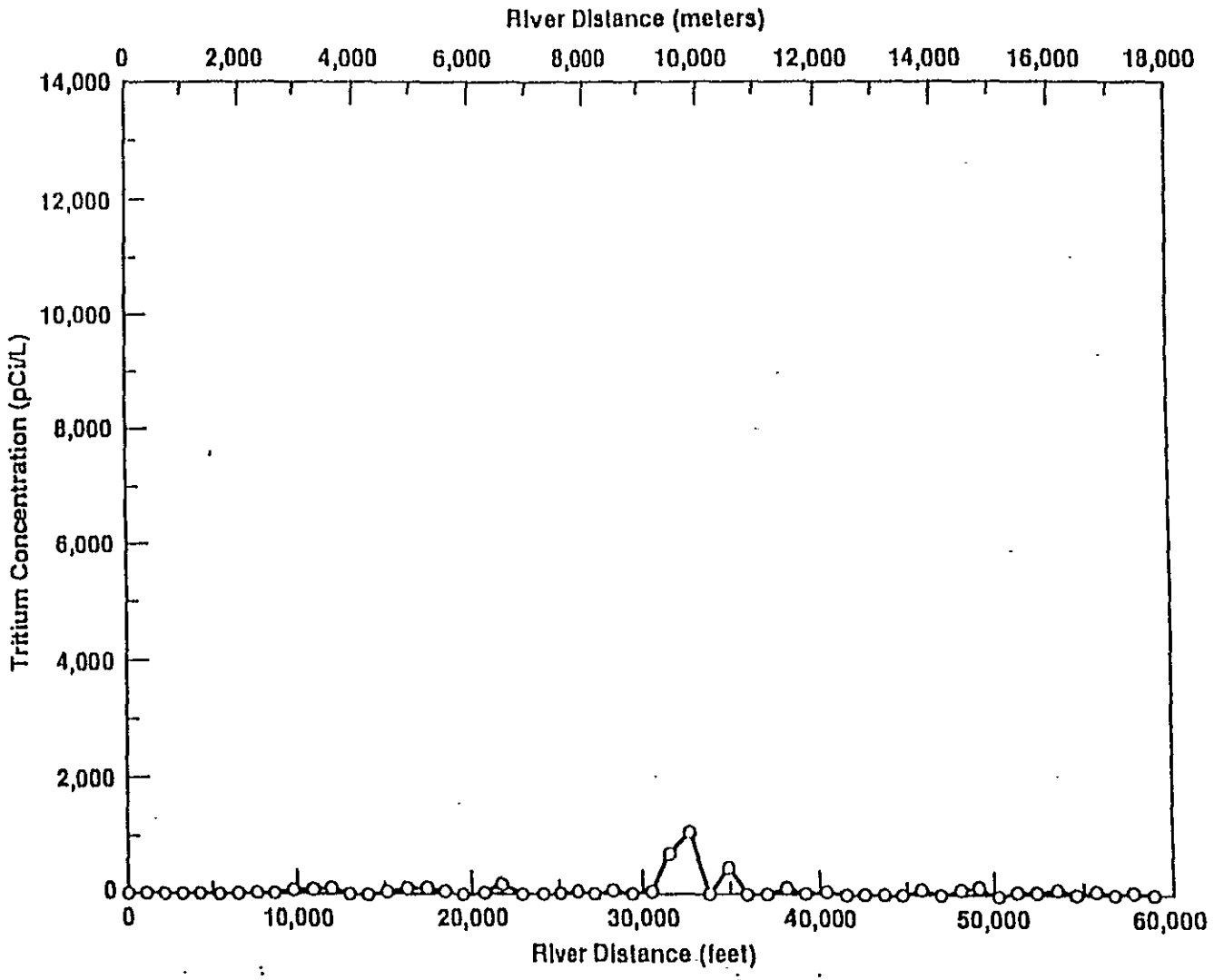
Legend:

5E2 Tritium Concentration in pCi/L

5E2 = 5×10^2

H9503006.16

57



See map of river distances on Figure 2-26

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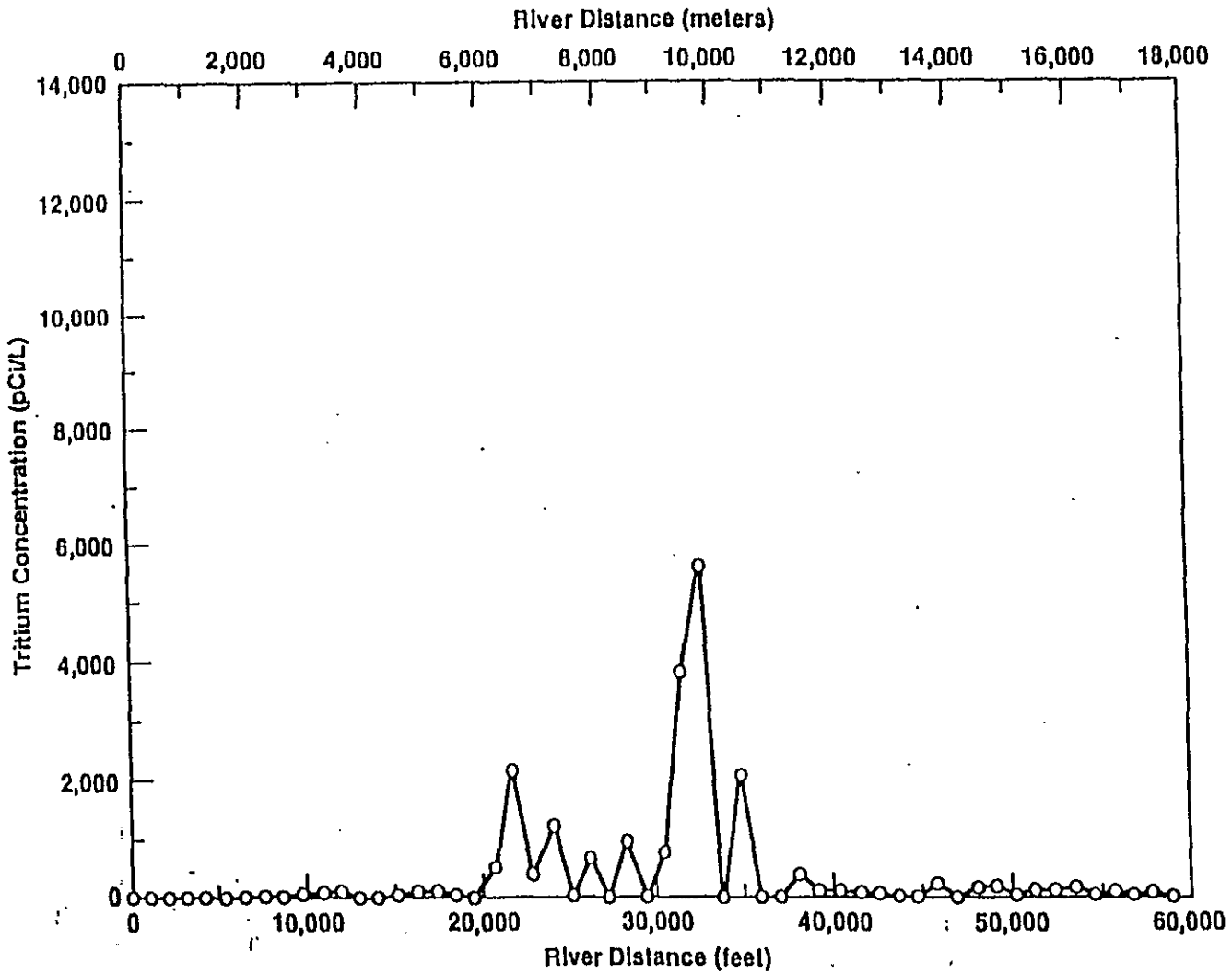
Figure 2-22. Simulated Profile of Tritium Concentration in Groundwater Entering the Columbia River after 105 Years.

Figure 2-23. Simulated Profile of Tritium Concentration in Groundwater Entering the Columbia River after 125 Years.



See map of river distances on Figure 2-26

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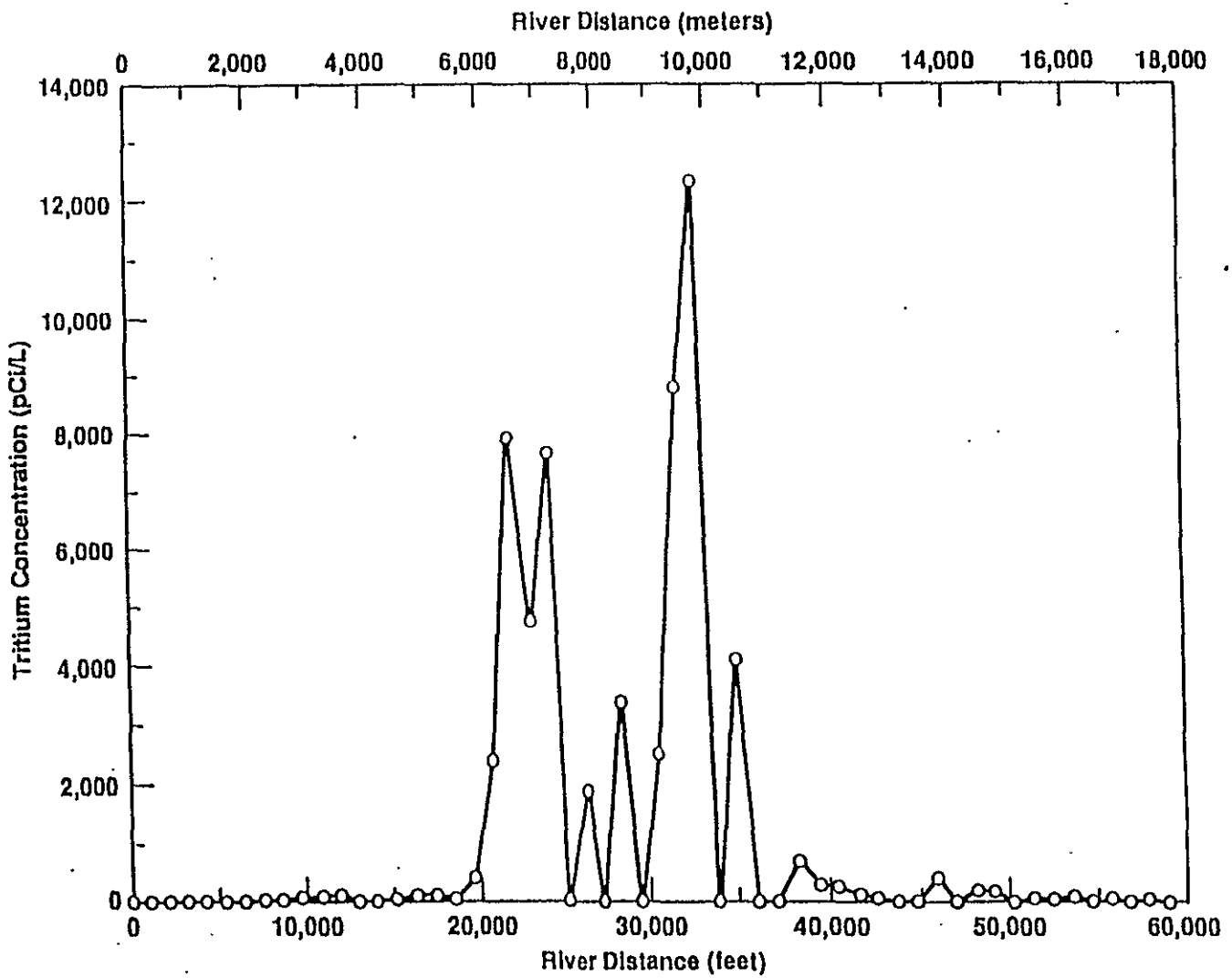
59



See map of river distances on Figure 2-26

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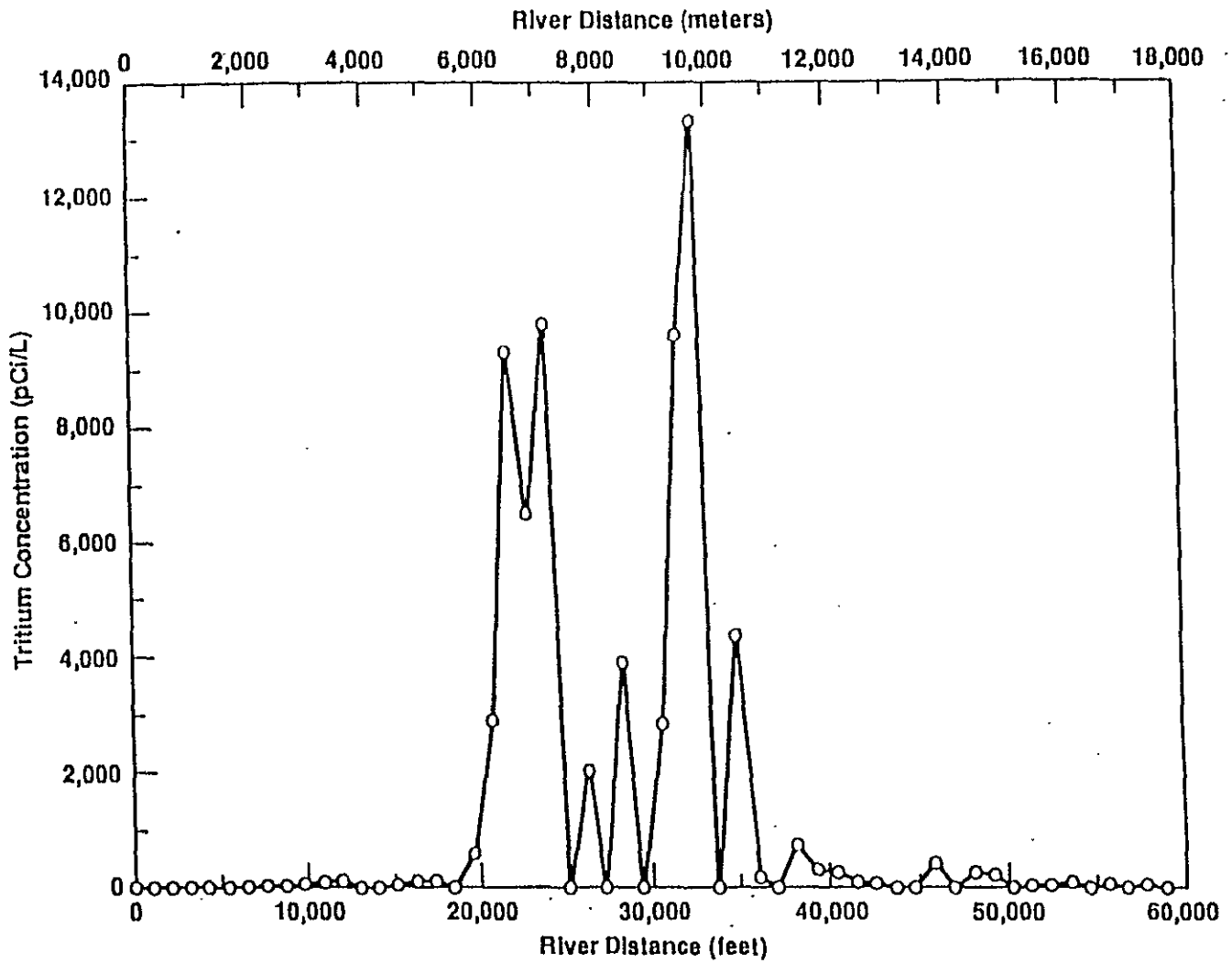
Figure 2-24. Simulated Profile of Tritium Concentration in Groundwater Entering the Columbia River after 165 Years.



See map of river distances on Figure 2-26

Figure 2-25. Simulated Profile of Tritium Concentration in Groundwater Entering the Columbia River after 205 Years.

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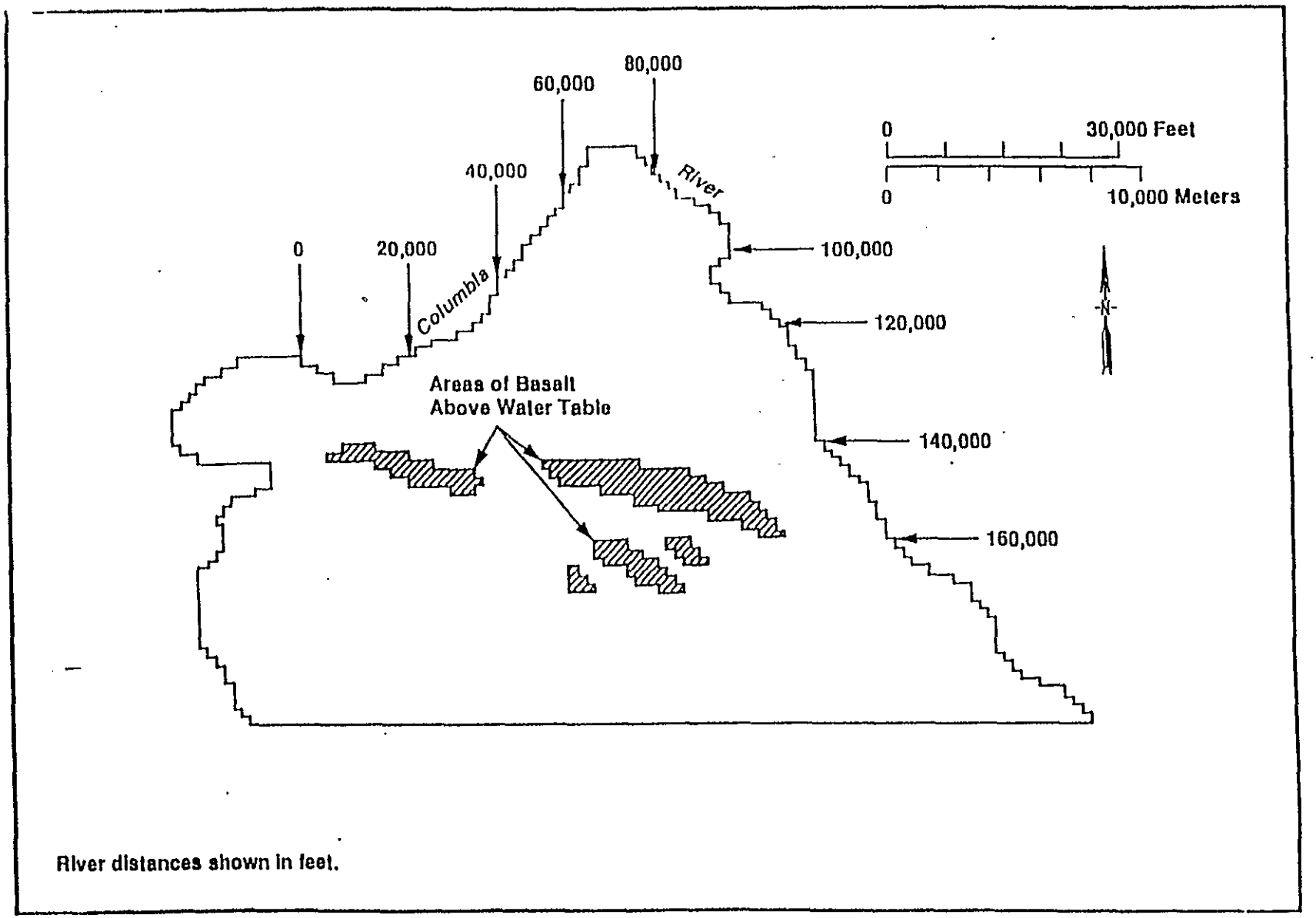

Figure 2-26. River Distances Used in Tritium Discharge Concentration Profiles.

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3.0 GROUNDWATER MONITORING PLAN

This chapter describes how the impacts on the environment of operating the TEDF will be assessed and identifies the documentation that will be provided to help ensure that operation of the facility is in compliance with groundwater quality standards. Section 3.1 addresses the objectives and scope of the monitoring. Section 3.2 identifies the media to be monitored. Section 3.3 describes the monitoring well network and its basis. Section 3.4 identifies the constituents that will be sampled and the analytical methods that will be used. Section 3.5 indicates how the monitoring data will be statistically evaluated. Section 3.6 describes the sampling and analytical protocol. Section 3.7 describes the well network that will be used to track movement of tritium from the discharge facility through the uppermost aquifer. Section 3.8 describes how the previous analysis of the effects of facility operations on the uppermost aquifer will be updated using groundwater monitoring data.

3.1 MONITORING OBJECTIVES AND SCOPE

The objectives and scope of groundwater monitoring at the TEDF derive from operating permit requirements, the geology and hydrology of the site, and discharge composition and volume.

The principal groundwater quality regulations applicable to the discharge, those of WAC 173-200, emphasize the nondegradation of current groundwater quality. The regulations require "establishment of an enforcement limit as near the natural groundwater quality as practical," and establishment of the point of compliance in groundwater "...as near the source as technically, hydrogeologically, and geographically feasible."

3.2 MEDIA TO BE MONITORED

Wastewater discharged to the TEDF will be sampled and analyzed in accordance with provisions of State Waste Discharge Permit ST-4500. Monitoring will include "end-of-pipe" sampling at the ETF, as well as continued groundwater monitoring at the TEDF. Groundwater will be sampled and analyzed in accordance with the permit provisions, as described by Sections 3.4, 3.5, and 3.6.

3.3 MONITORING WELL NETWORK DESIGN

Two boreholes were initially drilled at the TEDF site for hydrogeologic characterization and/or monitoring. Borehole 699-48-77A was drilled upgradient from the TEDF site and was completed as a RCRA-compliant groundwater monitoring well. Borehole 699-48-77B was abandoned at a depth of 18 m (~60 ft) when it began to substantially deviate from vertical (Figure 2-4).

Based on data from these boreholes and results from computer modeling (Golder Associates 1992) of the effluent-capture efficiencies of alternative locations for downgradient monitoring, wells 699-48-77C and 699-48-77D were drilled at the locations shown in Figure 2-4. Like well 699-48-77A, these RCRA-compliant wells were completed in the Ringold unit E fluvial gravel to monitor groundwater in the upper portion of the uppermost aquifer. Well 699-48-77A is ~91 m (300 ft) from the south edge, well 699-48-77C is ~13 m (40 ft) from the east edge, and well 699-48-77D is ~5 m (16 ft) from the north edge of the TEDF (Figure 2-4).

The locations and screened intervals of the two downgradient wells proposed to monitor groundwater quality were chosen based on the need to (1) comply with the *Hanford Site Groundwater Protection Management Program* (DOE-RL 1989), (2) monitor the upper part of the uppermost aquifer downgradient from the TEDF, (3) maximize the monitoring life of the wells based on the predicted change in direction and elevation of groundwater flow resulting from the cessation of discharges to U Pond in the 200 West Area, and (4) maximize the efficiency of the monitoring wells in capturing treated effluent.

Success in meeting the fourth need was evaluated by using a monitoring-efficiency model (Golder Associates 1992) to predict where treated effluent discharged to the TEDF would most likely be detected by two downgradient monitoring wells, given a range of potential downgradient flow directions. The predictions were evaluated in terms of which locations most closely approached 100% efficiency in monitoring the simulated area of the treated effluent plume. Modeling results from the two downgradient wells shown in Figure 2-4, for the likely range of potential downgradient flow directions, are summarized in Table 3-1.

Table 3-1. Modeling Results for Downgradient Monitoring Well Efficiencies.

Direction of hydraulic gradient	Predicted groundwater monitoring efficiency (%)
N 20° E	99.2
N 30° E	98.8
N 40° E	98.7
N 50° E	97.5

The upgradient well (699-48-77A) will continue to be used for future background water-quality monitoring. Continued use of this well to monitor background water quality for the TEDF is justified based on its RCRA-compliant construction and results from the monitoring efficiency model (Figure 3-1). This model was used to locate the TEDF downgradient of well 699-48-77A such that the well would have a 99% probability of detecting any change in the quality of water upgradient from the TEDF, for a hydraulic gradient direction of N 30°E (Figure 3-1).

3.4 CONSTITUENTS TO BE SAMPLED

Future analyses of groundwater from the three monitoring wells will be used to determine if groundwater quality has changed from the baseline, pre-operations condition. The constituents to be monitored are based on residual constituents potentially contained in the wastewater discharged to the TEDF. These constituents are discussed in the sections that follow in the context of the baseline groundwater monitoring results, as discussed in Section 2.3.4. Also discussed are the corresponding analytical methods to be used. Constituents to be sought and their highest allowable concentrations are listed in Table 3-2.

Figure 3-1. Optimization Modeling for Upgradient Well.

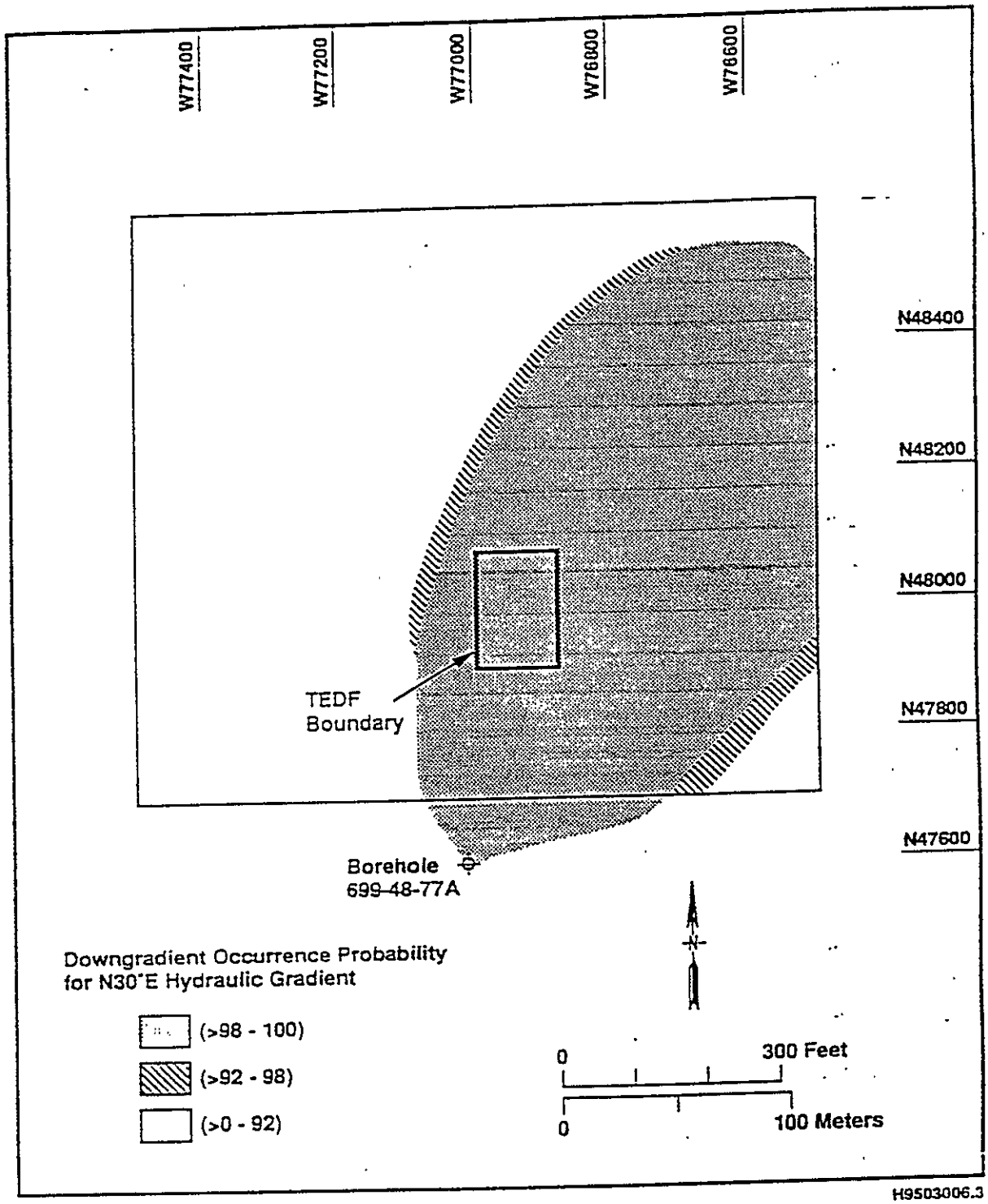

Table 3-2. Analytes to be Monitored in the Treated Effluent Disposal Facility Wells. (from Washington State Waste Discharge Permit ST-4500, 1995)

Constituent or characteristic	Highest allowable concentration (PPB) unless noted otherwise[a,b]
acetone	160[c]
ammonia	1,000[c]
benzene	5
cadmium, total	10
chloroform	6.2[c]
copper, total	70[c]
lead, total	50
mercury, total	2
pH, in pH units	6.5 to 8.5
sulfate	30,000[c]
tetrahydrofuran	100[c]
total dissolved solids	500,000
gross alpha	(pCi/L)[b] monitor only[d]
gross beta	(pCi/L)[b] monitor only[d]
strontium-90	(pCi/L)[b] monitor only[d]
tritium	(pCi/L)[b] monitor only[d]

Note: Enforcement limits shall be met in groundwaters collected from monitoring well numbers 699-48-77C and 699-48-77D.

[a] Defined as the average of all measurements from a well during a quarterly reporting period. The four quarters are defined as January through March, April through June, July through September, and October through December. At least one (1) sample will be analyzed and reported for each of the above constituents during each quarter.

[b] Parts per billion (micrograms per liter). pCi/L (picoCurie per liter).

[c] Noncompliance with these permit limits, up the water-quality-based limit per Chapter 173-200 WAC, if one exists, is not subject to penalty but is subject to the requirements of Special Condition No. 4.

[d] Constituents which require "monitoring only" have not been assigned permit limits or early warning values, but must be sampled, analyzed, and reported by the Permittee pursuant to this permit.

3.4.1 Turbidity and Other Field Parameters

Turbidity will be measured in the field to ensure consistent sample quality (see Section 2.3.4.1). Quadruplicate measurements of pH, SC, temperature, alkalinity, and turbidity will be made. Measurements of temperature, alkalinity, and turbidity will be made prior to groundwater sample collection. These measurements will aid in determining if groundwater quality is changing from the baseline, pre-operations condition.

3.4.2 Cations and Anions

Total cation milliequivalents (calcium, magnesium, potassium, and sodium), total anion milliequivalents (nitrate, sulfate, chloride, and alkalinity), SC, and TDS will be evaluated by means of the equations noted in Section 2.3.4.2. The results of the evaluation of anion and cation analyses will be used to confirm the results of SC measurements. The differences between water quality in the upgradient well (699-48-77A) and the two downgradient wells (699-48-77C and 699-48-77D), as well as differences in each monitoring well for different sampling dates, will be evaluated based on results of the cationic and anionic analyses.

3.4.3 Metals

Total dissolved metals will be analyzed in groundwater samples from each well. The metals that will be sought are listed in Table 3-2. Both filtered and unfiltered samples will be analyzed for metals for two reasons. First, the baseline water quality data reported in Section 2.3.4 show considerable sensitivity to well construction or sampling variability when comparisons are made between filtered and unfiltered samples. Analyses of both types of samples will aid in identifying these sensitivities. Second, strict criteria for consistency in the maximum allowable purging and sampling rates will be imposed to ensure that the sampling rate is commensurate with the pumping rate used during well development. These criteria are imposed to limit sample turbidity to acceptable values (see Section 2.3.4.1). Analytical data for metals sought in samples of groundwater collected during facility operation will be compared with pre-operation data to evaluate changes, if any, in groundwater quality.

3.4.4 Organic Compounds

Analyses will be made both for gross indicators of organic compounds and specific organic compounds. Samples for TOX and TOC will be collected and analyzed in quadruplicate because of the large known variability in analytical results for TOX and TOC. These data will be compared with the baseline data collected before TEDF operations begin to assess changes, if any, in groundwater quality. Specific organic compounds that will be sought are listed in Table 3-2.

3.4.5 Radionuclides

Radionuclides have been identified as potential residual constituents of wastewater discharged to the TEDF. Analyses will be made for gross indicators and specific isotopes (listed in Table 3-2). These data will be compared with the baseline data collected before TEDF operations begin to assess changes, if any, in groundwater quality.

3.5 STATISTICAL EVALUATION OF GROUNDWATER MONITORING DATA

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3.6 SAMPLING AND ANALYTICAL PROTOCOL

This section describes or references procedures for well purging, documentation of sample collection methods, chain-of-custody requirements, and laboratory analyses. Detailed descriptions of standard sampling and analysis procedures for specific analytes are provided by reference to the corresponding environmental investigations instructions (EIIs) (WHC 1988). Subcontractors will be contractually required to perform work according to preapproved standard operating procedures.

3.6.1 Well Purging

All sampling activities performed at the well sites will be recorded in the proper field logbook, as specified by EII 1.5, Field Log Books. Hydrostar pumps will continue to be used in existing monitoring wells for purging and sampling. Prior to sampling each well, the static water level will be measured and recorded as specified by EII 10.2, Measurement of Groundwater Levels. Based on the measured water level and well construction specifications, the volume of water in the well will be calculated and documented in the well sampling form and field notebook. As specified by EII 5.8, Groundwater Sampling, each well will be purged prior to sampling until the approved criteria are met. Purgewater will be managed according to EII 10.3, Purgewater Management. For instances in which the well is pumped dry because of very slow recharge, the sample will be collected after recharge. Samples will be collected and preserved in the field as specified by EII 5.8. Sampling personnel have the option not to decontaminate equipment if either single-use or dedicated sampling equipment is used.

The purge and sample collection pumping rates used at each of the three monitoring wells will be limited in accordance with the following criteria (see also Section 2.3.4). The monitoring wells were constructed to RCRA standards (WHC 1992) and were developed to a turbidity of less than <5 NTU. Hence, the pumping rate will be sufficiently slow and/or the pumping duration lengthened to achieve ≤ 5 NTU before samples are collected. Well 699-48-77A will be purged and samples collected at a pumping rate no greater than 5 L/min (1.5 gal/min). Well 699-48-77C will be purged and samples collected at a pumping rate no greater than 5 L/min (1.25 gal/min). Well 699-48-77D will be purged and samples collected at a pumping rate no greater than 42 L/min (11.1 gal/min).

