Surface Water Transport for the F/H Area Seepage Basins Groundwater Program (U)

by

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MASTER

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SURFACE WATER TRANSPORT FOR THE F/H AREA SEEPAGE BASINS GROUNDWATER PROGRAM (U)

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Key Words

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SURFACE WATER TRANSPORT FOR THE F/H AREA SEEPAGE BASINS GROUNDWATER PROGRAM (U)

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ABSTRACT

The contribution of the F- and H- Area Seepage Basins (FHSBs) tritium releases to the tritium concentration in the Savannah River are presented in this report. WASP5 was used to simulate surface water transport for tritium releases from the FHSBs. The WASP5 model was qualified with the 1993 tritium measurements at U.S. Highway 301. The tritium concentrations in Fourmile Branch and the Savannah River were calculated for tritium releases from FHSBs. The calculated tritium concentrations above normal environmental background in the Savannah River, resulting from FHSBs releases, drop from 1.25 pCi/ml (< 10% of EPA Drinking Water Guide) in 1995 to 0.0056 pCi/ml in 2045.

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1. INTRODUCTION

The Environmental Transport Group has analyzed the surface water transport of tritium released into Fourmile Branch and the Savannah River from the F- and H-Area seepage basins (FHSBs). This work was performed to support a risk assessment for contamination of drinking water with tritium from FHSBs, which was requested by the SRS Citizens Advisory Board, DOE, EPA and SCDHEC [1].

Reference 1 specified that in-stream concentrations should be calculated for time zero (1995), time zero plus 30 years, and time zero plus 100 years, with the tritium flux (Ci/yr) for the out-years to be obtained from flux modeling previously performed by SRTC [2]. Reference 1 also stipulated that in-stream tritium concentrations should be calculated for Fourmile Branch immediately below the F-Area Seepage Basin discharge zone, in the Savannah River immediately below its confluence with Fourmile Branch, and in the Savannah River at the approximate location of the Beaufort/Jaspar and Port Wentworth water system intakes (using a single point to approximate the location of both intakes). Finally, Reference 1 specified that the transport be modeled using 7Q10 stream flow rates consistent with those used in National Pollution Discharge Elimination System (NPDES) [3] permitting at SRS. It was recommended that the EPA surface water transport model, WASP5 [4], be used to perform the calculations.

2. WASP5 MODEL

River Geometry

WASP5 was used to model both the Savannah River and Fourmile Branch systems. The WASP5 was developed by the EPA to model stream/river systems and to provide predictions of pollutant concentrations and water qualities in surface water systems.

The Savannah River shown in Figure 1 was modeled from River Mile 168 (about 16.46 river miles upstream from the confluence with Fourmile Branch) to River Mile 16 (about 13 river miles downstream from Port Wentworth). To provide adequate detail for prediction of transient releases, the river was divided into 489 segments with a segment length of 500 m (0.31 mile). An average cross-section of 139 m^2 (1500 ft^2) was used for the river model.

Fourmile Branch shown in Figure 2 was modeled for a distance of 30.5 km (18.95 miles) which started above the F and H seepage basin discharge zones and extended to the Savannah River. Fourmile Branch was divided into 61 segments with a segment length of 500 m (0.31 mile) and an average cross section of 2.97 m^2 (31.97 ft^2) was used.

3. MODEL QUALIFICATION

The WASP5 was qualified by comparing predicted tritium concentrations to measured tritium concentrations at U.S. Highway 301, about 20 miles downriver of the SRS. Tritium concentration measurements were obtained from Reference 5 as described in the following section.

Tritium Concentration Data

The average measured tirtium concentration at U.S. Highway 301 bridge for 1993 is 1.24±0.46 pCi/ml [Table 24 of Reference 5]. The measured tritium concentrations at U.S. Highway 301 include contributions from all upstream tritium releases. This section presents the method to estimate the tritium concentration that would be measured at U.S. Highway 301 if only the tritium released from the FHSBs was considered.

Sources of tritium releases in SRS streams and the Savannah River are documented in Reference 5 and presented in Table 1 . Table 1 shows that the tritium released from the F-Area Seepage Basin for 1993 accounted for 2,180 Ci and released from H-Area Seepage Basin accounted for 1,020 Ci. The total tritium released to Savannah River including direct releases and migration for 1993 was 12,700 Ci. Thus, FHSBs contributed about 25% of the total tritium released to Savannah River and detected at U.S. Highway 301. The adjusted tritium concentration is 0.31± 0.115 pCi/ml, which would be measured at U.S. Highway 301 if only the tritium released from the FHSBs was counted.

WASP5 Simulations for 1993 Tritium Measurements

WASP5 was used to simulate the surface water transport of tritium released from FHSBs and to calculate the tritium concentration at U.S. Highway 301. The input data required by WASP5 include tritium release rates (Ci/day) from FHSBs, and the flow rates (m^3/s) of Fourmile Branch and the Savannah River. The FHSBs releases rates (Ci/yr) for 1993 listed in Table 1 were converted to Ci/day. The annual averaged Savannah River flow rate of 12,218.67 ft^3/s (345.99 m^3/s) and the annual averaged Fourmile Branch flow of 24.51 ft^3/s (0.69 m^3/s) were obtained from References 6 and 7. The calculated tritium concentration at Highway 301 is 0.293 pCi/ml. The measured tritium concentration contributed by the FHSBs is 0.31± 0.115 pCi/ml. Thus, the calculated tritium concentration at Highway 301 is within the measurement variation.

4. METHOD JUSTIFICATION

WASP5 uses a finite difference scheme to solve the one-dimensional transport differential equation. This scheme is subject to the Courant stability limit, which gives a maximum time step of 0.0064 day. With this time step, the SRS VAX computer would take 16 hours to perform a one-year transient simulation. Reference 1 requests for a 100-year transient simulation, which would require 2.3 months of computing time. One could increase the segment size from 500 m to 3,000 m to reduce the computing time to 12 days. However, this would sacrifice accuracy. An alternate method was used to reduce the computing time without compromising accuracy, as explained in this section.

