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**DEFENSE WASTE PROCESSING FACILITY: GEOTECHNICAL
INFORMATION (U)**

by

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John A. Haselow 10-4-90

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ABSTRACT

The information contained in this report is intended to supplement the original Environmental Impact Statement (EIS) for the Defense Waste Processing Facility (DWPF). Since the original EIS in 1982,¹ alterations have been made to the conceptual process that reduce the impact to the groundwater. This reduced impact is documented in this report along with an update of the understanding of seismology and geology of the Savannah River Site.

INTRODUCTION

The Savannah River Site (SRS) is a major Department of Energy (DOE) facility that has produced materials for national defense and other purposes since the 1950s. Radioactive by-products generated during processing of nuclear fuel at the SRS have been stored in large underground tanks. In the DWPF, the insoluble materials of this waste that have precipitated into sludge will be vitrified into a glass matrix, which will be stored in an underground repository at another location. The aqueous form of the waste will be processed into a cemented grout or saltstone at the Saltstone Disposal Facility (SDF) and will be disposed of in the Z-Area of the Facility.

an EIS was released for the DWPF and supporting facilities in 1982.¹ That EIS was based on the then proposed processes. Since 1982, there have been improvements made to the waste disposal facilities that substantially decrease the estimated impact on the subsurface environment compared to those reported for the 1982 concept.

This report contains an update of the estimated impact on the subsurface environment (groundwater hydrology) from the waste disposal facilities. Other seismic and geotechnical information for the SRS that has become available since 1982 is also included.

As required by the National Environmental Policy Act (NEPA), a major federal action,

DISCUSSION

Subsurface Hydrology

SRS technical personnel are currently revising the nomenclature that describes the subsurface hydrologic system. However, to remain consistent, the hydrologic nomenclature used for the 1982 DWPF EIS¹ will be used. From the land surface down, the hydrologic system is composed of the vadose zone (unsaturated), the water table or Barnwell, the tan clay aquitard, the McBean water bearing zone, the green clay aquitard, the Congaree water bearing zone, the Ellenton clay aquitard, the Ellenton sands water bearing zone, the Upper Tuscaloosa clay, the Upper Tuscaloosa aquifer, the Middle Tuscaloosa clay, the Lower Tuscaloosa aquifer, and, finally, the base confining unit. Figure 1 shows a schematic of this system.

Also shown in Figure 1 are recent hydrostatic heads at several wells at the central portion of the SRS. Comparison of these hydrostatic heads with those in Figure F.2 in the 1982 EIS¹ confirms that the heads have not fluctuated significantly. Therefore, hydraulic maps for the area have not been updated.

Groundwater Quality

The formulation of saltstone has changed since 1982 as a result of process alterations. The saltstone will now be on average 47 weight percent salt solution versus the previously reported 55 weight percent. The complete formulation of the saltstone and salt solution are given in Attachment 1, the South Carolina Department of Health and Environmental Control (SCDHEC) Waste Permit #12683.

As a result of the salt reduction, the concentrations of constituents in the saltstone are proportionally reduced, which also reduces the concentration of constituents in water that seeps through the SDF and subsequently reaches the saturated zone beneath Z-Area.

To estimate the reduction in the impact to the groundwater at the boundary of Z-Area, previous estimates in Wilhite² were extrapolated. The concentrations in the groundwater beneath the SDF were multiplied by 47/55 to reflect the current saltstone formulation. The concentration of each constituent was also reduced by a factor of five to account for dispersion as the constituents flow from the base of the disposal facility to the Z-Area boundary.³ (This was not considered in Wilhite².) Additionally, the concentration of mercury was multiplied by the square root of $2.1e - 15 / 4.1e - 08$ to account for the experimentally observed lower diffusion coefficient of mercury in saltstone in Langton.⁴ Using these assumptions, maximum groundwater concentrations at the Z-Area boundary were estimated and are reported in Table 1. The groundwater flow rates, retardation coefficients, stream flow rates, radioactive decay constants, and assumptions used are identical to those used for the 1982 EIS¹ (Attachment 2).

Comparison of the 1982 releases and estimated current releases (Table 2) to the Savannah River and the groundwater beneath Z-Area shows that the estimated impact is substantially reduced. The reduction is primarily the result of improvement in vault disposal.