3.6.2 Sample Collection

After the wells have been purged in accordance with the turbidity criteria described in Section 3.6.1, quadruplicate measurements of pH, SC, alkalinity, and temperature will be made to verify stability of the groundwater during sampling. The four replicate measurements will allow statistical evaluation of these indicator parameters to be made for subsequent use in evaluating water quality. After sample bottles are filled, they will be placed in an insulated cooler containing ice for transport to the laboratory.

3.6.3 Sample Analysis

Table 3-2 identifies constituents of concern monitored in groundwater at the TEDF. Corresponding analytical methods were selected from those listed in SW-846 (EPA 1992).

The analyses will be performed in a Washington State accredited laboratory. Laboratory QA requirements will, at a minimum, comply with the *Hanford Analytical Services Quality Assurance Plan* (DOE-RL 1994b).

3.6.4 Quality Control

The QC program is based on Chapter One of SW-846, "Quality Control" (EPA 1992). Analytical samples are subject to in-process QC measures in both the field and laboratory.

QC samples prepared without the knowledge of the analytical laboratory are called "external" QC samples; QC samples prepared by the analytical laboratory and used to establish and continue the quality of the analytical laboratory are called "internal" QC samples. Two types of external QC samples will be collected and used to evaluate quality in the field and laboratory: (1) a field duplicate sample and (2) two different types of blank samples. One duplicate sample will be collected during each sampling event and will be analyzed for all of the constituents listed in Table 3-2. A daily trip blank sample will be collected for each day that wells are sampled. One transfer blank sample will be collected during each sampling event. Both blank samples will be collected and analyzed only for volatile organic constituents.

The internal QC samples analyzed in the laboratory will consist of (1) matrix duplicate or matrix-spike duplicate samples, (2) laboratory control samples, (3) surrogate compound-spiked samples, (4) reagent-blank samples, and (5) calibration-check samples. These QC samples meet the minimum requirements, as applicable, for each analytical method specified in Table 3-2.

If the integrity of laboratory data is compromised, the analytical laboratory will notify the data user via nonconformance reports and/or records of decision.

3.7 TRITIUM TRACKING

Section S7.B of Permit ST-4500 requires the permittee to identify groundwater monitoring wells that will comprise the tritium tracking network for the facility and to report the results from this monitoring network at least annually. The network will monitor the location, concentration, and movement in groundwater of tritium discharged to the TEDF. This section describes the current monitoring of tritium in groundwater near the disposal facility and describes the wells that will be used to monitor facility operation.

3.7.1 Current Tritium Monitoring in the Vicinity of the Disposal Facility

Numerous wells in the immediate vicinity of the disposal facility are currently monitored for tritium. This monitoring occurs in conjunction with RCRA groundwater monitoring by WHC for the Low-Level Waste Burial Grounds (LLWBG), and the sitewide Groundwater Surveillance Project.

Figure 3-2 illustrates the results of tritium monitoring for Low-level Waste Management Area 5 (LLWMA-5) and the Groundwater Surveillance Project. A tritium plume is emanating from an as-yet undetermined source (Dresel et al. 1994) southeast of the disposal facility and due south of LLWMA-5. As the histograms in Figure 3-2 show, little change has occurred in the concentration of tritium at LLWMA-5 since the first quarter of 1993 (Mercer 1995). Currently, the northwest edge of the tritium plume is roughly 760 m (2,500 ft) southeast of the disposal facility.

Figure 3-3 shows nearby wells in the potential flow paths effluent discharged to the disposal site. Most of these wells are currently monitored for tritium by the Groundwater Surveillance Project. Sampling schedules and constituent monitoring lists for these wells are provided by Bisping (1995). Most wells shown in Figure 3-3 that are not currently sampled are serviceable and could be sampled for tritium, if needed. The wells furthest from the disposal site would be needed only after several decades of facility operation, based on travel times estimated for the treated effluent (see Section 2.4).

3.7.2 Wells Identified to Track Migration of Tritium from the Disposal Site

Figure 3-4 shows all serviceable groundwater monitoring wells near the facility. Each of these wells currently is being monitored for tritium on a quarterly, semiannual, or annual basis by the RCRA/Operational Monitoring Program, Liquid Effluents Program, or the Groundwater Surveillance Project. Consequently, these wells are proposed as the tritium tracking wells required by the discharge permit. Table 3-2 lists pertinent information for the wells and Appendix E provides well construction details.

Four of the wells; 699-48-77C, 699-48-77D, 699-48-71, and 699-51-75 are hydraulically downgradient of the disposal site. Well 699-48-71, although technically downgradient, is not within a probable flow path of the treated effluent. Nevertheless, it was also selected for monitoring because of its proximity to the facility.

Well 699-48-77A and 18 wells around the LLWBG facilities are to the south and are hydraulically upgradient from the disposal site. These wells were selected for inclusion in the tritium tracking network primarily for two reasons; to monitor potential encroachment by the tritium plume emanating from the area southeast of the facility, and to provide for the contingency that treated effluent discharged to the facility could flow southward (down slope) along the top of the relatively-impermeable Plio-Pleistocene/early Palouse soil unit. As noted in Section 3.7.1, historical trends and hydrogeologic data do not indicate that such encroachment is likely. However, monitoring of the tritium plume emanating from within the 200 West Area will continue to determine whether the changing hydraulic potential in the area changes the current direction of movement of this tritium plume, and to distinguish this plume from that which will emanate from the disposal facility.

If tritium monitoring in any well identified in Table 3-3 is discontinued by the existing programs, the importance of the well to the tritium tracking network established for Permit ST-4500 will be reevaluated by the Liquid Effluents Program. If the need for continued monitoring of the well is determined to be critical, based on prevailing hydraulic conditions, tritium sampling and analysis will be continued.

Figure 3-2. Tritium Concentrations in Groundwater in the Vicinity of the Disposal Facility.

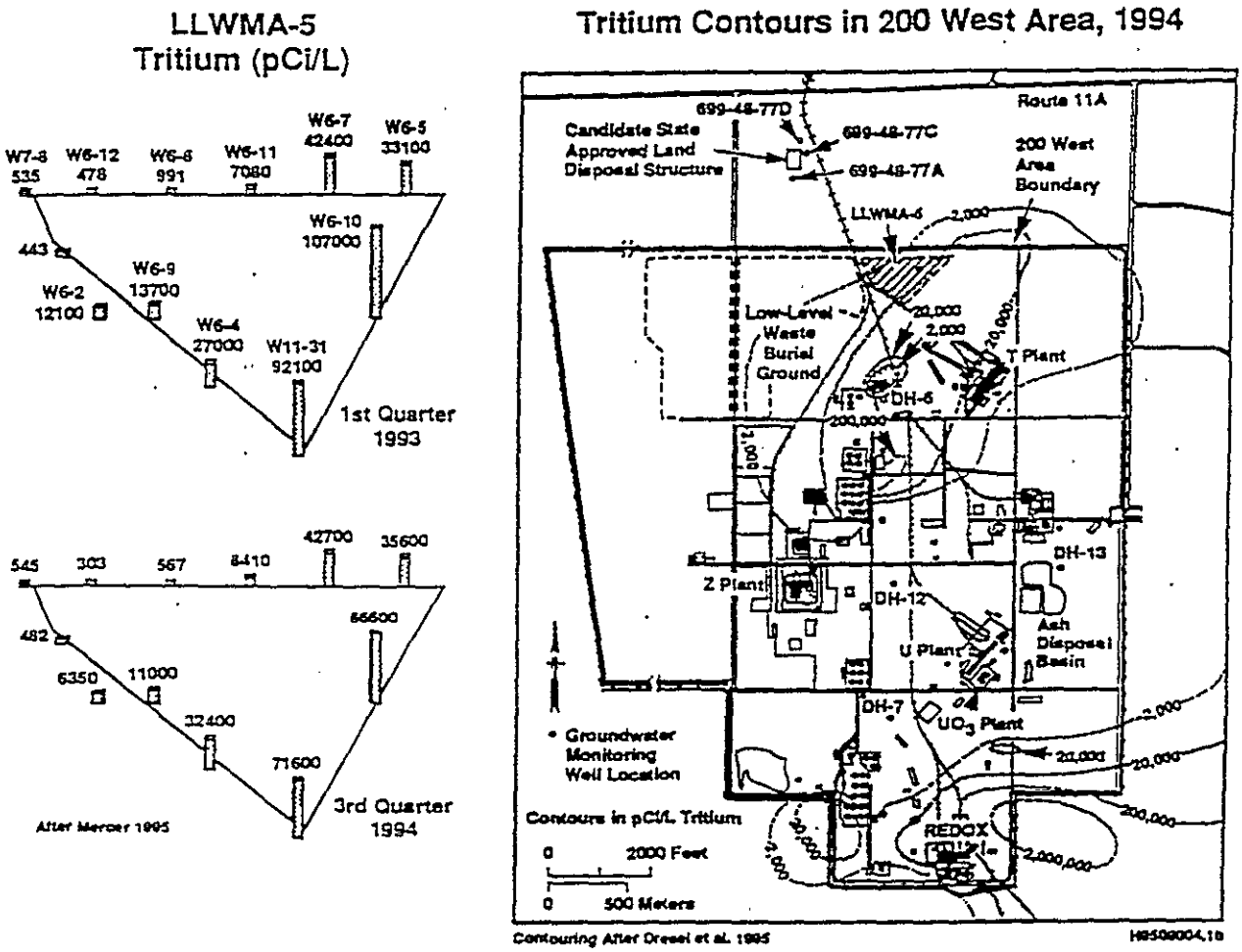
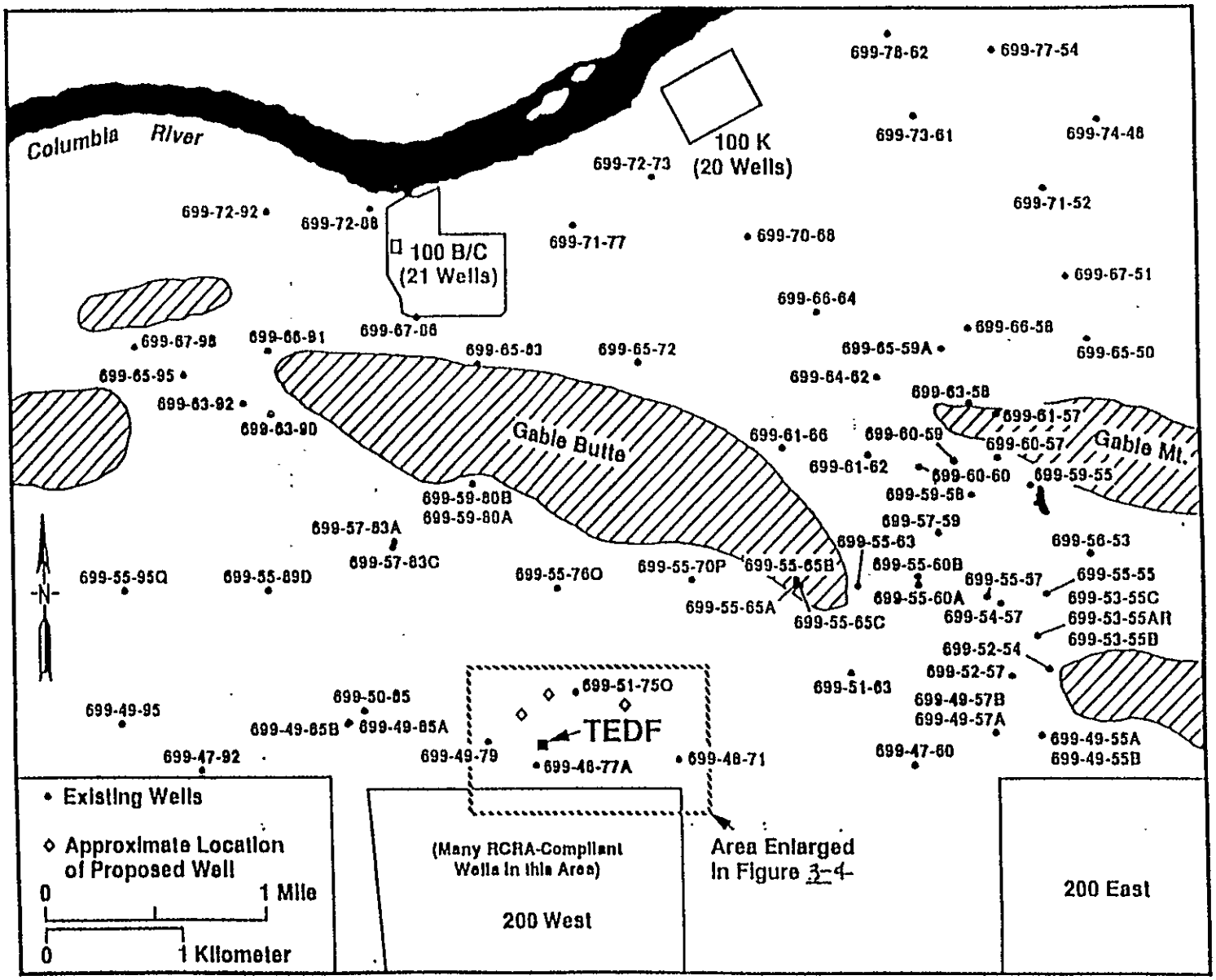


Figure 3-3. Well Locations in the Northern Portion of the Hanford Site.



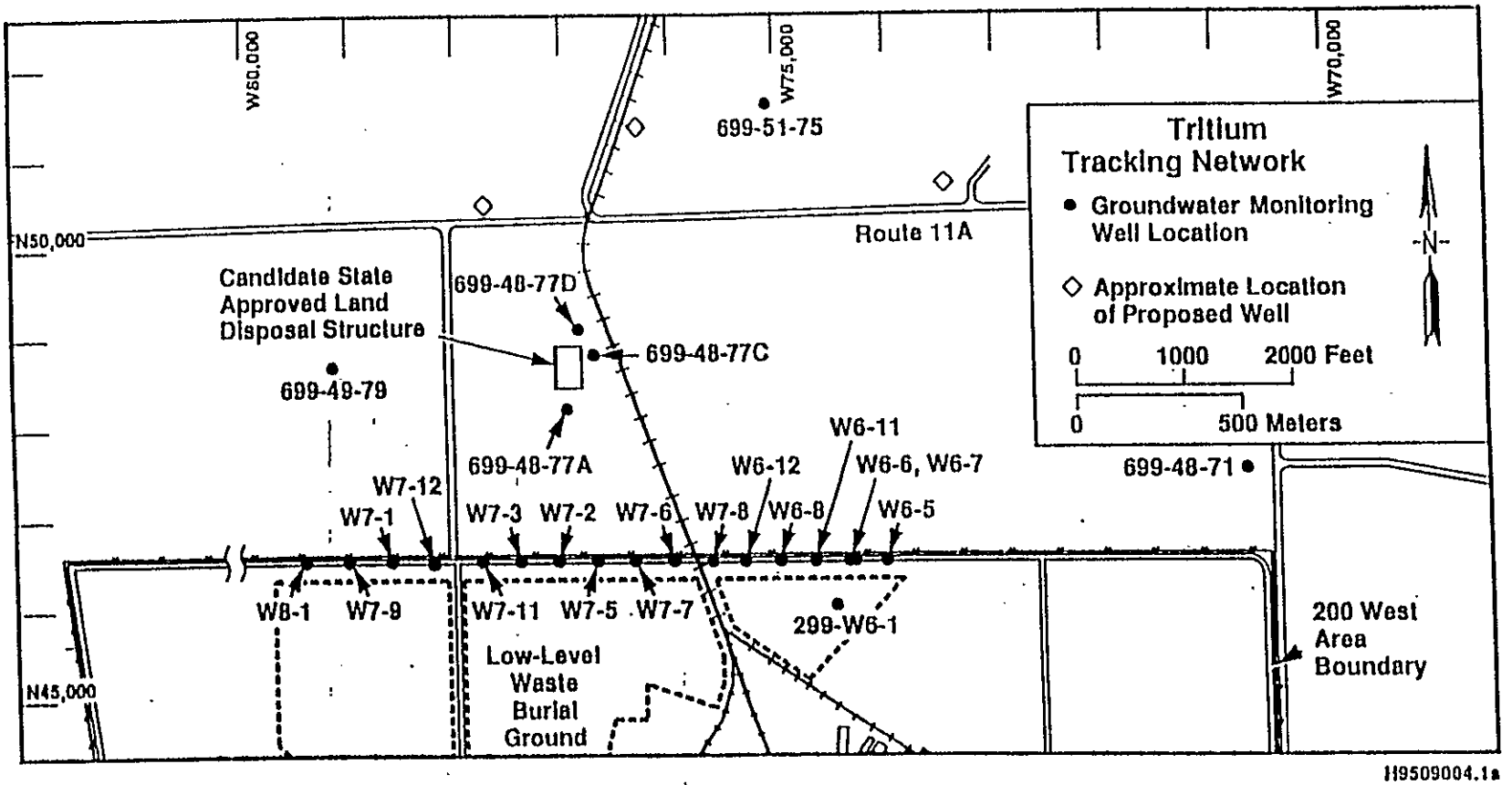


Figure 3-4. Wells Proposed for Tracking the Movement of Tritium in the Vicinity of the Disposal Facility.

Table 3-3. Groundwater Monitoring Wells Used for Tritium Tracking Network at State-Approved Land Disposal Sites.

Well number	Well location relative to facility	Well construction standard	Hydrogeologic unit and location of screen	Current tritium sampling frequency
299-W6-5	upgradient	RCRA	Ringold: unconfined upper portion of aquifer	SA
299-W6-6	upgradient	RCRA	Ringold: unconfined, lower portion of aquifer	SA
299-W6-7	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W6-8	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W6-11	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W6-12	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W7-1	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W7-2	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W7-3	upgradient	RCRA	Ringold: unconfined, lower portion of aquifer	SA
299-W7-5	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W7-6	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W7-7	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W7-8	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W7-9	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W7-11	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W7-12	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
299-W8-1	upgradient	RCRA	Ringold: unconfined, upper portion of aquifer	SA
699-48-71	downgradient	pre-RCRA	Ringold: water table	SA
699-48-77A	upgradient	RCRA	Ringold unit E: confined, upper portion of aquifer	Q
699-48-77C	downgradient	RCRA	Ringold unit E: confined, mid-to-lower portion of aquifer	Q
699-48-77D	downgradient	RCRA	Ringold unit E: confined, upper portion of aquifer	Q
699-49-79	downgradient	pre-RCRA	Ringold	A
699-51-75	downgradient	pre-RCRA	Ringold: confined (?)	A

A = annually
SA = semiannually
Q = quarterly

3.7.3 Evaluation of Monitoring Network

Groundwater flow velocities and tritium travel times from the discharge site to the Columbia River have been estimated by numerical modeling and direct-measurement techniques (see Section 2.4). Based on these methods, the time required for tritium discharged to the disposal site to be observed at groundwater monitoring wells surrounding the facility can be estimated. The current estimates will be updated based on the results of groundwater flowmeter measurements and consequent refinement of modeling input data. The increased hydraulic head from facility operation will also be determined and accounted for in model predictions.

If the arrival time of treated effluent at selected downgradient monitoring wells significantly differs from the times predicted by flowmeter and modeling methods, consideration may be given to installing additional monitoring wells. If needed, these wells would provide additional areal coverage to ensure interception of the treated effluent. The differential between predictions and observations that will be allowed before new wells are installed will be determined by the facility compliance officer.

3.8 UPDATE OF NUMERICAL ANALYSES OF THE EFFECTS OF FACILITY OPERATION ON THE UPPERMOST AQUIFER

In accordance with the requirements of Special Condition S7.B of State Discharge Permit ST-4500, this section contains plans for updating and maintaining predictive, computer-encoded conceptual and numerical models of groundwater flow and tritium transport for treated effluent originating at the TEDF. The revised and recalibrated models will be used to update the groundwater flow and contaminant transport predictions described in Section 2.4.3. Update of those 1991 analyses will be accomplished by using current information on the volume, composition, and durations of treated effluent discharges to the facility, site-specific hydrogeologic information collected since the date of the last analyses, and by using water-quality and hydraulic-head data collected from tritium-tracking wells (see Section 3.7) during the initial 5-yr period of facility operation authorized by the current discharge permit.

The updated prediction will be revised at least once during the 5-yr term of each successive discharge permit issued during the operating life of the facility. After each recalibration of the model, groundwater flow and tritium transport will be simulated to revise the prediction of the time required for tritium to travel from the TEDF to the Columbia River, and its concentration at the time and location of its arrival at the river.

3.8.1 Initial Baseline Analysis Update

Predictions of the movement of tritium from the TEDF to the Columbia River previously were made by Golder Associates and published as WHC reports (Golder Associates 1990, 1991). After these reports were issued, the assumptions for the effluent to be processed by the ETF and the expected schedule for operating the ETF drastically changed. Before construction of the ETF began, the need to operate the 242-A Evaporator to concentrate liquid wastes from the tank farms has diminished and wastewater previously expected to feed the ETF has not materialized because of the shutdown of the PUREX Plant.

Consequently, assumptions based on the previously projected volume of effluent to be discharged, earlier estimates of the concentration of tritium in that discharge, and past predictions of the durations and rates of the discharge are no longer valid. These assumptions will likely continue to change as various 200 Area facilities are deactivated, and waste management and groundwater remediation plans are revised and refined. In addition, newer, more detailed hydrogeologic information and more sophisticated numerical models have become available since 1991. Collectively, these developments make the 1991 predictions by Golder Associates of tritium travel time and downgradient concentrations outdated.

Newly reported data include:

- Refinement of site-specific hydrostratigraphic information based on lithologic logging of monitoring wells 699-48-77C and 699-48-77D (Section 2.3.2.2)
- Results of hydraulic testing in three zones of the uppermost aquifer intercepted by well 699-48-77C (Section 2.3.3.3)
- Direct measurement of the direction and velocity of groundwater flow in the three monitoring wells immediately adjoining the TEDF (Section 2.3.3.4)
- The results of previously unreported infiltration tests at the TEDF site (Section 2.3.6.2) and analyses of sediment chemistry (Section 2.3.6.3).

The timing of the recalibration of the flow and transport models during the initial 5-yr term of the discharge permit will depend, in part, on when tritium is first observed in wells closest to the TEDF. Once tritium is detected on one or more of the wells, recalibration of the models using the well observation data will be initiated. Alternatively, if tritium is not detected by a monitoring well during the first 4 yr of TEDF operation, recalibration of the 1991 model will proceed using all other information that has become available since 1991. In either case, the results of the initial recalibration will be published at least 6 months prior to the end of the 5-yr term of the permit, or within 6 months of initial detection of tritium from the facility in an observation well.

3.8.2 Periodic Recalibrations

After expiration of the initial 5-yr term of the discharge permit, periodic recalibrations of the groundwater flow and tritium transport models will be needed as additional monitoring data become available from the tritium tracking wells. Consequently, at least one recalibration and updated prediction of tritium transport will be completed during the term of each 5-yr permit issued during the life of the facility.

Because the current permit is valid only for effluent treated by the ETF that originates from the 242-A Evaporator, additions of effluent from other sources for treatment at the ETF would require application to Ecology for revision of the current discharge permit or issuance of a new permit. In these instances, recalibration of the conceptual and numerical models using new scenarios for the volumes and compositions of effluent to be treated by the ETF would be needed as supporting information for the new or revised application. Potential sources of effluent to be treated at the ETF include, for example, contaminated water pumped from wells in the 200-UP-1, 200-ZP-1, or other groundwater operable units.

4.0 REPORTING OF MONITORING RESULTS

Chapter 2.0 of this report is the Pre-operational Groundwater Monitoring Report required by Section S7.A of State Waste Discharge Permit No. ST-4500. Chapter 2.0 summarizes all groundwater monitoring data from the three wells prior to startup of facility operations. Chapter 3.0 is the Groundwater Monitoring Plan required by Section S7.B of the permit. Chapter 3.0 conveys the plans for evaluating the effects of the facility's operation on groundwater quality and documenting its compliance with applicable groundwater quality standards.

After startup of facility operations, quarterly monitoring of the two downgradient wells and the upgradient well will continue (Table 4-1). The applicable data from the monitoring for constituents listed in Section S1.A of the permit will be issued in quarterly reports, in compliance with permit Section S7.C. The data in these reports will be compared to the Enforcement Limits and Early Warning Values in groundwater as described, respectively, by Sections S1.A and S1.C of the permit. Any additional monitoring of pollutants using test procedures specified by the permit will be included in calculation and reporting of data submitted in the discharge monitoring report, as required by Section G17 of the permit. All reports submitted will be signed and certified in accordance with Section G18 of the permit.

Table 4-1. Schedule for Monitoring of Wells.

Well	Aquifer	Sampling frequency	Water level measurement	Well construction standard
699-48-77A	Uppermost	Quarterly[a]	Monthly	RCRA
699-48-77C[b]	Uppermost	Quarterly[a]	Monthly	RCRA
699-48-77D[b]	Uppermost	Quarterly[a]	Monthly	RCRA

[a] Quarters are defined as January though March, April through June, July through September, and October through December.

[b] Enforcement Limits and Early Warning Values will be met in groundwater collected from the points of compliance in these wells.

The tritium tracking plan required by Section S7.B of the permit is Section 3.7 of Chapter 3.0 in this report. The tritium sampling results required by Section S7.B of the permit will be issued as part of the annual report for RCRA groundwater monitoring projects at Hanford Site facilities.

The plan for updating and maintaining the computer-encoded numerical models of groundwater flow and tritium transport that is required by Section S7.B of the permit is provided in Section 3.8 of this report. Section 3.8 includes plans for updating the modeling results reported in Section 2.4.2. The updated results will be used to predict (1) tritium arrival times at the groundwater monitoring wells identified in Section 3.7 and at the Columbia River, (2) tritium concentrations within the area of its predicted areal extent in the uppermost aquifer, and (3) to describe of how the predictions will periodically be recalibrated using the well-monitoring data. Reports of the periodic model recalibrations, using the tritium tracking data required by Permit Section S7.B will be issued at least once per 5-yr permit cycle.

All associated records will be maintained in accordance with Section G12 of the permit, and specified by WHC implementation procedures. The reports will be maintained in various forms and locations which will be accessible at the 200 Area TEDF offices.

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ROUTINE RISK CALCULATIONS
FOR
TWRS FDEIS
10-17-95

Table 6-2. Unit Process: Operating Personnel Requirements (Staff Hours) (Boomer et al. 1994).

Unit Process	No Separations
Pumping and sluicing	*
Hydraulic retrieval	*
Sludge wash	0
Cesium removal	0
Other radionuclide removal	0
Low-level waste vitrification	0
Low-level waste disposal	0
High-level waste vitrification	1.97E7[1]
High-level waste transportation and disposal	*
Emptied single-shell tank closure	*
Emptied double-shell tank closure	*
Total (Staff hours)	1.97E7[1]

Notes:

*Data is outside the scope of this document.

[1]Total operating personnel are accounted from hot operations, startup, and decontamination and decommissioning.

Hot operations
(620 persons) (1812 hours/year)(14 years) = 1.57E7 hours

Startup
(620 persons)(1812 hours/year)(2 years) = 2.25E6 hours

Decontamination and decommissioning
(620 persons)(1812 hours/year)(1.5 years) = 1.69E6 hours

Total = 1.97E7 hours

For additional backup information, see Appendix B.

Boomer, K. D., J. M. Colby, T. W. Crawford, J. S. Garfield, J. D. Galbraith, C. E. Golberg, C. E. Leach, D. E. Mitchell, F. D. Nankani, B. J. Slaathaug, L. M. Swanson, T. L. Waldo and C. M. Winkler, 1994, *Tank Waste Remediation System Facility Configuration Study*, WHC-SD-WM-ES-295, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Table 6-3. Operating Personnel Requirements (Staff Hours).

Operating Personnel	No Separations[1]
Nonexempt	
Radiation worker	0
Nonradiation worker	1.70E6[2]
Exempt + BU	
Radiation worker	1.58E7[3]
Nonradiation worker	2.06E6[4]
Total (Staff hours)	1.96E7

Notes:

Bu = bargaining unit.

[1]Assumes all exempt and bargaining unit personnel are radiation workers and all nonexempt personnel are nonradiation workers. (Except during startup which assumes all personnel are nonradiation workers.)

[2]Nonexempt nonradiation workers

Hot operations
(53 nonexempt)(1812 hours/year)(14 years) = 1.36E6 hours

Startup
(53 nonexempt)(1812 hours/year)(2 years) = 1.92E5 hours

Decontamination and decommissioning
(53 nonexempt)(1812 hours/year)(1.5 years) = 1.44E5 hours

[3]Exempt and bargaining unit radiation workers:

Hot operations
(227 E + 338 BU)(1812 hours/year)(14 years) = 1.43E7 hours

Decontamination and decommissioning
(227 E + 338 BU)(1812 hours/year)(1.5 years) = 1.54E6 hours

[4]Exempt and bargaining unit nonradiation workers:

Startup
(227 E + 338 BU)(1812 hours/year)(2 years) = 2.06E6 hours

BU

1.43E7
.15E7
.21E7
1.79E7

For additional backup information, see Appendix B.

227/338

TITLE: SOURCE TERM AND RISK CALCULATION FOR WORKER EXPOSURE

Hours Per Year = 2000

Alternative	Dose	Phased Implementation				
	mrem/yr	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.
Construction						
Transfer Lines						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Continued Operations						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Retrieval						
Rad Zone	14	1000	0.5	7.00E-03	2.80E-06	a
Non Rad Zone	0	na	na	na	na	
Treatment Facilities (SEP+LAW/HLW)						
Rad Zone	14	0	0	0.00E+00	0.00E+00	a
Non Rad NEX	0	10204000	5102	0.00E+00	0.00E+00	a
Non Rad EX	0	2910000	1455	0.00E+00	0.00E+00	a
Treatment Facilities (SEP+LAW)						
Rad Zone	14	0	0	0.00E+00	0.00E+00	a
Non Rad NEX	0	7.94E+06	3970	0.00E+00	0.00E+00	a
Non Rad EX	0	2.22E+06	1111	0.00E+00	0.00E+00	a
Operations						
Continued Operations						
- Monitoring SSTs, DSTs, and MUSTs						
Rad Zone	14	1.00E+07	5000	70	2.80E-02	b
Non Rad Zone	0	?	?	?	?	b
-Operate 242A Evaporator						
Rad Zone NEX	200	1.28E+06	640	128	5.12E-02	c
Rad Zone EX	0	3.00E+05	150	0	0.00E+00	c
Non Rad Zone	0	1.50E+06	750	0	0.00E+00	c
Retrieval						
Rad Zone Nonexempt	200	0.00E+00	0	0.00E+00	0.00E+00	a
Rad Zone Exempt	200	4.00E+04	20	4.00E+00	1.60E-03	a
Non Rad Zone	0	0.00E+00	0	0.00E+00	0.00E+00	a
Bargaining Unit	200	1.60E+05	80	1.60E+01	6.40E-03	a
Separate and Treat Waste (SEP/LAW/HLW)						
Exempt						
-Rad	200	9.28E+05	464	9.28E+01	3.71E-02	a
-Non Rad	0	7.84E+05	392	0.00E+00	0.00E+00	a
Non Exempt						
-Rad	200	1.44E+06	720	1.44E+02	5.76E-02	a
-Non Rad	0	1.54E+06	768	0.00E+00	0.00E+00	a
Bargaining Unit						
-Rad	200	1.22E+06	612	1.22E+02	4.90E-02	a
-Non Rad	0	1.22E+06	612	0.00E+00	0.00E+00	a
Separate and Treat Waste (SEP/LAW)						
Exempt						
-Rad	200	6.88E+05	344	6.88E+01	2.75E-02	a
-Non Rad	0	7.20E+05	360	0.00E+00	0.00E+00	a
Non Exempt						
-Rad	200	1.44E+06	720	1.44E+02	5.76E-02	a
-Non Rad	0	1.54E+06	768	0.00E+00	0.00E+00	a
Bargaining Unit						
-Rad	200	1.01E+06	504	1.01E+02	4.03E-02	a
-Non Rad	0	1.01E+06	504	0.00E+00	0.00E+00	a
Storage and Disposal						
Rad	200	na	na	na	na	
Non Rad	0	na	na	na	na	
Monitoring and Maintenance						
Rad	14	na	na	na	na	
Non Rad	0	na	na	na	na	
Post Remediation						
Closure						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Monitoring of Final Waste Form						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	

Total	5.01E+07	2.50E+04	8.91E+02	3.56E-01
		9,255		

na is not applicable

References

(a)Henderson, Colin. "Response to Engineering Data Request Number 073." October 24, 1995.
(b) Estimated to be 1/10th of the value for the No Action alternative, since 10 years instead of 100 years.
(c) Same as for No Action alternative.

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95-CM-045
October 19, 1995

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JACOBS ENGINEERING GROUP
ALTERNATIVE BREAKDOWN BY COMPONENT

1.0 NO ACTION

1.1 Construction - N/A

1.2 Operation
1.2.1 Continued Operations
-Management of operations
-Operate and maintain facilities and equipment
-Monitor tanks
-Monitor leak detection equipment
-Tank status reporting
-Security and surveillance of facilities
-Operate Evaporator (periodic operations to maintain waste volumes up through yr 2005)
-Evaporate all diluted slurry transfers to maintain waste volume
-Transfer waste additions to DSTs for accumulation and batch transfer wastes to and from the evaporator
-Treat condensate at the Liquid Effluent Treatment Facility (LETF)
-Accept new wastes in DSTs (up to year 2005)
1.2.2 Retrieval - N/A
1.2.3 Separations - N/A
1.2.4 Treatment - N/A
1.2.5 Storage - N/A
1.2.6 Disposal - N/A
1.2.7 Monitoring and Maintenance - N/A(no immobilized HLW)

1.3 Post Remediation - N/A (no post remediation activities)
1.3.1 Decontamination and Decommissioning - N/A
1.3.2 Closure - N/A (no closure activities would occur)
1.3.3 Monitoring - N/A (no post remediation)

2.0 LONG-TERM MANAGEMENT

NOTE: The Long-Term Management alternative calls for retanking the DST wastes two times during the 100 year institutional control period. Each of the following construction activities (except for W-314) will occur twice during the Long-Term Management alternative.