At 7Q10 flow conditions, it would take about 10.5 days for the tritium released at FHSBs to pass Port Wentworth, as shown in Figure 3. This means that the tritium released at time zero has no effect on the downstream concentration until 10.5 days later. To

illustrate this point, two test cases were run to find the downstream tritium concentrations at the end of 1996. Case 1 simulated the transient from the beginning of 1996 to the end of 1996 and Case 2 simulated the transient from the 340th day of 1996 to the end of 1996.

Figure 4 presents the tritium release rates from FHSBs [2] for these test cases. The tritium release rates for 1996 are 2106 and 1434 Ci/yr from the F and H Area Seepage Basins, respectively. A linear decrease model was assumed to convert the release rate from curie per year to curie per day, as shown in Figures 5 and 6. Figure 7 depicts the calculated tritium concentration in the Savannah River at Port Wentworth. The results in this figure show that the calculated concentration at the end of year is not affected by the starting time for the transient. Consequently, there is no need to run a transient from the beginning of the year to find the concentration at the end of the year. Figure 7 also shows that the calculated tritium concentration first increases and then decreases as the tritium front passes. The decrease in concentration is due to the decrease in the source term. The transient time required for the tritium concentration to peak at Port Wentworth is about 11 days. Thus, one can save computing time by conducting short transient simulations (> 11 days) to obtain the peak concentrations for instantaneous releases from FHSBs. Results from these instantaneous release calculations can be combined to obtain an approximate long-term concentration profile for continuous releases.

5. CALCULATIONS

Using the method outlined in the previous section, nine transient calculations were performed, for the years 1995, 2005, 2015, 2025, 2035, 2045, 2055, 2065 and 2088, as shown in Table 2. No calculations were performed for later dates, because the tritium source concentration drops to about zero beyond 2088. Table 2 lists the input conditions. Table 3 and Figures 8 through 10 illustrate the results.

As shown in these figures, the tritium concentrations decrease with time because, after the FHSBs were closed in 1988, seepage of water began to flush the tritium contaminants from the system. The calculated tritium concentration in the Savannah River drops from about 1.25 pCi/ml in 1995 and to less than 0.0056 pCi/ml after 2045. The calculated tritium concentration in Fourmile Branch is about 500 times higher than that in the Savannah River because the Fourmile Branch flow rate (7.2 ft^3/s) is much lower than that of the Savannah River (3600 ft^3/s), so that the tritium flux is diluted significantly as it mixed with the Savannah River flow.

6. CONCLUSIONS

The contribution of the FHSBs tritium releases to the tritium concentration in the Savannah River were studied. WASP5 was used to simulate surface water transport for tritium releases from the FHSBs. The WASP5 model was qualified with the 1993 tritium measurements at U.S. Highway 301. The tritium concentrations in Fourmile Branch and the Savannah River were calculated for tritium releases from FHSBs. The calculated tritium concentrations above normal environmental background in the Savannah River, resulting from FHSBs releases, drop from 1.25 pCi/ml (< 10% of EPA Drinking Water Guide) in 1995 to 0.0056 pCi/ml in 2045.

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Table 1 Estimated Tritium Release in SRS Streams and the Savannah River

		Direct Releases (Curies)					
Area	**Release Point**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Reactor							
100–P	Par Pond overflow to Lower-Three Runs Creek	327	(321)[a]	(207)[a]	221	100	64
	*Process sewer to Par Pond		164	67	(43)[a]		
	*Reactor heat exchanger cooling water to Par Pond		464	125	(67)[a]		
	*Combined in 1992 (P019)					(8)[a]	(3)[a]
100–L	L-Lake overflow to Steel Creek	502	(556)[a]	(358)[a]	723	515	650
	*Process sewer to L Lake		24	27	(11)[a]		
	*Reactor heat exchanger cooling water to L Lake		98	72	(112)[a]		
	*Combined in 1992 (L007)					(58)[a]	(9)[a]
100–K	*Process sewer to Pen Branch	264	100	169	74		
	*Reactor heat exchanger cooling water to Pen Branch	2,470	112	249	6,470[b]		
	*Combined in 1992 (K-Canal)					126	16
	(K008)					3	
	K-Area secondary effluent				6	3	
100–C	Process Sewer to Four Mile Creek (C-Canal)	11	16	1	13	28	12
	Subtotal	3,570	978	710	7,510	775	742
Separations							
200–F	Effluent to Four Mile Creek	14	8	327	6	5	4
	Effluent to Upper Three Runs		2	0	0	1	1
200–H	Effluent to Four Mile Creek	12	20	22	14	13	12
	Effluent to Upper Three Runs		1	4	5	15	17
	Effluent Treatment Facility	101	2,070	1,200	3,070	1,010	395
	Subtotal	127	3,100	1,550	3,090	1,040	426
400–D	Process sewer to Beaver Dam Creek	1,740	562	358	681	576	499
	Subtotal	1,740	562	358	681	576	499
	Total Direct Releases[c]	**5,440**	**3,640**	**2,620**	**11,300**	**2,390**	**1,670**

a Not used in totals because release was counted elsewhere
b Includes heat exchanger leak of December 22-25, 1991
c Because of rounding, sums of individual columns might not equal totals.