Figure 1. Hydraulic Heads and the Hydrologic System for the Central Savannah River Site

Table 1. Estimated Groundwater Constituent Concentration at Z-Area Boundary

Contaminant	Maximum Concentration in Z-Area Groundwater ^a	Contaminant	Maximum Concentration in Z-Area Groundwater ^a
Nitrate ^b	0.7 ppm	¹⁵¹ Sm	3x10 ⁻¹⁶ pCi/L
Nitrite ^{b,c}	0.2	²³² U	2x10 ⁻³⁰
Mercury ^d	3.5x10 ⁻⁹	²³⁴ U	4x10 ⁻¹⁵
		²³⁶ U	3x10 ⁻²¹
Salt	8.6	²³⁸ U	8x10 ⁻¹⁷
³ H	3x10 ⁻¹⁴ pCi/L	²³⁷ Np	2x10 ⁻¹⁵
⁵⁹ Ni	1x10 ⁻¹⁶	²³⁸ Pu	3x10 ⁻²⁹
⁶³ Ni	2x10 ⁻³⁰	²³⁹ Pu	9x10 ⁻¹⁷
⁷⁹ Se	9x10 ⁻¹²	²⁴⁰ Pu	2x10 ⁻²⁰
⁹⁰ Sr	3x10 ⁻²⁵	²⁴¹ Pu	9x10 ⁻⁵⁹
⁹³ Zr	1x10 ⁻¹⁴	²⁴² Pu	6x10 ⁻¹⁸
⁹⁹ Tc	6x10 ⁻¹⁰	²⁴¹ Am	3x10 ⁻²⁵
¹⁰⁷ Pd	9x10 ⁻¹⁶	^{242m} Am	9x10 ⁻³¹
^{121m} Sn	3x10 ⁻¹⁵	²⁴² Am	4x10 ⁻²¹
¹²⁵ Sn	2x10 ⁻¹³	²⁴³ Cm	9x10 ⁻²⁹⁰
¹²⁹ I	1x10 ⁻¹²	²⁴⁴ Cm	0
¹³⁵ Cs	2x10 ⁻¹⁵	²⁴⁵ Cm	1x10 ⁻³²
¹³⁷ Cs	6x10 ⁻⁸⁹	²⁴⁶ Cm	3x10 ⁻³⁵
¹⁴⁷ Pm	3x10 ⁻²⁵	²⁴⁷ Cm	8x10 ⁻²⁶
		²⁴⁸ Cm	4x10 ⁻³⁰

^a Groundwater concentrations are based on DPST-88-332.² All concentrations are reduced to account for five-fold dilution at the Z-Area boundary (DPST-88-436³) and to account for 47 weight percent of salt solution in saltstone (the average value) (DPST-88-372, revised 5/13/88).

^b Calculated as nitrogen

^c Based on saltstone lysimeter results (DPST-86-251 and DPST-87-523), nitrite will be oxidized to nitrate in the soil and will not be observed in the Z-Area monitoring wells.

^d Based on mercury diffusion coefficient in saltstone of 2.1x10⁻¹⁵ cm²/sec (WSRC-RP-89-1375⁴)

Table 2. Estimated Releases to the Savannah River from Saltstone Disposal at Z-Area

<u>Constituent</u>	<u>Maximum Release to the Savannah River</u>
Nitrate	4.1E+01 Kg/yr
Nitrite	1.2E+01
Hg	1.2E-07
Salt	5.1E+02
³ H	4.3E-19 Ci/yr
⁵⁹ Ni	5.7E-21
⁶³ Ni	1.1E-34
⁷⁹ Se	5.1E-16
⁹⁰ Sr	0
⁹³ Zr	5.7E-19
⁹⁹ Tc	3.4E-14
¹⁰⁷ Pd	5.3E-20
^{121m} Sn	1.2E-19
¹²⁶ Sn	1.2E-17
¹²⁹ I	5.9E-17
¹³⁵ Cs	1.2E-19
¹³⁷ Cs	0
¹⁴⁷ Pm	2.3E-32
¹⁵¹ Sm	1.4E-20
²³² U	0
²³⁴ U	2.3E-19
²³⁶ U	1.7E-25
²³⁸ U	4.7E-21
²³⁷ Np	1.2E-19
²³⁸ Pu	0
²³⁹ Pu	9.0E-23
²⁴⁰ Pu	4.8E-31
²⁴¹ Pu	0
²⁴² Pu	2.7E-26
²⁴¹ Am	0
^{242m} Am	0
²⁴³ Am	2.0E-29
²⁴³ Cm	0
²⁴⁴ Cm	0
²⁴⁵ Cm	1.7E-40
²⁴⁶ Cm	7.5E-46
²⁴⁷ Cm	4.7E-30
²⁴⁸ Cm	1.9E-34

Seismic Activity

Since 1982, two earthquakes with epicenters at the SRS have been documented. On June 9, 1985, an earthquake of intensity III on the Modified Mercalli Scale with a local magnitude of 2.6 occurred at the SRS. This earthquake was not felt on site.

More recently, on August 5, 1988, an earthquake of local magnitude 2.0 and estimated intensity of I-II (Modified Mercalli) occurred. The focal depth was estimated at 2.86 km. The event was not felt on the SRS and the seismic alarms onsite were not activated. The earthquake was only detected by seismometers within 100 km of the SRS (Haselow⁵).

