DPST-85-688

ENVIRONMENTAL INFORMATION DOCUMENT

SAVANNAH RIVER LABORATORY SEEPAGE BASINS

[redacted]

E. I. du Pont de Nemours & Co.
Savannah River Laboratory
Aiken, SC 29808

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC09-76SR00001

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SAVANNAH RIVER LABORATORY SEEPAGE BASINS

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PREFACE

This document provides environmental information on postulated closure options for the Savannah River Laboratory Seepage Basins at the Savannah River Plant and was developed as background technical documentation for the Department of Energy's proposed Environmental Impact Statement (EIS) on waste management activities for groundwater protection at the plant. The results of groundwater and atmospheric pathway analyses, accident analysis, and other environmental assessments discussed in this document are based upon a conservative analysis of all foreseeable scenarios as defined by the National Environmental Policy Act (CFR, 1986). The scenarios do not necessarily represent actual environmental conditions. This document is not meant to be used as a closure plan or other regulatory document to comply with required federal or state environmental regulations.

Technical assistance in the environmental analyses of waste-site closures was provided by Clemson University; GeoTrans, Inc.; JBF Associates, Inc.; S. S. Papadopulos & Associates, Inc.; Radiological Assessments Corporation; Rogers and Associates Engineering Corporation; Science Applications International Corporation; C. B. Shedrow Environmental Consultants, Inc.; Exploration Software; and Verbatim Typing and Editing.

SUMMARY

The Savannah River Laboratory (SRL) Seepage Basins are located in the northwestern section of the Savannah River Plant (SRP) in the 700 Area. Currently, the four basins are out of service, and they are awaiting closure pursuant to applicable state and federal regulations for the closure of waste sites. When in operation, the basins received low-level radioactive wastewater from laboratories located in Buildings 735-A and 773-A. A total of 128,820 m^3 of wastewater was sent to the basins. Only wastewater with radioactivity less than 100 d/m/mL alpha and/or 50 d/m/mL beta-gamma was discharged to the basins. The basins were used from 1954 until October 1982.

In 1983 an extensive program to characterize the basins was conducted to determine whether sediment and groundwater contamination existed at the waste site as a consequence of the facility operation. Low concentrations of radioactive and nonradioactive constituents were found in the sediments beneath the seepage basins. There are nine groundwater monitoring wells located in the vicinity of the SRL Seepage Basins. Six of these wells are sampled quarterly to monitor the water table. The other three wells are A/M Area plume definition wells. A statistical analysis of monitoring data from the six water-table wells indicates elevated levels of chloride, manganese, and sodium in the groundwater.

The closure options considered for the basins are waste removal and closure, no waste removal and closure, and no action. Each of these options except the no action option would require dewatering of the basins. The predominant pathways for human exposure to chemical and/or radioactive constituents are through surface, subsurface, and atmospheric transport. Modeling calculations were made to determine the risks to human population via these general pathways for the three postulated closure options. An ecological assessment was conducted to predict the environmental impacts on aquatic and terrestrial biota. The relative costs for each of the closure options were estimated.

The environmental impact evaluation indicates that the human health risks for all closure options are low. Radioactive risk is dominated by tritium in the well pathways during the period of institutional control. There is no significant difference between the closure options because the tritium has leached from the site prior to the closure action. The most significant noncarcinogenic risk results from arsenic, which has an ADI fraction greater than one in the well pathways for some closure options after the assumed period of institutional control. The peak ADI fractions for arsenic for the well at 1 m are 6.1 for no action, 3.4 for no waste removal and closure without cap, and 0.6 for the no waste removal

and closure with cap and waste removal and closure options. All atmospheric and occupational risks are low. The primary calculated ecological effect is due to direct contact with the basin sediments in the no action option. This possibility is eliminated by all more rigorous closures. The relative costs for the various options are $9 million for waste removal and closure, $2.9 million for no waste removal and closure with cap, $2.4 million for no waste removal and closure without cap, and $0.26 million for no action.

NATURE OF DISPOSAL

GEOGRAPHICAL LOCATION

The four Savannah River Laboratory (SRL) Seepage Basins are located south of Road A-1 and west of Road D-1 (Figures 1 and 2). This location is in the northwestern section of the Savannah River Plant (SRP) and is about 1,000 m from the nearest plant boundary. Approximate latitude and longitude and SRP grid coordinates for the basins are listed below.