2.1 Construction
2.1.1 W-314 Transfer System Upgrade
-Replacement line from T Plant to the SY tank farm in 200 W
-Replacement line from PFP to the SY tank farm in 200 W
-Replacement lines within the 241-SY tank farm in 200 W
-A Farm Trunk line, replacement of the distribution lines going to the A tank farms in 200 W
-Replacement lines within the 241-AY/AZ tank farms in 200E
-204-AR replacement piping to replace the waste transfer line connecting the 204-AR truck and rail unloading station with the DSTs in 200 E
-Miscellaneous diversion box and valve pit lining to provide leak containment.
2.1.2 Continued Operations
-Build replacement evaporator (build a new evaporator for each retanking campaign)

-Build new DST at 50 year intervals
- -26 new DSTs (54 total) to replace existing 28 DSTs
- -Diesel generator building
- -Gas sampling and stack monitoring facilities
- -Administration building
- -Tank ventilation systems
- -Second retanking will have the required effluent treatment constructed with the new evaporator

2.1.3 Retrieval
-Build tank retrieval systems
- -Mixer pumps
- -Transfer pumps and associated facilities as necessary
- -Tank cooling systems
- -Modifications to existing valve and pump pits
- -Build DST transfer piping
- -Connect existing DST facilities with new tank farms and new evaporator

2.1.4 Separations - N/A
2.1.5 Treatment - N/A
2.1.6 Storage - N/A
2.1.7 Disposal - N/A

2.2 Operation
2.2.1 Continued Operations
-Management of operations
-Operate and maintain facilities and equipment
-Monitor tanks
-Monitor leak detection equipment
-Tank status reporting
-Security and surveillance of facilities
-Operate 242-A Evaporator
- -Evaporate all diluted slurry transfers to maintain waste volume
- -Transfer waste additions to DSTs for accumulation and batch transfer wastes to and from the evaporator
- -Treat condensate at the Liquid Effluent Treatment Facility (LETF)
  - -First retanking will use Liquid Effluent Treatment Facility (LETF)
  - -Second retanking will have the required effluent treatment constructed with the new evaporator

-Accept new wastes into DSTs (until yr 2005)
-Deactivate and stabilize empty DSTs
- -Cap piping, seal entrances
- -fill tank with gravel (not estimated in data package)
- -Continue to stabilize and isolate SSTs (interim stabilization) (seal entrances, cap piping etc.)

2.2.2 Retrieval
- -Retrieve DST wastes
- -Direct transfer supernate to new DSTs

-Add dilution liquids to remaining wastes, run mixer pumps and slurry pump
-Process slurry through the evaporator
-Retrieve 99% of DST waste

2.2.3 Separations - N/A
2.2.4 Treatment - N/A
2.2.5 Storage - N/A
2.2.6 Disposal - N/A
2.2.7 Monitoring and Maintenance - N/A(no immobilized HLW)

2.3 Post Remediation - N/A (no post remediation activities)
2.3.1 Decontamination and Decommissioning
-D&D evaporator facilities following each retanking campaign.
2.3.2 Closure - N/A (no closure activities would occur)
1.3.3 Monitoring - N/A (no post remediation)

3.0 IN SITU FILL AND CAP

3.1 Construction
3.1.1 W-314 Transfer System Upgrade
-Replacement line from T Plant to the SY tank farm in 200 W
-Replacement line from PFP to the SY tank farm in 200 W
-Replacement lines within the 241-SY tank farm in 200 W
-A Farm Trunk line, replacement of the distribution lines going to the A tank farms in 200 W
-Replacement lines within the 241-AY/AZ tank farms in 200E
-204-AR replacement piping to replace the waste transfer line connecting the 204-AR truck and rail unloading station with the DSTs in 200 E
-Miscellaneous diversion box and valve pit lining to provide leak containment.
3.1.2 Retrieval - N/A
3.1.3 Separations - N/A
3.1.4 Treatment
-Install gravel handling equipment for tank filling
-Modify tanks as required to accommodate gravel slingers (enlarge tank risers)
-Construct gravel storage sites for stockpiles, 4 stockpiles, 2 in 200E and 2 in 200W
3.1.5 Storage - N/A (no interim HLW storage)
3.1.6 Disposal - N/A (no construction of a disposal facility)

3.2 Operation
3.2.1 Continued Operations
-Management of operations
-Operate and maintain facilities and equipment
-Monitor tanks
-Monitor leak detection equipment
-Tank status reporting
-Security and surveillance of facilities
-Operating the 242A evaporator as a waste management activity (up to 2005)
-Accept new wastes into DSTs until yr 2005
3.2.2 Retrieval - N/A
3.2.3 Separations - N/A
3.2.4 Treatment

-Evaporate all excess DST liquids through the 242A evaporator
- -Use a 30 cu meter/min (1000 cfm) exhauster to ventilate tanks
- -Set up portable conveyors from gravel stock pile to slinger
- -Install cyclone separators in HVAC system to remove particulate
- -Operate gravel filling equipment, estimated 3 days to fill a tank at 50 mt/hr

3.2.5 Storage- N/A (no interim HLW storage)

3.2.6 Disposal

-Disposal would occur in the tanks following drying and filling operations

3.2.7 Monitoring and Maintenance - N/A (no operational phase monitoring of HLW product)

3.3 Post Remediation

3.3.1 Decontamination and Decommissioning

-D&D equipment

3.3.2 Closure

-Construct Hanford barriers
- -Grout fill all MUSTs and ancillary equipment
- -Barriers to be built over all tank farms and MUSTs

3.3.3 Monitoring and Maintenance

-Monitoring and maintenance activities would occur at the tank farms for 100 years following closure.

4.0 IN SITU VITRIFICATION

4.1 Construction

4.1.1 W-314 Transfer System Upgrade

-Replacement line from T Plant to the SY tank farm in 200 W

-Replacement line from PFP to the SY tank farm in 200 W

-Replacement lines within the 241-SY tank farm in 200 W

-A Farm Trunk line, replacement of the distribution lines going to the A tank farms in 200 W

-Replacement lines within the 241-AY/AZ tank farms in 200E

-204-AR replacement piping to replace the waste transfer line connecting the 204-AR truck and rail unloading station with the DSTs in 200 E

-Miscellaneous diversion box and valve pit lining to provide leak containment.

4.1.2 Retrieval - N/A

4.1.3 Separations - N/A

4.1.4 Treatment

-Construct tank farm confinement facilities (TFCFs). Construct a TFCF over each tank farm
- -Assemble in sections adjacent to tank farms
- -Construct foundation around perimeter of tank farm
- -Assemble prefabricated sections (75' wide)
- -Construct HVAC system
- -Construct off gas treatment system

-Construct frit handling system to fill tank domes with sand

-Construct electrical power system
- -New substation
- -Several miles of 115 KVA transmission line
- -Temporary runs of 115KVA lines from transmission line to individual farms

4.1.5 Storage - N/A (no interim HLW storage required)

4.1.6 Disposal - N/A (no construction of a disposal facility required, barriers addressed under post

remediation)

4.2 Operation

4.2.1 Continued Operations

-Management of operations
-Operate and maintain facilities and equipment
-Monitor tanks
-Monitor leak detection equipment
-Tank status reporting
-Security and surveillance of facilities
-Operating the 242A evaporator as a waste management activity (up to yr 2005)
-Accept new wastes into DSTs until yr 2005

4.2.2 Retrieval - N/A

4.2.3 Separations - N/A

4.2.4 Treatment

-Remove excess DST liquids in evaporator (5 years of continuous evaporator operation)
-Add required glass formers, sand to fill up tank dome spaces
-Vitrify wastes (includes tanks and area between resulting in the vitrification of the entire tank farm)
-Operate offgas treatment
-Collect and dispose of calcium sulfate from SO2 scrubbing
-Treat liquids condensed in offgas system by collecting and trucking to the LETF
-Move equipment from tank to tank

4.2.5 Storage - N/A (no interim HLW storage)

4.2.6 Disposal

-Disposal would occur in place following vitrification

2.2.7 Monitoring and Maintenance

-Monitoring activities would take place at vitrified tank farms prior to closure

4.3 Post Remediation

4.3.1 Decontamination and Decommissioning

-D & D TFCFs and the vitrification equipment
    -contaminated material and equipment disposed of onsite in LAW burial grounds

4.3.2 Closure

-Grout fill and construct Hanford barriers over all MUST tanks located outside of the tank farm areas
-Construct Hanford barriers
    -Surface barriers would be installed over each tank farm after ISV complete

4.3.3 Monitoring and Maintenance

-Monitor and maintenance activities would take place at the tank farms for 100 years following closure

5.0 EX SITU INTERMEDIATE SEPARATIONS

5.1 Construction

5.1.1 W-314 Transfer System Upgrade

-Replacement line from T Plant to the SY tank farm in 200 W
-Replacement line from PFP to the SY tank farm in 200 W
-Replacement lines within the 241-SY tank farm in 200 W
-A Farm Trunk line, replacement of the distribution lines going to the A tank farms in 200 W
-Replacement lines within the 241-AY/AZ tank farms in 200E

-204-AR replacement piping to replace the waste transfer line connecting the 204-AR truck and rail unloading station with the DSTs in 200 E
-Miscellaneous diversion box and valve pit lining to provide leak containment.

5.1.2 Retrieval

-Build retrieval and transfer system
- -Waste transfer annexes (2 in 200 East, 2 in 200 West)
- -Waste storage and sampling facility (in 200 West used for cross site transfer)
- -Piping, approx 40 miles of doublewall pipe (includes cross site transfer line)
- -24 SST sluicing systems
- -12 SST arm based systems with confinement structures
- -Install mixer pumps in DSTs, 2 to 4 mixer pumps per tank
- -Must retrieval and transfer system, retrieval similar to SST and DST tanks, transfer by container

5.1.3 Separations

-Build pretreatment facility
- -Pretreatment and LAW vit facility are combined
- -Waste receipt and sampling
- -Cesium ion exchange
- -Pretreatment will utilize between 4 and 8 existing DSTs for in tank sludge washing operations

5.1.4 Treatment

-Build support facilities
- -Mechanical Utilities building (shared utilities)
- -Cooling tower
- -Cold chemical facilities
- -Warehouses
- -Fab shop, Mockup shop
- -Fire protection facilities, storage and pumping
- -Operations control, Operations support buildings
- -Waste staging and sampling facility
- -Power lines, substation, 2.5 km of 13.8 KV line

-Construct LAW vitrification facility
- -Melter feed system
- -Glass former handling system
- -Fuel and oxygen system
- -Evaporator
- -Two 100 metric ton per day combustion melters
- -Cullet quench and handling system
- -Waste container handling system
- -Offgas system

-Construct HLW vitrification facility
- -Melter feed system
- -Glass former handling system
- -Evaporator
- -One 20 metric ton per day joule heated HLW melter
- -Offgas system
- -Canister handling system
- -Recycle streams

5.1.5 Storage
-Construct HLW interim storage facility
-Storage pads for interim HLW Cask storage
5.1.6 Disposal
-Construct LAW disposal facility
-Vaults constructed throughout operational period
-Total of 46 vaults constructed below grade at 5,300 cu. meters per vault

5.2 Operation
5.2.1 Continued Operations
-Management of operations
-Operate and maintain facilities and equipment
-Monitor tanks
-Monitor leak detection equipment
-Tank status reporting
-Security and surveillance of facilities
-Operating the 242A evaporator as a waste management activity (until yr 2005)
-Accept new wastes in DSTs until yr 2005
5.2.2 Retrieval
-Retrieve wastes
-Sluice SSTs (110 tanks)
-Arm based retrieval (50 tanks)
-Slurry pump DST wastes
-Retrieve MUST wastes (sluice and/or arm based retrieval)
-Move retrieval/confinement systems tank to tank
-SST sluicing systems move 4 to 5 times
-SST arm based systems and confinement structures move 4 times
-Transfer wastes to vitrification plant
-Batch transfer wastes from 200W to 200E
-Batch transfer wastes to waste staging and sampling facility
-Container transfer MUST wastes
-Place contaminated tank internal equipment retrieved from the tanks and contaminated retrieval equipment in burial boxes and dispose of at onsite burial grounds (10,000 cu. meters)
5.2.3 Separations
-Pretreat wastes to separate HLW and LAW streams
-Utilizes DSTs, in tank sludge wash plus enhanced wash with NaOH (could be done out of tank)
-Remove cesium from wash liquids and put into HLW with ion exchange
5.2.4 Treatment
-Operate LAW vitrification plant
-Receive and sample wastes
-Evaporate water from wastes
-Operate 2 combustion melters (feed streams of oxygen, kerosene, wastes, glass formers)
-Glass at 25 wt % sodium oxide
-Quench molten glass to make cullet

-Place vitrified cullet into canisters (32 cubic meter disposal containers)
- -Size and dry cullet
- -Mix with matrix material
- -Place cullet and matrix material into containers
- -Transport containers to the onsite LLW disposal vaults

-Operate HLW vitrification plant
- -Receive and sample wastes
- -Evaporate water from wastes
- -Operate 1 joule heated melter, capacity 20 metric ton/day
- -Glass at 45 wt % waste oxides
- -Pour glass monoliths .68m dia x 4.57 m long
- -Overpack glass into Hanford multi purpose canisters, 4 glass logs / cask

-Operate offgas treatment at both HLW and LAW plant
- -Quench and cool offgas
- -Remove radionuclides and recycle to process
- -Destroy NOx and recover sulfur from SO2

-Treat liquid effluent at both HLW and LAW plant
- -Collect effluent in recycle tanks
- -Sample and recycle off spec effluent, transfer on-spec to adjustment tank
- -Adjust pH of on spec effluent
- -Batch transfer to retention basin for later transfer to Liquid Effluent Treatment Facility

-Transport HLW casks to interim storage pads
- -Take overpacked casks and transport from canister handling facility to storage pad

5.2.5 Storage

-Store vitrified HLW MPCs on-site on interim storage pads prior to transport to the proposed national HLW repository

5.2.6 Disposal

-Transport casks to the proposed national HLW repository
- -Rail transport, 171 trips, 10 casks on 10 rail cars each week (repository limited to handling 2 casks per OD), transportation takes 3.3 years

-LAW disposal in on-site in retrievable disposal vaults

5.2.7 Monitoring and Maintenance

-Monitor and maintain stored casks
- -Routine surveillance on 1,705 casks

5.3 Post Remediation

5.3.1 Decontamination and Decommissioning

-D&D facilities
- -Entomb non-contaminated material
- -Demolish and landfill contaminated facilities at LAW burial ground

5.3.2 Closure

-Close tank farms
- -Barrier construction after completion of LAW vitrification
- -Grout fill MUSTs and ancillary equipment
- -Stabilize empty SSTs and DSTs by filling with grout or gravel

-Construct Hanford barriers (caps)
- -Construct barrier over all tank farms and LAW disposal vaults

5.3.3 Monitoring and Maintenance

-Monitoring and Maintenance would take place at the tank farms and disposal vaults for 100 yrs

following closure

6.0 EX SITU NO SEPARATIONS

6.1 Construction

6.1.1 W-314 Transfer System Upgrade

-Replacement line from T Plant to the SY tank farm in 200 W
-Replacement line from PFP to the SY tank farm in 200 W
-Replacement lines within the 241-SY tank farm in 200 W
-A Farm Trunk line, replacement of the distribution lines going to the A tank farms in 200 W
-Replacement lines within the 241-AY/AZ tank farms in 200E
-204-AR replacement piping to replace the waste transfer line connecting the 204-AR truck and rail unloading station with the DSTs in 200 E
-Miscellaneous diversion box and valve pit lining to provide leak containment.

6.1.2 Retrieval

-Build retrieval and transfer system
  -Waste transfer annexes (2 in 200 East, 2 in 200 West)
  -Waste storage and sampling facility (in 200 West used for cross site transfer)
  -Piping, approx 40 miles of doublewall pipe, includes cross site transfer line
  -Subsurface barriers for SSTs, package currently assumes all SSTs will have barrier
  -24 SST sluicing systems
  -12 SST arm based systems with confinement structures
  -Install mixer pumps in DSTs, 2 to 4 mixer pumps per DST
  -Must retrieval and transfer system, retrieval similar to SST and DST tanks, transfer by container

6.1.3 Separations - N/A (no high-level/low-level separations would be made)

6.1.4 Treatment

-Build support facilities
  -Mechanical Utilities building (shared utilities)
  -Cooling tower
  -Cold chemical handling facilities
  -Warehouses
  -Fab shop, Mockup shop
  -Fire protection facilities, water storage and pumping
  -Operations control, Operations support buildings
  -Waste staging and sampling facility (6 tanks @100 kgal each)
  -Power lines, substation, 2.5 km of 13.8 KV line
-Build one vitrification or calcination plant (all waste processed would be considered HLW)
  -feed system for the melter or calciner
  -glass former handling system for the vitrification melter
  -fuel and oxygen systems
  -evaporator
  -two 100 metric ton per day combustion melters
  -two 50 mt per day calciners (same waste input as vitrification, no glass formers so 50% of output)
  -cullet quench and handling system
  -offgas system
  -recycle loops

-Build canister handling and storage facilities
    -canister facilities
    -build interim storage pads

6.1.5 Storage

-Construct an on-site interim storage facility to store the vitrified or calicned HLW

6.1.6 Disposal

-All waste retrieved (assumed to be 99%) would be disposed of at the proposed national HLW repository

6.2 Operation

6.2.1 Continued Operations

-Management of operations
-Operate and maintain facilities and equipment
-Monitor tanks
-Monitor leak detection equipment
-Tank status reporting
-Security and surveillance of facilities
-Operating the 242A evaporator as a waste management activity(up to 2005)
-Accept new wastes into DSTs (up to 2005)

6.2.2 Retrieval

-Retrieve wastes
    -Sluice SSTs (110 tanks)
    -Arm based retrieval (50 tanks)
    -Slurry pump DST wastes
    -Retrieve MUST wastes (sluice and/or arm based)
-Move retrieval/confinement systems tank to tank
    -SST sluicing systems move 4 to 5 times
    -SST arm based systems and confinement structures move 4 times
-Transfer wastes to vitrification plant
    -Batch transfer wastes from 200W to 200E
    -Batch transfer wastes to waste staging and sampling facility
    -Container transFer MUST wastes
-Place contaminated tank internal equipment retrieved from the tanks and contaminated retrieval equipment in burial boxes and dispose of at onsite burial grounds (10,000 cu. meters)

6.2.3 Separations - N/A (no separations would be done)

6.2.4 Treatment

<u>Operate vitrification plant</u>
    -Receive and sample wastes
    -Evaporate water from wastes
    -Operate 2 combustion melters (feed streams of oxygen, kerosene, wastes, glass formers)
    -Glass at 25 wt % sodium oxide
    -Quench molten glass to make cullet
-Place vitrified cullet into canisters (22,481 canisters @ 10 cu. meters each)
    -Size and dry cullet
    -Transfer cullet to canisters
    -Weld and decontaminate canisters
    -Overpack canisters into multi purpose overpack canister (1 canister per overpack)

Operate Calcination plant
-Receive and sample wastes
-Evaporate water from wastes
-Operate two spray calciners
-Compact calcined wastes into briquettes
-Place briquettes into canisters (10,300 canisters @ 10 cu. meters each)
    -Cool briquettes prior to placement into canisters
    -Weld and decontaminate
    -Overpack canisters into a multi purpose overpack canister (1 canister per overpack)

Common to Vitrification or Calcination
-Operate offgas treatment
    -Quench and cool offgas
    -Remove radionuclides and recycle to process
    -Destroy NOx and recover sulfur from SO2
-Treat liquid effluent
    -Collect effluent in recycle tanks
    -Sample and recycle off spec effluent, transfer on-spec to adjustment tank
    -Adjust pH of on spec effluent
    -Batch transfer to retention basin for later transfer to Liquid Effluent Treatment Facility
-Transport casks to storage pads
    -Take overpacked casks and transport from canister handling facility to storage pad
-Transport casks to HLW repository
    -Rail transport, 10 casks on 10 rail cars each week, 2248 trips for vitrification 1,030 trips for calcination (repository limited to handling 2 casks per OD)

6.2.5 Storage
-Store canisters of HLW on interim storage pads pending shipment to the proposed national HLW repository

6.2.6 Disposal -N/A (no on-site disposal)

6.2.7 Monitoring and Maintenance
-Monitor and maintain stored HLW canisters

6.3 Post Remediation

6.3.1 Decontamination and Decommissioning
-D&D facilities
    -Entomb non contaminated in place
    -Demolish and landfill contaminated facilities at LAW burial ground

6.3.2 Closure
-Close tank farms
    -Grout fill MUSTs and ancillary equipment
    -Gravel fill empty DSTs and SSTs
-Construct surface barriers
    -Surface barrier to be installed over every tank farm

6.3.3 Monitoring and Maintenance
-Monitoring activities would take place in the tank farms for 100 years following closure

7.0 EX SITU EXTENSIVE SEPARATIONS

7.1 Construction

7.1.1 W-314 Transfer System Upgrade

-Replacement line from T Plant to the SY tank farm in 200 W
-Replacement line from PFP to the SY tank farm in 200 W
-Replacement lines within the 241-SY tank farm in 200 W
-A Farm Trunk line, replacement of the distribution lines going to the A tank farms in 200 W
-Replacement lines within the 241-AY/AZ tank farms in 200E
-204-AR replacement piping to replace the waste transfer line connecting the 204-AR truck and rail unloading station with the DSTs in 200 E
-Miscellaneous diversion box and valve pit lining to provide leak containment.

7.1.2 Retrieval

-Build retrieval and transfer system (identical to Extensive Retrieval (Ex Situ Vitrification))

7.1.3 Separations

-Build pretreatment facility, the separations facility and the HLW facility are combined(similar to but more extensive than the facility for Extensive Retrieval (Ex Situ Vit)

7.1.4 Treatment

-Build support facilities
-Construct LAW vitrification facility (200 mt/day)
for LAW
-Construct HLW vitrification facility (1 mt/day)

7.1.5 Storage

-Construct an interim storage facility for the vitrified HLW

7.1.6 Disposal

-Construct LAW disposal facility
-Construct sulfur cement handling and transfer system

7.2 Operation

7.2.1 Continued Operations

-Management of operations
-Operate and maintain facilities and equipment
-Monitor tanks
-Monitor leak detection equipment
-Tank status reporting
-Security and surveillance of facilities
-Operating the 242A evaporator as a waste management activity (up to 2005)
-Accept new wastes in DSTs

7.2.2 Retrieval

-Retrieve wastes
-Move retrieval/confinement systems tank to tank
-Transfer wastes to pretreatment facility
-Place contaminated tank internal equipment retrieved from the tanks and contaminated retrieval equipment in burial boxes and dispose of at onsite burial grounds (4,000 cu. meters)

7.2.3 Separations

-Operate pretreatment facility
-Operate offgas treatment
-Treat liquid effluent
-Transfer HLW and TRU to HLW vitrification plant
-Transfer LAW to LAW vitrification plant

7.2.4 Treatment (treatment operations similar to Exsitu Intermediate Separations
-Operate HLW vitrification plant
-Operate LAW vitrification plant
-Transport vitrified HLW to proposed national HLW repository
-Vitrify TRU wastes in HLW vitrification plant
-Transport vitrified TRU wastes to WIPP
7.2.5 Storage
-Temporarily store vitrified HLW on site
7.2.6 Disposal
-Dispose of LAW on site in containers
7.2.7 Monitoring and Maintenance
-Monitor HLW storage

7.3 Post Remediation
7.3.1 Decontamination and Decommissioning
-D & D pretreatment facilities, vitrification facilities, HLW interim storage
-D & D equipment
7.3.2 Closure
-Close tank farms
-Construct surface barriers
-Grout fill MUSTs and ancillary equipment
-Grout or gravel fill empty DSTs and SSTs
-Barrier to be placed over every tank farm and LAW disposal vaults
7.3.3 Monitoring and Maintenance
-Monitor LAW disposal and tank farms for 100 years following closure

8.0 EX SITU/IN SITU COMBINATION
8.1 Construction
8.1.1 W-314 Transfer System Upgrade
-Replacement line from T Plant to the SY tank farm in 200 W
-Replacement line from PFP to the SY tank farm in 200 W
-Replacement lines within the 241-SY tank farm in 200 W
-A Farm Trunk line, replacement of the distribution lines going to the A tank farms in 200 W
-Replacement lines within the 241-AY/AZ tank farms in 200E
-204-AR replacement piping to replace the waste transfer line connecting the 204-AR truck and rail unloading station with the DSTs in 200 E
-Miscellaneous diversion box and valve pit lining to provide leak containment.
8.1.2 Retrieval
-Build retrieval and transfer system
-Waste transfer annexes (2 in 200East and 2 in 200West)
-Waste storage and sampling facility located in 200West, used for cross site transfer
-Piping to connect the tanks selected for retrieval and the transfer annexes and from the transfer annexes to the cross site transfer system
-10 SST sluicing systems
-5 SST arm based systems with confinement structures
-Install mixer pumps in DSTs, 2 to 4 mixer pumps per DST

8.1.3 Separations

-Build pretreatment facility
- -Pretreatment and LAW vitrification facility would be combined
- -Waste receipt and sampling
- -Sludge washing
- -Cesium Ion Exchange

8.1.4 Treatment

Wastes left in tanks (107 tanks)

-Install gravel filling equipment for tank filling
-Modify tanks as required to accommodate gravel slingers
-Construct gravel storage sites for stockpiles, 4 stockpiles, 2 in each area
-No construction required for radiofrequency drying, all equipment required will be trailer mounted.

Retrieved wastes (70 tanks)

-Build support facilities
- -Mechanical Utilities building (shared utilities)
- -Cooling tower
- -Cold chemical facilities
- -Warehouses
- -Fab shop, Mockup shop
- -Fire protection facilities, storage and pumping
- -Operations control, Operations support buildings
- -Waste staging and sampling facility
- -Power lines, substation, 2.5 km of 13.8 KV line

-Construct LAW vitrification facility
- -Melter feed system
- -Glass former handling system
- -Fuel and oxygen system
- -Evaporator
- -Two 50 metric ton per day combustion melters
- -Cullet quench and handling system
- -LAW container handling system
- -Offgas system

-Construct HLW vitrification facility
- -Melter feed system
- -Glass former handling system
- -Evaporator
- -One 10 metric ton per day joule heated HLW melter
- -Offgas system
- -Canister handling system
- -Recycle streams

8.1.5 Storage

-Construct storage pads for interim storage of vitrified HLW before transport to the repository

8.1.6 Disposal

-Construct LAW disposal facility
- -Vaults constructed throughout operational period
- -Total of 23 vaults constructed below grade at 5,300 cu. meters per vault

8.2 Operations

8.2.1 Continued Operations

-Management of operations
-Operate and maintain facilities and equipment
-Monitor tanks
-Monitor leak detection equipment
-Tank status reporting
-Security and surveillance of facilities
-Operating the 242A evaporator as a waste management activity

8.2.2 Retrieval

-Retrieve wastes from selected tanks
    -Sluice SSTs (60 tanks)
    -Arm based retrieval (20 tanks)
    -Slurry pump DST wastes
-Move retrieval/confinement systems tank to tank
    -SST sluicing systems move 5 to 6 times
    -SST arm based systems and confinement structures move 4 times
-Transfer wastes to vitrification plant
    -Batch transfer wastes from 200W to 200E
    -Batch transfer wastes to waste staging and sampling facility
-Place contaminated tank internal equipment retrieved from the tanks and contaminated retrieval equipment in burial boxes and dispose of at onsite burial grounds (4,000 cu. meters)

8.2.3 Separations

-Pretreat wastes to separate HLW and LAW streams
    -Utilizes DSTs, in tank sludge wash plus enhanced wash with NaOH
    -Remove cesium from wash liquids using ion exchange, transfer cesium to HLW plant

8.2.4 Treatment

Wastes not retrieved (107 tanks)

-Evaporate pumpable DST liquids through the 242A evaporator (18 DSTs)
-Set up portable conveyors from gravel stock pile to slinger
-Install cyclone separators in HVAC system to remove particulate
-Operate gravel filling equipment, estimated 3 days to fill a tank at 50 mt/hr

Retrieved Wastes (70 tanks, 50% of total waste volume)

-Operate LAW vitrification plant
    -Receive and sample wastes
    -Evaporate water from wastes
    -Operate 2 combustion melters (feed streams of oxygen, kerosene, wastes, glass formers)
    -Glass at 25 wt % sodium oxide
    -Quench molten glass to make cullet
-Place vitrified cullet into containers (32 cubic meter containers)
    -Size and dry cullet
    -Mix with matrix material
    -Transport LAW containers to LAW vaults
-Operate HLW vitrification plant
    -Receive and sample wastes
    -Evaporate water from wastes

-Operate 1 joule heated melter, capacity 10 metric ton/day
-Glass at 45 wt % waste oxides
-Pour glass monoliths .68m dia x 4.57 m long
-Overpack glass into casks, 4 glass logs / cask
-Operate offgas treatment at both HLW and LAW plant
-Quench and cool offgas
-Remove radionuclides and recycle to process
-Destroy NOx and recover sulfur from SO2
-Treat liquid effluent at both HLW and LAW plant
-Collect effluent in recycle tanks
-Sample and recycle off spec effluent, transfer on-spec to adjustment tank
-Adjust pH of on spec effluent
-Batch transfer to retention basin for later transfer to Liquid Effluent Treatment Facility
-Transport HLW casks to interim storage pads
8.2.5 Storage
-Store MPC casks on site on interim storage pads
8.2.6 Disposal
-107 tanks disposed of in situ following drying and gravel filling
-LAW disposed of on site in retrievable disposal vaults
8.2.7 Monitoring and Maintenance
-Monitor and maintain approximately 850 stored HLW canisters.

8.3 Post Remediation
8.3.1 Decontamination and Decommissioning
-D&D facilities
-Entomb non-contaminated material/facilities
-Demolish and landfill contaminated facilities at LAW burial ground
8.3.2 Closure
-Close tank farms
-Barrier construction after completion of LAW vitrification
-Grout fill MUSTs and ancillary equipment
-Stabilize empty SSTs and DSTs that were selected for retrieval by filling with grout or gravel
-Construct Hanford barriers (caps)
-Construct barrier over all tank farms and LAW disposal vaults
8.3.3 Monitoring and Maintenance
-Monitoring and maintenance of disposal sites and tank farms for 100 years following closure

9.0 PHASED IMPLEMENTATION

The phased implementation alternative would consist of two LAW treatment plants using a treatment process such as vitrification (or a similar process) to produce a stabilized waste form meeting DOE specifications. The phased implementation alternative for LAW would operate for approximately 10 years and the HLW plant would operate for approximately 6 years. Each of the LAW plants would treat approximately 1 million gallons of DST liquid waste per year (equivalent to 20 mt/day of 20 wt% glass). A separate HLW facility would be built to process HLW into a stabilized product with an operating capacity of 1 metric ton per day of immobilized HLW.

9.1 Construction

9.1.1 W-314 Transfer System Upgrade (M&I responsibility)
-Replacement line from T Plant to the SY tank farm in 200 W
-Replacement line from PFP to the SY tank farm in 200 W
-Replacement lines within the 241-SY tank farm in 200 W
-A Farm Trunk line, replacement of the distribution lines going to the A tank farms in 200 W
-Replacement lines within the 241-AY/AZ tank farms in 200E
-204-AR replacement piping to replace the waste transfer line connecting the 204-AR truck and rail unloading station with the DSTs in 200 E
-Miscellaneous diversion box and valve pit lining to provide leak containment.
9.1.2 Retrieval
-Assumed that all DSTs have the necessary equipment and systems in place to pump out and transfer liquid wastes to the receiver tanks. For the HLW retrieval functions retrieval equipment would be installed in those tanks selected for HLW processing under separate projects.
-Build transfer lines from designated DST receiver tank to each LAW facility. Transfer lines would consist of a supply line, a return line and a spare. Each LAW facility would have a designated DST that would serve as a reciever tank.
-Build transfer lines (supply, return, spare) from the existing 200E waste transfer system to the HLW facility.
-Build transfer lines from LAW plants to the existing waste transfer system for the transfer of liquid effluents to the Liquid Effluent Retrention Facility or the Liquid Effluent Treatment Facility.
9.1.3 Separations
-Build pretreatment facilities, each LAW plant would have separations facilities
9.1.4 Treatment
-Build support facilities
    -Support facilities would be constructed to provide operations support and utilities
    -Overhead power lines from existing grid near the east fence of 200 East to each of the sites
    -Water supply lines from the existing distribution to each of the sites
-Construct LAW treatment facilities (two facilities treating approximately 1 million gal. of waste per year)
-Construct one HLW plant to process HLW from a specific group of DSTs. (HLW capacity 1 mt/day) note: the HLW plant would not process the HLW resulting from the separations at the LAW facilities but would instead be provided a separate HLW stream. The HLW plant would be combined with one of the LAW plants and would include:
    -Evaporator
    -One metric ton per day HLW treatment process
    -Offgas system
    -Canister handling system
    -Recycle streams
9.1.5 Storage
-Construct HLW interim storage facility
    -Assumed to be an onsite storage pad located in the same area as the interim HLW storage pads for other Ex Situ alternatives
-Construct LAW interim storage facility
    -Concrete storage pad located in the same area as the interim HLW storage pads for the all of the Ex Situ alternatives.
9.1.6 Disposal- N/A for phased implementation LAW would be disposed of onsite in the follow on phase and HLW would be stored for transport to the repository in the follow on phase.

9.2 Operation

9.2.1 Continued Operations

-Management of operations
-Operate and maintain facilities and equipment
-Monitor tanks
-Monitor leak detection equipment
-Tank status reporting
-Security and surveillance of facilities
-Operating the 242A evaporator as a waste management activity

9.2.2 Retrieval

-Retrieve DST liquid wastes
-Transfer wastes to one of two DST receiver tanks designated as LAW feed tanks
-Transfer wastes from the receiver tanks to the LAW treatment facilities by pipeline
-Retrieve and transfer HLW from designated DSTs for HLW treatment.