Geotechnical Surveys

At SRS, evidence from subsurface mapping and seismic reflection surveys suggests the presence of a fault that displaces Cretaceous through Tertiary (90 to 35 million years ago) sediments about 30 to 100 feet (offset). This feature has been described and named the Pen Branch Fault (PBF). Current understanding of the PBF is based on drilling activities completed in the fall of 1989 (PBF well series) and subsequent core analyses. Preliminary and ongoing investigations indicate that the fault is not capable,⁶ but further study is planned.

The PBF trends northeast across the site and is within about 1 km of K-Area and 3 km northwest of L- and P-Areas (Figure 2). The fault closely parallels the Triassic Basin northern boundary fault that forms the northern boundary of the Dunbarton Basin and trends northeast across the SRS. Brittle and ductile deformation features found at the Triassic/Paleozoic-Precambrian boundary

in the PBF-8 well support the opinion that the Triassic-aged Dunbarton Basin border fault has moved under both ductile and brittle conditions. It is suggested that the ductile faulting preceded brittle faulting and that brittle faulting during Cretaceous-through-Tertiary time resulted in the formation of the Pen Branch Fault in the Coastal Plain sediments covering the basement rock. In other words, the PBF is most likely a reactivation of the Dunbarton Basin border fault that moved again during Cretaceous through Cenozoic.

The fault dip is close to vertical and, in the crystalline basement, slip direction was originally down to the southeast. Movement during Cretaceous through Tertiary appears to be reverse movement, that is, up to the southeast. The fault appears to be similar to other faults mapped in the Atlantic Coastal Plain region from Georgia to Virginia as late Mesozoic-to-Tertiary faults.

The PBF series of drill holes were completed in pairs bracketing the fault trace. Data obtained from these holes constrains fault offset to the Dry Branch Formation. This would be the youngest strata or the shallowest strata that is broken by the fault. The formation is considered to be lower upper Eocene or about 40 to 43 million years old. High-resolution, shallow seismic-reflection surveys will be done this year to determine exactly how close it comes to the surface and what the geometry of the fault is as it nears the surface.

The PBF probably extends offsite to the east an undetermined amount. Shallow high-resolution seismic-reflection surveys conducted offsite will help determine the eastward extent of the PBF.

Figure 2. The Pen Branch Fault at the Savannah River Site

SUMMARY

Subsurface Hydrology

Comparison of recent subsurface hydrology studies with those conducted for the 1982 EIS¹ confirms that the hydraulic heads have not fluctuated significantly. As a result hydraulic maps of the area need no updating.

Groundwater Quality

Comparison of estimated current releases of groundwater to the Savannah River and the groundwater beneath Z-Area of the SDF with those reported in the 1982 EIS¹ show a substantial reduction. This is primarily the result of improvement in vault disposal.

Seismic Activity

Two minor earthquakes, which were not felt at the SRS, were recorded. Neither exceeded III on the Modified Mercalli Scale.

Geotechnical Surveys

Evidence from subsurface mapping and seismic reflection surveys have indicated a fault, which has been named the Pen Branch Fault. It appears that the fault is not capable, but further studies are planned, that will help determine the extent of the fault.

REFERENCES

- (1) *Final Environmental Impact Statement Defense Waste Processing Facility.* DOE/EIS-0082, Department of Energy (1982).
- (2) E. L. Wilhite. *Saltstone Disposal Vault Performance: Effect of Formulation Variation.* DPST-88-332, Savannah River Laboratory, Aiken, SC (1988).
- (3) E. L. Wilhite. *Predicted Impact of Saltstone Disposal Facility on Z-Area Groundwater Quality.* DPST-88-436, Savannah River Laboratory, Aiken, SC (1988).
- (4) C. A. Langton and E. L. Wilhite. *Revised Z-Area Salt Solution Feed Specification for Mercury.* WSRC-RP-89-1375, Savannah River Laboratory, Aiken, SC (1989).
- (5) J. S. Haselow, V. Price, D. E. Stephenson, H. W. Bledsoe, and B. B. Looney. *Reactor Operation Environmental Information Document Volume I Geology, Seismology and Subsurface Hydrology.* WSRC-RP-89-815, Westinghouse Savannah River Company, Aiken, SC (1989).
- (6) *Safety Evaluation Report Related to the Operation of Vogtle Electric Generating Plant, Units 1 and 2.* NUREG-1137, Supplement No. 8, United States Nuclear Regulatory Commission (1989).

ATTACHMENT 1

**REVISION OF SCDHEC PERMIT #12683
Z-AREA INDUSTRIAL WASTEWATER TREATMENT FACILITY**

E. I. DU PONT DE NEMOURS & COMPANY

ATOMIC ENERGY DIVISION

SAVANNAH RIVER PLANT
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January 29, 1988

Mr. S. R. Wright, Director (2)
Environmental Division
Savannah River Operations Office
U. S. Department of Energy
P. O. Box A
Aiken, SC 29802

Dear Mr. Wright:

REVISION OF SCDHEC PERMIT #12683, Z-AREA INDUSTRIAL
WASTEWATER TREATMENT FACILITY

Enclosed is the information necessary to update the subject permit to reflect changes that have been made since the construction permit was approved on 10/31/86. In summary, the major changes are:

- The Saltstone feed composition has been revised to reflect the addition of F/H Effluent Treatment Facility (ETF) waste concentrate. This was previously approved by SCDHEC during their review of the ETF (Construction Permit #12870).