Table 1 Cont'ed

Area	Release Point	Migration (Curies) 1988	1989	1990	1991	1992	1993
200–F&H	Solid Waste Disposal Facility and H-Area seepage basin to Four Mile Creek	3,670	3,600	4,280	6,420	4,090	5,330
	200–F seepage basin to Four Mile Creek	3,330	4,440	3,570	5,750	4,260	2,180
	200–H seepage basin to Four Mile Creek	3,980	3,310	1,900	1,810	1,470	1,020
100–C	Seepage basin to Four Mile Creek			7			
100–K	904–88G to Indian Grave Branch	2,780	2,220	3,560	2,160	1,530	1,100
100–P	Seepage basin to Steel Creek	133	137	224	(364)[a]	(232)[a]	(382)[a]
	Subtotal	13,900	13,700	13,500	16,100	11,400	9,630
	Total Direct Releases and Migration[b]	**18,300**	**17,300**	**16,100**	**27,400**	**13,800**	**11,300**

Area	Release Point	Stream Transport (Curies) 1988	1989	1990	1991	1992	1993
400–D	Beaver Dam Creek at swamp	2,510	879	756	801	576	499
20–F&H	Four Mile Creek at Road A13	11,200	11,200	9,370	13,300	8,710	9,000
100–K	Pen Branch at Road A	3,220	2,700	2,510	7,100	1,850	1,580
100–L	Steel Creek at Road A	502	556	358	723	515	650
100–P	Lower Three Runs at Road B	327	321	207	221	100	64
ETF	Upper Three Runs at Road A	535	2,160	2,380	4,410	1,300	879
	Total[b]	**18,300**	**17,800**	**15,600**	**26,600**	**13,100**	**12,700**

a Not used in totals because release was counted elsewhere
b Because of rounding, sums of individual columns might not equal totals.

Table 1 Cont'ed

	River Transport (Curies)					
	1988	1989	1990	1991[a]	1992	1993
Tritium measured in the Savannah River below SRS		17,110	16,570	28,700	16,000	12,600
Tritium measured in the Savannah River above SRS		1,480	2,080	2,420	2,210	433
Tritium measured in the Savannah River below SRS (downriver minus upriver)[a]	14,600	15,600	14,490	26,300	13,800	12,200

a Because of rounding, differences in individual columns might not equal totals.

Table 2 WASP5 Input

Year	Fourmile Branch 7Q10 Flow ft^3/s (m^3/s)	Savannah River 7Q10 Flow ft^3/s (m^3/s)	Seepage Basin Release Rate F-Area Ci/day	H-Area Ci/day
1995	7.2 (0.20388)	3600 (101.9406)	6.495890	4.547945
2005	7.2 (0.20388)	3600 (101.9406)	1.772603	1.290411
2015	7.2 (0.20388)	3600 (101.9406)	0.479452	0.463014
2025	7.2 (0.20388)	3600 (101.9406)	0.139726	0.186301
2035	7.2 (0.20388)	3600 (101.9406)	0.043836	0.079452
2045	7.2 (0.20388)	3600 (101.9406)	0.013699	0.035616
2055	7.2 (0.20388)	3600 (101.9406)	0.005479	0.016438
2065	7.2 (0.20388)	3600 (101.9406)	0.002740	0.008219
2088	7.2 (0.20388)	3600 (101.9406)	0.0	0.002740

Table 3 WASP5 Calculations for Tritium Concentrations Resulting from FHSBs Releases above Background

Year	Fourmile Branch at Road A pCi/ml	Savannah River downstream from Confluence with Fourmile Branch pCi/ml	Savannah River at Beaufort/Jaspar and Port Wentworth pCi/ml
1995	6.268E+02	1.251E+00	1.250E+00
2005	1.738E+02	3.469E-01	3.467E-01
2015	5.349E+01	1.067E-01	1.067E-01
2025	1.850E+01	3.692E-02	3.690E-02
2035	6.997E+00	1.396E-02	1.395E-02
2045	2.799E+00	5.584E-03	5.580E-03
2055	1.244E+00	2.482E-03	2.481E-03
2065	6.219E-01	1.241E-03	1.240E-03
2088	1.555E-01	3.103E-04	3.101E-04