9.2.3 Separations

-Pretreat wastes to separate HLW and LAW streams
    -Treatment would involve separating the liquids and solids, treating the waste streams to remove fission products, TRU and Tc-99, pumping the treated sludge back to DSTs, transporting the separated fission products and Tc in casks to dry storage (Canister Storage Building)

9.2.4 Treatment

-Operate LAW treatment plant and place immobilized LAW wastes into containers
-Operate HLW plant. If the HLW treatment plant is not implemented the separated HLW would be placed in canisters for dry storage.
-Operate offgas treatment at both HLW and LAW plant
    -Quench and cool offgas
    -Remove radionuclides and recycle to process
-Liquid effluent at both HLW and LAW plants to be collected and transferred to the Liquid Effluent Retention Facility or directly to the Liquid Effluent Treatment Facility.
-Transport HLW canisters to interim storage
-Transport LAW containers to interim storage facility prior to disposal onsite

9.2.5 Storage

-Store immobilized HLW on-site in the same manner as the immobilized HLW from all Ex Situ alternatives proposed national HLW repository
-Store immobilized LAW on storage pads prior to onsite disposal

9.2.6 Disposal- N/A disposal would occur under the follow on phase

9.2.7 Monitoring and Maintenance

-Monitor and maintain stored casks

9.3 Post Remediation

9.3.1 Decontamination and Decommissioning

-D&D facilities, D&D of demonstration plants to take place following 10 year demonstration phase (Clean Closure)

9.3.2 Closure

-Close tank farms

9.3.3 Monitoring and Maintenance

10.0 CESIUM / STRONTIUM CAPSULES

JACOBS ENGINEERING GROUP
ALTERNATIVE BREAKDOWN BY COMPONENT

10.1 Construction

No Action

-N/A

Onsite Disposal

-Construct dry well storage site

-Storage site to be approx 38,000 square meters

Overpack and Ship

-Overpack in WESF

Vitrify with Tank Waste

-Build or modify a cell in the HLW vitrification facility to cutup, remove capsule contents, and chemically treat if required and feed into the HLW vitrification feed stream.

-Cell to be a part of the HLW vitrification facility.

10.2 Operation

No Action

-Continued storage in WESF basins for up to 10 years

Onsite Disposal

-Continued Operations, continued storage of the capsules in WESF

-Retrieve and inspect capsules

-Overpack capsules into canisters

-Overpack at WESF 2-4 capsules per canister

-Seal canisters, 584 total canisters

-Transport to dry well storage facility

-Place capsules in dry wells

-Monitor & maintain dry well storage

Overpack and Ship

-Continued operations, continued storage of the capsules in WESF

-Remove and inspect capsules

-Overpack capsules into canisters

-215 to 387 canisters total (The data package specifies the range of canister based on the number of capsules overpacked per canister. Conservatively assume the 387 number)

-Place canisters into Hanford multi purpose cask (MPC), 4 canisters per cask

-Transport to interim storage, casks to be stored with HLW casks from vit plant

-Monitor interim storage

-Transport to HLW repository

Vitrify with Tank Waste

-Continued operations, continued storage of the capsules in WESF

-Remove/transport capsules to processing facility

-Cut up capsules and remove Cs/Sr contents

-Chemically treat Cs/Sr if/as required for vitrification

-Blend with vitrification feed stream

-Decontaminate and crush empty capsule containers

-Transport empty capsule containers to onsite burial grounds

10.3 Post Remediation

No Action - N/A

Onsite Disposal

-Install intrusion prevention barriers (precast concrete blocks) over dry-wells

Overpack and Ship

-Close storage facility

Vitrify with Tank Wastes

-Close HLW storage facility

-D & D capsule processing cell

Jacobs Engineering Group Inc.

3250 West Clearwater
Kennewick, Washington 99336

Telephone: (509) 736-0616
Fax: (509) 736-7504

FAX TRANSMISSION COVER SHEET

Date: 9/26/95

To: Alex Nazarali

Fax: 6812

Subject: Alternate Names

Sender: Michelle for M. Nelson

YOU SHOULD RECEIVE 3 PAGE(S), INCLUDING THIS COVER SHEET. IF YOU DO NOT RECEIVE ALL THE PAGES, PLEASE CALL.

MEMORANDUM

TO: TWRS EIS Team

September 26, 1995
95-MN-055

FROM: Marc Nelson

SUBJECT: **ALTERNATIVE NAMES**

Attached is a list of revised names for the TWRS DEIS. In response to comments during the PDEIS review we have attempted to simplify the names for the public and make the name reflect the most important aspect of the alternatives. We have dropped the concept of a subalternative for simplification.

MFN:ns

Attachment: Alternative Names

cc: Jacobs Hanford Staff
P. Rogers, ESE
J. Shrock, ESE
J. Kuhn, ESE
A. Nazarali, ASI
L. Dean, ASI
A. Bachrach, Jacobs
B. Bosan, Jacobs
K. Bostic, Jacobs
Project File

ALTERNATIVE NAMES AND ORDER OF PRESENTATION IN THE DEIS

NEW NAME	PREVIOUS NAME
Tank Waste Alternatives	
No Action	N/A
Long-Term Management	No Action
In Situ Fill and Cap	Fill and Cap
In Situ Vitrification	Minimal Retrieval (In Situ Vitrification)
Ex Situ Intermediate Separations	Extensive Retrieval (Ex Situ Vitrification)
Ex Situ No Separations	No Separations (Vitrification or Calcination)
Ex Situ Extensive Separations	Extensive Retrieval
Ex Situ/In Situ Combination	Selective Retrieval
~~Staged~~ Implementation PHASED	N/A
Capsule Alternatives	
No Action	No Action
Onsite Disposal	Dry-Well Storage
Overpack and Ship	Overpack and Ship
Vitrify with Tank Waste	Vitrify with Tank Waste

Page D-73
Insert 1300a

"The GENII computer program allows calculation of radiation doses to individuals or the population from airborne and waterborne radionuclide releases of radionuclides to the environment. Exposure pathways are included for ingestion, inhalation, and external exposure routes. For the present analysis, exposure pathways are included in the dose analysis for inhalation of airborne activity, external exposure to airborne and deposited activity, and ingestion of agricultural products grown in soil contaminated from atmospheric deposition. Parameter values used in the analysis were as defined by Schreckhise et al. (1993) for dose analyses performed for Hanford activities. The parameters used for the individual and population dose analyses are generally more conservative than those used for the baseline and post-remediation analyses. The dose estimates generated by GENII were converted to risk as described in Section D.2.2.4."

The reference citation for Schreckhise et al. 1993 is:
Schreckhise, R. G., K. Rhoads, J. S. Davis, B. A. Napier, and J. V. Ramsdell. 1993. Recommended Environmental Dose Calculation Methods and Hanford-Specific Parameters. PNL-3777 Rev. 2. Pacific Northwest Laboratory, Richland, Washington.

Page D-74
Insert 1300b

"The non involved maximum individual worker was assumed to be exposed from inhalation and external radiation from the plume continuously throughout the year and from deposited activity for half of the year (4380 hr/yr). The non involved worker population was assumed to be exposed from inhalation and external radiation from the plume continuously throughout the year and from deposited activity for one third of the year (2920 hr/yr). The dose from inhalation of resuspended activity was evaluated using the mass loading approach with a particulate air concentration of 100 $\mu g/m^3$ for both the maximum individual and population analyses."

Page D-74
Insert 1300c

"The assumptions for the general public maximum exposed individual and population were the same as for the non involved workers (see D.2.2.3.2), plus consideration of ingestion of contaminated farm products. The general public maximum exposed individual was assumed to ingest the following foods: leafy vegetables (82 g/d), root vegetables (600 g/d), fruit (900 g/d), grain (220 g/d), beef (220 g/d), poultry (50 g/d), milk (740 g/d), and eggs (82 g/d). The individuals in the general population were each assumed to ingest the following foods: leafy vegetables (41 g/d), root vegetables (383 g/d), fruit (175 g/d), grain (197 g/d), beef (192 g/d), poultry (23 g/d), milk (630 g/d), and eggs (55 g/d)."

Insert 1243 §.D-73

The historical dose for a tank farm worker has been 14 millirems per year. This same average is assumed for radiation workers during construction of the transfer lines, retrieval system tie ins, and the tank farm confinement facilities. This same dose of 14 millirems per year is also assumed for monitoring, maintenance, and closure activities. A dose of 200 millirems per year is assumed for personnel operating the evaporators, retrieval facilities, separation and treatment facilities (both in situ and ex situ), and for processing the capsules. The dose of 200 millirems per year is the average whole body deep exposure to operational personnel at the PUREX plant during 1986. ~~Exempt radiation personnel operating the evaporator are assumed to receive trivial doses so they are not included in the calculation. For other activities, all radiation workers receive the aforementioned doses~~ (WHC 1995, and JEG 1995). A dose of 6.2 millirems per year is assumed for Capsule alternative (WHC 1995b and

BY_____ DATE_____

D.4.0 REMEDIATION RISK

This section presents the results of the assessment for radiological and toxicological risk during remediation to remediation workers, non-involved workers, and the general public for each of the TWRS alternatives and subalternative. The risks presented in this section were evaluated using the methodology described in Section D.2.0. Under this methodology, remediation risk to the individual is expressed as the probability that an individual will contract a fatal cancer as a result of exposure to a radioactive substance and/or carcinogenic chemicals during the duration of the proposed project. In the case of an exposed population, remediation risk represents the expected increase in latent cancer fatalities in the population at risk of potential exposure. The toxic effects (such as nervous system disorders) resulting from chemical exposure are also analyzed.

D.4.1 NO ACTION ALTERNATIVE

This section presents the anticipated remediation risks associated with the No Action alternative for tank waste, as outlined in Appendix B of the EIS.

The radiological and toxicological risk for this alternative was based upon the air emissions from the evaporator facility and the tank farms during continued operations. Direct exposure to the facility workers from radiation fields in the work place would also add to the radiological risk. There would be no construction, retrieval, pretreatment, treatment, storage, disposal, or waste transportation activities associated with this alternative; therefore, there would be no risk from these components.

Evaporator operations would include maintaining the waste volume by the evaporation of all diluted slurry transfers. Evaporator condensate would be treated in the liquid effluent treatment facility. Evaporator operations would occur over a period of (ten ??? years) (WHC 1995).

Tank farm operations would include performing monitoring and routine maintenance at current levels throughout the administrative control period, assumed to be 100 years for purposes of this analysis. Monitoring the tanks would include in-tank temperatures, corrosion rates, tank pressure, stack gas monitoring, stack gas sampling, annulus leak detection, pit leak detection, and other measurements.

D.4.1.1 Radiological Risk

A latent cancer fatality risk to the worker, non-involved worker, and general public receptors could result from atmospheric emissions from the evaporator and tank farms. The risk was determined by analyzing the radiological (and carcinogenic chemical) source term, transport mechanism, exposure, and the risk associated with the exposure as discussed in the following subsections.

D.4.1.1.1 Source Term

Operating air emissions shown in Table D.4.1.1 are the evaporator and tank farm source term for the non-involved workers and the general public. The workers would receive a combined dose from the air emissions and from direct exposure to radiation fields associated with the evaporator and tank farm operations.

Table D.4.1.1 Atmospheric Radiological Emissions for No Action Alternative, Tank Waste			
Tank Farm Emissions		Evaporator Emissions	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	8.64e-08	Total Alpha	2.10e-05
Total Beta	7.91e-07	Total Beta	1.20e-05
^{90}Sr	1.81e-05		
^{137}Cs	5.38e-05		
^{129}I	4.60e-05		

Source: Henderson, C. Personal Communication. Jacobs Engineering Group, Kennewick, WA. September 1995.

Notes:

[1] Source: (WHC 1995), Table 5.6.

[2] These emissions were analyzed without using decay equations. Total alpha is assumed to be Pu-239. Total beta is assumed to be Sr-90.

D.4.1.1.2 Transport

Ground Releases

Text will change now that we have tables.

Tank farm emissions

The tank farm atmospheric radiological operating emissions were modeled as a ground release. For modeling purposes, it was assumed that the source term would be released at a point in the 200 Areas represented by the meteorological conditions at the Hanford Meteorological Station. The analysis used the Hanford Meteorological Station joint frequency data from 10 m (33 ft) aboveground (Table D.35, Figure D.3).

For ground releases, dilution in the atmosphere would cause contaminant air concentrations and exposures to decrease with increasing distance from the source. Maximum individual exposures therefore would occur at the inner boundaries (i.e., closest distance to the source) of the defined receptor occupancy zones. For the non-involved worker, the maximum exposure would occur 100 m (330 ft) from the source (in an east-southeast direction). For the general public, the maximum exposure would occur 22 km (14 mi) from the source (i.e., the distance to the Hanford Site boundary in an east-southeast direction from the center of the 200 East Area).

The calculated Chi/Q values for ground releases from the tank farms were calculated by the GENII computer code to be 4.0E-04 sec/cm (6.6E-03 sec/in.^{3}) for the non-involved worker MEI and 6.0E-08 sec/cm^3 (9.8E-07 sec/in.^{3}) for the general public MEI. For the non-involved worker population of 10,900 occupying an area between 100 m (330 ft) from the source and the Hanford Site boundary, the population-

weighted Chi/Q was 1.6E-03 sec/cm^3 (2.6E-02 sec/in.^{3}). For the general public population of 376,000 occupying an area outside the Hanford Site boundary within an 80 km (50 mi) radius centered on the 200 Areas, the population-weighted Chi/Q was 2.9E-03 sec/cm^3 (4.8E-02 sec/in.^{3}).

Elevated Releases

Evaporator

Atmospheric radiological operating emissions would occur from the evaporator stack and were modeled as elevated releases. For modeling purposes, it was assumed that the source term (i.e., emissions shown in Table D.4.1.1) would be released at a point in the 200 Areas represented by the meteorological conditions at the Hanford Meteorological Station. The analysis used the Hanford Meteorological Station joint frequency data from 10 m (33 ft) aboveground (Table D.35, Figure D.3). Air transport modeling conditions for evaporator operations were as follows:

- Stack height equals 6.7 m (22 ft);
- Stack flow equals 6.5 m^3/s (8.5 yd^3/s);
- Stack radius equals 0.55 m (1.8 ft); and
- Effluent temperature equals 46° C.

For elevated releases (stack releases), the maximum exposure would not necessarily occur at the closest distance to the source. Air transport modeling indicates that the maximum exposure for the non-involved worker would occur 200 m (660 ft) from the source (in an east-southeast direction). The maximum exposure for a member of the general public would occur 22 km (14 mi) from the source (i.e., the distance to the Hanford Site boundary in an east-southeast direction from the 200 East Area).

The calculated Chi/Q values for 10 years of evaporator operation were 4.2E-06 sec/cm^3 (6.9E-05 sec/in.^{3}) for the non-involved worker MEI and 4.6E-08 sec/cm^3 (7.5E-07/in^3) for the general public MEI. For the non-involved worker population of 10,900 occupying an area between 100 m (330 ft) from the source and the Hanford Site boundary, the population-weighted Chi/Q values were 5.0E-04 sec/cm^3 (8.2E-03 sec/in.^{3}). For the general public population of 376,000 occupying an area outside the Hanford Site boundary within an 80 km (50 mi) radius centered on the 200 Areas, the population-weighted Chi/Q values were 1.9E-03 sec/cm^3 (3.1E-02 sec/in.^{3}).

Table D.4.1.2 Atmospheric Transport Parameters for No Action Alternative, Tank Waste		
	Tank Farm Emissions	Evaporator Emissions
Stack height in m (ft)	Ground	6.7 (22)
Stack radius in m (ft)		0.53 (2)
Stack flow rate in m^3/s (ft^3/s)		10 (353)
Stack temperature in °C (°F)		46 (117)
Non-involved worker MEI location in m ESE (ft)	100 (328)	200 (646)
Public MEI location in km ESE (mi)	22 (14)	22 (14)
Chi/Q for non-involved worker - population in s/m^3	0.0016	0.0004
Chi/Q for non-involved worker - MEI in s/m^3	0.0004	0.0000044
Chi/Q for general public - population in s/m^3	0.0029	0.0016
Chi/Q for general public - MEI in s/m^3	0.00000007	0.0000001

D.4.1.1.3 Exposure

Worker dose

The worker dose would be a combination of the exposure from air emissions and direct exposure to radiation. Historically, the average occupational dose for a tank farm worker has been 14 mrem per person per year [(DOE, 1992) Environmental Assessment for the Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101, Hanford Site, Richland, Washington, DOE/EA-0803, U.S. Department of Energy, Washington, D.C.]. Assuming the individual historical average of 14 mrem per year: (14 mrem per person per year) x (196 persons) x (100 years) = 2.8E+05 mrem or 2.8E+02 rem.

The worker dose from the evaporator was assumed to be the same as the operational personnel dose received at the PUREX plant during 1986 of 200 mrem per person per year.

Worker MEI text will be added based on 500 mrem/yr

Non-involved Worker and General Public dose

The non-involved worker and general public receptor exposures to the atmospheric emissions (source term) were converted to a radiological dose in rem using the GENII computer code and applying the appropriate Chi/Q. The dose for each receptor from tank farm and evaporator operations are presented in Table D.4.1.2.

Table D.4.1.3 Summary of Anticipated Radiological Exposure for No Action Alternative, Tank Waste			
Receptor	Tank Farms (100-yr)	Evaporator (10-yr)	Total
Worker - Population			
Worker - MEI			
Non-involved Worker - Population in Person-Rem	0.0013	0.0012	0.0025
Non-involved Worker - MEI in Rem	0.00032 3.2E-	0.00013 1.3	0.00045 4.5E-
General Public - Population in Person-Rem	0.11	0.048	0.16
General Public - MEI in Rem	0.0000034	0.0000019	0.0000053

Notes:
[1]MEI worker is assumed to work for 30 years

D.4.1.1.4 Risk

Latent cancer fatalities are calculated as the product of the estimated dose times the dose-to-risk conversion factor (Section D.2.2.4, Risk). The dose-to-risk conversion factors used were 4.0E-04 LCFs per person-rem for workers and non-involved workers and 5.0E-04 LCFs per person-rem for the general public.

The sum of the radiological dose from the evaporator and tank farms, shown in the combined dose column in Table D.4.1.3, was multiplied by the appropriate dose-to-risk conversion factor to produce the LCF risk. The LCF risk for each receptor is presented in Table D.4.1.3.

Table D.4.1.4 Summary of Anticipated Risk for No Action Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Worker - Population		
Worker - MEI		
Non-involved Worker - Population (Person-rem)	2.5E-03 ~~person-rem~~	
Non-involved Worker - MEI	4.5E-04 ~~rem~~	
General Public - Population	1.6E-01 ~~person-rem~~	
General Public - MEI	5.3E-06 rem	

Population in Person-rem

D.4.1.2 Chemical Exposure
(Bill Bosan)

D.4.2 LONG-TERM MANAGEMENT ALTERNATIVE

This section presents the anticipated remediation risks associated with the Long-term Management alternative for tank waste, as outlined in Appendix B of the EIS.

The radiological and toxicological risk for this alternative was based upon the air emissions from the evaporator facility and the tank farms during continued operations. Direct exposure to the facility workers from radiation fields in the work place would also add to the radiological risk. There would be no construction, retrieval, pretreatment, treatment, storage, disposal, or waste transportation activities associated with this alternative; therefore, there would be no risk from these components.

Evaporator operations would include maintaining the waste volume by the evaporation of all diluted slurry transfers. Evaporator condensate would be treated in the liquid effluent treatment facility. Evaporator operations would occur over a period of (ten ??? years) (WHC 1995).

Tank farm operations would include performing monitoring and routine maintenance at current levels throughout the administrative control period, assumed to be 100 years for purposes of this analysis. Monitoring the tanks would include in-tank temperatures, corrosion rates, tank pressure, stack gas

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TITLE: SOURCE TERM AND RISK CALCULATION FOR WORKER EXPOSURE

Hours Per Year = 2000

Alternative	Dose	1.0 No Action					2.0 Long Term Management			
	mrem/yr	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.	Worker Hours	Person Year	Person Rem	Risk L
Construction										
Transfer Lines										
Rad Zone	14	na	na	na	na		2.73E+05	137	2	7.66E
Non Rad Zone	0	na	na	na	na		3.82E+04	19	0	1.07E
Continued Operations										
Rad Zone	14	na	na	na	na		3.75E+05	188	3	1.05E
Non Rad Zone	0	na	na	na	na		7.13E+06	3,563	0	0.00E
Retrieval										
Rad Zone	14	na	na	na	na		7.84E+05	392	5	2.19E
Non Rad Zone	0	na	na	na	na		1.49E+07	7,445	0	0.00E
Treatment Facilities										
Rad Zone	14	na	na	na	na		na	na	na	na
Non Rad Zone	0	na	na	na	na		na	na	na	na
Operation										
Continued Operations										
- Monitoring SSTs, DSTs, and MUSTs										
Rad Zone	14	1.00E+08	50000	700	2.80E-01	b,l	1.00E+08	50,000	700	2.80E
Non Rad Zone	0	?	?	?	?	b,l	?	?	?	?
-Operate 242A Evaporator										
Rad Zone NEX	200	1.28E+06	640	128	5.12E-02	l,m	1.28E+06	640	128	5.12E
Rad Zone EX	0	3.00E+05	150	0	0.00E+00	l,m	3.00E+05	150	0	0.00E-
Non Rad Zone	0	1.50E+06	750	0	0.00E+00	l,m	1.50E+06	750	0	0.00E-
Retrieval										
Rad Zone Nonexempt	200	na	na	na	na		2.87E+06	1,435	287	1.15E-
Rad Zone Exempt	200	na	na	na	na		7.73E+05	386	77	3.09E-
Non Rad Zone	0	na	na	na	na		2.43E+06	1,214	0	0.00E-
Evaporate DSTs										
Rad EX	0	na	na	na	na		1.17E+06	585	0	0.00E+
Rad NEX	200	na	na	na	na		2.92E+05	146	29	1.17E-
Non Rad	0	na	na	na	na		1.02E+06	509	0	0.00E+
Separate and Treat Waste										
Rad EX	200	na	na	na	na		na	na	na	na
Rad NEX	0	na	na	na	na		na	na	na	na
Bargaining Unit	200	na	na	na	na		na	na	na	na
Non Rad	0	na	na	na	na		na	na	na	na
Process Capsules										
Rad	200	na	na	na	na		na	na	na	na
Non Rad	0	na	na	na	na		na	na	na	na
Storage and Disposal										
Rad	200	na	na	na	na		na	na	na	na
Non Rad	0	na	na	na	na		na	na	na	na
Monitoring and Maintenance										
Rad	14	na	na	na	na		na	na	na	na
Non Rad	0	na	na	na	na		na	na	na	na
Post Remediation										
Closure										
Rad Zone	14	na	na	na	na		na	na	na	na
Non Rad Zone	0	na	na	na	na		na	na	na	na
Monitoring of Final Waste Form										
Rad Zone	14	na	na	na	na		na	na	na	na
Non Rad Zone	0	na	na	na	na		na	na	na	na
Total		1.03E+08	5.15E+04	8.28E+02	3.31E-01		1.35E+08	6.76E+04	1.23E+03	4.93E-0

na is not applicable

References

(a) Henderson, Lam "Project W-314 Waste Transfer System Upgrades - Engineering Data" Internal Memo from Kirk Block WHC September 18, 1992 Assumed 2000

(b) Henderson, Lam "Responses to Engineering Data Request" Personal Communication September 28, 1992

(c) from Tables 5-2 and 5-5 of Henderson 1994, Hav U Worker hours adjusted to 2000 hrs per year

(d) from Tables 1-2, 1-3, 1-4, and 1-5 of McLamb 1992, Hav U Worker hours adjusted to 2000 hours per year

(e) Assumes 25% of construction hours are rad zone work

(f) the value is 50% of the total for the Preferred Alternative

(g) the value is 50% of the total for the in Situ Vit and Legal Alternative

(h) from Tables 3-3 and 3-5 of Mulvihill 1994, Hav U and Appendix F-6 Worker hours adjusted to 2000 hours per year

(i) from Tables 6-2, 6-3, and 6-14 of Lamb 1994, Hav U Worker hours adjusted to 2000 hours per year

(j) from Tables 3-3 and 3-5 of Hanson et al 1992, Hav U Worker hours adjusted to 2000 hours per year

(k) from Tables 4-2 and 4-3 of Hanson 1992, Hav U Worker hours adjusted to 2000 hours per year

(l) Henderson, Lam "Combined Upgrades" Internal Memo and Lab Calculations

(m) from Tables 3-2 and 3-3 of Wang 1992, Hav U See footnotes to Table 3-3 for dose assumptions Worker hours adjusted to 2000 hours per year

(n) included in total hours

(o) assumes half of the labor hours required for the Long Term Management Alternative since one employee for 3 hours instead

(p) assumes the labor hours are 50% less for the calcination alternative

	3.0 Minimal Removal In Situ Vitrification					4.0 In Situ Fill and Cap					6.0 Selective Removal					
Ref.	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.	Wo Ho
a	2.73E+05	137	2	7.66E-04	a	2.73E+05	137	2	7.66E-04	a	2.73E+05	137	2	7.66E-04	a	2.7
a	3.82E+04	19	0	0.00E+00	a	3.82E+04	19	0	0.00E+00	a	3.82E+04	19	0	0.00E+00	a	3.8
b	na	na	na	na		na	na	na	na		na	na	na	na		
b	na	na	na	na		na	na	na	na		na	na	na	na		
c	na	na	na	na		na	na	na	na		7.98E+05	399	6	2.23E-03	c,f	1.3
c	na	na	na	na		na	na	na	na		1.52E+07	7,581	0	0.00E+00	c,f	2.5
	1.12E+07	5,595	78	3.13E-02	d,e	4.80E+04	24	0	1.34E-04	d,e	3.15E+04	16	0	8.81E-05	f,g	
	3.36E+07	16,785	0	0.00E+00	d,e	1.44E+05	72	0	0.00E+00	d,e	2.66E+07	13,292	0	0.00E+00	f,g	4.0
b,l	2.12E+07	10,610	149	5.94E-02	b,l	2.42E+07	12,100	169	6.78E-02	b,l	3.79E+07	18,960	265	1.06E-01	b,l	3.8
b,l	?	?	?	?	b,l	?	?	?	?	b,l	?	?	?	?	b,l	
l,m	1.28E+06	640	128	5.12E-02	l,m	1.28E+06	640	128	5.12E-02	l,m	1.28E+06	640	128	5.12E-02	l,m	1.2
l,m	3.00E+05	150	0	0.00E+00	l,m	3.00E+05	150	0	0.00E+00	l,m	3.00E+05	150	0	0.00E+00	l,m	3.0
l,m	1.50E+06	750	0	0.00E+00	l,m	1.50E+06	750	0	0.00E+00	l,m	1.50E+06	750	0	0.00E+00	l,m	1.5
c	na	na	na	na		na	na	na	na		2.25E+07	11,258	2252	9.01E-01	c,f	3.7
c	na	na	na	na		na	na	na	na		3.97E+06	1,987	397	1.59E-01	c,f	6.6
c	na	na	na	na		na	na	na	na		1.66E+07	8,278	0	0.00E+00	c,f	2.7
m	na	na	na	na	n	5.85E+05	293	0	0.00E+00	m,o	3.51E+05	176	0	0.00E+00	g	
m	na	na	na	na	n	1.46E+05	73	15	5.84E-03	m,o	8.76E+04	44	9	3.50E-03	g	
m	na	na	na	na	n	5.09E+05	255	0	0.00E+00	m,o	3.05E+05	153	0	0.00E+00	g	
	3.97E+06	1,987	397	1.59E-01	d	5.23E+05	262	52	2.09E-02	d	1.84E+07	9,202	1840	7.36E-01	f,h	2.9
	1.88E+06	938	0	0.00E+00	d	5.23E+05	262	0	0.00E+00	d	5.23E+05	262	0	0.00E+00	f,h	
	7.95E+06	3,974	795	3.18E-01	d	1.55E+06	773	155	6.18E-02	d	1.55E+06	773	155	6.18E-02	f,h	
	3.97E+06	1,987	0	0.00E+00	d	6.50E+05	325	0	0.00E+00	d	3.17E+06	1,583	0	0.00E+00	f,h	4.1
	na	na	na	na		na	na	na	na		na	na	na	na		
	na	na	na	na		na	na	na	na		na	na	na	na		
	na	na	na	na		na	na	na	na		na	na	na	na		
	na	na	na	na		na	na	na	na		na	na	na	na		
	na	na	na	na		na	na	na	na		120,000	60	1	3.36E-04	b	1.2
	na	na	na	na		na	na	na	na		?	?	?	?	b	
	3.64E+05	182	3	1.02E-03	b	3.66E+05	183	3	1.02E-03	b	4.88E+05	244	3	1.37E-03	b	5.5
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	b	0.00E+00	0	0	0.00E+00	b	0.00E+00	0	0	0.00E+00	b	0.0
	1.00E+06	500	7	2.80E-03	b	1.25E+06	625	9	3.50E-03	b	1.35E+06	677	9	3.79E-03	b	1.3
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	b	0.00E+00	0	0	0.00E+00	b	0.00E+00	0	0	0.00E+00	b	0.0
	8.85E+07	4.43E+04	~~1.56E+03~~ 1.51E-03	6.23E-01 6.06E-01		3.39E+07	1.69E+04	5.32E+02	2.13E-01		1.53E+08	7.66E+04	5.07E+03	2.03E+00		2.1

see new

.20/year

10/16/95

7.0 Extensive Retrieval (Ex Situ VR) Alternative					8.0 No Separations Alternative					9.0 Extensive Separations Alternative						
orker ours	Person Year	Person Rem	Risk LCFs	Ref.	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.	Dose	Wor Hou
3E+05	137	2	7.66E-04	a	2.73E+05	137	2	7.66E-04	a	2.73E+05	137	2	7.66E-04	a		na
2E+04	19	0	1.07E-04	a	3.82E+04	19	0	0.00E+00	a	3.82E+04	19	0	0.00E+00	a		na
na	na	na	na		na	na	na	na		na	na	na	na			na
na	na	na	na		na	na	na	na		na	na	na	na			na
3E+06	665	9	3.72E-03	c	1.33E+06	665	9	3.72E-03	c	1.33E+06	665	9	3.72E-03	c		na
3E+07	12,635	0	0.00E+00	c	2.53E+07	12,635	0	0.00E+00	c	2.53E+07	12,635	0	0.00E+00	c		na
0	0	0	0.00E+00	h	0	0	0	0.00E+00	i	0	0	0	0.00E+00	i	14	na
0E+07	20,000	0	0.00E+00	h	3.27E+07	19,030	0	0.00E+00	i	5.74E+07	31,675	0	0.00E+00	i	0	na
0E+07	19,003	266	1.06E-01	b,l	2.17E+07	10,852	152	6.08E-02	b,l	2.47E+07	12,370	173	6.93E-02	b,l		na
?	?	?	?	b,l	?	?	?	?	b,l	?	?	?	?	b,l		na
3E+06	640	128	5.12E-02	l,m	1.28E+06	640	128	5.12E-02	l,m	1.28E+06	640	128	5.12E-02	l,m		na
0E+05	150	0	0.00E+00	l,m	3.00E+05	150	0	0.00E+00	l,m	3.00E+05	150	0	0.00E+00	l,m		na
0E+06	750	0	0.00E+00	l,m	1.50E+06	750	0	0.00E+00	l,m	1.50E+06	750	0	0.00E+00	l,m		na
5E+07	18,764	3753	1.50E+00	c	3.64E+07	18,212	3642	1.46E+00	c	3.75E+07	18,764	3753	1.50E+00	c		na
2E+06	3,311	662	2.65E-01	c	5.52E+06	2,759	552	2.21E-01	c	6.62E+06	3,311	662	2.65E-01	c		na
5E+07	13,797	0	0.00E+00	c	2.76E+07	13,797	0	0.00E+00	c	2.76E+07	13,797	0	0.00E+00	c		na
na	na	na	na		na	na	na	na		na	na	na	na			na
na	na	na	na		na	na	na	na		na	na	na	na			na
na	na	na	na		na	na	na	na		na	na	na	na			na
3E+07	14,901	2980	1.19E+00	h	1.52E+06	759	152	6.07E-02	i	9.38E+06	4,691	938	3.75E-01	i		na
0	0	0	0.00E+00	h	0	0	0	0.00E+00	i	0	0	0	0.00E+00	i		na
0	0	0	0.00E+00	h	2.26E+06	1,130	226	9.04E-02	i	2.32E+07	11,589	2318	9.27E-01	i		na
3E+06	2,097	0	0.00E+00	h	4.15E+06	2,075	0	0.00E+00	i	3.64E+06	1,821	0	0.00E+00	i		na
na	na	na	na		na	na	na	na		na	na	na	na		6.2	na
na	na	na	na		na	na	na	na		na	na	na	na		0	na
na	na	na	na		na	na	na	na		na	na	na	na		6.2	1.52E+
na	na	na	na		na	na	na	na		na	na	na	na		0	4.13E+
3E+05	60	1	3.36E-04	b	1.08E+06	540	8	3.02E-03	b,p	1.20E+05	60	1	3.36E-04	b		na
?	?	?	?	b	1.20E+05	60	0	0.00E+00	b,p	?	?	?	?	b		na
1E+05	277	4	1.55E-03	b	4.30E+05	215	3	1.20E-03	b	5.62E+05	281	4	1.57E-03	b		na
0E+00	0	0	0.00E+00	b	0.00E+00	0	0	0.00E+00	b	0.00E+00	0	0	0.00E+00	b		na
5E+06	677	9	3.79E-03	b	1.19E+06	593	8	3.32E-03	b	1.64E+06	820	11	4.59E-03	b		na
0E+00	0	0	0.00E+00	b	0.00E+00	0	0	0.00E+00	b	0.00E+00	0	0	0.00E+00	b		na
5E+08	1.08E+05	7.81E+03	3.13E+00		1.65E+08	8.40E+04	4.88E+03	1.95E+00		2.22E+08	1.14E+05	8.00E+03	3.20E+00			1.94E+