To incorporate new information on the chromium concentration in the feed. SCDHEC was informed of this change on May 8, 1987 (Letter, Wright to Joy) and supplemental information was provided on November 18, 1987 (Letter, Wright to Ruiters).

- To improve the characteristics of the final waste form, Grade 120 slag is being substituted for Portland Class H cement and Class F instead of Class C fly ash will be used. This was identified as a potential change and was also discussed in the previously cited letters to SCDHEC.
- Agitators will be added to the salt solution hold tank and the low point drain tank. This will assure that particulates from the ETF concentrate are in suspension before transfer to the mixer.

S. R. Wright
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January 29, 1988

It is important to note that these and other changes described in the enclosure are minor and do not affect design or the process. However, more importantly, they result in a reduction of the potential environmental impact from the operation of this facility.

Testing using simulated (nonhazardous, nonradioactive) feed is scheduled for April 1988 and startup in June 1988.

Yours very truly,

J. E. Hoisington
Chief Supervisor
Environment and Energy

MH:rbl
Att

CC: G. S. Hoover, 703-41A
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R. L. Hooker, 247-F
Central Files, 703-A, A-027
File 0202B

*With Attachment

Savannah River Plant
 DWPF SALTSTONE INDUSTRIAL WASTEWATER TREATMENT
 SCDHEC Permit # 12683
TREATMENT PLANT CHANGES SINCE PERMIT APPROVAL 10/31/86

The Z-area saltstone wastewater treatment facility is under construction at the Savannah River Plant. Checkout with simulated feed (nonhazardous, nonradioactive) is scheduled for April, 1988, and startup with actual salt solution is scheduled for the end of June, 1988. There have been four changes in the DWPF Saltstone industrial waste treatment plant since permit approval: (1) process feed and product feed rate; (2) salt solution wastewater composition; (3) saltstone formulation; and, (4) equipment modifications. SCDHEC approved the addition of feed from the F/H Treatment Facility via the construction permit #12870. None of the changes affect equipment design or process:

Process Feed & Product Feed Rate

The permit application shows the facility design basis as 105 gpm for the treatment of up to 10,000,000 gallons per year (6,000,000 gallons per year average) of salt solution. The maximum and average treatment rates have been increased to 15,000,000 gallons per year and 9,000,000 gallons per year, respectively, in order to support the current estimates for the waste tank farm retirement program (an additional 2,000,000 gallons per year average) and the disposal of waste generated from the F/H Effluent Treatment Facility (an additional 1,000,000 gallons per year average). Revised process rates are shown below. Although the annual maximum and average rates are increased, the design instantaneous rate will remain at 105 gpm. The extra capacity may be achieved by operating two shifts per day as needed, instead of the one shift per day as originally forecast.

PROCESS FEED AND PRODUCT RATES

	Annual Maximum Rate	Annual Average Rate	(Instantaneous Rate) Design Basis
Salt Solution	15,000,000 gal/yr	9,000,000 gal/yr	105 gpm
Cement(lime)/Flyash/Slag	87,000 T/yr	52,000 T/yr	1,200 lb/min
Saltstone	163,000 T/yr	98,000 T/yr	1.1 T/min

Salt Solution Wastewater Composition

The approximate chemical and radionuclide compositions of the salt solution feed vary slightly from the initial permit application. Recent pilot scale studies with simulated salt solution feed show that small amounts of several organic compounds (mostly benzene) are generated from the radiolytic decomposition of tetraphenyl borate added during the tank farm "in-tank precipitation process". Most of the benzene is emitted

upstream of saltstone, the remainder is subsequently emitted while being transported through the inter-area transfer facility to the saltstone treatment process and during saltstone mixing. Small quantities of methanol and isopropanol are also added during the in-tank precipitation process. Also, tank farm processing from a waste tank receiving high concentrations of chromium will cause higher concentrations of chromium in the salt solution feed than previously reported. The approximate waste composition shown in Tables 1 and 2 reflects these changes as well as disposal of waste generated from the F/H Effluent Treatment Facility (ETF). Nominally, ETF waste will be blended with DWPF waste at an approximate ratio of 1:8 by volume. However, at some times, waste being processed in Z-area may be all from the DWPF or all from the ETF.

Saltstone Formulation

The ratio of salt solution feed to dry cementitious material will not change significantly. However, there will be a change in the dry material composition. The permit application states "the cementing material will be API Class H cement and ASTM Class C flyash, however, future replacements of equal quality may be used." Research has been ongoing to improve the leaching characteristics of the final saltstone waste form. Tests show adding Grade 120 slag to the cement/flyash premix greatly decreases leaching and can be incorporated into the process without equipment changes. Actual ratios of cement/flyash/slag may vary as shown.