Building No.	SRP Coordinates (ft)*		Latitude and Longitude	
904-53G				
Basin 1	N 105605	E 52590	33.345128°N	81.733505°W
	N 105645	E 52634	33.345288°N	81.733467°W
	N 105550	E 52730	33.345235°N	81.733029°W
	N 105510	E 52687	33.345076°N	81.733065°W
Basin 2	N 105647	E 52637	33.345297°N	81.733463°W
	N 105740	E 52741	33.345673°N	81.733370°W
	N 105645	E 52838	33.345621°N	81.732930°W
	N 105552	E 52734	33.345246°N	81.733023°W
904-54G				
Basin 3	N 105756	E 52755	33.345731°N	81.733364°W
	N 105840	E 52853	33.346077°N	81.733270°W
	N 105710	E 52985	33.346005°N	81.732669°W
	N 105626	E 52887	33.345659°N	81.732764°W
904-55G				
Basin 4	N 105856	E 52871	33.346141°N	81.733253°W
	N 105956	E 52983	33.346545°N	81.733153°W
	N 105734	E 53209	33.346424°N	81.732126°W
	N 105635	E 53775	33.345986°N	81.732286°W

* Coordinates relative to the SRP grid, a local Department of Energy plane system whose "grid north" is approximately 36.4° west of true north at SRP.