Figure 1 Savannah River

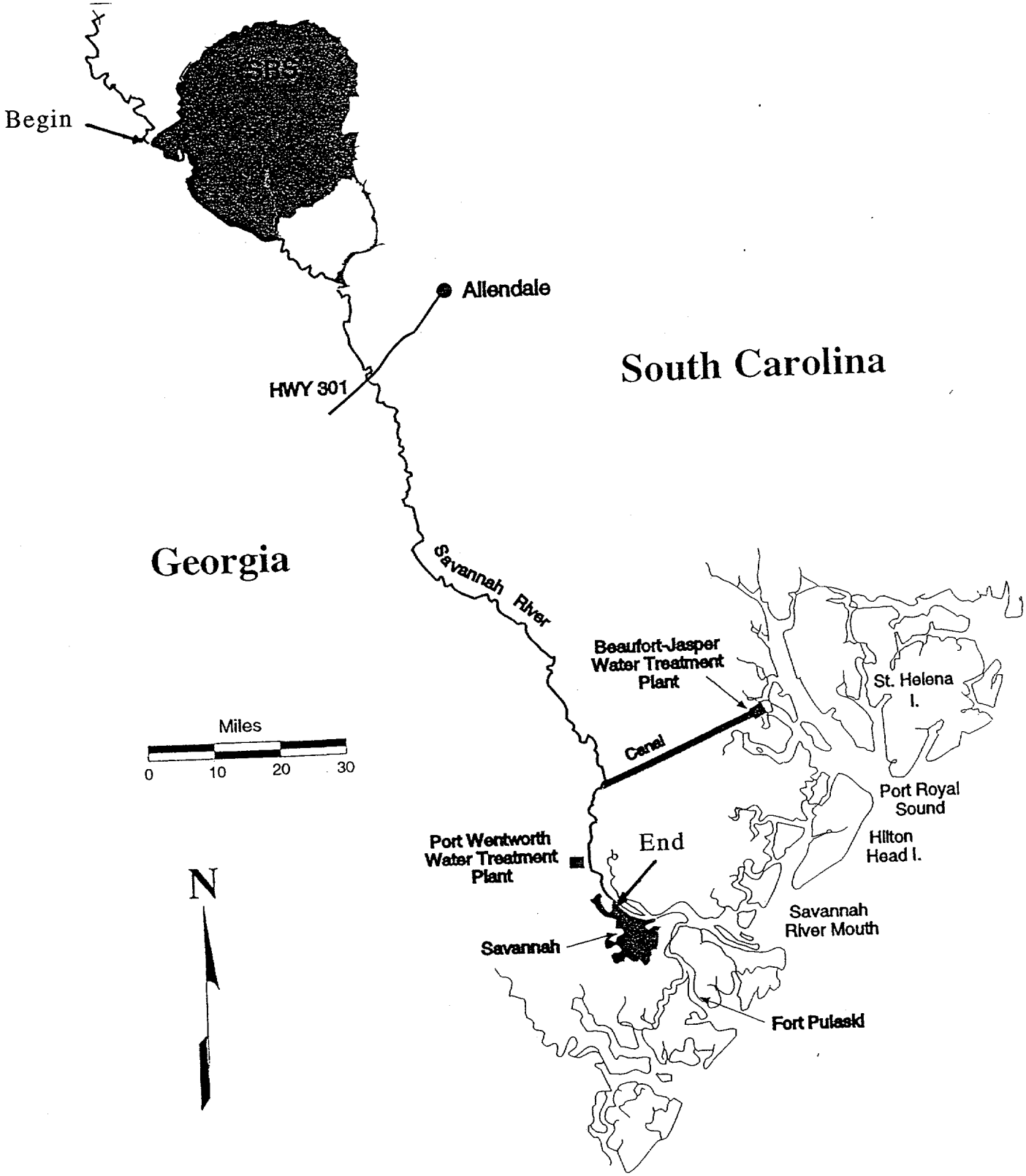


Figure 2 Fourmile Branch

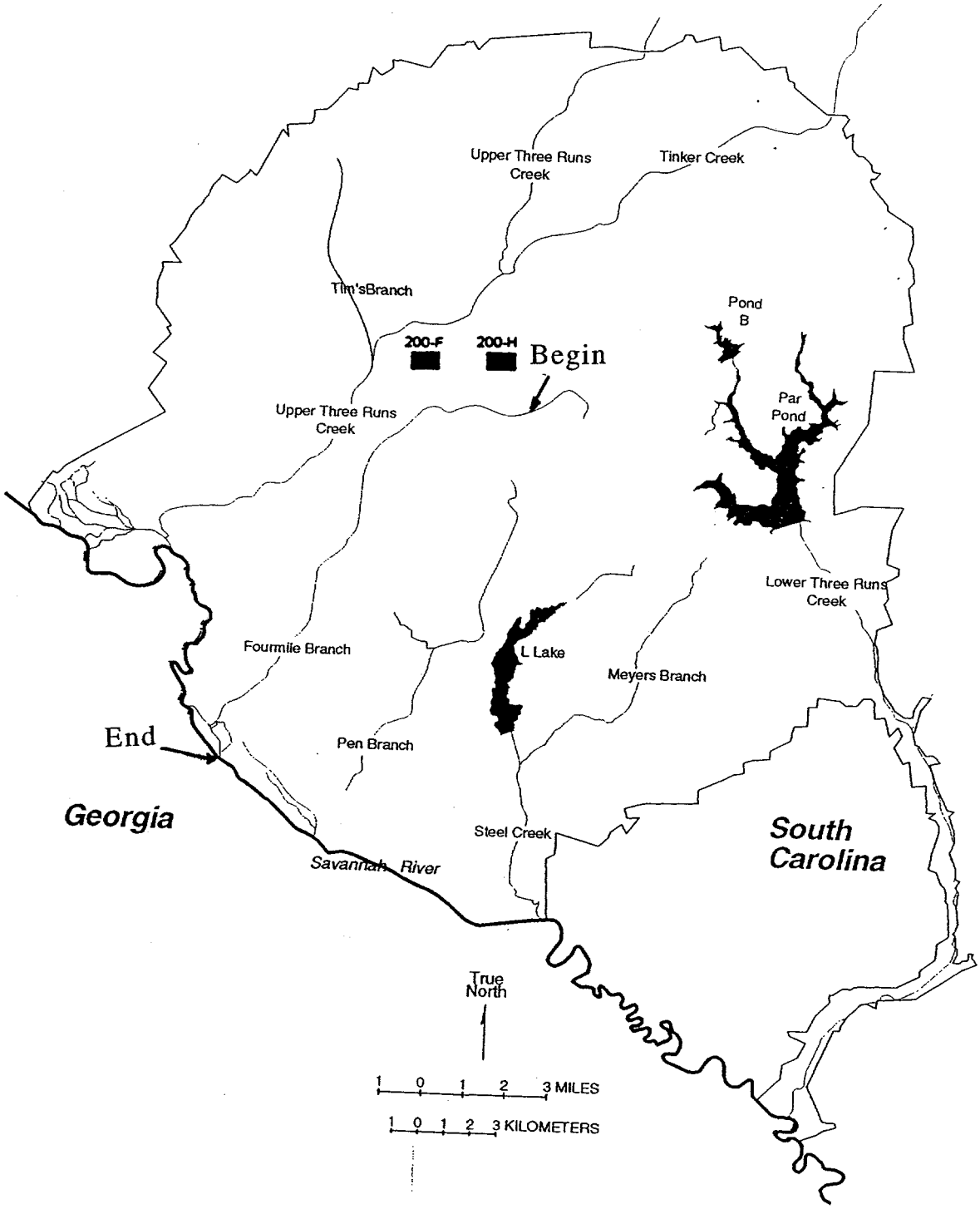


Figure 3 WASP5 Simulations for an Instant Release at FHSBs
(Using 7Q10 Flow Conditions)