<u>Component</u>	<u>Weight %</u>	
	<u>Nominal</u>	<u>Range</u>
Lime source *	3	0 - 10
Fly ash	25	15 - 40
Slag	25	15 - 40
Salt solution	47	40 - 55

* Either Portland Class II cement or Ca(OH)_2

The approximate chemical and radionuclide compositions of saltstone have not changed significantly and are shown in Tables 3 and 4. The quantities involved are too small to affect the treatment process or grout physical characteristics. Effects on the final saltstone waste form include decreased leachability, particularly of chromium and technetium-99, with reduced impact on groundwater quality. The effects of the new materials in saltstone will be addressed in the proposed Saltstone Industrial Solid Waste Disposal permit modification request.

Equipment Modifications

Since the design basis flow rate has not changed, no changes are

DWPF Saltstone Industrial Waste Treatment
29-Jan-1988
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required in the size of equipment. An agitator will be added to the salt solution hold tank and the low point drain tank to put additional particulates expected from the P/H Effluent Treatment Facility in suspension before transfer to the mixer. See the attached Specification 2-2678, item nos. Z201-10-013-00-AG, and Z551-100-013-AG.

One of the three silos reserved for flyash will now be used to store Grade 120 slag. Since all four silos are identical, and the dry material characteristics of cement and slag are similar, no design changes are needed in the silo or cement/flyash/slag material handling system, premix process or equipment.

TABLE 1

APPROXIMATE CHEMICAL COMPOSITION OF SALT SOLUTION FEED
(Blend Ratio 8 million gallons DWPF to 1 million gallons ETF)

Component	Weight Percent		
	DWPF	ETF	Nominal Blend
H ₂ O	71.8	69.9	71.6
NaNO ₃	13.3	21.9	14.3
NaNO ₂	4.1	0.02	3.6
NaOH	4.2	4.4	4.2
Na ₂ CO ₃	1.4	1.4	1.4
NaAl(OH) ₄	2.9	0.06	2.6
Na ₂ SO ₄	1.6	0.22	1.4
NaF	0.05	0.017	0.05
NaCl	0.11	0.008	0.1
Na ₂ SiO ₃	0.04	0.2	0.06
Na ₂ CrO ₄	0.04	9×10^{-4}	0.04 (Cr-114 ppm)
NaHgO(OH)	4.2×10^{-6}	5×10^{-4}	6×10^{-5} (Hg-0.5 ppm)
NaAg(OH) ₂	1.3×10^{-7}	-	1.2×10^{-7} (Ag-0.0008 ppm)
Na ₂ MoO ₄	0.007	-	0.006
KNO ₃	7.8×10^{-6}	0.02	0.002
CaSO ₄	2.3×10^{-4}	0.3	0.034
Na ₂ C ₂ O ₄	0.16	0.05	0.15
Na ₃ PO ₄	0.11	0.02	0.10
NH ₄ NO ₃	6.1×10^{-6}	0.6	0.07
NaB(C ₆ H ₅) ₄	0.07	-	0.06
Other Salts*	0.007	0.7	0.08
Total Organics	0.10	-	0.09

* Other Salts include:

As	3×10^{-8}	-	3×10^{-8} (0.0003 ppm)
Ba	1.9×10^{-8}	3×10^{-4}	3×10^{-5} (0.3 ppm)
Cd	5×10^{-6}	7×10^{-5}	1×10^{-5} (0.12 ppm)
Se	8×10^{-5}	-	7×10^{-5} (0.7 ppm)
Pb	2×10^{-12}	0.0011	1×10^{-4} (1.3 ppm)

TABLE 2

APPROXIMATE RADIONUCLIDE COMPOSITION OF SALT SOLUTION FEED
 (Blend Ratio 8 million gallons DWPF to 1 million gallons ETF)