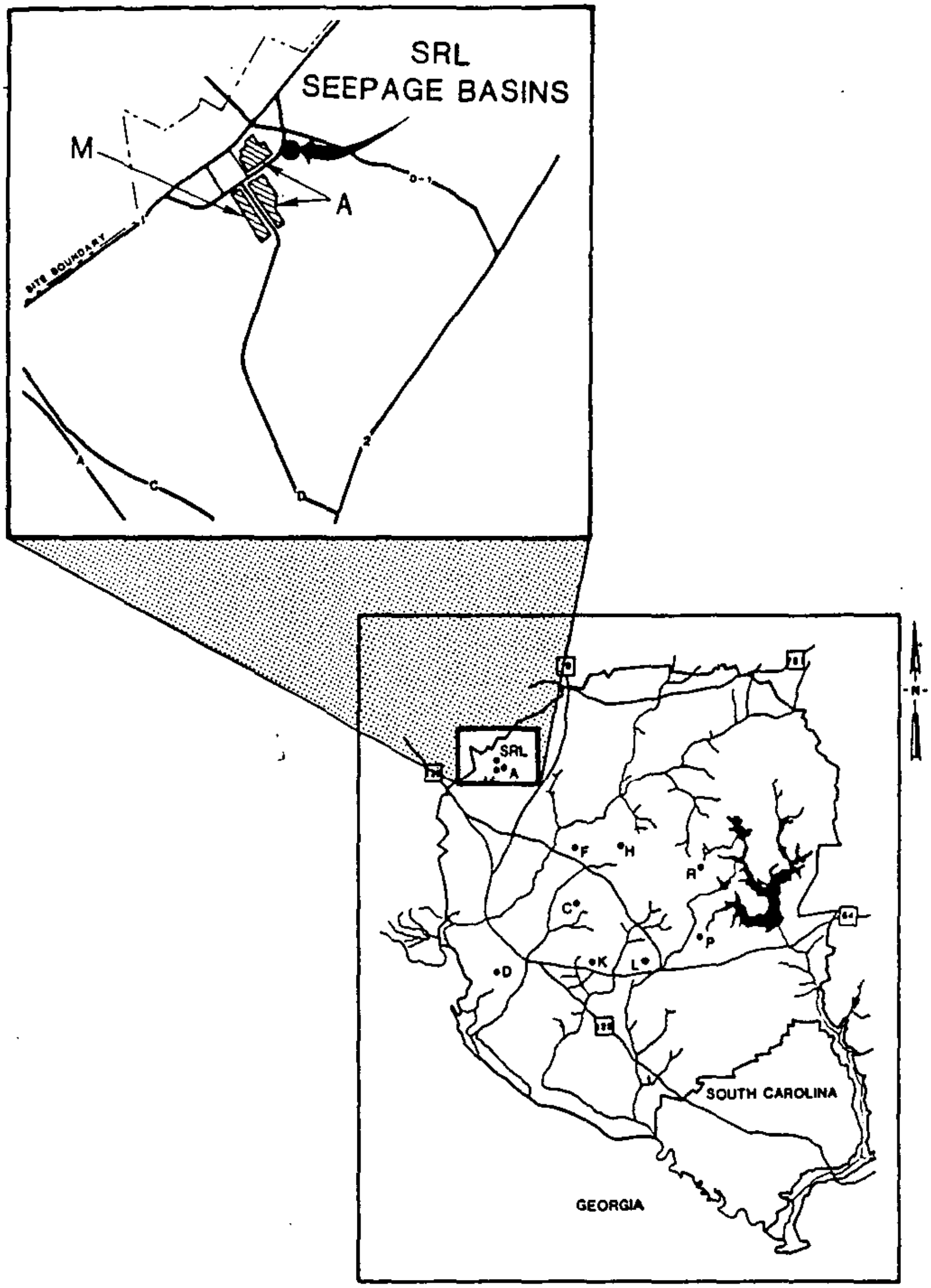


FIGURE 1. Location of the SRL Seepage Basins

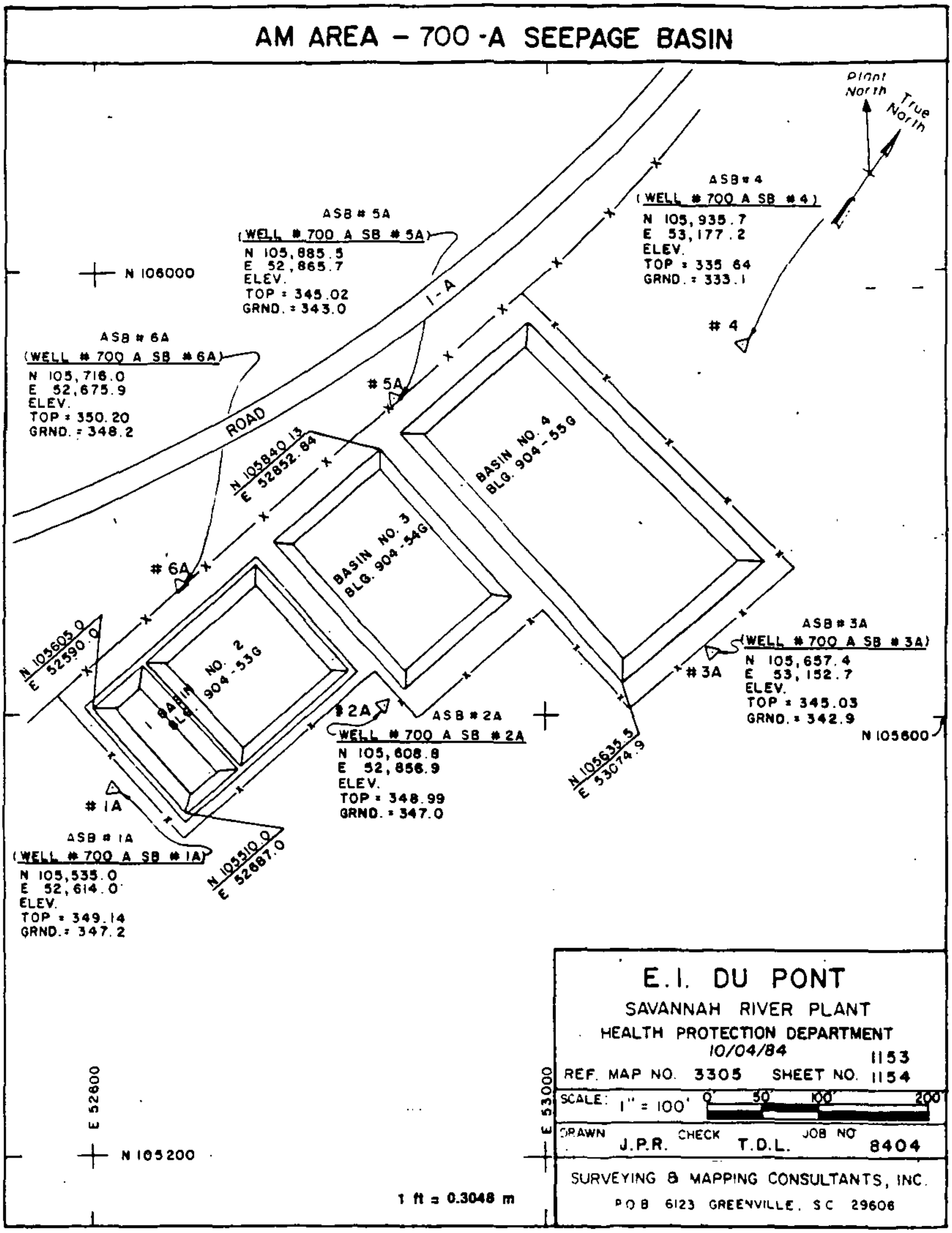


FIGURE 2. SRL Seepage Basins Blueprint

SITE DIMENSIONS

The basins are rectangular in shape and were constructed by removing the earth from within the basins to form the surrounding dikes. The construction of basins 1, 2, and 3 primarily involved excavation of natural soils and the construction of limited perimeter dikes. By contrast, the construction of basin 4 required substantial filling at the north end (adjacent to Tims Branch) to achieve both the basin bottom and the dike crest elevation.

Dimensions and approximate volume capacities for the basins are listed below.