10.0 Capsule-No Action Alternative				*11. Capsule-Onsite Storage*					*12.0 Capsule-Overpack and Ship*					*13.0 Ca… with Ta…*		
Person Year	Person Rem	Risk LCFs	Ref.	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.	Worker Hours	Person Year	Pe…
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		0.00E+00	0	0	0.00E+00	k	0.00E+00	0	0	0.00E+00	k	na	na	
na	na	na		4.20E+05	210	0	0.00E+00	k	2.00E+05	100	0	0.00E+00	k	na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		2.80E+05	140	1	3.47E-04	k	1.54E+05	77	0	1.91E-04	k	na	na	
na	na	na		1.08E+05	54	0	0.00E+00	k	6.80E+04	34	0	0.00E+00	k	na	na	
761	5	1.89E-03	b	1.40E+06	700	4	1.74E-03	k	1.30E+05	65	0	1.61E-04	k	na	na	
207	0	0.00E+00	b	3.80E+05	190	0	0.00E+00	k	5.00E+04	25	0	0.00E+00	k	na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		na	na	na	na		na	na	na	na		na	na	
na	na	na		8.80E+05	440	6	2.46E-03	b	na	na	na	na		na	na	
na	na	na		?	?	?	?	b	na	na	na	na		na	na	
.68E+02	4.72E+00	1.89E-03		3.47E+06	1.73E+03	1.14E+01	4.55E-03		6.02E+05	3.01E+02	8.80E-01	3.52E-04		0.00E+00	0.00E+00	0.0

ouse-Vitrify of Waste		
rson em	Risk LCFs	Ref.
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
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na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
na	na	
+00	0.00E+00	

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TITLE: SOURCE TERM AND RISK CALCULATION FOR WORKER EXPOSURE

Hours Per Year = 2000

Alternative	Dose	Phased Implementation				
	mrem/yr	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.
Construction						
Transfer Lines						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Continued Operations						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Retrieval						
Rad Zone	14	1000	1	7.00E-03	2.80E-06	a
Non Rad Zone	0	na	na	na	na	
Treatment Facilities (SEP+LAW/HLW)						
Rad Zone	14	0	0	0.00E+00	0.00E+00	a
Non Rad NEX	0	10204000	5,102	0.00E+00	0.00E+00	a
Non Rad EX	0	2910000	1,455	0.00E+00	0.00E+00	a
Treatment Facilities (SEP+LAW)						
Rad Zone	14	0	0	0.00E+00	0.00E+00	a
Non Rad NEX	0	7.94E+06	3,970	0.00E+00	0.00E+00	a
Non Rad EX	0	2.22E+06	1,111	0.00E+00	0.00E+00	a
Operations						
Continued Operations						
- Monitoring SSTs, DSTs, and MUSTs						
Rad Zone	14	1.00E+07	5,000	7.00E+01	2.80E-02	b
Non Rad Zone	0	?	?	?	?	b
-Operate 242A Evaporator						
Rad Zone NEX	200	1.28E+06	640	1.28E+02	5.12E-02	c
Rad Zone EX	0	3.00E+05	150	0.00E+00	0.00E+00	c
Non Rad Zone	0	1.50E+06	750	0.00E+00	0.00E+00	c
Retrieval						
Rad Zone Nonexempt	200	0.00E+00	0	0.00E+00	0.00E+00	a
Rad Zone Exempt	200	4.00E+04	20	4.00E+00	1.60E-03	a
Non Rad Zone	0	0.00E+00	0	0.00E+00	0.00E+00	a
Bargaining Unit	200	1.60E+05	80	1.60E+01	6.40E-03	a
Separate and Treat Waste (SEP/LAW/HLW)						
Exempt						
-Rad	200	9.28E+05	464	9.28E+01	3.71E-02	a
-Non Rad	0	7.84E+05	392	0.00E+00	0.00E+00	a
Non Exempt						
-Rad	200	1.44E+06	720	1.44E+02	5.76E-02	a
-Non Rad	0	1.54E+06	768	0.00E+00	0.00E+00	a
Bargaining Unit						
-Rad	200	1.22E+06	612	1.22E+02	4.90E-02	a
-Non Rad	0	1.22E+06	612	0.00E+00	0.00E+00	a
Separate and Treat Waste (SEP/LAW)						
Exempt						
-Rad	200	6.88E+05	344	6.88E+01	2.75E-02	a
-Non Rad	0	7.20E+05	360	0.00E+00	0.00E+00	a
Non Exempt						
-Rad	200	1.44E+06	720	1.44E+02	5.76E-02	a
-Non Rad	0	1.54E+06	768	0.00E+00	0.00E+00	a
Bargaining Unit						
-Rad	200	1.01E+06	504	1.01E+02	4.03E-02	a
-Non Rad	0	1.01E+06	504	0.00E+00	0.00E+00	a
Storage and Disposal						
Rad	200	na	na	na	na	
Non Rad	0	na	na	na	na	
Monitoring and Maintenance						
Rad	14	na	na	na	na	
Non Rad	0	na	na	na	na	
Post Remediation						
Closure						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Monitoring of Final Waste Form						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Total		5.01E+07	25,047	8.91E+02	3.56E-01	

na is not applicable *Rad Workerhours* 9,255

References

(a) Henderson, Colin, "Response to Engineering Data Request Number 073." October 24, 1995.

(b) Estimated to be 1/10th of the value for the No Action alternative, since 10 years instead of 100 years.

(c) Same as for No Action alt ~ative.

PHASED IMPLEMENTATION STAFFING ESTIMATE

	STAFF HOURS	STAFF YEARS	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
SEPARATIONS +HLW/LAW																				
CONSTRUCTION																				
DESIGN AND ENG	1874000	937	51	61	170	383	255	17												
CONSTRUCTION	10204000	5102		340	1020	1360	1360	680											171	171
SUPERVISORY	1036000	518		34	102	138	136	68											21	21
	0	0																		
	0	0																		
OPERATION	0	0																		
EXEMPT	0	0																		
RAD	928000	464							30	30	30	30	43	43	43	43	43	43	43	43
NONRAD	784000	392							30	30	30	30	34	34	34	34	34	34	34	34
NONEXEMPT	0	0																		
RAD	1440000	720							60	60	60	60	60	60	60	60	60	60	60	60
NONRAD	1536000	768							64	64	64	64	64	64	64	64	64	64	64	64
BARGAINING UNIT	0	0																		
RAD	1224000	612							43	43	43	43	55	55	55	55	55	55	55	55
NONRAD	1224000	612							43	43	43	43	55	55	55	55	55	55	55	55
	0																			
SEPARATIONS + LAW	0																			
CONSTRUCTION	0																			
DESIGN AND ENG	1344000	672	38	47	149	234	191	13												
CONSTRUCTION	7940000	3970		259	778	1037	1037	519											170	170
SUPERVISORY	878000	439		29	85	113	114	56											21	21
	0	0																		
	0	0																		
OPERATION	0	0																		
EXEMPT	0	0																		
RAD	688000	344							28	28	28	28	29	29	29	29	29	29	29	29
NONRAD	720000	360							30	30	30	30	30	30	30	30	30	30	30	30
NONEXEMPT	0	0																		
RAD	1440000	720							60	60	60	60	60	60	60	60	60	60	60	60
NONRAD	1536000	768							64	64	64	64	64	64	64	64	64	64	64	64
BARGAINING UNIT	0	0																		
RAD	1008000	504							42	42	42	42	42	42	42	42	42	42	42	42
NONRAD	1008000	504							42	42	42	42	42	42	42	42	42	42	42	42
			1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOTAL			89	770	2304	3263	3093	1353	536	536	536	536	578	578	578	578	578	578	961	961

15% Reduction. INCLUDED

PHASED IMPLEMENTATION

Retrieval of Waste From Tank Farm and Pump to Supply Tanks(s) for Phased Implementation Alternative												
Retrieval Operations	Staff Hours	Person Years	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Exempt												
Rad Workers	40,000	20	2	2	2	2	2	2	2	2	2	2
Nonexempt												
Rad Workers	0	0	0									
Nonrad Workers	0	0	0									
Bargaining Unit												
Rad Workers	120,000	60	6	6	6	6	6	6	6	6	6	6
Health Physics	40,000	20	2	2	2	2	2	2	2	2	2	2
1. Assumed 1 shift per day.												

	person years	
No Act	50790	3.30E-01
LTM	54058	4.93E-01
ISFC	15520	2.13E-01
ISV	24712	6.23E-01
SEL	44983	2.03
EXINT	58584	3.13
EXNO	36652	1.95
EXEXT	53478	3.2
CPNA	761	1.89E-03
CPOD	1280	4.55E-03
CPOS	142	3.52E-04
CPV		

To Loretta Crow
From Joan Young

Date: Oct. 19, 1995

Alternative	Dose	3.0 Minimal Retrieval In Situ Vitrification				
	mrem/yr	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.
Construction						
Transfer Lines						
Rad Zone	14	2.73E+05	137	2	7.66E-04	a
Non Rad Zone	0	3.82E+04	19	0	0.00E+00	a
Continued Operations						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Retrieval						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Treatment Facilities						
Rad Zone	14	1.12E+07	5,595	78	3.13E-02	d,e
Non Rad Zone	0	3.36E+07	16,785	0	0.00E+00	d,e
Operation						
Continued Operations						
- Monitoring SSTs, DSTs, and MUSTs						
Rad Zone	14	2.12E+07	10,610	149	5.94E-02	b,l
Non Rad Zone	0	?	?	?	?	b,l
-Operate 242A Evaporator						
Rad Zone NEX	200	1.28E+06	640	128	5.12E-02	l,m
Rad Zone EX	0	3.00E+05	150	0	0.00E+00	l,m
Non Rad Zone	0	1.50E+06	750	0	0.00E+00	l,m
Retrieval						
Rad Zone Nonexempt	200	na	na	na	na	
Rad Zone Exempt	200	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
		New				
Evaporate DSTs						
Rad EX	0	5.85E+05	293	0	0.00E+00	m,o
Rad NEX	200	1.46E+05	73	15	5.84E-03	m,o
Non Rad	0	5.09E+05	255	0	0.00E+00	m,o
Separate and Treat Waste						
Rad EX	200	3.39E+06	1,694	339	1.36E-01	d
Rad NEX	0	1.73E+06	865	0	0.00E+00	d
Bargaining Unit	200	7.95E+06	3,974	795	3.18E-01	d
Non Rad	0	3.46E+06	1,732	0	0.00E+00	d
					4.53E-01	
Process Capsules		New Total for alternative		1.51E-03 personrem	6.06E-01 LCF	

Date: Oct. 19, 1995

Alternative	Dose	3.0 Minimal Retrieval In Situ Vitrification				
	mrem/yr	Worker Hours	Person Year	Person Rem	Risk LCFs	Ref.
Construction						
Transfer Lines						
Rad Zone	14	2.73E+05	137	2	7.66E-04	a
Non Rad Zone	0	3.82E+04	19	0	0.00E+00	a
Continued Operations						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Retrieval						
Rad Zone	14	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Treatment Facilities						
Rad Zone	14	1.12E+07	5,595	78	3.13E-02	d,e
Non Rad Zone	0	3.36E+07	16,785	0	0.00E+00	d,e
Operation						
Continued Operations						
- Monitoring SSTs, DSTs, and MUSTs						
Rad Zone	14	2.12E+07	10,610	149	5.94E-02	b,l
Non Rad Zone	0	?	?	?	?	b,l
-Operate 242A Evaporator						
Rad Zone NEX	200	1.28E+06	640	128	5.12E-02	l,m
Rad Zone EX	0	3.00E+05	150	0	0.00E+00	l,m
Non Rad Zone	0	1.50E+06	750	0	0.00E+00	l,m
Retrieval						
Rad Zone Nonexempt	200	na	na	na	na	
Rad Zone Exempt	200	na	na	na	na	
Non Rad Zone	0	na	na	na	na	
Evaporate DSTs						
Rad EX	0	5.85E+05	293	0	0.00E+00	m,o
Rad NEX	200	1.46E+05	73	15	5.84E-03	m,o
Non Rad	0	5.09E+05	255	0	0.00E+00	m,o
Separate and Treat Waste						
Rad EX	200	3.39E+06	1,694	339	1.36E-01	d
Rad NEX	0	1.73E+06	865	0	0.00E+00	d
Bargaining Unit	200	7.95E+06	3,974	795	3.18E-01	d
Non Rad	0	3.46E+06	1,732	0	0.00E+00	d
					4.53E-01	
Process Capsules						

New Total for alternative 1.51E-03 personrem 6.06E-01 LCF

na is not applicable

References

(a)Henderson, Colin. "Project W-314 Waste Transfer System Upgrades - Engineering Data." Internal Memo from Kirk Boes, WHC. Septer

(b) Henderson, Colin. "Response to Engineering Data Request," Personal Communication. September 28, 1995

(c) from Tables 5-2 and 5-6 of Fredenburg 1995, Rev.0. Worker hours adjusted to 2000 hrs per year.

(d) from Tables 7-2, 7-3, 7-8, and 7-24 of McConville 1995, Rev. 0. Worker hours adjusted to 2000 hours per year.

(e) Assume25% of construction hours are rad zone work.

(f) the value is 60% of the total for the Extensive Retrieval Alternative.

(g) the value is 60% of the total for the In Situ Fill and Cap Alternative

(h) from Tables 9-3 and 9-9 of Slaathaug 1995, Rev 0 and Appendix F-6. Worker hours adjusted to 2000 hours per year.

(i) from Tables 6-3, 6-8, and 6-14 of Colby 1995, Rev. 0. Worker hours adjusted to 2000 hours per year.

(j) from Tables 9-3 and 9-8 of Jansen et. al. 1995, Rev.0. Worker hours adjusted to2000 hours per year.

(k) from Tables 4-2 and 4-5 of Nankani 1995, Rev. 0. Worker hours adjusted to 2000 hours per year.

(l) Henderson, Colin. "Continued Operations." Internal Memo and JEG Calculations.

(m) from Tables 5-2 and 5-23 of Meng 1995, Rev. 0. See footnotes to Table 5-23 for dose assumptions. Worker hours adjusted to 2000 h

(n) included in treat waste

(o) assume half of the labor hours required for the Long Term Managment Alternative since evaporate for 5 years instead of 10 years

(p)assume the laborhours are 50% less for the calcination alternative

(7)

nber 18, 1995. Assumed 2000 hours per year.				
ours per year				

(8)

WORKER MEI

Alternative	Duration	mrem / yr	Dose (rem)	Dose-to-Risk Conversion	LCF Risk
No Action	30 years	5.00e+02	1.50e+01	4.00e-04	6.00e-03
Long-Term Management	30 years	5.00e+02	1.50e+01	4.00e-04	6.00e-03
In Situ Fill and Cap	19 years	5.00e+02	9.50e+00	4.00e-04	3.80e-03
In Situ Vitrification	19 years	5.00e+02	9.50e+00	4.00e-04	3.80e-03
Ex Situ Intermediate Separations	29 years	5.00e+02	1.45e+01	4.00e-04	5.80e-03
Ex Situ No Separations	24 years	5.00e+02	1.20e+01	4.00e-04	4.80e-03
Calcination Subalternative	24 years	5.00e+02	1.20e+01	4.00e-04	4.80e-03
Ex Situ Extensive Separations	30 years	5.00e+02	1.20e+01	4.00e-04	4.80e-03
Ex Situ/In Situ Combination	29 years	5.00e+02	1.45e+01	4.00e-04	5.80e-03
Phased Implementation		5.00e+02		4.00e-04	
Capsules - No Action	10 years	5.00e+02	5.00e+00	4.00e-04	2.00e-03
Capsules - Onsite Disposal	19 years	5.00e+02	9.50e+00	4.00e-04	3.80e-03
Capsules - Overpack & Ship	19 years	5.00e+02	9.50e+00	4.00e-04	3.80e-03
Capsules - Vitrify with Tank Waste	19 years	5.00e+02	9.50e+00	4.00e-04	3.80e-03

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FAX TRANSMISSION COVER SHEET

Date: 10/18/95

To: ALEX / A-SI

Fax:

Subject: Worker - MEI #s

Sender: Mike Harker / Loretta

YOU SHOULD RECEIVE 2 PAGE(S), INCLUDING THIS COVER SHEET. IF YOU DO NOT RECEIVE ALL THE PAGES, PLEASE CALL.

Alternatives						
	Workers		Non-Involved Workers		General Public	
Tank Waste	Population	MEI	Population	MEI	Population	MEI
No Action	3.31E-01	6.00E-03	2.50E-03	4.50E-04	1.60E-01	5.30E-06
Long Term Management	4.90E-01	6.00E-03	8.30E-02	9.40E-04	4.90E-01	1.40E-05
In Situ Fill and Cap	2.13E-01	3.80E-03	4.20E-02	3.90E-04	2.40E-01	6.70E-06
In Situ Vitrification	6.06E-01	3.80E-03	4.20E-02	3.90E-04	2.40E-01	6.70E-06
Ex Situ Intermediate Separations	3.13E+00	5.80E-03	9.20E-01	3.10E-03	3.10E+02	6.80E-03
Ex Situ No Separations	1.95E+00	4.80E-03	1.01E+00	2.42E-03	3.12E+02	6.76E-03
Calcination Subalternative	1.95E+00	4.80E-03	9.08E-01	2.37E-03	2.22E+02	4.86E-03
Ex Situ Extensive Separations	3.20E+00	4.80E-03	7.50E-01	2.80E-03	2.50E+02	5.60E-03
Ex Situ/In Situ Combination	2.03E+00	5.80E-03	8.50E-01	3.00E-03	2.62E+02	6.10E-03
Phased Implementation						
Cesium and Strontium Capsules						
No Action	1.89E-03	2.00E-03	1.30E-04	1.90E-07	6.30E-04	1.30E-08
Onsite Disposal	4.55E-03	3.80E-03	2.50E-04	3.60E-07	1.20E-03	2.50E-08
Overpack and Ship	3.52E-04	3.80E-03	2.50E-04	3.60E-07	1.20E-03	2.50E-08
Vitrify with Tank Waste	3.52E-04	3.80E-03	2.50E-04	3.60E-07	1.20E-03	2.50E-08
4.00E-04						
5.00E-04						
Tank Waste	Population	MEI	Population	MEI	Population	MEI
No Action	3.31E-01	6.00E-03	1.00E-06	1.80E-07	8.00E-05	2.58E-09
Long Term Management	4.90E-01	6.00E-03	3.32E-05	3.76E-07	2.45E-04	7.00E-09
In Situ Fill and Cap	2.13E-01	3.80E-03	1.68E-05	1.56E-07	1.20E-04	3.35E-09
In Situ Vitrification	6.06E-01	3.80E-03	1.68E-05	1.56E-07	1.20E-04	3.35E-09
Ex Situ Intermediate Separations	3.13E+00	5.80E-03	3.68E-04	1.24E-06	1.55E-01	3.40E-06
Ex Situ No Separations	1.95E+00	4.80E-03	4.03E-04	9.68E-07	1.56E-01	3.38E-06
Calcination Subalternative	1.95E+00	4.80E-03	3.63E-04	9.48E-07	1.11E-01	2.43E-06
Ex Situ Extensive Separations	3.20E+00	4.80E-03	3.00E-04	1.12E-06	1.25E-01	2.80E-06
Ex Situ/In Situ Combination	2.03E+00	5.80E-03	3.40E-04	1.20E-06	1.31E-01	3.05E-06
Phased Implementation						
Cesium and Strontium Capsules						

dose

revised 11-23-95 nsb LCF

No Action	1.89E-03	2.00E-03	5.20E-08	7.60E-11	3.15E-07	6.50E-12
Onsite Disposal	4.55E-03	3.80E-03	1.00E-07	1.44E-10	6.00E-07	1.25E-11
Overpack and Ship	3.52E-04	3.80E-03	1.00E-07	1.44E-10	6.00E-07	1.25E-11
Vitrify with Tank Waste	3.52E-04	3.80E-03	1.00E-07	1.44E-10	6.00E-07	1.25E-11

Calculations for Summary Tables				23-Oct-95		
No Action			Combined			
	tf	ev1	Dose	Risk		
on pop	1.30E-03	1.20E-03	2.50E-03	1.00E-06		
on mel	3.20E-04	7.00E-05	3.90E-04	1.56E-07		
off pop	1.10E-01	4.80E-02	1.58E-01	7.90E-05		
off mel	3.40E-06	1.20E-06	4.60E-06	2.30E-09		
Long Term Mgmt					Combined	
	tf	ev1	ret	ev2	Dose	Risk
on pop	1.30E-03	1.20E-03	9.20E-05	8.00E-02	8.26E-02	3.30E-05
on mel	3.20E-04	7.00E-05	2.40E-06	4.90E-04	8.82E-04	3.53E-07
off pop	1.10E-01	4.80E-02	2.30E-03	3.30E-01	4.90E-01	2.45E-04
off mel	3.40E-06	1.20E-06	7.10E-08	8.30E-06	1.30E-05	6.49E-09
ISFC					Combined	
	tf	ev1	ev2	gf	Dose	Risk
on pop	2.50E-04	1.20E-03	4.00E-02	3.20E-07	4.15E-02	1.66E-05
on mel	6.10E-06	7.00E-05	2.50E-04	8.00E-08	3.26E-04	1.30E-07
off pop	2.10E-02	4.80E-02	1.70E-01	2.96E-05	2.39E-01	1.20E-04
off mel	6.50E-07	1.20E-06	4.10E-06	8.80E-10	5.95E-06	2.98E-09
ISV					Combined	
	tf	ev1	ev2	ISV	Dose	Risk
on pop	2.50E-04	1.20E-03	4.00E-02	3.50E-04	4.18E-02	1.67E-05
on mel	6.10E-06	7.00E-05	2.50E-04	2.20E-06	3.28E-04	1.31E-07
off pop	2.10E-02	4.80E-02	1.70E-01	1.40E-03	2.40E-01	1.20E-04
off mel	6.50E-07	1.20E-06	4.10E-06	3.10E-08	5.98E-06	2.99E-09

Ex Situ/In Situ Comb										
									Combined	
	tf	ev1	ev2		gf	ret	vit		Dose	Risk
				per year	8 yr (50%)					
on pop	3.80E-04	1.20E-03	2.40E-02	4.00E-08	1.60E-07	7.70E-03	8.20E-01		8.53E-01	3.41E-04
on mei	9.30E-05	7.00E-05	1.50E-04	1.00E-08	4.00E-08	2.10E-03	4.80E-04		2.89E-03	1.16E-06
off pop	3.20E-02	4.80E-02	1.02E-01	3.70E-06	1.48E-05	2.1	2.60E+02		2.62E+02	1.31E-01
off mei	9.90E-07	1.20E-06	2.50E-06	1.10E-10	4.40E-10	6.80E-05	6.00E-03		6.07E-03	3.04E-06
Ex Situ Intermediate Sep						Combined				
	tf	ev1	Ret	Sep/Vit	Dose	Risk				
on pop	3.80E-04	1.20E-03	9.10E-03	9.10E-01	9.21E-01	3.68E-04				
on mei	9.30E-05	7.00E-05	2.40E-03	5.30E-04	3.09E-03	1.24E-06				
off pop	3.20E-02	4.80E-02	2.30E+00	3.10E+02	3.12E+02	1.56E-01				
off mei	9.90E-07	1.20E-06	7.50E-05	6.70E-03	6.78E-03	3.39E-06				
Ex Situ No Sep-vitrify						Combined				
	tf	ev1	Ret	Sep/Vit	Dose	Risk				
on pop	3.10E-04	1.20E-03	6.70E-03	1.00E+01	1.00E+01	4.00E-03				
on mei	7.70E-07	7.00E-05	1.70E-03	5.90E-04	2.36E-03	9.44E-07				
off pop	2.60E-02	4.80E-02	1.70E+00	3.10E+02	3.12E+02	1.56E-01				
off mei	8.20E-07	1.20E-06	5.50E-05	6.70E-03	6.76E-03	3.38E-06				
Ex Situ No Sep-Calcination						Combined				
	tf	ev1	Ret	calc	Dose	Risk				
on pop	3.10E-04	1.20E-03	6.70E-03	9.00E-01	9.08E-01	3.63E-04				
on mei	7.70E-07	7.00E-05	1.70E-03	5.20E-04	2.29E-03	9.16E-07				
off pop	2.60E-02	4.80E-02	1.70E+00	2.20E+02	2.22E+02	1.11E-01				
off mei	8.20E-07	1.20E-06	5.50E-05	4.80E-03	4.86E-03	2.43E-06				

Ex Situ Extensive Sep						Combined				
	tf	ev1	Ret	Vit	Dose	Risk				
on pop	3.90E-04	1.20E-03	8.10E-03	7.40E-01	7.50E-01	3.00E-04				
on mei	9.60E-05	7.00E-05	2.10E-03	4.20E-04	2.69E-03	1.07E-06				
off pop	3.30E-02	4.80E-02	2.10E+00	2.50E+02	2.52E+02	1.26E-01				
off mei	1.00E-06	1.20E-06	6.70E-05	5.50E-03	5.57E-03	2.78E-06				

Alternative	1.0 No Action					2.0 Long Term Management				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NOT APPLICABLE					NO EMISSIONS				
Operation										
Continued Operations	emiss1.xls (actual)	100 yr	Ground			emiss1.xls (actual)	100 yr	Ground		
	Total Alpha=2.88E-08 Ci/yr					See No Action				
	Total Beta=7.91E-07 Ci/yr					100% of current				
-Monitor SSTs, DSTs, and MUSTs	Sr-90=1.81E-05 Ci/yr									
	Cs-137=5.35E-05 Ci/yr									
	I-129=4.6E-05 Ci/yr		100% of current							
-Operate 242A Evaporator	emit.xls (periodic)	10 yr	6.7 m	10.3 cu m/s	46 C	emit.xls (periodic)	10 yr	6.7 m	10.3 cu m/s	46 C
	Tot. Alpa =2.1E-5 Ci/Y		.53 m			See No Action		.53 m		
	Tot. Beta=1.2E-5 Ci/Y									
Retrieval		NOT APPLICABLE				Cs-137=.0007 Ci		Ground		
						I-129=.001 Ci	10 yr			
						Sr-90=.0001 Ci	(per memo from Colin)			
Evaporate DSTS (a)		NOT APPLICABLE				emit.xlas (continuous)	10 yr	6.7 m	10.3 cu m/s	46 C
						Tot. Alpha=1.4E-04 Ci/Y				
						Tot. Beta=8.04E-05 Ci/Y		.53 m		
Separations		NOT APPLICABLE					NOT APPLICABLE			
Vitrify Tank Waste (a)		NOT APPLICABLE					NOT APPLICABLE			
Process Capsules		NOT APPLICABLE					NOT APPLICABLE			
Storage and Disposal		NOT APPLICABLE					NOT APPLICABLE			
Monitoring and Maintenance		NOT APPLICABLE					NOT APPLICABLE			
Post Remediation										
Closure		NOT APPLICABLE					NOT APPLICABLE			
Monitoring of Final Waste Form		NOT APPLICABLE					NOT APPLICABLE			

(a) for gravel and fill, these emissions are based on ten times the value of current emissions per hour for 24 hours (3 days) for 22 tanks per year.

Alternative	3.0 Minimal Retrieval In Situ Vitrification					4.0 In Situ Fill and Cap				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NO EMISSIONS					NO EMISSIONS				
Operation										
Continued Operations -Monitor SSTs, DSTs, and MUSTs	emiss1.xls (actual) See No Action ~~82% of current~~	19 yr ~~(15.6 yr adj)~~	Ground			emiss1.xls (actual) See No Action ~~75% of current~~	19 yr ~~(14.25 yr adj)~~	Ground		
-Operate 242A Evaporator	emit.xls (periodic) See No Action	10 yr	6.7 m .53 m	10.3 cu m/s	46 C	emit.xls (periodic) See No Action	10 yr	6.7 m .53 m	10.3 cu m/s	46 C
Retrieval	NOT APPLICABLE					NOT APPLICABLE				
Evaporate DSTS (a)	emit.xlas (continuous) See Long Term Mgmt	5 yr	6.7 m .53 m	10.3 cu m/s	46 C	emit.xlas (continuous) See Long Term Mgmt	3 yr	6.7 m .53 m	10.3 cu m/s	46 C
Separations	NOT APPLICABLE					NOT APPLICABLE				
Vitrify Tank Waste (a)	Table D.45 pg. D-88	9 yr	31 m .33m	4.3 cu m/s	93 oC	Total Alpha=9.83E-11 Ci/yr Total Beta=2.69E-09 Ci/yr Sr-90=2.91E-08 Ci/yr Cs-137=1.81E-07 Ci/yr I-129=1.57E-07 Ci/yr	8 yr (calculated from emiss1.xls)	Ground		
Process Capsules	NOT APPLICABLE					NOT APPLICABLE				
Storage and Disposal	NO EMISSIONS					NO EMISSIONS				
Monitoring and Maintenanc	NO EMISSIONS					NO EMISSIONS				
Post Remediation										
Closure	NO EMISSIONS					NO EMISSIONS				
Monitoring of Final Waste Fo	NO EMISSIONS					NO EMISSIONS				

(a) for gravel and fill, these e

Alternative	6.0 Selective Retrieval					7.0 Extensive Retrieval (Ex Situ Vit) Alternative				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NO EMISSIONS					NO EMISSIONS				
Operation										
Continued Operations	emiss1.xls (actual) See No Action ~~53% of current~~	29 yr ~~(15.4 yr adj)~~	Ground			emiss1.xls (actual) See No Action ~~59% of current~~	29 yr ~~(17.1 yr adj)~~	Ground		
-Monitor SSTs, DSTs, and MUSTs										
-Operate 242A Evaporator	emit.xls (periodic) See No Action	10 yr	6.7 m .53 m	10.3 cu m/s	46 C	emit.xls (periodic) See No Action	10 yr	6.7 m .53 m	10.3 cu m/s	46 C
Retrieval	Table D.56	26 yr	Ground			Table D.60	26 yr	Ground		
Evaporate DSTS (a)	emit.xlas (continuous) See Long Term Mgmt	3 yr	6.7 m .53 m	10.3 cu m/s	46 C	NOT APPLICABLE				
Separations	INCLUDED IN VITRIFICATION					INCLUDED IN VITRIFICATION				
Vitrify Tank Waste (a)	Table D.54 pg. D-103	24 yr	55 m .88 m	33 cu m/s	160 oC	Table D.61	24 yr	55 m .88 m	33 cu m/s	160 oC
	See Insitu gravel and fill (60%)	8 yr	Ground							
Process Capsules	NOT APPLICABLE					NOT APPLICABLE				
Storage and Disposal	NO EMISSIONS					NO EMISSIONS				
Monitoring and Maintenanc	NO EMISSIONS					NO EMISSIONS				
Post Remediation										
Closure	NO EMISSIONS					NO EMISSIONS				
Monitoring of Final Waste Fo	NO EMISSIONS					NO EMISSIONS				

(a) for gravel and fill, these e

Alternative	8.0 No Separations Alternative					9.0 Extensive Separations Alternative				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NO EMISSIONS					NO EMISSIONS				
Operation										
Continued Operations -Monitor SSTs, DSTs, and MUSTs	emiss1.xls (actual) See No Action ~~69% of current~~	24 yr ~~(16.6 yr adj)~~	Ground			emiss1.xls (actual) See No Action ~~58% of current~~	30 yr ~~(17.4 yr adj)~~	Ground		
-Operate 242A Evaporator	emit.xls (periodic) See No Action	10 yr	6.7 m .53 m	10.3 cu m/s	46 C	emit.xls (periodic) See No Action	10 yr	6.7 m .53 m	10.3 cu m/s	46 C
Retrieval	Table D.60	19 yr	Ground			Table D.60	23 yr	Ground		
Evaporate DSTS (a)	NOT APPLICABLE					NOT APPLICABLE				
Separations	NOT APPLICABLE									
Vitrify Tank Waste (a)	Table D.65 (change C-14 to 812 Ci or 58 Ci/Yr for calcination)	14 yr	55 m .88 m	33 cu m/s	160 oC	Table D.69	21 yr	55 m .88 m	33 cu m/s	160 C
Process Capsules	NOT APPLICABLE					NOT APPLICABLE				
Storage and Disposal	NO EMISSIONS					NO EMISSIONS				
Monitoring and Maintenanc	NO EMISSIONS					NO EMISSIONS				
Post Remediation										
Closure	NO EMISSIONS					NO EMISSIONS				
Monitoring of Final Waste Fo	NO EMISSIONS					NO EMISSIONS				

(a) for gravel and fill, these e

Alternative	*10.0 Capsule-No Action Alternative*					*11. Capsule-Onsite Storage*				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NOT APPLICABLE					NO EMISSIONS				
Operation										
Continued Operations	NOT APPLICABLE					NOT APPLICABLE				
-Monitor SSTs, DSTs, and MUSTs										
-Operate 242A Evaporator	NOT APPLICABLE					NOT APPLICABLE				
Retrieval	NOT APPLICABLE					NOT APPLICABLE				
Evaporate DSTS (a)	NOT APPLICABLE					NOT APPLICABLE				
Separations	NOT APPLICABLE					NOT APPLICABLE				
Vitrify Tank Waste (a)	NOT APPLICABLE					NOT APPLICABLE				
Process Capsules	wesfops.xls	10 yr	21 m	10.2 mps	20 C	wesfops.xls	19 yr	21 m	10.2 mps	20 C
			.53 m radius	9.2 cu m/s				.53 m radius	9.2 cu m/s	
Storage and Disposal	NOT APPLICABLE					NO EMISSIONS				
Monitoring and Maintenanc	NOT APPLICABLE					NOT APPLICABLE				
Post Remediation										
Closure	NOT APPLICABLE					NO EMISSIONS				
Monitoring of Final Waste Fo	NOT APPLICABLE					NO EMISSIONS				

(a) for gravel and fill, these e

Alternative	*12.0 Capsule-Overpack and Ship*					*13.0 Capsule-Vitrify with Tank Waste*				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction		NO EMISSIONS					NO EMISSIONS			
Operation										
Continued Operations		NOT APPLICABLE					NOT APPLICABLE			
-Monitor SSTs, DSTs, and MUSTs										
-Operate 242A Evaporator		NOT APPLICABLE					NOT APPLICABLE			
Retrieval		NOT APPLICABLE					NOT APPLICABLE			
Evaporate DSTS (a)		NOT APPLICABLE					NOT APPLICABLE			
Separations		NOT APPLICABLE					NOT APPLICABLE			
Vitrify Tank Waste (a)		NOT APPLICABLE					NOT APPLICABLE			
Process Capsules	wesfops.xls	19 yr	21 m	10.2 mps	20 C	wesfops.xls	19 yr	21 m	10.2 mps	20 C
			.53 m radius	9.2 cu m/s				.53 m radius	9.2 cu m/s	
Storage and Disposal		NOT APPLICABLE					NOT APPLICABLE			
Monitoring and Maintenanc		NOT APPLICABLE					NOT APPLICABLE			
Post Remediation										
Closure		NOT APPLICABLE					NOT APPLICABLE			
Monitoring of Final Waste Fo		NOT APPLICABLE					NOT APPLICABLE			

(a) for gravel and fill, these e

Alternative	1.0 No Action (N/Gt#)					2.0 Long Term Management				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction		NOT APPLICABLE					NO EMISSIONS			
Operation										
Continued Operations	Cs137=7.67E-7 Ci /Y	100 yr	Ground	10.3 cu m/s	TF✓	Cs137=7.67E-7 Ci /Y	100 yr	Ground	10.3 cu m/s	TF✓
-Monitor SSTs, DSTs, and MUSTs	Sr90=9.52E-6Ci/Y	100% of current				Sr90=9.52E-6Ci/Y	100% of current			
-Operate 242A Evaporator	Tot. Alpa =2.1e-5 Ci/Y	10 yr	6.7 m	10.3 cu m/s	46 C	Tot. Alpa =2.1e-5 Ci/Y	10 yr	6.7 m	10.3 cu m/s	46 C
	Tot. Beta=1.2e-5 Ci/Y		.53 m		EV1✓	Tot. Beta=1.2e-5 Ci/Y		.53 m		EV1✓
Retrieval		NOT APPLICABLE				Cs-137=.0007 Ci ÷10 I-129=.001. Ci ÷10 Sr-90=.0001 Ci ÷10	10 yr	Ground		RT
Evaporate DSTS (a)		NOT APPLICABLE				Tot. Alpha=1.4e-4 Ci/Y	10 yr	6.7 m	10.3 cu m/s	46 C
						Tot. Beta=8.04E-5 Ci/Y		.53 m		EV2✓
Separations		NOT APPLICABLE					NOT APPLICABLE			
Vitrify Tank Waste		NOT APPLICABLE					NOT APPLICABLE			
Process Capsules		NOT APPLICABLE					NOT APPLICABLE			
Storage and Disposal		NOT APPLICABLE					NOT APPLICABLE			
Monitoring and Maintenance		NOT APPLICABLE					NOT APPLICABLE			
Post Remediation										
Closure		NOT APPLICABLE					NOT APPLICABLE			
Monitoring of Final Waste Form		NOT APPLICABLE					NOT APPLICABLE			

References

(a)For ISV and In Situ Gravel and Fill, use emissions from Table D.39 instead.