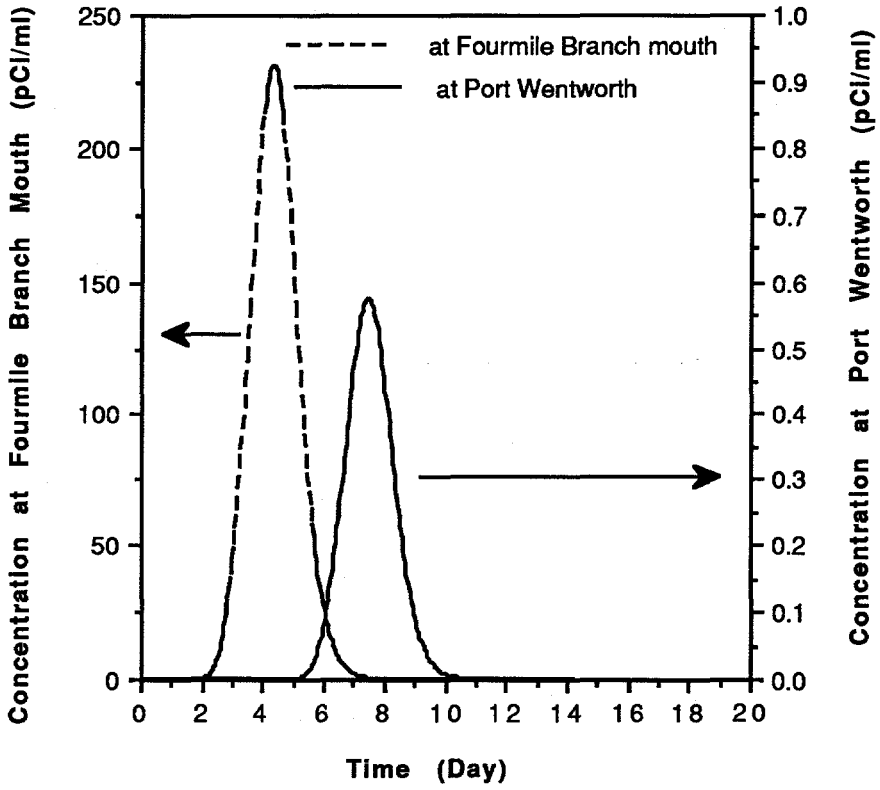


Figure 4 Tritium Release Rates from F and H Area Seepage Basins

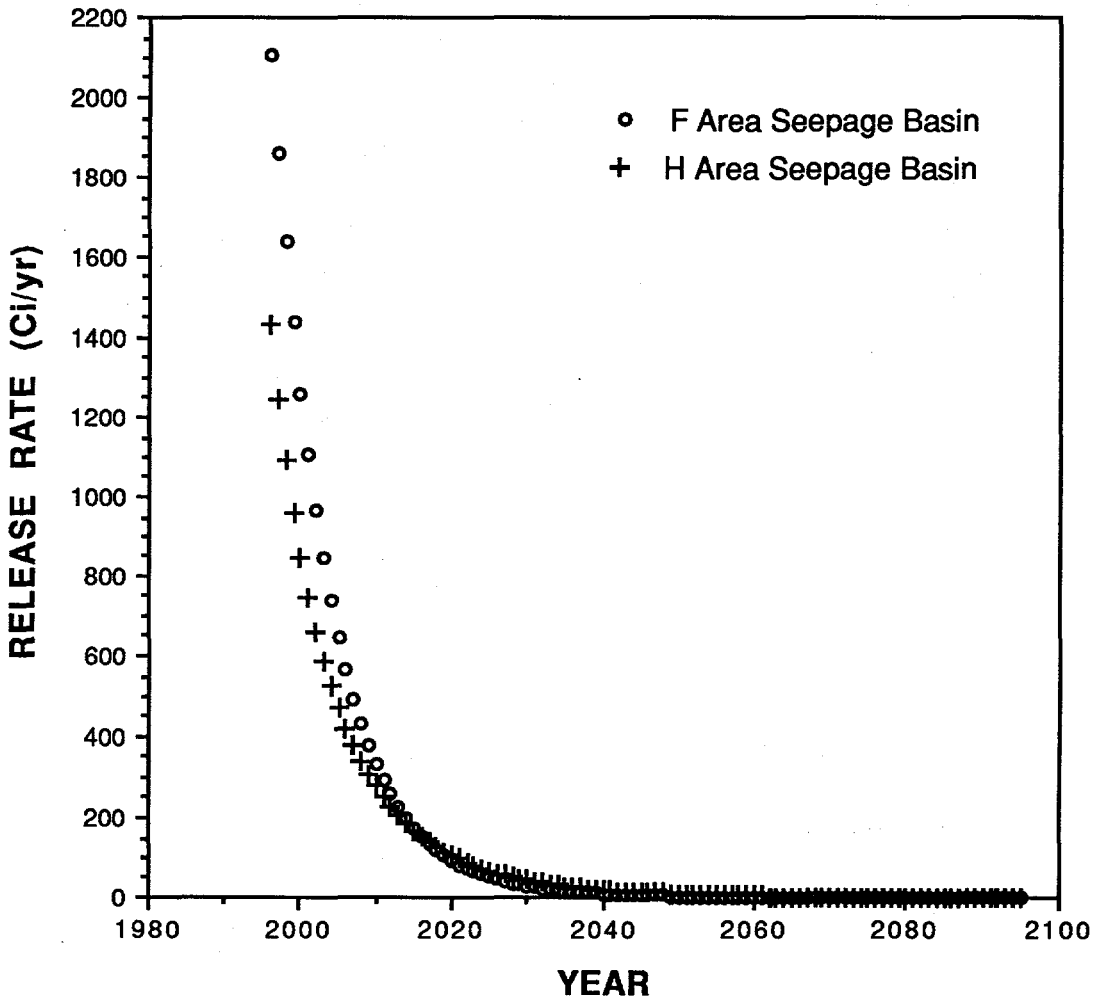


Figure 5 Source Term from F-Area Seepage Basin for 1996
(Linear Approximation was used)