Basin No.	Dimensions L x W x D (m)	Volume Capacity (m^3)
1	40 x 19 x 2.0	1,520
2	40 x 40 x 2.0	3,200
3	53 x 38 x 2.7	5,440
4	94 x 46 x 3.4	14,700

HISTORY OF DISPOSAL

SRL used the seepage basins to dispose of low-level radioactive liquid waste generated in the laboratories located in Buildings 735-A and 773-A. Pipes in the 904 trench, which tied into the low-level drains in these laboratories, transferred the waste to one of the four 22-m^3 underground tanks located in 776-A. When a tank accumulated approximately 20 m^3 of waste, a grab sample was taken for analysis, and a new receiving tank was valved online. When the basins were in operation, wastewater not exceeding 100 d/m/mL alpha and/or 50 d/m/mL beta-gamma was discharged to the basins. If the waste exceeded these standards, then it was transferred to a tank trailer and shipped to the 200-F Area Separations Facility (221-F) for final disposition. The average activity for waste discharged to the basins was 50 d/m/mL for both alpha and beta-gamma.

The first two basins (Building No. 904-53G) were placed into operation in 1954, and basin 3 (Building No. 904-54G) and basin 4 (Building No. 904-55G) were added in 1958 and 1960, respectively. The four basins are connected sequentially in cascade via overflow channels. The final basin, however, has no overflow. Any fluid losses from the SRL Seepage Basins were predominantly from seepage through the bottom of the basins. Wastewater seldom entered basin 4 because seepage in basins 1 through 3 was approximately equal to input volume.

During the 28-year loading history, approximately 130,000 m^3 of water were discharged to the basins (Table 1). The fissile content of the waste transferred to the basins during 1982 averaged 0.4 mCi per month. Uranium and plutonium in these analyses were divided as follows: ^{238}U (90%), ^{238}Pu (5%), and ^{239}Pu (5%). A summary of the total historical discharge of radionuclides to the SRL Seepage Basins is given in Table 2.

Using the discharge volume of water to the basin from the waste tanks and the concentrations of chemicals in the low-level waste stream as determined from the measurements in October 1982 (Tables 3 and 4), the average annual and total 28-year loadings of chemicals to the basin were calculated (Table 4).

Note that a volume reduction program (primarily repiping to eliminate extremely dilute waters such as noncontact cooling water) was instituted in 1982, prior to the sampling and analyses shown in Tables 3 and 4. Actual concentrations entering the basins are expected to have been variable, but lower than those shown by at least a factor of five. As shown below, samples during operation (1979) were all within EP toxicity guidelines. These samples represent the arithmetic mean of five samples taken in June 1979:

Arsenic	<5 mg/L
Barium	0.93 mg/L
Cadmium	<0.01 mg/L
Chromium	0.32 to 2.46 mg/L
Lead	0.26 mg/L
Mercury	<0.01 mg/L
Selenium	<5 mg/L
Silver	<0.01 mg/L

HISTORY AND USE OF CHLORINATED SOLVENTS AT SRL

Previous documents related to the SRL Seepage Basins (e.g., Christensen & Gordon, 1983) suggest that chlorinated organic solvents may have been disposed of in the drains leading to the basins. In general, these data were preliminary in nature, and detailed evaluation of several sources of information supports a consistent picture related to the SRL Seepage Basins--only low-level radioactive wastes, small quantities of miscible organics, and other dilute wastes (rinses of glassware, small quantities of reagents, and noncontact cooling water) from laboratories 773-A and 735-A were sent to the basins. No significant quantities of chlorinated organic solvents were ever known to have been disposed to the facility. Previous documents which list chlorinated organics were based on response to a survey in which use of Freon® was reported (a small quantity was evaporated in a laboratory hood). These organics were subsequently, and improperly, assumed

TABLE 1

Discharges of Low-Level Wastewater to the SRL Seepage Basins

Period	Volume (m^3)
1954-1971	92,000
1972	6,720
1973-1977	15,900
1978-1982	14,200
Total (1954-1982)	128,820

TABLE 2

Radioactive Releases to the SRL Seepage Basins from 1958 to 1980

Parameter	Activity (Ci)
^{3}H	105
$^{89,90}Sr$	0.4
^{137}Cs	4.7
Natural U	0.022
^{238}Pu	0.009
^{239}Pu	0.003
^{241}Am	0.001
$^{242,244}Cm$	0.001
$^{103,106}Ru$	1.4
^{60}Co	0.1
$^{141,144}Ce$	2.7
Alpha (unidentified)	4.2
Beta-gamma (unidentified)	10.6