Alternative	*8.0 No Separations Alternative*					*9.0 Extensive Separations Alternative*				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NO EMISSIONS					NO EMISSIONS				
Operation										
Continued Operations	tankfarm.xls	24 yr	Ground			tankfarm.xls	30 yr	Ground		
-Monitor SSTs, DSTs, and MUSTs	actual	69% of current or 16.6 yr adjusted				actual	58 % of current or 17.4 yr adjusted			
-Operate 242A Evaporator	emit.xls	10 yr	6.7 m	6.1 cu m/s	46 C	emit.xls	10 yr	6.7 m	6.1 cu m/s	46 C
	periodic		.53 m			periodic		.53 m		
Retrieval	Table D.60	19 yr	Ground			Table D.60	23 yr	Ground		
Evaporate DSTS (a)	NOT APPLICABLE					NOT APPLICABLE				
Separations	NOT APPLICABLE									
Vitrify Tank Waste	Table D.65	14 yr	55 m	33 cu m/s	160 oC	Table D.69	21 yr	55 m	33 cu m/s	160 C
	(change C-14 to		.88 m					.88 m		
	812 Ci for calcination)									
Process Capsules	NOT APPLICABLE					NOT APPLICABLE				
Storage and Disposal	NO EMISSIONS					NO EMISSIONS				
Monitoring and Maintenance	NO EMISSIONS					NO EMISSIONS				
Post Remediation										
Closure	NO EMISSIONS					NO EMISSIONS				
Monitoring of Final Waste Form	NO EMISSIONS					NO EMISSIONS				

References

(a)For ISV and In Situ Gravel and

Alternative	1.0 No Action					2.0 Long Term Management				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction		NOT APPLICABLE					NO EMISSIONS			
Operation										
Continued Operations	emiss1.xls	100 yr	Ground		TFA	emiss1.xls	100 yr	Ground		TFA
	Cs137=7.67E-7 Ci /Y				TFP	Cs137=7.67E-7 Ci /Y				TFP
-Monitor SSTs, DSTs, and MUSTs	Sr90=9.52E-6Ci/Y	100% of current				Sr90=9.52E-6Ci/Y	100% of current			
-Operate 242A Evaporator	emit.xls (periodic)	10 yr	6.7 m	10.3 cu m/s	46 C	emit.xls (periodic)	10 yr	6.7 m	10.3 cu m/s	46 C
	Tot. Alpa =2.1E-5 Ci/Y		.53 m			Tot. Alpa =2.1E-5 Ci/Y		.53 m		
	Tot. Beta=1.2E-5 Ci/Y				EV1	Tot. Beta=1.2E-5 Ci/Y				EV1
Retrieval		NOT APPLICABLE				Cs-137=.0007 Ci		Ground		
						I-129=.001 Ci	10 yr			
						Sr-90=.0001 Ci	(per memo from Colin)			
Evaporate DSTS (a)		NOT APPLICABLE				emit.xlas (continuou	10 yr	6.7 m	10.3 cu m/s	46 C
						Tot. Alpha=1.4e-4 Ci/Y				
						Tot. Beta=8.04E-5 Ci/Y		.53 m		EV 2
Separations		NOT APPLICABLE					NOT APPLICABLE			
Vitrify Tank Waste		NOT APPLICABLE					NOT APPLICABLE			
Process Capsules		NOT APPLICABLE					NOT APPLICABLE			
Storage and Disposal		NOT APPLICABLE					NOT APPLICABLE			
Monitoring and Maintenance		NOT APPLICABLE					NOT APPLICABLE			
Post Remediation										
Closure		NOT APPLICABLE					NOT APPLICABLE			
Monitoring of Final Waste Form		NOT APPLICABLE					NOT APPLICABLE			

References

(a)For ISV and In Situ Gravel and Fill, use emissions from Table D.39 instead.

Alternative	6.0 Selective Retrieval					7.0 Extensive Retrieval (Ex Situ Vit) Alternative				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NO EMISSIONS					NO EMISSIONS				
Operation										
Continued Operations	emiss1.xls Cs137=7.67E-7 Ci /Y Sr90=9.52E-6Ci/Y	100 yr 53% of current	Ground			emiss1.xls Cs137=7.67E-7 Ci /Y Sr90=9.52E-6Ci/Y	100 yr 59% of current	Ground		
-Monitor SSTs, DSTs, and MUSTs										
-Operate 242A Evaporator	emit.xls (periodic) Tot. Alpa =2.1E-5 Ci/Y Tot. Beta=1.2E-5 Ci/Y	10 yr	6.7 m .53 m	10.3 cu m/s	46 C	emit.xls (periodic) Tot. Alpa =2.1E-5 Ci/Y Tot. Beta=1.2E-5 Ci/Y	10 yr	6.7 m .53 m	10.3 cu m/s	46 C
Retrieval	Assume 50% of Table D.60	26 yr	Ground			Table D.60	26 yr	Ground		
Evaporate DSTS (a)	emit.xlas (continuo Tot. Alpha=1.4e-4 Ci/Y Tot. Beta=8.04E-5 Ci/Y	5 yr	6.7 m .53 m	10.3 cu m/s	46 C	NOT APPLICABLE				
Separations	INCLUDED IN VITRIFICATION					INCLUDED IN VITRIFICATION				
Vitrify Tank Waste	Table D.54 pg. D-103	24 yr	55 m .88 m	33 cu m/s	160 oC	Table D.61	24 yr	55 m .88 m	33 cu m/s	160 oC
Process Capsules	NOT APPLICABLE					NOT APPLICABLE				
Storage and Disposal	NO EMISSIONS					NO EMISSIONS				
Monitoring and Maintenanc	NO EMISSIONS					NO EMISSIONS				
Post Remediation										
Closure	NO EMISSIONS					NO EMISSIONS				
Monitoring of Final Waste For	NO EMISSIONS					NO EMISSIONS				

References

(a)For ISV and In Situ Gravel

Alternative	8.0 No Separations Alternative					9.0 Extensive Separations Alternative				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NO EMISSIONS					NO EMISSIONS				
Operation										
Continued Operations	emiss1.xls	100 yr	Ground			emiss1.xls	100 yr	Ground		
	Cs137=7.67E-7 Ci /Y					Cs137=7.67E-7 Ci /Y				
-Monitor SSTs, DSTs, and MUSTs	Sr90=9.52E-6Ci/Y	69% of current				Sr90=9.52E-6Ci/Y	58% of current			
-Operate 242A Evaporator	emit.xls (periodic)	10 yr	6.7 m	10.3 cu m/s	46 C	emit.xls (periodic)	10 yr	6.7 m	10.3 cu m/s	46 C
	Tot. Alpa =2.1E-5 Ci/Y		.53 m			Tot. Alpa =2.1E-5 Ci/Y		.53 m		
	Tot. Beta=1.2E-5 Ci/Y					Tot. Beta=1.2E-5 Ci/Y				
Retrieval	Table D.60	19 yr	Ground			Table D.60	23 yr	Ground		
Evaporate DSTS (a)	NOT APPLICABLE					NOT APPLICABLE				
Separations	NOT APPLICABLE									
Vitrify Tank Waste	Table D.65	14 yr	55 m	33 cu m/s	160 oC	Table D.69	21 yr	55 m	33 cu m/s	160 C
	(change C-14 to		.88 m					.88 m		
	812 Ci or 58 Ci/Yr for calcination)									
Process Capsules	NOT APPLICABLE					NOT APPLICABLE				
Storage and Disposal	NO EMISSIONS					NO EMISSIONS				
Monitoring and Maintenanc	NO EMISSIONS					NO EMISSIONS				
Post Remediation										
Closure	NO EMISSIONS					NO EMISSIONS				
Monitoring of Final Waste For	NO EMISSIONS					NO EMISSIONS				

References

(a)For ISV and In Situ Gravel

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Alternative	*10.0 Capsule-No Action Alternative*					*11. Capsule-Onsite Storage*				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NOT APPLICABLE					NO EMISSIONS				
Operation										
Continued Operations -Monitor SSTs, DSTs, and MUSTs	NOT APPLICABLE					NOT APPLICABLE				
-Operate 242A Evaporator	NOT APPLICABLE					NOT APPLICABLE				
Retrieval	NOT APPLICABLE					NOT APPLICABLE				
Evaporate DSTS (a)	NOT APPLICABLE					NOT APPLICABLE				
Separations	NOT APPLICABLE					NOT APPLICABLE				
Vitrify Tank Waste	NOT APPLICABLE					NOT APPLICABLE				
Process Capsules	wesfops.xls	10 yr	21 m .53 m radius	10.2 mps 9.2 cu m/s	20 C	wesfops.xls	19 yr	21 m .53 m radius	10.2 mps 9.2 cu m/s	20 C
Storage and Disposal	NOT APPLICABLE					NO EMISSIONS				
Monitoring and Maintenanc	NOT APPLICABLE					NOT APPLICABLE				
Post Remediation										
Closure	NOT APPLICABLE					NO EMISSIONS				
Monitoring of Final Waste For	NOT APPLICABLE					NO EMISSIONS				

References

(a)For ISV and In Situ Gravel

Alternative	*12.0 Capsule-Overpack and Ship*					*13.0 Capsule-Vitrify with Tank Waste*				
	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.	Source	Duration in Years	Stack Ht/Rad	Stack Velocity	Stack Temp.
Construction	NO EMISSIONS					NO EMISSIONS				
Operation										
Continued Operations	NOT APPLICABLE					NOT APPLICABLE				
-Monitor SSTs, DSTs, and MUSTs										
-Operate 242A Evaporator	NOT APPLICABLE					NOT APPLICABLE				
Retrieval	NOT APPLICABLE					NOT APPLICABLE				
Evaporate DSTS (a)	NOT APPLICABLE					NOT APPLICABLE				
Separations	NOT APPLICABLE					NOT APPLICABLE				
Vitrify Tank Waste	NOT APPLICABLE					NOT APPLICABLE				
Process Capsules	wesfops.xls	19 yr	21 m	10.2 mps	20 C	wesfops.xls	19 yr	21 m	10.2 mps	20 C
			.53 m radius	9.2 cu m/s				.53 m radius	9.2 cu m/s	
Storage and Disposal	NOT APPLICABLE					NOT APPLICABLE				
Monitoring and Maintenanc	NOT APPLICABLE					NOT APPLICABLE				
Post Remediation										
Closure	NOT APPLICABLE					NOT APPLICABLE				
Monitoring of Final Waste For	NOT APPLICABLE					NOT APPLICABLE				

References

(a)For ISV and In Situ Gravel

Table D.9-1 Atmospheric Radiological Emissions for the Phased Implementation Alternative, Tank Waste							
Tank Farm Emissions[1,2]		Evaporator Emissions[1]		Separation and LAW Vitrification Emissions[1,3]		Separation/LAW Vitrification and HLW Vitrification Emissions[1,4]	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	2.88E-08	Total Alpha	2.10E-05	^{241}Am	9.13E-07	^{241}Am	4.03E-04
Total Beta	7.91E-07	Total Beta	1.20E-05	^{14}C	1.12E+02	^{14}C	1.18E+02
^{129}I	4.60E-05			^{137}Cs	5.24E-03	^{137}Cs	2.91E-01
^{137}Cs	5.38E-05			^{239}Pu	2.21E-07	^{239}Pu	4.42E-04
^{90}Sr	1.81E-05			^{90}Sr	2.02E-04	^{90}Sr	4.48E-01
				^{99}Tc	2.75E-06	^{99}Tc	2.79E-05

[1] Jacobs Engineering Group Inc. Engineering Calculations for the Tank Waste Remediation System Environmental Impact Statement. Jacobs Engineering Group Inc. Kennewick, WA. September 1995.
[2] This estimate includes retrieval emissions.
[3] There will be two treatment facilties with these emissions. One facility will operate for ten years and the second will operate for four years.
[4] These emissions will occur during the last six years of operation for the second treatment facility.

Table D.9-2 Atmospheric Transport Parameters for the Phased Implementation Alternative, Tank Waste			
	Tank Farms	Evaporator 1	Separation and Vitrification
Stack height in m (ft)	Ground	6.70 (22)	45.7 (150)
Stack radius in m (ft)		0.53 (1.6)	.50 (1.6)
Stack flow rate in m^3/s (ft^3/s)		10 (353)	10.8 (381)
Stack temperature in °C (°F)		46 (117)	65.6 (150)
Noninvolved worker MEI location in m ESE (ft)	100 (328)	200 (656)	400 (1312)
Public MEI location in km ESE (mi)	22 (14)	22 (14)	22 (14)
Chi/Q for noninvolved worker - population in s/m^3	1.60E-03	4.00E-04	1.20E-04
Chi/Q for noninvolved worker - MEI in s/m^3	4.00E-04	2.50E-06	9.40E-08
Chi/Q for general public - population in s/m^3	2.90E-03	1.60E-03	8.00E-04
Chi/Q for general public - MEI in s/m^3	6.60E-08	3.90E-08	1.50E-08

Table D.9-3 Summary of Anticipated Radiological Exposure for Ex Situ Extensive Separations Alternative, Tank Waste

Receptor	Tank Farms (10-yr)	Evaporator (10-yr)	Seperation and LAW Vitrification (10-yr)	Separation and LAW Vitrification (4-yr)	Seperation and LAW/HLW Vitrification (6-yr)	Total
Noninvolved Worker - Population in Person-Rem	1.3E-04	1.2E-03	7.1E-02	2.8E-02	1.5E-01	2.5E-01
Noninvolved Worker - MEI in Rem	3.2E-05	7.0E-05	5.8E-05	2.3E-05	1.2E-04	3.0E-04
General Public - Population in Person-Rem	1.1E-02	4.8E-02	3.2E+01	1.3E+01	2.2E+01	6.7E+01
General Public - MEI in Rem	3.4E-07	1.2E-06	9.1E-04	3.6E-04	6.6E-04	1.94E-03

Table D.9-4 Summary of Anticipated Risk for Phased Implementation Alternative, Tank Waste

Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	2.5E-01 person-rem	1.0E-04
Noninvolved Worker - MEI	3.0E-04 rem	1.2E-07
General Public - Population	6.7E+01 person-rem	3.4E-02
General Public - MEI	1.94E-03 rem	9.7E-07

phased implementation										
		x2.8	per yr		x2.8	per yr				
am241	3.26E-06	9.13E-06	9.13E-07	1.44E-03	4.03E-03	4.03E-04				
c14	4.00E+02	1.12E+03	1.12E+02	4.20E+02	1.18E+03	1.18E+02				
cs137	1.87E-02	5.24E-02	5.24E-03	1.04E+00	2.91E+00	2.91E-01				
pu239/240	7.90E-07	2.21E-06	2.21E-07	1.58E-03	4.42E-03	4.42E-04				
sr90	7.20E-04	2.02E-03	2.02E-04	1.60E+00	4.48E+00	4.48E-01				
tc99	9.83E-06	2.75E-05	2.75E-06	9.95E-05	2.79E-04	2.79E-05				
at 100% capacity							10 yr			
		source sep/law				dose/yr	tot dose	risk		
am241	3.26E-06	9.13E-06	9.13E-07		onsite pop	7.10E-03	7.10E-02	2.84E-05		
c14	4.00E+02	1.12E+03	1.12E+02		onsite mei	5.80E-06	5.80E-05	2.32E-08		
cs137	1.87E-02	5.24E-02	5.24E-03		offsite pop	3.2	3.20E+01	0.016		
pu239/240	7.90E-07	2.21E-06	2.21E-07		offsite mei	9.10E-05	9.10E-04	4.55E-07		
sr90	7.20E-04	2.02E-03	2.02E-04							
tc99	9.83E-06	2.75E-05	2.75E-06				4 YR			
						dose/yr	tot dose	risk		
					onsite pop	7.10E-03	2.84E-02	1.14E-05		
					onsite mei	5.80E-06	2.32E-05	9.28E-09		
					offsite pop	3.2	1.28E+01	0.0064		
					offsite mei	9.10E-05	3.64E-04	1.82E-07		
		source sep/law/hlw					6 yr			
am241	1.44E-03	4.03E-03	4.03E-04			dose/yr	tot dose	risk		
c14	4.20E+02	1.18E+03	1.18E+02		onsite pop	2.50E-02	1.50E-01	0.00006		
cs137	1.04E+00	2.91E+00	2.91E-01		onsite mei	2.00E-05	1.20E-04	4.8E-08		
pu239/240	1.58E-03	4.42E-03	4.42E-04		offsite pop	3.7	2.22E+01	0.0111		
sr90	1.60E+00	4.48E+00	4.48E-01		offsite mei	1.10E-04	6.60E-04	3.3E-07		
tc99	9.95E-05	2.79E-04	2.79E-05							
				10 yr		4 YR		6 yr		
	TF	EVAP	dose/yr	tot dose	dose/yr	tot dose	dose/yr	tot dose	COMB DOSE	
onsite pop	1.30E-04	1.20E-03	7.10E-03	7.10E-02	7.10E-03	2.84E-02	2.50E-02	1.50E-01	2.51E-01	1.00E-04
onsite mei	3.20E-05	7.00E-05	5.80E-06	5.80E-05	5.80E-06	2.32E-05	2.00E-05	1.20E-04	3.03E-04	1.21E-07
offsite pop	1.10E-02	4.80E-02	3.2	3.20E+01	3.2	1.28E+01	3.7	2.22E+01	6.71E+01	3.35E-02
offsite mei	3.40E-07	1.20E-06	9.10E-05	9.10E-04	9.10E-05	3.64E-04	1.10E-04	6.60E-04	1.94E-03	9.68E-07

Oct. 20, 1995
To Loretta Crow
From: Joan Young

Errors in summary tables – Please note

Table D.65 Summary of Anticipated Radiological Exposure for Ex Situ No Separations Alternative, Tank Waste							
Receptor	Tank Farms (24-yr)	Evaporator 1 (10-yr)	Retrieval (19-yr)	Separate and Vitrify (14-yr)	Calcination (14-yr)	Total for Vitrification	Total for Calcination
Noninvolved Worker - Population	3.1E-04	1.2E-03	6.7E-03	1.0E+00	9.0E-01	1.0E+00	9.1E-01
Noninvolved Worker - MEI	7.7E-07	1.3E-04	1.7E-03	5.90E-04	5.2E-04	2.4E-03	2.4E-03
General Public - Population	2.6E-02	4.8E-02	1.7E+00	3.10E+02	2.2E+02	~~1.8E+00~~ 3.1E+02	2.2E+02
General Public - MEI	8.2E-07	1.9E-06	5.5E-05	6.7E-03	4.8E-03	4.9E-03	6.8E-03

Table D.66 Summary of Anticipated Risk for Ex Situ No Separations Alternative, Tank Waste				
Receptor	Combined Dose for Vitrification	LCF Risk for Vitrification	Combined Dose for Calcination	LCF Risk for Calcination
Noninvolved Worker - Population	1.0E+00 person-rem		9.1E-01 person-rem	
Noninvolved Worker - MEI	2.4E-03 rem		2.4E-03 rem	
General Public - Population	~~1.8E+00~~ person-rem	3.1E+02	2.2E+02 person-rem	
General Public - MEI	~~4.9E-03~~ rem 6.8E-03		~~6.8E-03~~ rem 4.9E-03	

4 pages

Table D.57 Summary of Anticipated Radiological Exposure for Selective Retrieval Alternative, Tank Waste							
Receptor	Tank Farms (29-yr)	Evaporator 1 (10-yr)	Evaporator 2 (3-yr)	Gravel Fill[1] (8-yr)	Retrieval (26-yr)	Separate and Vitrify (24-yr)	Total
Noninvolved Worker - Population in Person-Rem	3.8E-04	1.2E-03	2.4E-02	1.6E-07	7.7E-03	8.2E-01	8.5E-01
Noninvolved Worker - MEI in Rem	9.3E-05	1.3E-04	1.5E-04	4.0E-08	2.1E-03	4.8E-04	3.0E-03
General Public - Population in Person-Rem	3.2E-02	4.8E-02	1.02E-01	1.5E-05	2.1E+00	2.6E+02	~~2.3E+00~~ 2.62E+02
General Public - MEI in Rem	9.9E-07	1.9E-06	2.5E-06	4.4E-10	6.8E-05	6.0E-03	6.1E-03

Table D.58 Summary of Anticipated Risk for Selective Retrieval Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	8.5E-01 person-rem	
Noninvolved Worker - MEI	3.0E-03 rem	
General Public - Population	~~2.3E+00~~ person-rem	2.62E+02
General Public - MEI	6.1E-03 rem	

OK

Table D.39 Atmospheric Radiological Emissions for No Action Alternative, Tank Waste			
Tank Farm Emissions		Evaporator Emissions	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	2.88 ~~8.64~~e-08	Total Alpha	2.10e-05
Total Beta	7.91e-07	Total Beta	1.20e-05
^{90}Sr	1.81e-05		
^{137}Cs	5.38e-05		
^{129}I	4.60e-05		

Source: Henderson, C. Personal Communcation. Jacobs Engineering Group, Kennewick, WA. September 1995.

Table D.40 Atmospheric Transport Parameters for No Action Alternative, Tank Waste		
	Tank Farm Emissions	Evaporator Emissions
Stack height in m (ft)	Ground	6.7 (22)
Stack radius in m (ft)		0.53 (2)
Stack flow rate in m^3/s (ft^3/s)		10 (353)
Stack temperature in °C (°F)		46 (117)
Noninvolved worker MEI location in m ESE (ft)	100 (328)	200 (646)
Public MEI location in km ESE (mi)	22 (14)	22 (14)
Chi/Q for noninvolved worker - population in s/m^3	1.60e-03	4.00e-04
Chi/Q for noninvolved worker - MEI in s/m^3	4.00e-04	~~4.40e-06~~ 2.5e-06
Chi/Q for general public - population in s/m^3	2.90e-03	1.60e-03
Chi/Q for general public - MEI in s/m^3	6.60e-08	~~6.00e-08~~ 3.9e-08

Table D.41 Summary of Anticipated Radiological Exposure for No Action Alternative, Tank Waste			
Receptor	Tank Farms (100-yr)	Evaporator (10-yr)	Total
Noninvolved Worker - Population in Person-Rem	1.3E-03	1.2E-03	2.5E-03
Noninvolved Worker - MEI in Rem	3.2E-04	~~1.3E-04~~ 7.0e-05	~~4.5E-04~~ 3.9E-04
General Public - Population in Person-Rem	1.1E-01	4.8E-02	1.6E-01
General Public - MEI in Rem	3.4E-06	~~1.9E-06~~ 1.2E-06	~~5.3E-06~~ 4.6E-06

Table D.42 Summary of Anticipated Risk for No Action Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	2.5E-03 person-rem	1.00e-6
Noninvolved Worker - MEI	~~4.5E-04~~ rem 3.9e-04 ~~7.4e-05~~	1.56e-7
General Public - Population	1.6E-01 person-rem	7.9e-5
General Public - MEI	~~5.3E-06~~ rem 4.6E-06	2.3e-9

Table D.43 Atmospheric Radiological Emissions for Long Term Management Alternative, Tank Waste							
Tank Farm Emissions		Evaporator Emissions		Retrieval Emissions		Evaporator Emissions	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	2.22 ~~8.64~~e-08	Total Alpha	2.10e-05	^{90}Sr	1.00e-05	Total Alpha	1.04e-04
Total Beta	7.91e-07	Total Beta	1.20e-05	^{137}Cs	7.00e-05	Total Beta	8.04e-05
^{90}Sr	1.81e-05			^{129}I	1.00e-04		
^{137}Cs	5.38e-05						
^{129}I	4.60e-05						

Source: Henderson, C. Personal Communcation. Jacobs Engineering Group, Kennewick, WA. September 1995.

Table D.44 Atmospheric Transport Parameters for Long Term Management Alternative, Tank Waste				
	Tank Farms	Evaporator 1	DST Retrieval	Evaporator 2
Stack height in m (ft)	Ground	6.70 (22)	Ground	6.70 (22)
Stack radius in m (ft)		0.53 (1.6)		0.53 (1.6)
Stack flow rate in m^3/s (ft^3/s)		10 (~~364~~ 363)		10 (~~364~~ 363)
Stack temperature in °C (°F)		46 (117)		46 (117)
Noninvolved worker MEI location in m ESE (ft)	100 (328)	200 (656)		200 (656)
Public MEI location in km ESE (mi)	22 (14)	22 (14)		22 (14)
Chi/Q for noninvolved worker - population in s/m^3	1.60e-03	4.00e-04	1.6E-03	4.00e-04
Chi/Q for noninvolved worker - MEI in s/m^3	4.00e-04	~~4.40e-06~~ 2.50e-06 copy	4.0e-04	2.50e-06
Chi/Q for general public - population in s/m^3	2.90e-03	1.60e-03	2.9e-03	1.60e-03
Chi/Q for general public - MEI in s/m^3	6.60e-08	~~6.00e-08~~ 3.90e-08 copy	6.6e-08	3.90e-08

Table D.45 Summary of Anticipated Radiological Exposure for Long Term Management Alternative, Tank Waste					
Receptor	Tank Farms (100-yr)	Evaporator 1 (10-yr)	DST Retrieval (10-yr)	Evaporator 2 (10 yr)	Total
Noninvolved Worker - Population in Person-Rem	1.3E-03	1.2E-03	9.2E-05	8.0E-02	8.3E-02
Noninvolved Worker - MEI in Rem	3.2E-04	~~1.3E-04~~ 7.0E-05	2.4E-06	4.9E-04	~~9.4E-04~~ 8.8e-04
General Public - Population in Person-Rem	1.1E-01	4.8E-02	2.3E-03	3.3E-01	4.9E-01
General Public - MEI in Rem	3.4E-06	~~1.9E-06~~ 1.2E-06	7.1E-08	8.3E-06	~~1.4E-05~~ 1.3e-05

Table D.46 Summary of Anticipated Risk for Long Term Management Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	8.3E-02 person-rem	
Noninvolved Worker - MEI	~~9.4E-04~~ rem 8.8e-4	
General Public - Population	4.9E-01 person-rem	
General Public - MEI	~~1.4E-05~~ re, 1.3e-05	

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.7
8.8

Table D.47 Atmospheric Radiological Emissions for In Situ Fill and Cap Alternative, Tank Waste							
Tank Farm Emissions		Evaporator Emissions		DST Evaporator Emissions		Gravel Fill Emissions	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	8.64e-08	Total Alpha	2.10e-05	Total Alpha	1.04e-04	Total Alpha	9.83e-11
Total Beta	7.91e-07	Total Beta	1.20e-05	Total Beta	8.04e-05	Total Beta	2.69e-09
^{90}Sr	1.81e-05					^{90}Sr	2.91e-08
^{137}Cs	5.38e-05					^{137}Cs	1.81e-07
^{129}I	4.60e-05					^{129}I	1.57e-07

Source: Henderson, C. Personal Communcation. Jacobs Engineering Group, Kennewick, WA. September 1995.

Table D.48 Atmospheric Transport Parameters for In Situ Fill and Cap Alternative, Tank Waste				
	Tank Farms	Evaporator 1	Evaporator 2	Gravel Fill
Stack height in m (ft)	Ground	6.70 (22)	6.70 (22)	Ground
Stack radius in m (ft)		0.53 (1.6)	0.53 (1.6)	
Stack flow rate in m^3/s (ft^3/s)		10 (~~364~~ 253)	10 (~~364~~ 353)	
Stack temperature in °C (°F)		46 (117)	46 (117)	
Noninvolved worker MEI location in m ESE (ft)	100 (328)	200 (656)	200 (656)	100 (328)
Public MEI location in km ESE (mi)	22 (14)	22 (14)	22 (14)	22 (14)
Chi/Q for noninvolved worker - population in s/m^3	1.60e-03	4.00e-04	4.00e-04	1.60E-03
Chi/Q for noninvolved worker - MEI in s/m^3	4.00e-04	~~4.40e-06~~	2.50e-06 copy	4.00E-04
Chi/Q for general public - population in s/m^3	2.90e-03	1.60e-03	1.60e-03	2.90E-03
Chi/Q for general public - MEI in s/m^3	6.60e-08	~~6.00e-08~~	3.90e-08 copy	~~6.00e08~~ 6.6e-08

Table D.49 Summary of Anticipated Radiological Exposure for In Situ Fill and Cap Alternative, Tank Waste					
Receptor	Tank Farms (19-yr)	Evaporator 1 (10-yr)	Evaporator 2 (5-yr)	Gravel Fill (8-yr)	Total
Noninvolved Worker - Population in Person-Rem	2.5E-04	1.2E-03	4.0E-02	3.2E-07	4.2E-02
Noninvolved Worker - MEI in Rem	6.1E-06	~~1.3E-04~~ 7.0 e-05	2.5E-04	8.0E-08	~~3.9E-04~~ 3.3e-4
General Public - Population in Person-Rem	2.1E-02	4.8E-02	1.7E-01	3.0E-05	2.4E-01
General Public - MEI in Rem	6.5E-07	~~1.9E-06~~ 1.2e-06	4.1E-06	8.8E-10	~~6.7E-06~~ 6.0e-6

Table D.50 Summary of Anticipated Risk for In Situ Fill and Cap Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	4.2E-02 person-rem	
Noninvolved Worker - MEI	~~3.9E-04~~ rem 3.3e-4	
General Public - Population	2.4E-01 person-rem	
General Public - MEI	~~6.7E-06~~ rem 6.0e-6	

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Table D.51 Atmospheric Radiological Emissions for In Situ Vitrification Alternative, Tank Waste							
Tank Farm Emissions[1]		Evaporator Emissions[1]		DST Evaporator Emissions[1]		In Situ Vitrification Emissions[2]	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	8.64e-08	Total Alpha	2.10e-05	Total Alpha	1.04e-04	^{241}Am	1.90e-06
Total Beta	7.91e-07	Total Beta	1.20e-05	Total Beta	8.04e-05	^{14}C	1.10e+03
^{90}Sr	1.81e-05					^{137}Cs	6.20e-04
^{137}Cs	5.38e-05					^{129}I	3.20e+00
^{129}I	4.60e-05					^{239}Pu	6.00e-07
						^{106}Ru	6.80e-13
						^{151}Sm	1.14e-05
						^{90}Sr	9.40e-04
						^{99}Tc	5.80e-07
						^{93}Zr	7.00e-08

[1] Henderson, C. Personal Communcation. Jacobs Engineering Group, Kennewick, WA. September 1995.
[2] WHC. 1995a. (C. M. McConville) In Situ Treatment and Disposal of Radioactive Tank Waste in Hanford Site Underground Storage Tanks Engineering Data Package for the Tank Waste Remediation System Environmental Impact Statement. WHC-SD-WM-EV-101, Rev. B (Draft). Westinghouse Hanford Company, Richland, Washington. February 1995.