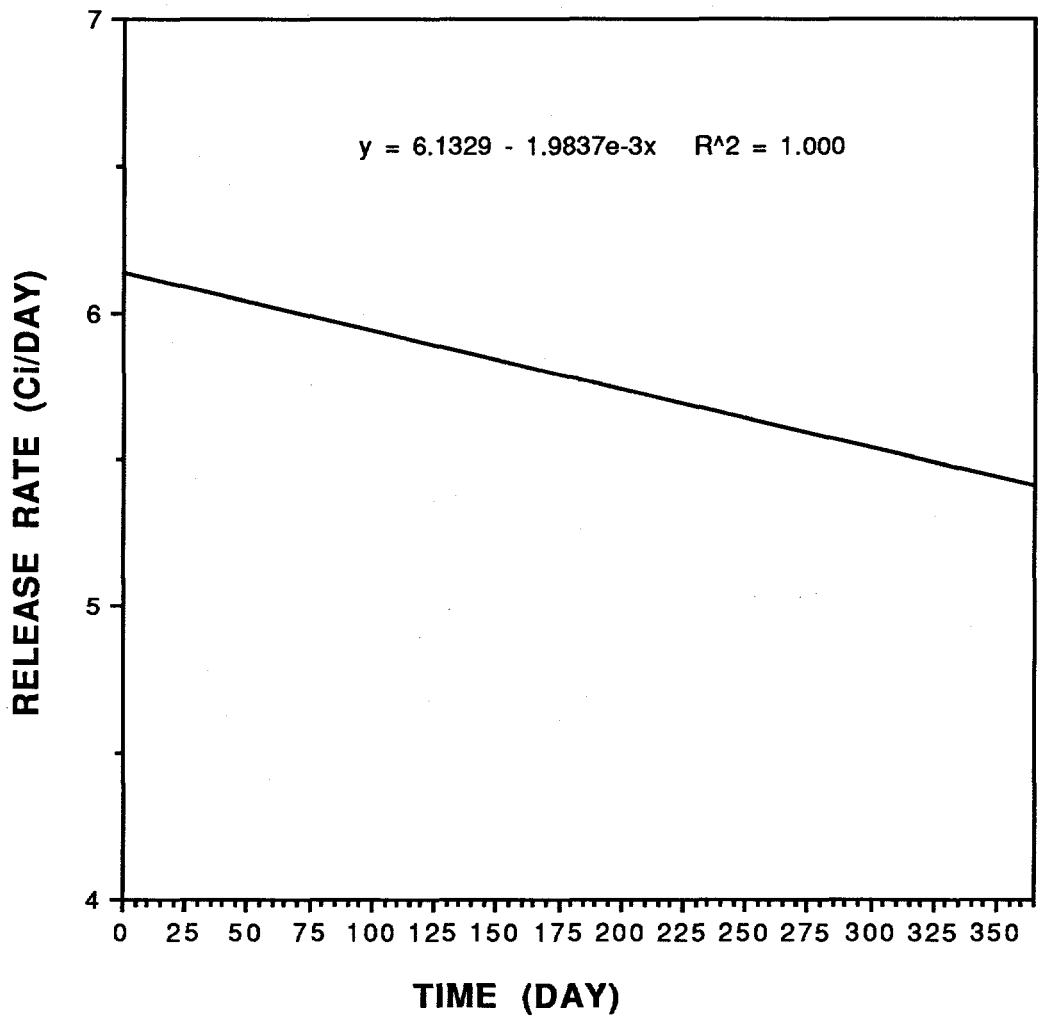


Figure 6 Source Term from H-Area Seepage Basin for 1996
(Linear Approximation was used)