TABLE 3

Analysis of Low-Level Waste from the Collection Tanks in 776-A

Constituent	Concentration (mg/L) Tank E*	Tank D	Tank F	Tank E
Al	2.32	4.81	4.96	2.91
As	0.1	<0.1	0.115	<0.1
B	<2.18	3.57	3.64	3.53
Ba	0.47	0.110	2.79	0.213
Be	0.003	0.0034	0.0037	<0.003
Bi	<0.05	0.0698	0.0699	<0.05
Ca	<36.9	20.5	18.7	16.9
Cd	0.01	0.0139	0.0116	0.0125
Co	<0.01	2.07	5.40	0.470
Cr	<9.52	4.84	0.522	0.687
Cu	0.408	0.295	0.227	0.151
Fe	5.07	6.24	6.73	2.87
Hg	0.239	1.06	0.852	0.288
La	0.039	0.603	12.3	1.10
Li	0.669	0.528	0.731	0.688
Mg	6.26	1.98	1.31	1.17
Mn	3.42	0.876	2.46	1.95
Mo	0.0249	0.062	0.0997	0.0394
Na	189	106	368	53.8
Ni	5.17	1.06	3.33	0.880
P	30.1	0.54	16.0	3.06
Pb	3.95	1.09	6.68	1.28
Ru	0.05	<0.05	0.0632	<0.05
Si	<8.51	14.7	15.5	10.1
Sn	0.05	0.106	0.0954	<0.05
Sr	<0.113	2.66	0.108	0.0781
Ti	0.085	0.180	0.211	0.160
U	2.90	8.12	8.52	2.94
V	0.0277	0.0702	0.118	0.0582
Y	0.01	0.0145	0.0245	0.0123
Yb	<0.275	0.330	1.02	0.249
Zn	1.65	0.442	0.655	0.320
Zr	0.0607	0.213	0.531	0.0842

* These analyses were performed during 10/82; the others were performed in 11/82.

TABLE 4

Historical Loadings to the SRL Seepage Basins

Constituent	Concentration* (mg/L)	Annual Load (kg/yr)	28-Year Total (kg)
Al	2.3	10	295
As	<0.1	0.5	13
B	2.2	10	283
Ba	0.5	2.3	64
Be	<0.003	<0.01	<0.4
Bi	<0.05	<0.2	<6.4
Ca	37.0	170	4,800
Cd	<0.01	<0.05	<1.3
Co	<0.01	<0.05	<1.3
Cr	9.5	44	1,220
Cu	0.4	1.8	52
Fe	5	23	643
Hg	0.2	1	26
La	0.04	0.2	5
Li	0.7	3.2	90
Mg	6.3	29	810
Mn	3.4	16	438
Mo	0.02	0.1	2.6
Na	189	869	24,500
Ni	5.2	24	670
P	30	138	3,860
Pb	4	18	515
Ru	<0.05	<0.2	<6.4
Si	8.5	39	1,095
Sn	<0.05	<0.2	<6.4
Sr	0.11	0.5	14
Ti	0.09	0.4	12
U	2.9	13	373
V	0.03	0.1	3.9
Y	<0.01	<0.05	<1.3
Yb	0.28	1.3	36
Zn	1.7	7.8	219
Zr	0.06	0.28	7.8
Cl	148	680	19,000
NO_3	600	2,760	77.000

Note: Soil core analyses provide better estimates of loadings for those constituents that are relatively immobile in soil. Importantly, soil cores suggest that approximately 320 kg of Cr, 10 kg of Hg, and 230 kg of As have been released to the SRL Seepage Basins.

* Analyses performed 10/01/82.

to be solvents such as trichloroethylene. Similarly, the small quantity of ethylene dichloride previously reported is expected to have evaporated to the atmosphere.

SRL has used a variety of chemicals to carry out its research and technical support mission. The use and handling of these chemicals is defined by procedures that are periodically updated. A file of the current and obsolete procedures is maintained in the SRL Document Control Group. A brief investigation related to the historical handling and disposal of chlorinated organic solvents in SRL was carried out to aid in identification and assessment of SRP waste sites. The comments below are based on this investigation which consisted of (1) a review of SRL waste handling procedures (particularly those related to chlorocarbons), (2) interviews with SRL staff who were familiar with actual implementation of the procedures, and (3) an assessment of the data presented in previous documents (along with the background information) to determine if they are accurate.

The SRL Seepage Basins were used to dispose of low-level radioactive wastes. The wastes originated in laboratory sinks in Building 773-A and hood cup sinks in Building 735-A. The wastes flowed through pipes in the 904-A containment trench to Building 776-A where the wastes were temporarily stored in tanks. While the basins were in operation, one storage tank was filled at a time. After a tank was filled, the water was analyzed for radiation and pH. If the water did not exceed 100 d/m/mL alpha or 50 d/m/mL beta-gamma, it was discharged to the basins. Any waste that contained more than trace quantities of radiation was treated as high-level radioactive waste. The applicable waste-handling procedures state that the only solvents that were sent to the low-level system were water-soluble organics (e.g., alcohols and acetone). A specific procedure was spelled out for disposal of chlorinated solvents: "Chlorinated organic solvent waste will be placed in 1-gallon glass bottles instead of 'Safety-Seal' cans." Disposal of the filled containers was arranged by the M & E Control Group (a laboratory service group). Interviews of members of the M & E Control Group staff from the period of interest suggest that

- Containers of organic waste (as well as other types of wastes) were temporarily stored. The wastes were segregated into radioactive and nonradioactive storage areas. M & E Control Group staff indicated that the primary nonradioactive waste received was metals; however, they also remembered receiving liquid wastes in safety cans or glass bottles. According to the applicable procedure, chlorinated solvents were packaged in glass jars. These were placed in metal cans that were then filled with oil-dry adsorbent.