Table D.52 Atmospheric Transport Parameters for In Situ Vitrification Alternative, Tank Waste				
	Tank Farms	Evaporator 1	Evaporator 2	In Situ Vitrification
Stack height in m (ft)	Ground	6.70 (22)	6.70 (22)	Ground
Stack radius in m (ft)		0.53 (1.6)	0.53 (1.6)	
Stack flow rate in m^3/s (ft^3/s)		10 (~~364~~ 353)	10 (~~364~~ 353)	
Stack temperature in °C (°F)		46 (117)	46 (117)	
Noninvolved worker MEI location in m ESE (ft)	100 (328)	200 (656)	200 (656)	300 (984)
Public MEI location in km ESE (mi)	22 (14)	22 (14)	22 (14)	22 (14)
Chi/Q for noninvolved worker - population in s/m^3	1.60e-03	4.00e-04	4.00e-04	2.00e-04
Chi/Q for noninvolved worker - MEI in s/m^3	4.00e-04	~~4.40e-06~~ Copy	2.50e-06	2.30e-07
Chi/Q for general public - population in s/m^3	2.90e-03	1.60e-03	1.60e-03	1.10e-03
Chi/Q for general public - MEI in s/m^3	6.60e-08	~~6.00e-08~~ Copy	3.90e-08	2.40e-08

Table D.53 Summary of Anticipated Radiological Exposure for In Situ Vitrification Alternative, Tank Waste					
Receptor	Tank Farms (19-yr)	Evaporator 1 (10-yr)	Evaporator 2 (5-yr)	In Situ Vitrification (9-yr)	Total
Noninvolved Worker - Population in Person-Rem	2.5E-04	1.2E-03	4.0E-02	3.50E-04	4.2E-02
Noninvolved Worker - MEI in Rem	6.1E-06	~~1.3E-04~~ 7.0 e-05	2.5E-04	2.2E-06	~~3.9E-04~~ 3.3e-04
General Public - Population in Person-Rem	2.1E-02	4.8E-02	1.7E-01	1.4E-03	2.4E-01
General Public - MEI in Rem	6.5E-07	~~1.9E-06~~ 1.2e-06	4.1E-06	3.1E-08	~~6.7E-06~~ 6.0e-6

Table D.54 Summary of Anticipated Risk for In Situ Vitrification Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	4.2E-02 person-rem	
Noninvolved Worker - MEI	~~3.9E-04~~ rem 3.3e-04	
General Public - Population	2.4E-01 person-rem	
General Public - MEI	~~6.7E-06~~ rem 6.0e-6	

OK

Table D.55 Atmospheric Radiological Emissions for Selective Retrieval Alternative, Tank Waste

Tank Farm Emissions[1]		Evaporator Emissions[1]		Evaporator Emissions		Retrieval Emissions[2]		Gravel and Fill Emissions[1]		Separation and Vitrification Emissions[3]	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	8.[illegible]e-08	Total Alpha	2.10e-05	Total Alpha	1.04e-04	^{90}Sr	5.00e-04	Total Alpha	4.92e-11	^{241}Am	3.08e-03
Total Beta	7.91e-07	Total Beta	1.20e-05	Total Beta	8.04E-05	^{137}Cs	2.00e-03	Total Beta	1.34e-09	^{14}C	2.21e+02
^{90}Sr	1.81e-05					^{129}I	4.00e-03	^{90}Sr	1.45e-08	^{137}Cs	1.49e-00
^{137}Cs	5.38e-05							^{137}Cs	9.01E-08	^{129}I	2.13e+00
^{129}I	4.60e-05							^{129}I	7.85e-08	^{239}Pu	6.71e-04
										^{106}Ru	4.83e-07
										^{151}Sm	1.43e-02
										^{90}Sr	1.47e+00
										^{99}Tc	8.46e-04
										^{93}Zr	8.29e-03

[1] Henderson, C. Personal Communcation. Jacobs Engineering Group, Kennewick, WA. September 1995.
[2] WHC. 1994. (E. A. Fredenberg) Waste Retrieval and Transfer Engineering Data Package for the Tank Waste Remediation System Environmental Impact Statement, WHC-SD-WM-EV-097, Rev. A (Draft). Westinghouse Hanford Company, Richland, Washington. October 1994.
[3] WHC. 1994a. (E. J. Slaathaug) Engineering Data Package for the Tri-Party Agreement Alternative, WHC-SD-WM-EV-ERIC, Rev. A (Draft). Westinghouse Hanford Company, Richland, Washington. November 1994.

Table D.56 Atmospheric Transport Parameters for Selective Retrieval Alternative, Tank Waste

	Tank Farms	Evaporator 1	Evaporator 2	Gravel Fill	Retrieval	Separate and Vitrify
Stack height in m (ft)	Ground	6.70 (22)	6.70 (22)	Ground	Ground	55 (180)
Stack radius in m (ft)		0.53 (1.6)	0.53 (1.6)			.88(3)
Stack flow rate in m^3/s (ft^3/s)		10 (~~364~~ 353)	10 (~~364~~ 353)			33 (1,165)
Stack temperature in °C (°F)		46 (117)	46 (117)			160 (32)
Noninvolved worker MEI location in m ESE (ft)	100 (328)	200 (656)	200 (656)	100 (328)	100 (328)	800 (2,625)
Public MEI location in km ESE (mi)	22 (14)	22 (14)	22 (14)	22 (14)	22 (14)	22 (14)
Chi/Q for noninvolved worker - population in s/m^3	1.60e-03	4.00e-04	4.00e-04	1.6e-03	1.60e-03	5.00e-05
Chi/Q for noninvolved worker - MEI in s/m^3	4.00e-04	~~4.40e-06~~ F Copy	2.50e-06	4.00e-04	4.00e-04	2.90e-08
Chi/Q for general public - population in s/m^3	2.90e-03	1.60e-03	1.60e-03	2.90e-03	2.90e-03	5.00e-04
Chi/Q for general public - MEI in s/m^3	6.60e-08	~~6.00e-08~~ F Copy	3.90e-08	6.00e-08	6.60e-08	7.70e-09

Table D.57 Summary of Anticipated Radiological Exposure for Selective Retrieval Alternative, Tank Waste							
Receptor	Tank Farms (29-yr)	Evaporator 1 (10-yr)	Evaporator 2 (3-yr)	Gravel Fill[1] (8-yr)	Retrieval (26-yr)	Separate and Vitrify (24-yr)	Total
Noninvolved Worker - Population in Person-Rem	3.8E-04	1.2E-03	2.4E-02	1.6E-07	7.7E-03	8.2E-01	8.5E-01
Noninvolved Worker - MEI in Rem	9.3E-05	~~1.3E-04~~ 7.0E-05	1.5E-04	4.0E-08	2.1E-03	4.8E-04	2.9E-03 ~~3.0E-03~~
General Public - Population in Person-Rem	3.2E-02	4.8E-02	1.02E-01	1.5E-05	2.1E+00	2.6E+02	2.6E+02
General Public - MEI in Rem	9.9E-07	~~1.9E-06~~ 1.2E-06	2.5E-06	4.4E-10	6.8E-05	6.0E-03	6.1E-03

Table D.58 Summary of Anticipated Risk for Selective Retrieval Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	8.5E-01 person-rem	
Noninvolved Worker - MEI	~~3.0E-03~~ rem	2.9E-03
General Public - Population	~~2.3E+00~~ person-rem	2.6E+02
General Public - MEI	~~6.1E-03~~ rem OK	

OK

Table D.59 Atmospheric Radiological Emissions for Ex Situ Intermediate Separations Alternative, Tank Waste							
Tank Farm Emissions[1]		Evaporator Emissions[1]		Retrieval Emissions[2]		Separation and Vitrification Emissions[3]	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	8.64e-08	Total Alpha	2.10e-05	^{90}Sr	5.00e-04	^{241}Am	3.08e-03
Total Beta	7.91e-07	Total Beta	1.20e-05	^{137}Cs	2.00e-03	^{14}C	2.21e+02
^{90}Sr	1.81e-05			^{129}I	4.00e-03	^{137}Cs	1.49e-00
^{137}Cs	5.38e-05					^{129}I	2.13e+00
^{129}I	4.60e-05					^{239}Pu	6.71e-04
						^{106}Ru	4.83e-07
						^{151}Sm	1.43e-02
						^{90}Sr	1.47e+00
						^{99}Tc	8.46e-04
						^{93}Zr	8.29e-03

[1] Henderson, C. Personal Communcation. Jacobs Engineering Group, Kennewick, WA. September 1995.
[2] WHC. 1994. (E. A. Fredenberg) Waste Retrieval and Transfer Engineering Data Package for the Tank Waste Remediation System Environmental Impact Statement, WHC-SD-WM-EV-097, Rev. A (Draft). Westinghouse Hanford Company, Richland, Washington. October 1994.
[3] WHC. 1994a. (E. J. Slaathaug) Engineering Data Package for the Tri-Party Agreement Alternative, WHC-SD-WM-EV-ERIC, Rev. A (Draft). Westinghouse Hanford Company, Richland, Washington. November 1994.

Table D.60 Atmospheric Transport Parameters for Ex Situ Intermediate Separations Alternative, Tank Waste				
	Tank Farms	Evaporator 1	Retrieval	Separate and Vitrify
Stack height in m (ft)	Ground	6.70 (22)	Ground	55 (180)
Stack radius in m (ft)		0.53 (1.6)		.88(3)
Stack flow rate in m^3/s (ft^3/s)		10 (364)		33 (1,165)
Stack temperature in °C (°F)		46 (117)		160 (32)
Noninvolved worker MEI location in m ESE (ft)	100 (328)	200 (656)	100 (328)	800 (2,625)
Public MEI location in km ESE (mi)	22 (14)	22 (14)	22 (14)	22 (14)
Chi/Q for noninvolved worker - population in s/m^3	1.60e-03	4.00e-04	1.60e-03	5.00e-05
Chi/Q for noninvolved worker - MEI in s/m^3	4.00e-04	4.40e-06 2.5e-06	4.00e-04	2.90e-08
Chi/Q for general public - population in s/m^3	2.90e-03	1.60e-03	2.90e-03	5.00e-04
Chi/Q for general public - MEI in s/m^3	6.60e-08	6.00e-08 3.9e-08	6.60e-08	7.70e-09

Table D.61 Summary of Anticipated Radiological Exposure for Ex Situ Intermediate Separations Alternative, Tank Waste					
Receptor	Tank Farms (29-yr)	Evaporator 1 (10-yr)	Retrieval (26-yr)	Separate and Vitrify (24-yr)	Total
Noninvolved Worker - Population in Person-Rem	3.8E-04	1.2E-03	9.1E-03	9.1E-01	9.2E-01
Noninvolved Worker - MEI in Rem	9.3E-06	~~1.3E-04~~ 7.0E-05	2.4E-03	5.3E-04	3.1E-03
General Public - Population in Person-Rem	3.2E-02	4.8E-02	2.3E+00	3.1E+02	3.1E+02
General Public - MEI in Rem	9.9E-07	~~1.9E-06~~ 1.7E-06	7.5E-05	6.7E-03	6.8E-03

Table D.62 Summary of Anticipated Risk for Ex Situ Intermediate Separations Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	9.2E-01	
Noninvolved Worker - MEI	3.1E-03	
General Public - Population	3.1E+02	
General Public - MEI	6.8E-03	

OK

Table D.63 Atmospheric Radiological Emissions for Ex Situ No Separations Alternative, Tank Waste							
Tank Farm Emissions[1]		Evaporator Emissions[1]		Retrieval Emissions[2]		Vitrification/Calcination Emissions[3]	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	8.64e-08	Total Alpha	2.10e-05	^{90}Sr	5.00e-04	^{241}Am	5.30e-03
Total Beta	7.91e-07	Total Beta	1.20e-05	^{137}Cs	2.00e-03	^{14}C	3.80e+02[3]
							5.80E+01[1,4]
^{90}Sr	1.81e-05			^{129}I	4.00e-03	^{137}Cs	1.80e-00
^{137}Cs	5.38e-05					^{129}I	3.60e+00
^{129}I	4.60e-05					^{239}Pu	1.20e-03
						^{106}Ru	8.30e-07
						^{151}Sm	2.50e-02
						^{90}Sr	2.50e+00
						^{99}Tc	1.50e-03
						^{93}Zr	1.40e-02

[1] Henderson, C. Personal Communcation. Jacobs Engineering Group, Kennewick, WA. September 1995.
[2] WHC. 1994. (E. A. Fredenberg) Waste Retrieval and Transfer Engineering Data Package for the Tank Waste Remediation System Environmental Impact Statement, WHC-SD-WM-EV-097, Rev. A (Draft). Westinghouse Hanford Company, Richland, Washington. October 1994.
[3] WHC. 1994b. (S. A. Colby) Tank Waste Remediation System Environmental Impact Statement No Pretreatment Data Package, WHC-SD-WM-EV-COLBY, Rev. A (Draft). Westinghouse Hanford Company, Richland, Washington. November 1994.
[4] ^{14}C emissions are reduced for the calcination.

Table D.64 Atmospheric Transport Parameters for Ex Situ No Separations Alternative, Tank Waste				
	Tank Farms	Evaporator 1	Retrieval	Vitrification or Calcination
Stack height in m (ft)	Ground	6.70 (22)	Ground	55 (180)
Stack radius in m (ft)		0.53 (1.6)		.88(3)
Stack flow rate in m^3/s (ft^3/s)		10 (~~364~~ 253)		33 (1,165)
Stack temperature in °C (°F)		46 (117)		160 (32)
Noninvolved worker MEI location in m ESE (ft)	100 (328)	200 (656)	100 (328)	800 (2,625)
Public MEI location in km ESE (mi)	22 (14)	22 (14)	22 (14)	22 (14)
Chi/Q for noninvolved worker - population in s/m^3	1.60e-03	4.00e-04	1.60e-03	5.00e-05
Chi/Q for noninvolved worker - MEI in s/m^3	4.00e-04	~~4.40e-06~~ 2.5e-06	4.00e-04	2.90e-08
Chi/Q for general public - population in s/m^3	2.90e-03	1.60e-03	2.90e-03	5.00e-04
Chi/Q for general public - MEI in s/m^3	6.60e-08	~~6.00e-08~~ 3.9e-08	6.60e-08	7.70e-09

To Loretta Crow
From: Joan Young

Table D.65 Summary of Anticipated Radiological Exposure for Ex Situ No Separations Alternative, Tank Waste							
Receptor	Tank Farms (24-yr)	Evaporator 1 (10-yr)	Retrieval (19-yr)	Separate and Vitrify (14-yr)	Calcination (14-yr)	Total for Vitrification	Total for Calcination
Noninvolved Worker - Population	3.1E-04	1.2E-03	6.7E-03	1.0E+00	9.0E-01	1.0E+00	9.1E-01
Noninvolved Worker - MEI	7.7E-07	~~1.3E-04~~ 7.0E-05	1.7E-03	5.90E-04	5.2E-04	2.4E-03	~~2.4E-03~~ 2.3E-03
General Public - Population	2.6E-02	4.8E-02	1.7E+00	3.10E+02	2.2E+02	~~1.8E+00~~ 3.1E+02	2.2E+02
General Public - MEI	8.2E-07	~~1.9E-06~~ 1.2E-06	5.5E-05	6.7E-03	4.8E-03	~~4.9E-03~~ 6.8E-03	~~9.8E-03~~ 4.9E-3

Table D.66 Summary of Anticipated Risk for Ex Situ No Separations Alternative, Tank Waste				
Receptor	Combined Dose for Vitrification	LCF Risk for Vitrification	Combined Dose for Calcination	LCF Risk for Calcination
Noninvolved Worker - Population	1.0E+00 person-rem		9.1E-01 person-rem	
Noninvolved Worker - MEI	2.4E-03 rem		~~2.4~~ 2.3E-03 rem	
General Public - Population	~~1.8E+00~~ person-rem	3.1E+02	2.2E+02 person-rem	
General Public - MEI	~~4.9E-03~~ rem 6.8E-03		~~6.8E-03~~ rem 4.9E-03	

Table D.67 Atmospheric Radiological Emissions for Ex Situ Extensive Separations Alternative, Tank Waste							
Tank Farm Emissions[1]		Evaporator Emissions[1]		Retrieval Emissions[2]		Separation and Vitrification Emissions[3]	
Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released	Contaminants	Ci/yr Released
Total Alpha	~~8.64~~ 2.28e-08	Total Alpha	2.10e-05	^{90}Sr	5.00e-04	^{241}Am	2.40e-03
Total Beta	7.91e-07	Total Beta	1.20e-05	^{137}Cs	2.00e-03	^{14}C	2.50e+02
~~^{129}~~ ^{137}Cs	5.38e-05			^{129}I	4.00e-03	^{137}Cs	5.70e+01
~~^{137}Cs~~ ^{129}I	4.60e-05					^{129}I	1.90e-00
^{90}Sr	1.81e-05					^{239}Pu	8.90e-04
						^{106}Ru	1.70e-07
						^{90}Sr	1.10e-02
						^{99}Tc	2.30e-01
						^{93}Zr	5.50e-04

[1] Henderson, C. Personal Communcation. Jacobs Engineering Group, Kennewick, WA. September 1995.
[2] WHC. 1994. (E. A. Fredenberg) Waste Retrieval and Transfer Engineering Data Package for the Tank Waste Remediation System Environmental Impact Statement, WHC-SD-WM-EV-097, Rev. A (Draft). Westinghouse Hanford Company, Richland, Washington. October 1994.
[3] WHC. 1995b. (G. Janson, Jr., B. J. Knutson, G. K. Allen, L. Lauerhass) Extensive Separations Engineering Data Package for the Tank Waste Remediation System Environmental Impact Statement. WHC-SD-WM-EV-100, Rev. B (Draft). Westinghouse Hanford Company, Richland, Washington. May 1995.

Table D.68 Atmospheric Transport Parameters for Ex Situ Extensive Separations Alternative, Tank Waste				
	Tank Farms	Evaporator 1	Retrieval	Separation and Vitrification
Stack height in m (ft)	Ground	6.70 (22)	Ground	55 (180)
Stack radius in m (ft)		0.53 (1.6)		.88(3)
Stack flow rate in m^3/s (ft^3/s)		10 (~~384~~ 362)		33 (1,165)
Stack temperature in °C (°F)		46 (117)		160 (32~~2~~)
Noninvolved worker MEI location in m ESE (ft)	100 (328)	200 (656)	100 (328)	800 (2,625)
Public MEI location in km ESE (mi)	22 (14)	22 (14)	22 (14)	22 (14)
Chi/Q for noninvolved worker - population in s/m^3	1.60e-03	4.00e-04	1.60e-03	5.00e-05
Chi/Q for noninvolved worker - MEI in s/m^3	4.00e-04	~~4.40e-06~~ 2.5e-06	4.00e-04	2.90e-08
Chi/Q for general public - population in s/m^3	2.90e-03	1.60e-03	2.90e-03	5.00e-04
Chi/Q for general public - MEI in s/m^3	6.60e-08	~~6.00e-08~~ 3.9e-08	6.60e-08	7.70e-09

Table D.69 Summary of Anticipated Radiological Exposure for Ex Situ Extensive Separations Alternative, Tank Waste					
Receptor	Tank Farms (30-yr)	Evaporator 1 (10-yr)	Retrieval (23-yr)	Separate and Vitrify (21-yr)	Total
Noninvolved Worker - Population in Person-Rem	3.90E-04	1.2E-03	8.1E-03	7.4E-01	7.5E-01
Noninvolved Worker - MEI in Rem	9.6E-05	~~1.3E-04~~ 12-05	2.1E-03	4.2E-04	~~2.8E-03~~ 2.7e-03
General Public - Population in Person-Rem	3.3E-02	4.8E-02	2.1E+00	2.5E+02	2.5E+02
General Public - MEI in Rem	1.0E-06	~~1.9E-06~~ 1.2e-06	6.7E-05	5.5E-03	~~5.6E-03~~ 5.5e-03

Table D.70 Summary of Anticipated Risk for Ex Situ Extensive Separations Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	7.5E-01 person-rem	
Noninvolved Worker - MEI	~~2.8E-03~~ 2.7 rem	
General Public - Population	2.5E+02 person-rem	
General Public - MEI	~~5.6E-03~~ 5.5 rem	

Table D.71 Atmospheric Radiological Emissions for No Action Alternative, Capsules	
WESF Operating Emissions	
Contaminants	Ci/yr Released
Total Beta	4.70E-09
^{90}Sr	5.10e-06
^{137}Cs	2.60e-06
$^{239/240}Pu$	2.40e-07

Source: Henderson, C. Personal Communcation. Jacobs Engineering Group, Kennewick, WA. September 1995.

Table D.72 Atmospheric Transport Parameters for No Action Alternative, Capsules

	WESF Operations
Stack height in m (ft)	21 (69)
Stack radius in m (ft)	0.53 (1.6)
Stack flow rate in m^3/s (ft^3/s)	9.2 (325)
Stack temperature in °C (°F)	20 (68)
Noninvolved worker MEI location in m ESE (ft)	200 (656)
Public MEI location in km ESE (mi)	22 (14)
Chi/Q for noninvolved worker - population in s/m^3	3.70e-04
Chi/Q for noninvolved worker - MEI in s/m^3	5.4e-07
Chi/Q for general public - population in s/m^3	1.70e-03
Chi/Q for general public - MEI in s/m^3	3.40e-08

Table D.73 Summary of Anticipated Radiological Exposure for Capsule Alternatives				
Receptor	No Action (10-yr)	Onsite Dry Storage (19-yr)	Overpack and Ship (19-yr)	Vitrify with Tank Waste (19-yr)
Noninvolved Worker - Population in Person-Rem	1.3E-04	2.5E-04	2.5E-04	2.5E-04
Noninvolved Worker - MEI in Rem	1.9E-07	3.6E-07	3.6E-07	3.6E-07
General Public - Population in Person-Rem	6.3E-04	1.2E-03	1.2E-03	1.2E-03
General Public - MEI in Rem	1.3E-08	2.5E-08	2.5E-08	2.5E-08

Table D.74 Summary of Anticipated Risk for No Action Alternative, Capsules		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	1.3E-04 person-rem	
Noninvolved Worker - MEI	1.9E-07 rem	
General Public - Population	6.3E-04 person-rem	
General Public - MEI	1.3E-08 rem	

Table D.75 Summary of Anticipated Risk for Onsite Dry Storage Alternative, Tank Waste		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	2.5E-04 person-rem	
Noninvolved Worker - MEI	3.6E-07 rem	
General Public - Population	1.2E-03 person-rem	
General Public - MEI	2.5E-08 rem	

Table D.76 Summary of Anticipated Risk for Overpack and Ship Alternative, Capsules		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	2.5E-04 person-rem	
Noninvolved Worker - MEI	3.6E-07 rem	
General Public - Population	1.2E-03 person-rem	
General Public - MEI	2.5E-08 rem	

7

Table D.7~~4~~ Summary of Anticipated Risk for Vitrify with Tank Waste Alternative, Capsules		
Receptor	Combined Dose	LCF Risk
Noninvolved Worker - Population	2.5E-04 person-rem	
Noninvolved Worker - MEI	3.6E-07 rem	
General Public - Population	1.2E-03 person-rem	
General Public - MEI	2.5E-08 rem	

Alternative	1.0 No Action		2.0 Long Term Managment		3.0 In Situ Vitrification		4.0 In Situ Gravel and Fill	
	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI
	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI
Construction	NOT APPLICABLE		NO EMISSIONS		NO EMISSIONS		NO EMISSIONS	
Operation								
Continued Operations	100 m ESE	22 km ESE	100 m ESE	22 km ESE	100 m ESE	22 km ESE	100 m ESE	22 km ESE
-Monitor SSTs, DSTs, and MUSTs								
-Operate 242A Evaporator	200 m ESE	22 km ESE	200 m ESE	22 km ESE	200 m ESE	22 km ESE	200 m ESE	22 km ESE
Retrieval	NOT APPLICABLE		100 m ESE	22 km ESE	NOT APPLICABLE		NOT APPLICABLE	
Evaporate DSTS (a)	NOT APPLICABLE		200 m ESE	22 km ESE	200 m ESE	22 km ESE	200 m ESE	22 km ESE
Separations	NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
Vitrify Tank Waste	NOT APPLICABLE		NOT APPLICABLE		300 m ESE	22 km ESE	NOT APPLICABLE	
(or Gravel Fill for Alt4)							100 m ESE	22 km ESE
Process Capsules	NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
Storage and Disposal	NOT APPLICABLE		NOT APPLICABLE		NO EMISSIONS		NO EMISSIONS	
Monitoring and Maintenance	NOT APPLICABLE		NOT APPLICABLE		NO EMISSIONS		NO EMISSIONS	
Post Remediation								
Closure	NOT APPLICABLE		NOT APPLICABLE		NO EMISSIONS		NO EMISSIONS	
Monitoring of Final Waste Form	NOT APPLICABLE		NOT APPLICABLE		NO EMISSIONS		NO EMISSIONS	

Alternative	*6.0 Selective Retrieval*		*7.0 Extensive Retrieval*		*8.0 No Separations*		*9.0 Extensive Separations*	
	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI
	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI
Construction	**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**	
Operation								
Continued Operations	100 m ESE	22 km ESE	100 m ESE	22 km ESE	100 m ESE	22 km ESE	100 m ESE	22 km ESE
-Monitor SSTs, DSTs, and MUSTs								
-Operate 242A Evaporator	200 m ESE	22 km ESE	200 m ESE	22 km ESE	200 m ESE	22 km ESE	200 m ESE	22 km ESE
Retrieval	100 m ESE	22 km ESE	100 m ESE	22 km ESE	100 m ESE	22 km ESE	100 m ESE	22 km ESE
Evaporate DSTS (a)	200 m ESE	22 km ESE	**NOT APPLICABLE**		**NOT APPLICABLE**		**NOT APPLICABLE**	
Separations	**INCLUDED IN VITRIFICAT**		**INCLUDED IN VITRIFICAT**		**NOT APPLICABLE**		**INCLUDED IN VITRIFICATIO**	
Vitrify Tank Waste	800 m ESE	22 km ESE	800 m ESE	22 km ESE	800 m ESE	22 km ESE	800 m ESE	22 km ESE
(or Gravel Fill for Alt4)	100 m ESE	22 km ESE						
Process Capsules	**NOT APPLICABLE**		**NOT APPLICABLE**		**NOT APPLICABLE**		**NOT APPLICABLE**	
Storage and Disposal	**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**	
Monitoring and Maintenance	**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**	
Post Remediation								
Closure	**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**	
Monitoring of Final Waste Form	**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**		**NO EMISSIONS**	

Alternative	*10.0 Capsule-No Action*		*11. Capsule-Onsite*		*12.0 Capsule-Overpack*		*13.0 Capsule-Vitrify*	
	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI
	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI	Worker MEI	Public MEI
Construction	NOT APPLICABLE		NO EMISSIONS		NOT APPLICABLE		NO EMISSIONS	
Operation								
Continued Operations	NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
-Monitor SSTs, DSTs, and MUSTs								
-Operate 242A Evaporator	NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
Retrieval	NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
Evaporate DSTS (a)	NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
Separations	NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
Vitrify Tank Waste	NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
(or Gravel Fill for Alt4)								
Process Capsules	200 m ESE	22 km ESE	200 m ESE	22 km ESE	200 m ESE	22 km ESE	200 m ESE	22 km ESE
Storage and Disposal	NOT APPLICABLE		NO EMISSIONS		NOT APPLICABLE		NOT APPLICABLE	
Monitoring and Maintenance	NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
Post Remediation								
Closure	NOT APPLICABLE		NO EMISSIONS		NOT APPLICABLE		NOT APPLICABLE	
Monitoring of Final Waste Form	NOT APPLICABLE		NO EMISSIONS		NOT APPLICABLE		NOT APPLICABLE	

phased implementation						
		x2.8	per yr		x2.8	per yr
am241	3.26E-06	9.13E-06	9.13E-07	1.44E-03	4.03E-03	4.03E-04
c14	4.00E+02	1.12E+03	1.12E+02	4.20E+02	1.18E+03	1.18E+02
cs137	1.87E-02	5.24E-02	5.24E-03	1.04E+00	2.91E+00	2.91E-01
pu239/240	7.90E-07	2.21E-06	2.21E-07	1.58E-03	4.42E-03	4.42E-04
sr90	7.20E-04	2.02E-03	2.02E-04	1.60E+00	4.48E+00	4.48E-01
tc99	9.83E-06	2.75E-05	2.75E-06	9.90E-05	2.77E-04	2.77E-05
at 100% capacity						

phased implementation scenarios

phased implementation						
		x2.8	per yr		x2.8	per yr
am241	3.26E-06	9.13E-06	9.13E-07	1.44E-03	4.03E-03	4.03E-04
c14	4.00E+02	1.12E+03	1.12E+02	4.20E+02	1.18E+03	1.18E+02
cs137	1.87E-02	5.24E-02	5.24E-03	1.04E+00	2.91E+00	2.91E-01
pu239/240	7.90E-07	2.21E-06	2.21E-07	1.58E-03	4.42E-03	4.42E-04
sr90	7.20E-04	2.02E-03	2.02E-04	1.60E+00	4.48E+00	4.48E-01
tc99	9.83E-06	2.75E-05	2.75E-06	9.9~~0~~E-05 5	2.7~~6~~7E-04	2.7~~6~~7E-05
at 100% capacity						

P. 60

Mike

10 (353 ft)

160 (320°F)

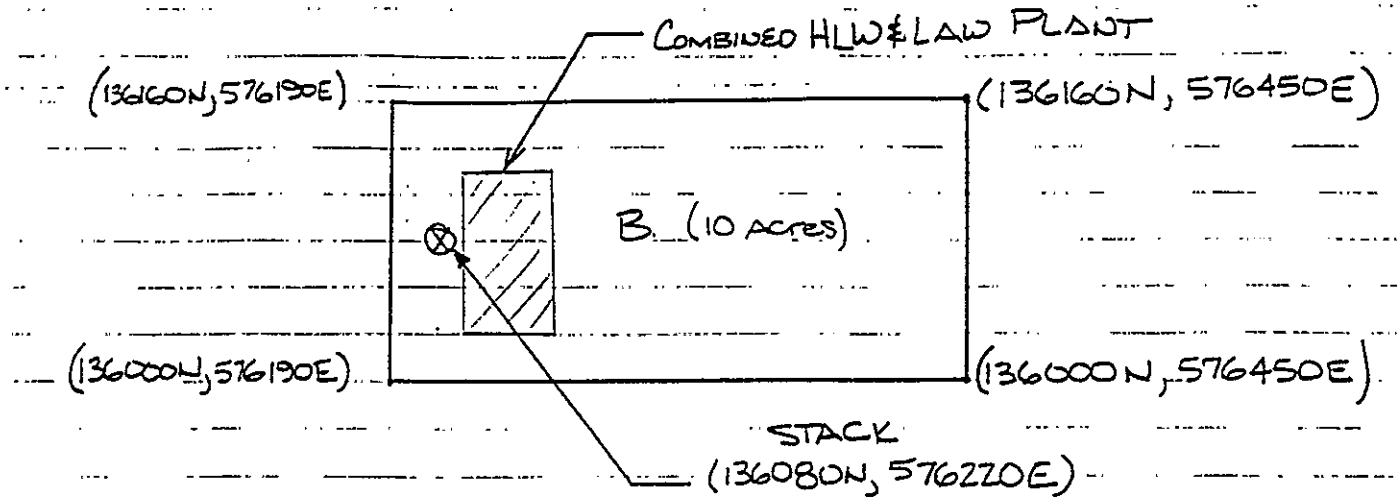
Not called in

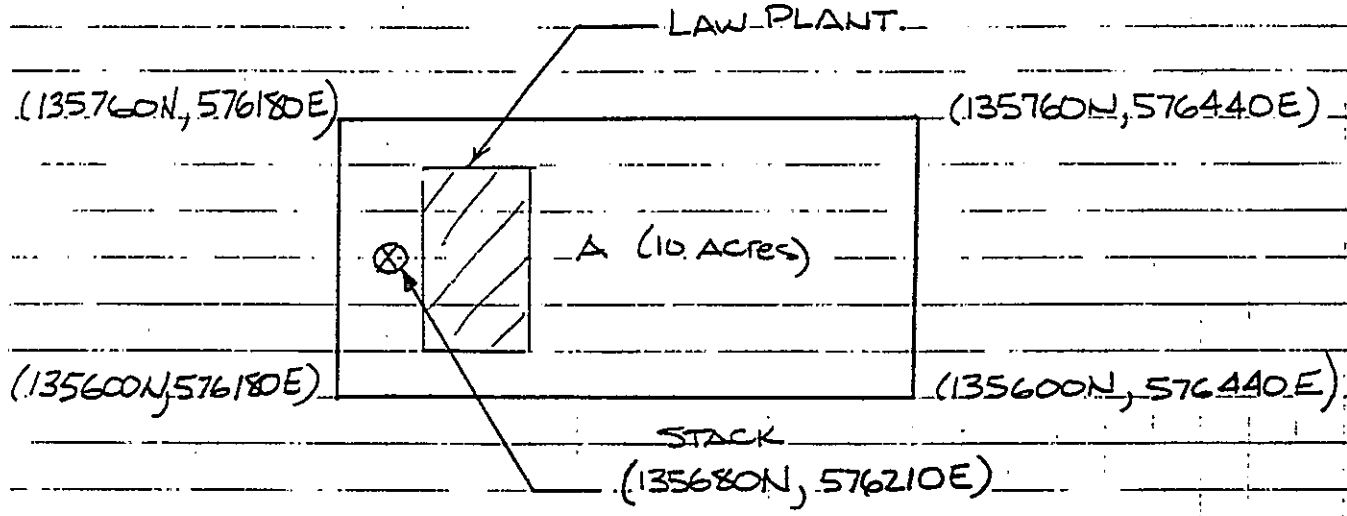
JACOBS ENGINEERING GROUP INC.