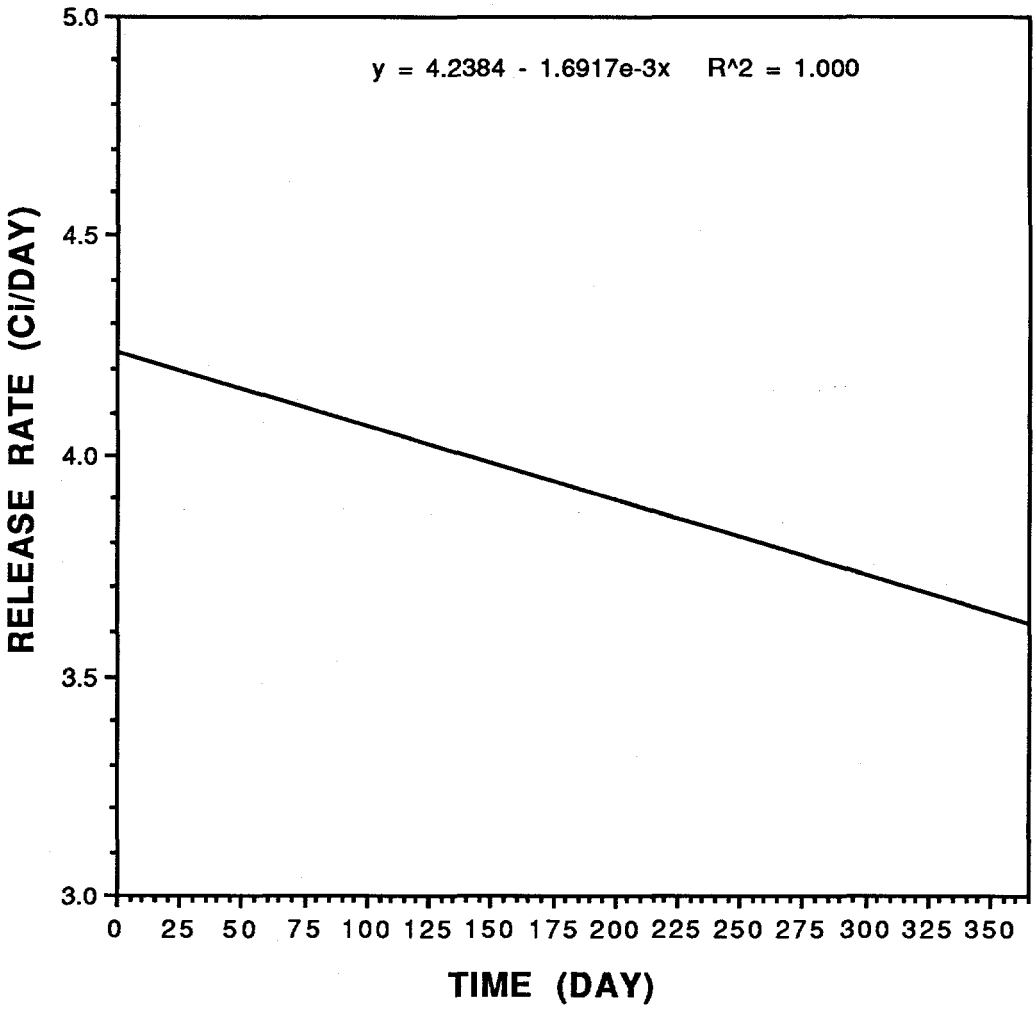


Figure 7 Calculated Tritium Concentration in the Savannah River at Port Wentworth

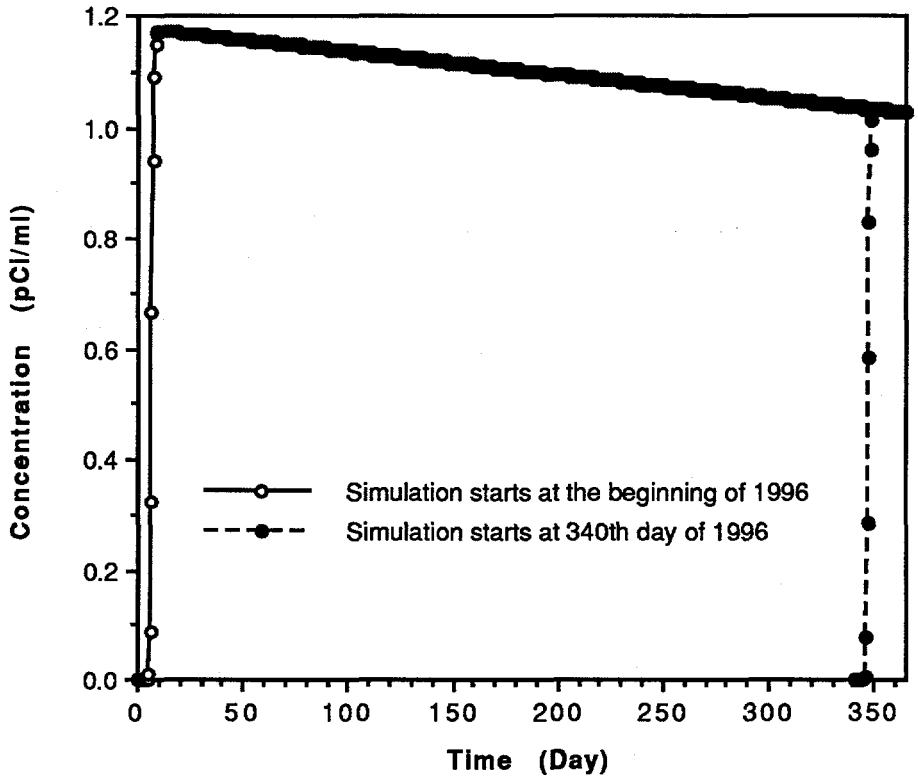


Figure 8 WASP5 Calculations for Tritium Concentration in the Fourmile Branch at Road A (Resulting from FHSBs Releases above Background)