- Periodically, the nonradioactive wastes were transported to a chemical/solvent waste disposal facility (e.g., the CMP Pits in 1979) for disposal, while the radioactive wastes were sent to the Radioactive Waste Burial Grounds.

- Beginning in 1980, organic solvents that were collected have been stored in a permitted hazardous waste storage facility (710-U).

The primary use of chlorinated solvents (trichloroethylene) at SRL was in the fabrication laboratory. This laboratory was never physically connected to the low-level radioactive waste system that supplied the SRL Seepage Basins. The fabrication laboratory was served by the trade waste system; trade waste was sent to surface streams through outfalls such as A-001 (i.e., these wastes were not sent to the SRL Seepage Basins). Trichloroethylene was not detected in cores from the SRL Seepage Basins.

In 1982, a survey of laboratory staff as well as purchase records and comments by active/inactive researchers was carried out to aid in identifying any potential contaminants that might have entered the low-level radioactive waste system during the operation of the SRL Seepage Basins. The original survey asked what chemicals were used in the laboratories; a follow-up survey was to have been taken, asking what chemicals were discarded to the low-level radioactive drain system. The follow-up was apparently not carried out. Freon® remained on the list, even though it was evaporated in the hood; other chemicals were not checked. The results of the original survey were reported in Christensen and Gordon (1983), and, in fact, the masses were multiplied by 28 to account for the operating time of the site. Freons® were designated as chlorinated organics in the resulting table and have been incorrectly interpreted as chlorinated degreasing solvents such as trichloroethylene.

In summary, waste handling procedures and interviews with SRL staff persons are consistent, and they do not support a scenario of significant chlorinated organic disposal to the SRL Seepage Basins. Thus, these chemicals will not be assessed in subsequent sections.

CURRENT STATUS

The basins were taken out of service in October 1982, and the current plans are to close the basins pursuant to applicable state and federal regulations. The SRL Seepage Basins are enclosed by a 2-m-high fence, which is approximately 8 m from the edge of the basins. Water-level measurements for the basins as of July 12, 1985, are reported below:

Basin Number	Water Depth (m)	Water Volume (m^3)
1	0.814	230
2	1.2	1,000
3	0.710	1,250
4	Dry	0
Estimated Total Volume		2,480

Vegetation in the vicinity of the basins and outside of the fence consists primarily of woods ranging from lightly to thickly wooded. The ground inside of the fence, however, is predominantly covered with scattered tufts of low-lying grass, weeds, and bushes. Several small trees are scattered throughout the waste site area, particularly at the bottom of basin 4.

GEOHYDROLOGIC SETTING

PHYSIOGRAPHY

The Savannah River Plant lies mostly on the Aiken Plateau as defined by Cooke (1936). The Aiken Plateau is bounded by the Savannah and Congaree rivers (Figure 3) and slopes from an elevation of 198 m at the Fall Line to an elevation of approximately 76 m (all elevations based on mean sea level). The surface of the Aiken Plateau is highly dissected and is characterized by broad, interfluvial areas with narrow, steep-sided valleys. Relief is locally as much as 91 m (Siple, 1967). The plateau is generally well drained although small, poorly drained depressions occur. The area is underlain by a wedge of seaward-dipping unconsolidated and semiconsolidated sediments.

The SRL Seepage Basins are located in the northwestern section of SRP. Ground surface elevations approach 110 m and slope southeasterly in the area of the basins (Figure 4). Consistent with the regional dip, sedimentary formations would be expected to dip to the southeast. The bottom and crest elevations and the side slopes for the basins are listed below.

Basin No.	Crest Elevation (m)	Side Slopes	Bottom Elevation (m)
1	105.5	1:2	102.2
2	105.5	1:2	102.2
3	104.9	1:1	101.5
4	104.9	1:1	100.6

Surface water in the vicinity of the basins originally consisted of two natural intermittent streams: Tims Branch and the unnamed tributary to Tims Branch. The confluence of the two streams is approximately 60 m northeast of basin 4. The combined streams flow southerly to Upper Three Runs Creek about 6 km away. The two streams are predominantly fed by storm water runoff from both the SRL and Savannah River Ecology Laboratory (SREL) NPDES-permitted wastewater discharges. The stream to the north of the basins also receives overflow water from SREL greenhouses, duck ponds, and alligator ponds.