DATE 10/18 SUBJECT Phased Implementation Locations. SHEET NO. _____

BY _____ CHKD. _____ JOB NO. _____

SITE COORDINATES:





ASSUME STACK HEIGHT = 150 ft

EXIT VELOCITY = 45 ft/sec. (13.7 m/sec)

T = 150°F Calculated

Diam = 1 m 10.8 m³/sec

FORM 91-005T (4/81)

10.3 cum/sec
.53 m
11.5 m/sec

242-A EVAPORATOR EMISSIONS

Tank Farm Emissions From Current Operations							
242A 6 Source Emissions Roll-UP		Avg Exit Velocity 37.8 (ft/sec)		Area 9.62 (sq. ft)			
Active Ventilation		Avg Exit Temperature 117 (F)		Height 22 (ft)			
					Operating release		
	Continuous Ops	Periodic Ops	Periodic Ops	Continuous	Concentration		
Emissions	Potential (tons/yr)	Actual (tons/yr)	Actual (kg/hr)	Actual (kg/hr)	g/m^3	Area (ft^2)	Velocity (ft/s)
2-Hexanone	3.80E-04	2.88E-05	2.98E-06	3.94E-05	1.06E-06	9.62	37.8
Acetone	1.06E-01	7.98E-03	8.27E-04	1.10E-02	2.97E-04	9.62	37.8
Methyl Isobutyl Ketone	7.25E-03	5.44E-04	5.64E-05	7.51E-04	2.03E-05	9.62	37.8
N-Butyl Alcohol	8.00E-01	6.00E-02	6.22E-03	8.29E-02	2.24E-03	9.62	37.8
Ammonia	1.00E-01	7.51E-03	7.78E-04	1.04E-02	2.80E-04	9.62	37.8
	Ci/yr	Ci/yr		Ci/hr	grams/m^3		
Total Alpha (Ci) (Pu)	1.41E-04	2.10E-05		1.61E-08	7.00E-12	9.62	37.8
Total Beta (Ci) (Sr-90)	8.04E-05	1.20E-05		9.18E-09	1.78E-15	9.62	37.8

note: total alpha and beta taken from WHC-SD-WM-EV-099 and are from 1987 evaporator operations (11 MM gal run, Capacity=73.6 MM gal/yr so continuous ops =6.7 times periodic)

note: evaporator emissions are the sum of the building ventilation and the vessel vent systems which each have a stack. The shorter stack was chosen as the release point for all emissions.

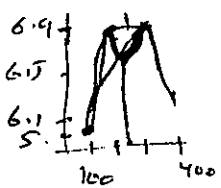
Need MEI @ around 200m ESE

(2) (1)
@ 6 m^3/sec
run rosmiev1.in

	Ch/Q	Dose
200 m	4.4E06	1.3E-05
300 m	4.0E-06	1.2E-05
150 m	4.1E-06	1.2E-05

ROSMIEV1 Periodic OPS { Pu 2.1E-5, Sr-90 1.2E-5
at 10.3 m^3/sec

	X/Q	Dose
200 m	2.3E-6	6.9E-6
250	2.1E-6	6.4E-6
300 m	2.3E-6	6.9E-6
100 m	1.7E-6	5.0E-6
400	2.1E-6	6.4E-6



ROSMI EV2
Continuous OPS { Pu = 1.41E-4, Sr = 8.04E-5

Dim (m)	X/Q	Dose
200	2.5E-6	4.9E-5

Same stack as for vitrification

(***)

Calcination

Table D.65 Atmospheric Radiological Operating Emissions for Treatment, No Separation Subalternative [1]

Radionuclide	Air Release (Ci/year)
Am-241	5.3E-03
C-14	~~3.8E+02~~ 812 Ci/yr
Cs-137	1.8E+00
I-129	3.6E+00
Pu-239	1.2E-03
Ru-106	8.3E-07
Sm-151	2.5E-02
Sr-90	2.5E+00
Tc-99	1.5E-03
Zr-93	1.4E-02

Notes:

[1] Source: (WHC 1994a).

Workers

The exposure rate would be the same as those described in Section D.2.2.3.

Non Involved Workers and General Public

Atmospheric emissions from storage and disposal operations would be negligible compared to emissions from the other two major actions. For purposes of this assessment, the storage and disposal source term for both the non involved worker and general public was assumed to be zero.

D.4.4.6.2 Transport

The transport methodology was previously discussed in Table D.36. The following sections discuss the transport analysis performed for each major category of activity.

Retrieval and Transfer

Because the source term for retrieval and transfer operations was the same as the Extensive Retrieval (Ex Situ Vitrification) alternative a separate air transport modeling analysis was not required. Modeling results for the Extensive Retrieval (Ex Situ Vitrification) alternative (Section D.4.4.2.1) also apply to the No Separation subalternative.

Treatment

The source term for treatment (immobilization) operations under the No Separations subalternative would differ from the Extensive Retrieval (Ex Situ Vitrification) alternative, and thus a separate air transport analysis was required. Input parameters (other than source term) and modeling conditions (i.e., meteorological data, stack parameters, effluent temperature) used for this analysis were the same as for the Extensive Retrieval (Ex Situ Vitrification) alternative (Section D.4.4.2.2). Following are the results of the air transport analysis for the MEIs population weighted cases.

EMISSIONS

Tanks or Farm	Single Shell 200 east		Single Shell 200 west			
Emissions (tons/yr)	Potential	Actual	Potential	Actual	TPotential	TActual
Carbon Monoxide	3.63E-02	3.62E-02	5.13E-02	5.13E-02	8.76E-02	8.76E-02
Nitrogen Oxide	2.48E-03	2.24E-03	3.14E-03	3.14E-03	5.62E-03	5.39E-03
1,3-Butadiene	1.58E-04	1.57E-04	2.23E-04	2.23E-04	3.81E-04	3.80E-04
2-Hexanone	2.87E-03	2.87E-03	4.05E-03	4.05E-03	6.92E-03	6.92E-03
2-Pentanone	4.56E-03	4.52E-03	6.42E-03	6.42E-03	1.10E-02	1.09E-02
Acetone	5.47E-02	5.47E-02	7.72E-02	7.72E-02	1.32E-01	1.32E-01
Acetonitrile	2.63E-02	2.63E-02	3.72E-02	3.72E-02	6.35E-02	6.35E-02
Benzene	1.25E-03	1.25E-03	2.45E-03	2.45E-03	3.70E-03	3.70E-03
Heptane	3.22E-03	3.22E-03	4.53E-03	4.53E-03	7.75E-03	7.75E-03
Methyl N-Amyl Ketone	3.11E-03	3.11E-03	4.39E-03	4.39E-03	7.49E-03	7.49E-03
N-Hexane	3.37E-03	3.37E-03	4.73E-03	4.73E-03	8.10E-03	8.10E-03
Nonane	1.75E-03	1.75E-03	2.46E-03	2.46E-03	4.21E-03	4.21E-03
Octane	1.83E-03	1.83E-03	2.58E-03	2.58E-03	4.42E-03	4.42E-03
Toluene	2.58E-04	2.58E-04	3.54E-04	3.54E-04	6.12E-04	6.12E-04
Americium-241 Ci/yr	1.49E-06		1.96E-06		3.45E-06	
Cesium-137 Ci/yr	8.41E-04	4.17E-07	8.42E-04	3.50E-07	1.68E-03	7.67E-07
Plutonium-239 Ci/yr	2.11E-06		1.04E-06		3.15E-06	
Strontium-090 Ci/yr	8.87E-03	4.42E-06	1.28E-02	5.10E-06	2.17E-02	9.52E-06
Ammonia	2.61E-01	2.61E-01	3.61E-01	3.61E-01	6.22E-01	6.22E-01
Phosphoric Acid, Tributyl E	6.57E-03	6.57E-03	1.23E-02	9.33E-03	1.88E-02	1.59E-02

RosMITFP

RosMITFA
RosPoTFA

RosPoTFP

10/13/95										
SII 521, 531 541		561	571	581	591					
Tank Emissions in Ci/yr				DSTs				SSTs		
		SY (a)	AN	AP	AW	AYAZ		Other	SX (a)	Total
Total Alpha		8.10E-09			1.50E-08	5.70E-09				2.88E-08
Total Beta		7.00E-07							9.10E-08	7.91E-07
Sr-90			1.20E-07	6.60E-08	1.60E-07	8.20E-06		9.52E-06		1.81E-05
Cs-137					2.80E-08	5.30E-05		7.67E-07		5.38E-05
I-129						4.60E-05				4.60E-05

Tank Farm Emissions From Current Operations							
242A 6 Source Emissions Roll-UP		Avg Exit Velocity 37.8 (ft/sec)		Area 9.62 (sq. ft)			
Active Ventilation		Avg Exit Temperature 117 (F)		Height 22 (ft)			
					Operating release		
	Continuous Ops	Periodic Ops	Periodic Ops	Continuous	Concentration		
Emissions	Potential (tons/yr)	Actual (tons/yr)	Actual (kg/hr)	Actual (kg/hr)	g/m^3	Area (ft^2)	Velocity (ft/s)
2-Hexanone	3.80E-04	2.88E-05	2.98E-06	3.94E-05	1.06E-06	9.62	37.8
Acetone	1.06E-01	7.98E-03	8.27E-04	1.10E-02	2.97E-04	9.62	37.8
Methyl Isobutyl Ketone	7.25E-03	5.44E-04	5.64E-05	7.51E-04	2.03E-05	9.62	37.8
N-Butyl Alcohol	8.00E-01	6.00E-02	6.22E-03	8.29E-02	2.24E-03	9.62	37.8
Ammonia	1.00E-01	7.51E-03	7.78E-04	1.04E-02	2.80E-04	9.62	37.8
	Ci/yr	Ci/yr		Ci/hr	grams/m^3		
Total Alpha (Ci) (Pu)	1.41E-04	2.10E-05		1.61E-08	7.00E-12	9.62	37.8
Total Beta (Ci) (Sr-90)	8.04E-05	1.20E-05		9.18E-09	1.78E-15	9.62	37.8

note: total alpha and beta taken from WHC-SD-WM-EV-099 and are from 1987 evaporator operations (11 MM gal run, Capacity=73.6 MM gal/yr so continuous ops =6.7 times periodic)

note: evaporator emissions are the sum of the building ventilation and the vessel vent systems which each have a stack. The shorter stack was chosen as the release point for all emissions.

524 512

Capsules No Action Emissons

S101
S111
S121
S131

(**)

Worker MEI ~~st#~~ 200, 300, 400
Public MEI at 22km

WESF Continued Operations Emissions				
Stack Height = 70 feet (was 75 ft. in prior communications)			= 21.3 m	
Stack diameter= 3.5 feet			= 1.06 m	
Stack exit velocity 33.4 ft/sec			= 10.2 m/sec	
Stack gas temperature = 20 degrees C			OK	
Volumetric Flow rate 9.17 cubic meters /sec			OK	
Releases occur 365 days/yr, 24 hrs/day				
Stack coordinates = N136433 , E573361				
Isotope	Annual Emission	Average Concentration		
	Ci/yr	uCi/ml		
Sr-90	5.10E-06	1.74E-14		
Cs-137	2.60E-06	8.70E-15		
Pu-239/240	2.40E-07	8.00E-16		
Total Beta	4.70E-09	7.70E-14		
Based on 1994 Emissions , Emissions assumed to be the same for 1997-2006				

Emissions for Gravel Fill Operations					
	Ci/hr	by 10	for 3 days	for 22 out of 177 tan	
				Ci/yr	
Total Alpha	3.30E-12	3.3E-11	7.91E-10	9.83E-11	
Total Beta	9.03E-11	9.03E-10	2.17E-08	2.69E-09	
Sr-90	9.76E-10	9.76E-09	2.34E-07	2.91E-08	
Cs-137	6.05E-09	6.05E-08	1.45E-06	1.81E-07	
I-129	5.25E-09	5.25E-08	1.26E-06	1.57E-07	
10/13/95	-				

544

10/13/95										
SII 521 531 541		561 571 581		591						
Tank Emissions in Ci/yr				DSTs				SSTs		
		SY (a)	AN	AP	AW	AYAZ		Other	SX (a)	Total
Total Alpha		8.10E-09			1.50E-08	5.70E-09				2.88E-08
Total Beta		7.00E-07							9.10E-08	7.91E-07
Sr-90			1.20E-07	6.60E-08	1.60E-07	8.20E-06		9.52E-06		1.81E-05
Cs-137					2.80E-08	5.30E-05		7.67E-07		5.38E-05
I-129						4.60E-05				4.60E-05

Table D4.4-6. Atmospheric Radiological Operating Emissions for Treatment, Extensive Retrieval (Ex Situ Vitrification) Alternative, No Separation Subalternative.[1]

Radionuclide	Air Release (Ci/yr)
Am-241	5.3E-03
C-14	3.8E+02
Cs-137	1.8E+00
I-129	3.6E+00
Pu-239	1.2E-03
Ru-106	8.3E-07
Sm-151	2.5E-02
Sr-90	2.5E+00
Tc-99	1.5E-03
Zr-93	1.4E-02

[1] Source: WHC (1994a)

D4.4.5.1.3 Storage and Disposal

Storage and disposal operations would involve interim onsite storage of treated HLW pending shipment to an offsite geologic repository (WHC 1994a). No waste would be disposed of onsite. Following are the storage and disposal source terms for each receptor.

Involved Worker

The worst case and nominal case exposures for involved workers performing this operation are assumed to be 200 mrem/yr and 25 mrem/yr, respectively (Section D2.2.3).

Noninvolved Worker and General Public

As in the main alternative (Section D4.4.1.3.2, Noninvolved Worker and General Public), atmospheric emissions from storage and disposal operations are expected to be negligible compared to emissions from the other two major actions (Murray 1995, 1995a). For purposes of this assessment, the storage and disposal source term for both the noninvolved worker and general public is assumed to be zero.

D4.4.5.2 Transport

Transport for the no separation subalternative is analyzed with the aid of the computer code GENII using the same air transport modeling approach used for the main alternative (Section

EX SEP

Table 9-3. Operating Personnel Requirements (Staff Hours)[1,2].

Operating Personnel	Extensive Separation Alternative
Nonexempt	
Radiation worker	0
Nonradiation worker	3.3 E+06
Exempt	
Radiation worker	8.5 E+06
Nonradiation worker	0
Bargaining Unit	
Radiation worker	2.1 E+07
Nonradiation worker	0
Total Staff Hours	3.3 E+07

Notes:

[1]All exempt and bargaining unit employees are assumed to be radiation workers. All nonexempt employees are nonradiation workers.

[2]Includes staffing for start-up, decontamination and decommissioning, and monitoring and maintenance.

For additional information, see Appendix F, and also Jansen, G., 1995, *Backup Information for Data Tables in Extensive Separations Alternative Engineering Data Package*, WHC-SD-WM-DP-129, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

NO SEP

Table 6-2. Unit Process: Operating Personnel Requirements (Staff Hours) (Boomer et al. 1994).

Unit Process	No Separations
Pumping and sluicing	*
Hydraulic retrieval	*
Sludge wash	0
Cesium removal	0
Other radionuclide removal	0
Low-level waste vitrification	0
Low-level waste disposal	0
High-level waste vitrification	1.97E7[1]
High-level waste transportation and disposal	*
Emptied single-shell tank closure	*
Emptied double-shell tank closure	*
Total (Staff hours)	1.97E7[1]

Notes:

*Data is outside the scope of this document.

[1]Total operating personnel are accounted from hot operations, startup, and decontamination and decommissioning.

Hot operations
(620 persons) (1812 hours/year)(14 years) = 1.57E7 hours

Startup
(620 persons)(1812 hours/year)(2 years) = 2.25E6 hours

Decontamination and decommissioning
(620 persons)(1812 hours/year)(1.5 years) = 1.69E6 hours

Total = 1.97E7 hours

For additional backup information, see Appendix B.

Boomer, K. D., J. M. Colby, T. W. Crawford, J. S. Garfield, J. D. Galbraith, C. E. Golberg, C. E. Leach, D. E. Mitchell, F. D. Nankani, B. J. Slaathaug, L. M. Swanson, T. L. Waldo and C. M. Winkler, 1994, *Tank Waste Remediation System Facility Configuration Study*, WHC-SD-WM-ES-295, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Table 6-3. Operating Personnel Requirements (Staff Hours).

Operating Personnel	No Separations[1]
Nonexempt	
Radiation worker	0
Nonradiation worker	1.70E6[2]
Exempt + BU	
Radiation worker	1.58E7[3]
Nonradiation worker	2.06E6[4]
Total (Staff hours)	1.96E7

Notes:

Bu = bargaining unit.

[1]Assumes all exempt and bargaining unit personnel are radiation workers and all nonexempt personnel are nonradiation workers. (Except during startup which assumes all personnel are nonradiation workers.)

[2]Nonexempt nonradiation workers

Hot operations
(53 nonexempt)(1812 hours/year)(14 years) = 1.36E6 hours

Startup
(53 nonexempt)(1812 hours/year)(2 years) = 1.92E5 hours

Decontamination and decommissioning
(53 nonexempt)(1812 hours/year)(1.5 years) = 1.44E5 hours

[3]Exempt and bargaining unit radiation workers:

Hot operations
(227 E + 338 BU)(1812 hours/year)(14 years) = 1.43E7 hours

Decontamination and decommissioning
(227 E + 338 BU)(1812 hours/year)(1.5 years) = 1.54E6 hours

[4]Exempt and bargaining unit nonradiation workers:

Startup
(227 E + 338 BU)(1812 hours/year)(2 years) = 2.06E6 hours

BU

1.43 E7
.15 E7
.21 E7
1.79 E7

For additional backup information, see Appendix B.

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Table 6-14. Monitoring and Maintenance Personnel Requirements (Staff Hours)[1].

Operating Personnel	No Separations
Nonexempt	
Radiation worker	8.70E5[2]
Nonradiation worker	1.09E5[3]
Exempt	
Radiation worker	1.09E5[4]
Nonradiation worker	0
Total Staff Hours	1.09E6

Notes:

[1]Assumes that 10 people will monitor the high-level storage casks that are stored temporarily for 42 years on Hanford Site. Monitoring and maintenance is defined as oversight of the high-level waste storage casks located on the onsite interim storage pads awaiting shipment to Yucca Mountain for final disposal.

[2]8 persons x 1812 hours per year x 60 years = 8.70E5 hours.

[3]1 person x 1812 hours per year x 60 years = 1.09E5 hours.

[4]1 person x 1812 hours per year x 60 years = 1.09E5 hours.

Table 4-5. Personnel Requirements for Each Disposal Mode: Operational Phase for Cesium and Strontium Capsules (worker years)[1].

Module	No Action	Onsite stabilization and disposal[2]		Geologic disposal[3]	Vitrification and disposal[5]
		Barrier	Total[4]	Storage and containerization	
Process					
Radiation	140	-	140	77	
Nonradiation	54	-	54	34	
Storage/disposal					
Radiation	700	-	260	65	
Nonradiation	190	-	100	25	
Transport					
Radiation	-	-	-	-	
Nonradiation	-	-	-	-	
Total					
Radiation	840	-	400	142	
Nonradiation	240	-	150	59	

Notes:

Surveillance of the Drywell Storage Facility under the No Action option includes 440 worker years of radiation personnel and 87 worker years for nonradiation personnel.

[1]Worker years are evenly distributed over the operating periods shown in Figure 3-2.

[2]Worker years are evenly distributed over the operating periods shown in Figure 3-7.

[3]Worker years are evenly distributed over the operating periods shown in Figure 3-4.

[4]Total equals barrier values plus continued storage values except land.

[5]Resource usage, costs, and personnel requirements for the vitrification and disposal option.

Under this alternative, the contents of the cesium and strontium capsules are sent to an existing vitrification plant for processing. The mass requiring vitrification from the cesium and strontium capsules is less than 1% of the tank materials that require vitrification. Therefore, the processing of the capsule contents does not impose any significant additional resource (both usage and personnel) requirements on the vitrification plant. Thus no separate estimate of impacts is provided.

 LTM

Table 5-2. Operating Personnel Requirements (Staff-Hours) by Unit Operation[1].

Unit Process	No Disposal Action
Tank farm operations	159,000,000
Evaporator operations	5,000,000
Total (staff hours)	164,000,000

Notes:

[1]See Table 5-3 for basis of estimate of staffing. Based on the TWRS multi-year program plan, evaporator operations are estimated at 1,548 staff years through 2007, plus 1,240 staff years for 10 years of evaporation campaigns for retanking. The breakdown by worker category as shown in Table 5-3 is assumed to apply in equal proportions to the two unit processes listed in Table 5-2.

657 staff yrs BU
116
773 staff yrs - rai

use 1240 instead

5,000,000 Hours.

% 47 Exempt = 2.35 E6 → 20% 5E5 Rad

% 53 Non Exempt = 2.65 E6 → 80% 2.12 E6 Rad

≈ 2.7 E6.

Periodic Ops: 3.1 E6 hrs total
= 1.5 E6 Exempt = 3E5 hrs
= 1.6 E6 Non Ex = 1.28 E6 hrs

1.12 E6 Rad hrs Retanking
80% Rad = 8.96 E5 Non Ex.

Non Rad 7.8E5

Table 5-3. Operating Personnel Requirements (Staff-Hours).

Operating Personnel	No Disposal Action[1]
Nonexempt	
Radiation worker	72,000,000
Nonradiation worker	15,000,000
Exempt	
Radiation worker	15,000,000
Nonradiation worker	61,000,000
Total (staff-hours)	164,000,000

Notes:

[1]The operating staff in this table refer to the monitoring and maintaining of the tank farms and operation of the evaporator. The values are based on estimated staffing levels for tank farms operations and maintenance (excluding SST stabilization) from the 1995 TWRS multi-year program plan (extrapolated for 100 years). Breakdown of this overall staffing into the personnel categories indicated is based on current staffing. Twenty percent of current exempt staff are radiation workers. Non-exempt bargaining unit personnel are assumed to be radiation workers. Other non-exempt personnel are assumed to be nonradiation workers. Staffing head count is converted to staff hours at the rate of 1,812 hours per person per year.

Table 5-8. Construction Personnel Requirements (Staff-Hours) by Unit Process.

Unit Process	No Disposal Action
New double-shell tanks and evaporator[1]	7.5×10^6

Notes:

[1]Construction personnel requirements were factored from the *Title I Design Report Summary Report, Multi-Function Waste Tank Facility Project W-236A*, (KEHC 1994) with additions made for the evaporator and piping connections. The entry reflects retanking the waste twice.

KEHC, 1994, *Title I Design Summary Report, Multi-Function Waste Tank Facility Project W-236A*, WHC-SD-W236A-RPT-002, CR-9996, Vol. 1, Kaiser Engineers Hanford Company, Richland, Washington.

Table 9-2. Unit Process: Operating Personnel Requirements (Staff-Hours)[1].

Unit Process	Tri-Party Agreement Preferred Alternative
Sludge wash	2.3E+6
Cesium removal	5.0E+6
Other radionuclide removal	n/a
Low-level waste vitrification	1.1E+7
Low-level waste disposal	2.8E+5
High-level waste vitrification	1.1E+7
High-level waste transportation/disposal	6.2E+5
Total	3.1E+7 * ~~2000~~ 1812

Notes:

[1]Includes staffing for start-up, decontamination and decommissioning, and monitoring and maintenance.

Note: *adjusted to 2000/hrs per yr

Table 9-3. Operating Personnel Requirements (Staff-Hours)[1].

Operating Personnel[2]	Tri-Party Agreement Preferred Alternative
Nonexempt	
Radiation worker	0
Nonradiation worker	3.8E+6
Exempt	
Radiation worker	2.7E+7
Nonradiation worker	0
Total Staff Hours	3.1E+7

Notes:

[1]All exempt and bargaining unit employees are assumed to be radiation workers. All nonexempt employees are nonradiation workers.

[2]Includes staffing for start-up, decontamination and decommissioning, and monitoring and maintenance.

Table 9-8. Unit Process: Construction Personnel Requirements. (Staff-Hours)[1]

Unit process	Tri-Party Agreement Preferred Alternative
Sludge wash[1,2]	4.4E+5
Cesium removal[1,3]	4.0E+6
Centralized facilities	6.0E+6
Low-level waste vitrification[1]	1.3E+7
Low-level waste disposal	0
High-level waste vitrification	1.6E+7
High-level waste transportation	0
High-level waste disposal	0
Total	4.0E+7

assume 1812 hrs/y

Notes:

[1]Backup in Appendix F contains staff hours for pretreatment/low-level waste (LLW) combined. To separate sludge wash and cesium removal from LLW vitrification other cost estimates were employed. Cost estimates were found for a detached pretreatment facility and a detached LLW facility (these are contained in Appendix F). The staff hours for each were taken and added together. This total was then divided into each staff hour value separately. The calculation was as follows:

Detached Separations - Total staff hours = 1,463,389
Detached LLW - Total staff hours = 4,704,549
Total = 6,167,938

% separations = 1,463,389/6,167,938 = 0.237 => Value used is 25 %
Therefore % LLW = 75%

[2]Engineering judgement set the sludge wash staff hours equal to 10% of the total staff hours for separations (see number 2 above).

[3]Engineering judgement set the cesium removal staff hours equal to 90% of the total staff hours for separations (see number 2 above).

Table 9-9. Construction Personnel Requirements. (Staff-Hours)

Construction Personnel	Tri-Party Agreement Preferred Alternative
Design and engineering	1.0E+7
Construction[1]	
Radiation worker	0
Nonradiation worker	2.4E+7
Supervisory[2]	5.6E+6
Total	4.0E+7

Notes:

[1]Staff hours equal to summation of staff hours calculated for equipment/facility installation and subcontract in backup. All construction staff hours are assumed to be for nonradiation work.

[2]Staff hours equal to summation of staff hours calculated for construction and project management.

Table 7-2. Comparison of Alternatives by Unit Process: Operating Personnel Requirements (Staff-Hours).[1]

Unit Process	In Situ Chemical Stabilization			Drying and Gravel Fill			In Situ Vitrification		
	E	NE	BU	E	NE	BU	E	NE	BU
Startup[2]	1.2E6	5.7E5	2.8E6	~~4.3E5~~ 2.18E5	~~2.8E5~~ 1.16	~~5.4E5~~ 1.27	1.2E6	7.2E5	1.6E6
Double-shell tank evaporation[3]	5.3E5	5.4E5	0	5.3E5	5.4E5	0	5.3E5	5.4E5	0
Confinement facility[4]	8.7E5	3.0E5	2.5E6	—	—	—	—	—	—
Grout mixing[5]	1.3E5	5.4E4	3.3E5	—	—	—	—	—	—
Vitrification[6]	—	—	—	—	—	—	2.6E6	1.2E6	4.0E6
Radio frequency drying[7]	—	—	—	~~2.1E5~~	~~4.9E4~~	~~1.3E6~~	—	—	—
Gravel fill[8]	—	—	—	3.4E5	1.0E5	5.1E5	—	—	—
Decontamination and decommissioning[9]	1.2E6	5.7E5	2.8E6	2.18 ~~4.3E5~~	1.16 ~~2.8E5~~	1.27 ~~5.4E5~~	1.2E6	7.2E5	1.6E6
Total staff-hours[10]	3.9E6	2.0E6	8.4E6	~~1.9E6~~ 1.3	~~1.2E6~~ 9.6E5	~~2.9E6~~ 7.6E5	5.5E6	3.2E6	7.2E6

Notes:

[1] 1 worker year = 1812 staff hours, according to Westinghouse Hanford Company Fiscal Year 1995 planning rate. Staff hours associated with TWRS program management, tank farm operations and maintenance characterization, tank farm upgrades, and tank farm safety are not included in this table.

[2] Startup = 3 years (2005-2008)
1st year at 1/3 operating staff
2nd year at 2/3 operating staff
3rd year at full operating staff
= 2 years full operating staff.

1.3E6
.96E6
.76E6
3.02E6

[3] Previous 242-A operation was used as a basis.
242-A operating life = 5 years (2000-2005)

Gravel fill 950,000 total
E: 4.5E5 Real = 20% = 90,000 hrs =
NE: 5E5 Real = 80% = 400,000 hrs =

Table 7-3. Comparison of Alternatives by Operating Personnel Requirements (Staff-Hours).[1]

Operating Personnel[2]	In Situ Chemical Stabilization[3]	Drying and Gravel Fill[4]	In Situ Vitrification[5]
Exempt			
Radiation worker	2.4 E6	9.5 E5 4.75 E5	3.6 E6
Nonradiation worker	1.6 E6	1.0 E6 5 E5	2.2 E6
NonExempt			
Radiation worker	1.2 E6	9.5 E5 4.75 E5	1.7 E6
Nonradiation worker	8.2 E5	3.0 E5 1.5 E5	1.4 E6
Bargaining Units			
Radiation worker	8.4 E6	2.8 E6 x 3/6 1.4 E6	7.2 E6
Nonradiation worker	0	0	0
Total Staff-Hours[6]	1.4 E7	~~6.0 E6~~ 3.0 E6	1.6 E7

6.5 E5

Notes:

[1]Values are total quantities for facility operating life, including startup and decontamination and decommissioning.

1 worker-year = 1812 staff-hours, according to Westinghouse Hanford Company Fiscal Year 1995 planning rate.

Startup = 2 years operating staff (see Table 7-2)
242-A operating life = 5 years
In Situ Chemical Stabilization (ISCS) (Tank Farm Confinement Facility [TFCF] grout mixing) operating life = 2 years
Radio frequency drying operating life = 9 years
Gravel fill operating life = 4 years
In Situ Vitrification (ISV) operating life = 5 years
Decontamination and decommissioning = 2 years operating staff (see Table 7-2)

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Table 5-1. Comparison of Alternatives by Retrieval and Transfer Unit Process: Operating Personnel Requirements (Staff-Hours x 10^6)[1,2,3].

Unit Process	No Disposal Action	In Situ Disposal	Extensive Pretreatment	No Separations	TPA Preferred Alternative
SST retrieval	0	0	20	20	20
SST confinement	0	0	11	11	11
SST waste transfers	0	0	19	19	19
SST subsurface barriers	0	0	4.5	4.5	4.5
DST retrieval	2.1	0	3.7	2.8	3.7
DST waste transfers	3.4	0	5.8	4.3	5.8
MUST retrieval	0	0	0.4	0.4	0.4
MUST waste transfers	0	0	0.9	0.9	0.9
Total	5.5	0	65	63	65

Notes:

DST = double-shell tank
MUST = miscellaneous underground storage tank
SST = single-shell tank
TPA = Tri-Party Agreement

[1]Operating personnel (millions of staffhours) estimates were derived from the *Tank Waste Technical Options Report*, Appendix F (Boomer et al. 1993).

[2]See Appendix A, Backup to Table 5-1, Operating Staff Hours.

[3]Percent distribution of annual staffhours for operations personnel for each alternative are shown in Appendix A, Backup to Table 5-1, Peak and Annual Average Operations Staffhours.

Boomer, K. D., et al., 1993, *Tank Waste Technical Options Report*, WHC-EP-0616, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Table 5-2. Comparison of Alternatives by Operating Personnel Requirements for Retrieval and Transfer (Staff-Hours x 10^6)[1,2,3].

Operating Personnel	No Disposal Action	In Situ Disposal	Extensive Pretreatment	No Separations	TPA Preferred Alternative
Nonexempt Radiation worker	2.6	0	34	33	34
Nonradiation worker	0.8	0	12	12	12
Exempt Radiation worker	0.7	0	6	5	6
Nonradiation worker	1.4	0	13	13	13
Total	5.5	0	65	63	65

Notes:

TPA = Tri-Party Agreement

[1]Operating personnel (millions of staff hours) estimates are derived from *Tank Waste Technical Options Report*, Appendix F (Boomer et al. 1993).

[2]Appendix A, Backup to Table 5-2, Nonexempt and Exempt Radiation Worker and Nonexempt and Exempt Nonradiation Worker.

[3]Annual percent distribution of operating staff hours in each worker category would be as shown in Appendix A, Backup to Table 5-1 plots for each alternative.

Boomer, K. D., et al., 1993, *Tank Waste Technical Options Report*, WHC-EP-0616, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Table 5-5. Comparison of Alternatives by Radiological Operating Emissions for Retrieval and Transfer (curies). (2 sheets)

Radionuclide	No Disposal Action		In Situ Disposal		Extensive Pretreatment		No Separations		TPA Preferred Alternative	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
241Am	0	0	0	0	0	3	0	3	0	3
14C	0	0	0	0	0	50	0	50	0	50
137Cs	.0007	0	0	0	.02	1E 4	.02	1E 4	.02	1E 4
129I	.001	0	0	0	.03	.01	.03	.01	.03	.01
239,240Pu	0	0	0	0	0	13	0	13	0	13
106Ru	0	0	0	0	0	4E-5	0	4E-5	0	4E-5
151Sm	0	0	0	0	0	0	0	0	0	0
90Sr	.0001	0	0	0	.003	50	.003	50	.003	50
99Tc	0	0	0	0	0	14	0	14	0	14
93Zr	0	0	0	0	0	0	0	0	0	0
% PM-10	100	0	n/a	-	100	-	100	-	100	-

NOTES:

TPA = Tri-Party Agreement

The *Draft Environmental Impact Statement for Safe Interim Storage of Hanford Tank Wastes*, (DOE-RL 1994), reports prior estimates that operation of the mixer pump in Tank 101-SY for 4 hours per day, 7 days per week would increase emissions by a factor of 2.5.

Table 5-6. Comparison of Alternatives by Unit Process for Retrieval and Transfer: Construction Personnel Requirements (Staff-Hours x 10^6).[1]

Unit Process	No Disposal Action	In Situ Disposal	Extensive Pretreatment	No Separations	TPA Preferred Alternative
SST retrieval	0	0	6.3	6.3	6.3
SST confinement	0	0	4.3	4.3	4.3
SST waste transfers	0	0	3.0	3.0	3.0
SST subsurface barriers	0	0	2.9	2.9	2.9
DST retrieval	14.2	0	7.1	7.1	7.1
DST waste transfers	0	0	0	0	0
MUST retrieval	0	0	0.3	0.3	0.3
MUST waste transfers	0	0	0.2	0.2	0.2
Total	14.2	0	24.1	24.1	24.1

Note:

DST = double-shell tank
MUST = miscellaneous underground storage tank
SST = single-shell tank
TPA = Tri-Party Agreement

[1]Construction staffhours are estimated as shown in Appendix A, Backup to Table 5-6, Construction Staff Hours.