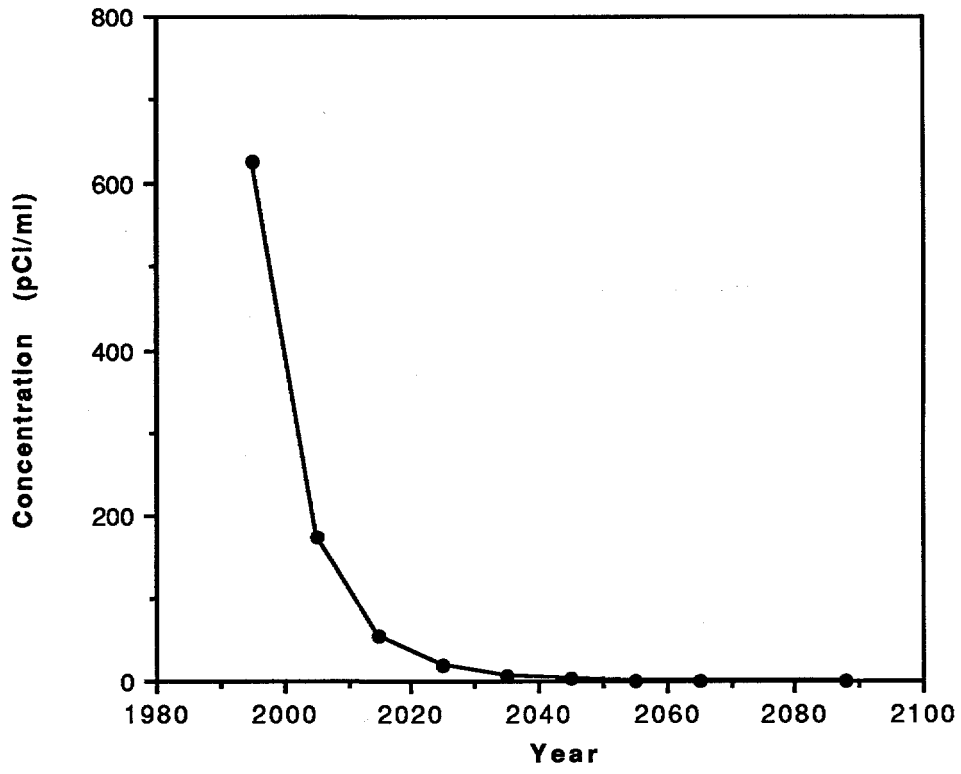


Figure 9 WASP5 Calculations for Tritium Concentration in Savannah River at Downstream of Confluence with Fourmile Branch (Resulting from FHSBs Releases above Background)

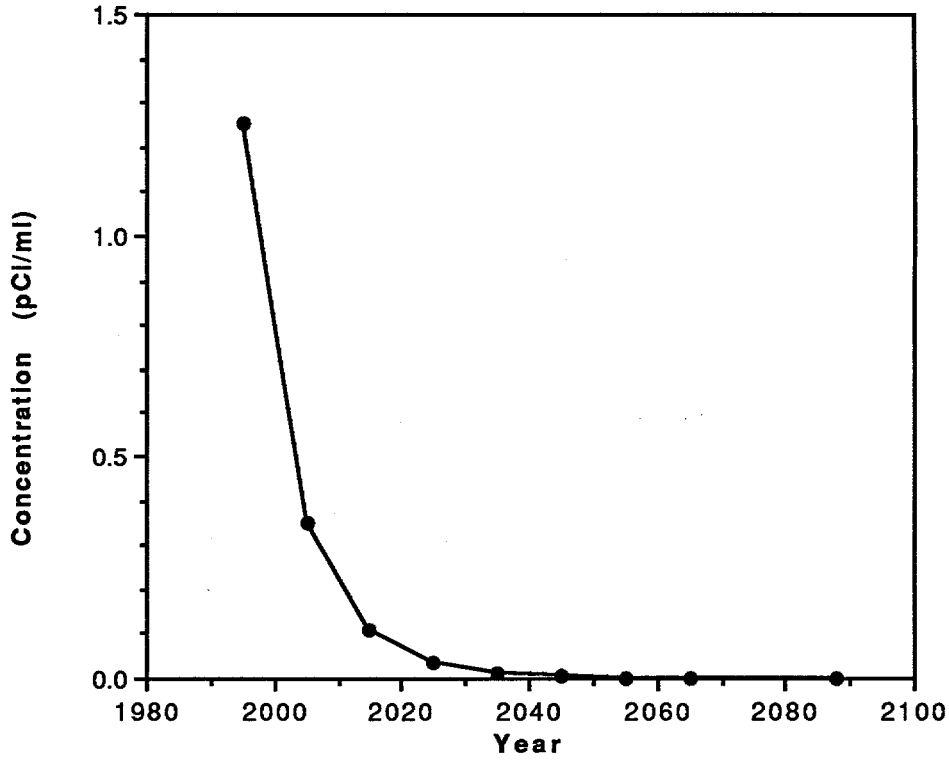
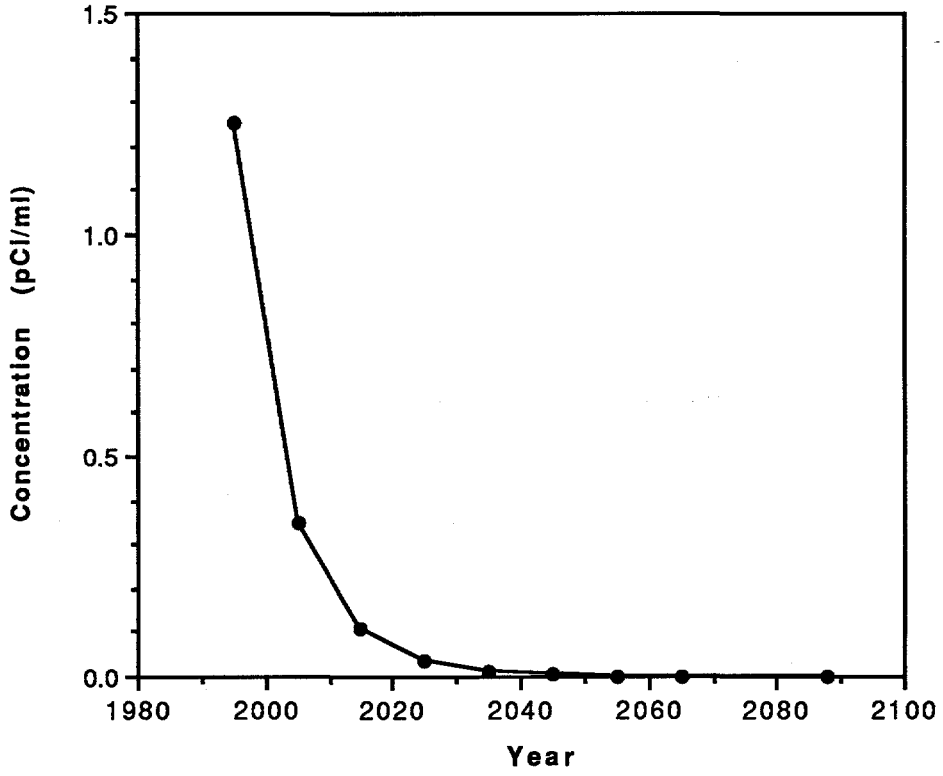


Figure 10 WASP5 Calculations for Tritium Concentration in Savannah River at Beauford/Jaspar & Port Wentworth (Resulting from FHSBs Releases above Background)



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