Radionuclide (half-life, yrs)	nCi/g		Nominal Blend
	DWPF	ETF	
³ H (12.33)	10	60	15.7
¹⁴ C (5730)	0.009	-	0.008
⁵⁹ Ni (80,000)	0.0002	-	0.0002
⁶⁰ Co (5.27)	0.2	0.12	0.2
⁶³ Ni (100)	0.02	-	0.02
⁷⁹ Se ($\sim 6.5 \times 10^4$)	0.3	-	0.2
⁹⁰ Sr (29)	0.4	0.3	0.4
⁹⁰ Y (3.1 hr) ^a	0.4	0.3	0.4
⁹⁹ Tc (2.1×10^5)	60	-	53
¹⁰⁶ Ru (1.0)	30	4	27
¹⁰⁶ Rh (2.18 hr) ^a	30	4	27
¹²⁵ Sb (2.73)	9	0.05	8
^{125m} Te (58 da) ^a	0.2	0.05	0.2
¹²⁶ Sn ($\sim 10^5$)	0.2	-	0.2
¹²⁶ Sb (12.5 da) ^a	0.02	-	0.02
^{126m} Sb (19 min) ^b	0.2	-	0.2
¹²⁹ I (1.7×10^7)	0.035	0.015	0.03
¹³⁷ Cs (30.2)	10	4.9	9.4
^{137m} Ba (2.5 min) ^a	9.2	4.5	8.7
¹⁴⁷ Pm (2.62)	4	0.4	3.6
¹⁵¹ Sm (93)	2	-	1.8
¹⁵⁴ Eu (8.2)	1	-	0.9
¹⁵⁵ Eu (4.76)	0.3	-	0.3
²³⁸ Pu (87.7)	0.7	0.03	0.6
²³⁹ Pu (24,000)	0.007	0.01	0.007
Other Beta, Gamma ^c	-	9	1
Total Alpha Emitters	0.9	0.17	0.9

a Daughter of preceding isotope

b Daughter of ¹²⁶Sn

c Miscellaneous short-lived radionuclides

TABLE 3

APPROXIMATE CHEMICAL COMPOSITION OF SALTSTONE
(Blend Ratio 8 million gallons DWPF to 1 million gallons ETF)

Component	Weight Percent		
	DWPF	ETF	Nominal Blend
H ₂ O	33.7	32.9	33.6
NaNO ₃	6.3	10.3	6.7
NaNO ₂	1.9	0.01	1.7
NaOH	2.0	2.1	2.0
Na ₂ CO ₃	0.7	0.7	0.7
NaAl(OH) ₄	1.4	0.03	1.2
Na ₂ SO ₄	0.8	0.10	0.7
NaF	0.02	0.008	0.02
NaCl	0.1	0.03	0.05
Na ₂ SiO ₃	0.02	0.09	0.03
Na ₂ CrO ₄	0.02	4. x 10 ⁻⁴	0.02
NaHgO(OH)	2. x 10 ⁻⁶	2.4 x 10 ⁻⁴	2.8 x 10 ⁻⁵
NaAg(OH) ₂	6. x 10 ⁻⁸	-	5.4 x 10 ⁻⁸
Na ₂ MoO ₄	0.003	-	0.003
KNO ₃	4. x 10 ⁻⁶	0.01	0.0010
CaSO ₄	0.0001	0.14	0.016
Na ₂ C ₂ O ₄	0.08	0.02	0.07
Na ₃ PO ₄	0.05	0.01	0.05
NH ₄ NO ₃	3. x 10 ⁻⁶	0.3	0.03
NaB(C ₆ H ₅) ₄	0.03	-	0.02
Other Salts	0.003	0.33	0.04
Total Organics	0.05	-	0.04
Total	47	47	47
Lime Source *	3	3	3
Class F Flyash	25	25	25
Grade 120 Slag	25	25	25
Admixture(s) (if needed)	0.5	0.5	0.5

* Either Portland Class II cement or Ca(OH)₂

TABLE 4

APPROXIMATE RADIONUCLIDE COMPOSITION OF SALTSTONE
 (Blend Ratio 8 million gallons DWPF to 1 million gallons ETF)

Radionuclide (half-life, yrs)	nCi/g		Nominal Blend
	DWPF	ETF	
³ H (12.33)	5	28	7
¹⁴ C (5730)	0.004	-	0.004
⁵⁹ Ni (80,000)	0.0001	-	0.0001
⁶⁰ Co (5.27)	0.09	0.06	0.09
⁶³ Ni (100)	0.009	-	0.008
⁷⁹ Se ($\sim 6.5 \times 10^4$)	0.1	-	0.13
⁹⁰ Sr (29)	0.3	0.14	0.18
⁹⁰ Y (3.1 hr) ^a	0.3	0.14	0.18
⁹⁹ Tc (2.1×10^5)	28	-	25
¹⁰⁶ Ru (1.0)	14	1.9	13
¹⁰⁶ Rh (2.18 hr) ^a	14	1.9	13
¹²⁵ Sb (2.73)	4	0.02	4
^{125m} Te (58 da) ^a	0.09	0.02	0.09
¹²⁶ Sn ($\sim 10^5$)	0.09	-	0.08
¹²⁶ Sb (12.5 da) ^a	0.009	-	0.008
^{126m} Sb (19 min) ^b	0.09	-	0.08
¹²⁹ I (1.7×10^7)	0.02	0.007	0.015
¹³⁷ Cs (30.2)	9	2.3	4.4
^{137m} Ba (2.5 min) ^a	9	2.1	4.1
¹⁴⁷ Pm (2.62)	2	0.2	1.7
¹⁵¹ Sm (93)	0.9	-	0.8
¹⁵⁴ Eu (8.2)	0.4	-	0.4
¹⁵⁵ Eu (4.76)	0.1	-	0.13
²³⁸ Pu (87.7)	0.02	0.014	0.3
²³⁹ Pu (24,000)	0.003	0.005	0.003
Other Beta, Gamma ^c	-	4.2	0.5
Total Alpha	0.4	0.08	0.4

a Daughter of preceeding isotope

b Daughter of ¹²⁶Sn

c Miscellaneous short-lived radionuclides

ATTACHMENT 2

**EXCERPT FROM 1982 EIS:
ENGINEERED LANDFILL DISPOSAL**

tanks are unacceptable because sodium hydroxide, mercury, nitrate, and nitrite might contaminate SRP surface streams and groundwater.²² The disposal of saltcrete in Type III tanks²³ affords a similar degree of environmental protection at substantially increased costs compared with saltcrete burial in an engineered landfill.

5.4.2 Engineered landfill disposal

Analysis of the landfill design shows that water that enters the engineered landfill as infiltration will become contaminated by permeating the saltcrete monoliths in the following manner.

A small amount of the total rainfall on the burial site will enter the containment system by permeating through the clay cap. Once inside the landfill, some of this water will migrate downward through the saltcrete monoliths, dissolving salt from the saltcrete. The salt solution and associated radionuclides, after permeating the monolith, will pass through the basal clay liner and enter the groundwater.

B-1, E-9, & J-37 The primary drinking water standard for nitrate, expressed as nitrogen (N), is 10 ppm; the toxicity for nitrite is about 10-fold higher and the design limit for the nitrate/nitrite combination in DWPF salt is about 2.7 ppm (N). The calculations of the radionuclide concentrations in the groundwater at the boundary of the saltcrete landfill (Table 5.39) were based on the conservative assumption that the radionuclides would leach from the landfill at the same relative rates as sodium nitrate and sodium nitrite. The landfill design criterion is to limit the nitrate/nitrite to ≤ 2.7 ppm. Research is underway to develop a disposal system that will meet all radioactive and nonradioactive requirements. Preliminary calculations show concentrations of mercury in the groundwater to be less than 10% of the safe drinking water limit standard (0.002 ppm). These calculations were based on leach data from saltcrete samples made from both actual and simulated DWPF salt solutions.*

Once in the groundwater, N, Hg, ^{129}I , and other species having no potential for retardation by ion exchange (i.e., $K_d = 0$) move with the groundwater at its flow rate. Laboratory and field tests show that groundwater velocities are likely to be less than 12 m/year between the base of the landfill and an unnamed tributary of Upper Three Runs Creek, the nearest point of discharge. Because this creek is approximately 300 m distant, the groundwater travel time through the Barnwell Formation would be about 25 years. Table 5.39 lists the concentrations of the radioactive constituents entering the groundwater at the boundary of the engineered, secure landfill after its closure. These concentrations are not corrected for radioactive decay subsequent to placement of the saltcrete in the landfill. Table 5.39 also shows concentrations of radionuclides in the groundwater outfall† as it enters the tributary to Upper Three Runs Creek. These latter concentrations have been corrected for radioactive decay during the period of groundwater transport. Maximum groundwater concentrations and annual releases to the surface stream are given below for N, Hg, and total salt.

Species	Maximum groundwater concentration (ppm)	Maximum quantity discharged per year (kg)
Nitrogen	2.7	1.6×10^2
Mercury	<0.002	1.2×10^{-1}
Salt	29	1.7×10^3

Maximum doses would occur from releases of radionuclides that migrated through the soil at the same rate as the groundwater ($K_d = 0$). Based on an annual river flow of $8.9 \times 10^9 \text{ m}^3$, the related individual dose commitments are presented in Table 5.40. The maximum individual dose commitments are approximately a factor of 10^7 less than received from natural background radiation. The 100-year total body dose commitment to the local population is expected to be about 0.001 man-rem, as shown in Table 5.41.

The EDCs from the salt disposal area are lower than those from the reference DWPF by a factor of 4000. The resulting health effects from salt disposal will also be lower by a factor of 4000.

TE| Extraction procedure tests are being performed on saltcrete. Preliminary results indicate that saltcrete is not a hazardous waste and that the mercury is bound in the concrete. Leachability of mercury is typically a factor of 300 to 1000 less than that of a material that is not bound, such as nitrite.

The outfall is estimated to consist of $5.9 \times 10^6 \text{ m}^3$ of groundwater that is discharged from beneath the landfill each year. The transit time for this groundwater to reach the outcrop is estimated to be 25 years.

Table 5.39. Radionuclide concentration at the boundary of the landfill and discharge quantities to the Savannah River (corresponding to 2.7 ppm N in the groundwater)

Nuclide	Concentration in saltcrete (nCi/g)	Maximum concentration in groundwater ^a (Ci/L)	Ion exchange (K _d)	Transit time from burial site to outfall ^b (years)	Maximum release to Savannah River (Ci/year)
⁴ H	2.0E1	3.8E-9	0	2.5E1	5.4E-2
⁵⁹ Ni	<1.9E-4	<3.7E-14	c	2.5E1	2.1E-6
⁶³ Ni	<1.9E-2	3.7E-12	c	2.5E1	2.1E-4
⁷⁶ Se	7.0E-2	1.4E-11	c	2.5E1	8.0E-4
⁹⁰ Sr	2.9E-1	5.6E-11	1.0E2	1.0E4	0
¹³⁷ Zr	1.8E-2	3.5E-12	c	2.5E1	2.0E-4
⁹⁹ Tc	1.9E1	3.7E-9	c	2.5E1	2.1E-1
¹⁰⁷ Pd	4.7E-3	9.1E-13	c	2.5E1	5.4E-5
^{119m} Sn	2.8E-3	5.4E-13	c	2.5E1	2.2E-5
¹¹⁹ Sn	1.5E-3	2.9E-13	c	2.5E1	1.7E-5
¹²⁹ I	7.3E-2	1.4E-11	c	2.5E1	8.2E-4
¹³⁷ Cs	6.0E-5	1.2E-14	7.3E2	7.3E4	7.0E-7
¹³⁷ Cs	1.5E1	2.9E-9	7.3E2	7.3E4	0
¹⁴⁷ Pm	1.6E0	3.1E-10	c	2.5E1	2.4E-5
¹⁵¹ Sm	2.2E1	4.3E-9	c	2.5E1	2.0E-1
²³⁵ U	6.7E-5	1.3E-14	6.0E1	6.0E3	0
²³⁵ U	3.6E-4	7.0E-14	6.0E1	6.0E3	4.0E-6
²³⁸ U	1.1E-5	2.1E-15	6.0E1	6.0E3	1.2E-7
²³⁸ U	2.9E-6	5.6E-16	6.0E1	6.0E3	3.3E-8
²³⁷ Np	8.8E-5	1.7E-14	6.0E2	6.0E3	1.0E-6
²³⁹ Pu	7.7E-2	1.5E-11	1.4E3	1.4E5	0
²⁴⁰ Pu	7.8E-4	1.5E-13	1.4E3	1.4E5	1.5E-7
²⁴¹ Pu	4.9E-4	9.5E-14	1.4E3	1.4E5	2.3E-12
²⁴¹ Pu	5.8E-2	1.1E-11	1.4E3	1.4E5	0
²⁴² Pu	6.6E-7	1.3E-16	1.4E3	1.4E5	5.9E-9
²⁴¹ Am	2.1E-1	4.1E-11	1.0E3	1.0E5	0
²⁴² Am	1.4E-4	2.7E-14	1.0E3	1.0E5	0
²⁴³ Am	5.7E-5	1.1E-14	1.0E3	1.0E5	5.4E-11
²⁴⁴ Cm	4.3E-5	8.5E-15	1.0E3	1.0E5	0
²⁴⁴ Cm	1.1E-3	2.1E-13	1.0E3	1.0E5	0
²⁴⁴ Cm	6.6E-8	1.3E-17	1.0E3	1.0E5	2.2E-13
²⁴⁴ Cm	5.2E-9	1.0E-18	1.0E3	1.0E5	2.5E-17
²⁴⁴ Cm	6.4E-15	1.2E-24	1.0E3	1.0E5	7.0E-17
²⁴⁴ Cm	6.7E-15	1.3E-24	1.0E3	1.0E5	6.2E-17

^aMaximum concentration associated with 2.7 ppm N.

^bTransit time to Upper Three Runs Creek and the Savannah River.

^cValue unknown; K_d assumed to be 0.

The DWPF decontaminated salt fixed in saltcrete and buried in an engineered landfill results in exposures to an individual from well-water (groundwater) consumption of less than 0.1 millirem/year when the nitrogen concentration is 2.7 ppm. This value is less than 0.4% of the dose rate limit currently being proposed by NRC for incorporation into 10CFR61, which regulates the disposal of commercial low-level radioactive wastes.²⁵

5.4.3 Dose commitment to intruders

Reference 25 indicates that 10 CFR 61 will require low-level waste repositories to be designed so that the waste will not present an undue risk to an intruder into the disposal site, assuming secondary controls are maintained for 500 years after closure and limited controlled access is maintained for 100 years. The saltcrete disposal technology presented here appears not to subject the hypothetical intruder to undue risk.

5.5 ACCIDENT ANALYSIS

5.5.1 Construction accidents

Construction accidents affecting the safety of the construction workers were discussed in Sect. 5.1.1.2.

Construction accidents having ecological consequences are primarily spills of oil, gasoline, and diesel fuel. Spills of these types would be relatively small and localized and are not expected to have significant ecological consequences. The SRP Spill Prevention Control and Contingency Plan will be used to minimize these types of accidents. In case of an oil or hazardous substance spill corrective action will be taken to protect personnel and to contain and clean up the spill.

END

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