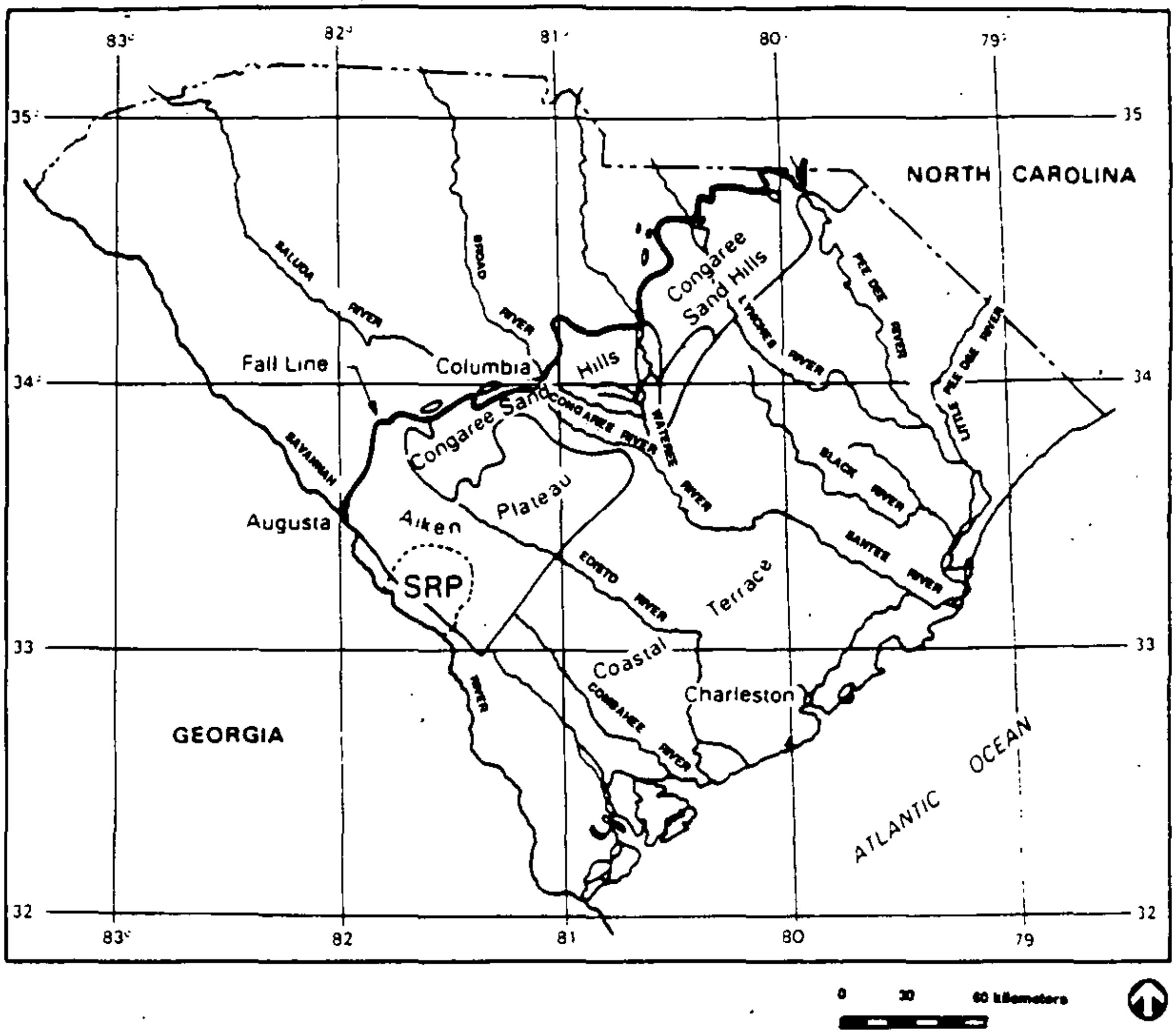


FIGURE 3. Physiography of the Savannah River Region

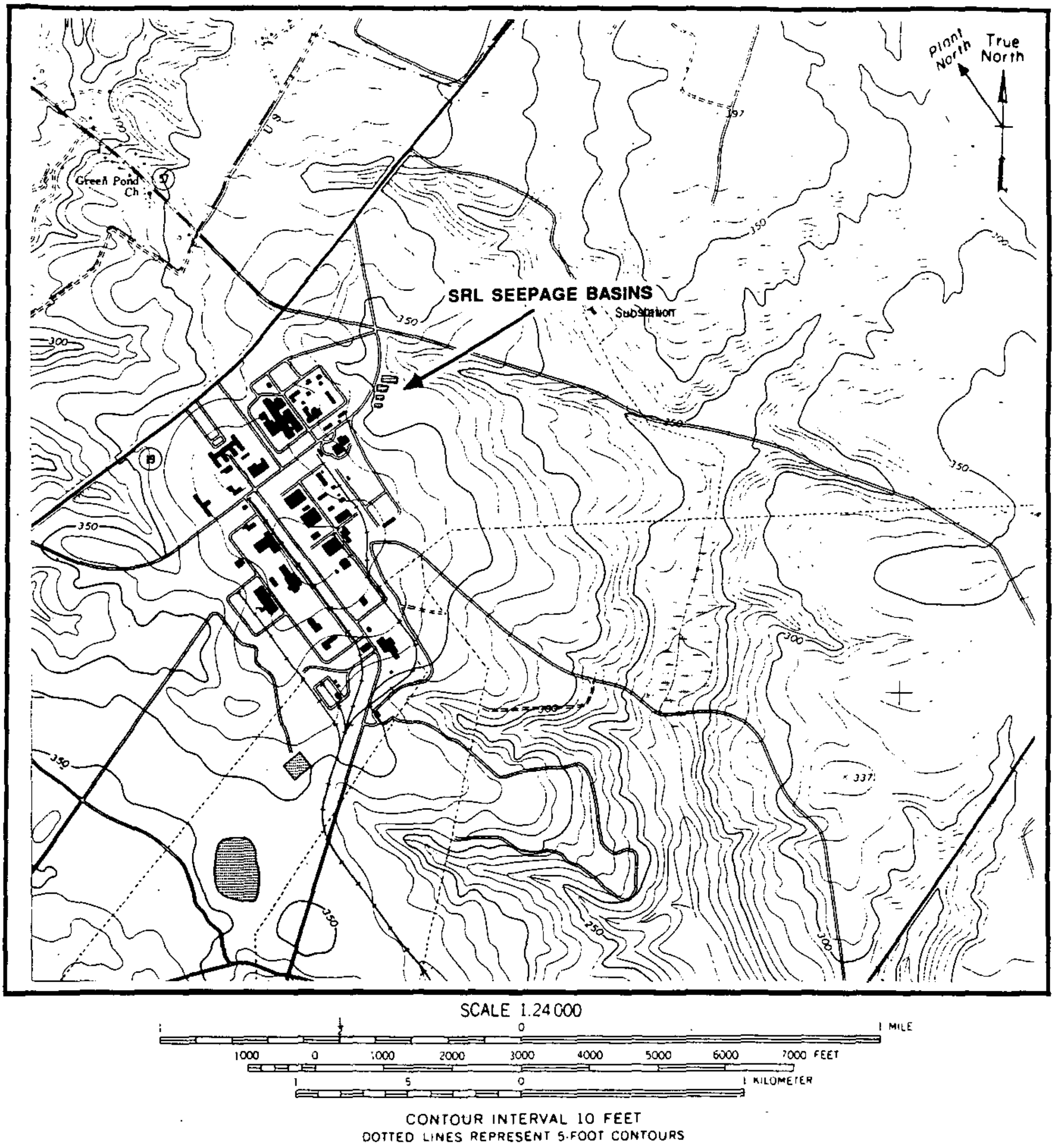


FIGURE 4. Location of the SRL Seepage Basins on New Ellenton SW Quadrangle 7.5 Minute Series Topographic Map

HYDROSTRATIGRAPHY

A descriptive and graphic log of the subsurface geology near the central part of the SRP site, where much of the geohydrologic data have been collected in the past, along with a tentative correlation of stratigraphic terminology, is presented in Figure 5 (Christensen & Gordon, 1983). It should be noted that recent studies have found that the sediments mapped as Tuscaloosa at SRP are geologically younger than the Tuscaloosa-type section in Alabama. Therefore, from a purely stratigraphic point of view, it is improper to continue to use the term Tuscaloosa for these sediments. However, in this report the term Tuscaloosa Formation will be retained, but "Tuscaloosa" will be placed within quotation marks to indicate that it is used as a hydrostratigraphic term and not as a formal stratigraphic term. Table 5 describes the lithologic and water-bearing characteristics of the different stratigraphic units.

In comparing the stratigraphic column for the central part of the plant (Figure 5) with one developed for the A/M Area (Figure 6), several changes in the geologic column can be noted: (1) the Tan Clay is only about 1-m thick and lies in the unsaturated zone; (2) the calcareous zone is not present; (3) the Green Clay may be discontinuous; (4) the Congaree Formation has fewer separated lenses of clay and lenses of sand and is better described generally as clayey sand even though well-sorted sands do occur; (5) the Ellenton Formation is mostly a gray clayey sand or sandy clay with plentiful mica and the occurrence of marcasite or gypsum; and (6) the "Tuscaloosa" section is similar to that described for the central part of SRP.

As a result of these different geologic features, the subsurface hydrologic characteristics also differ. Since the layers of clay are less extensive in the Tertiary age sediments, head changes are less abrupt and are more gradual than in the central part of SRP. The water table is deeper below the surface. The Green Clay is less continuous and, therefore, does not impede downward water flow as much as in the central part of SRP. The Congaree and "Tuscaloosa" formations are the major water-producing zones. Because the Congaree has fewer permeable sands and lateral conduction of water within the formation is slower than in the central part of the plant, the head is not drawn down below that of the "Tuscaloosa." Therefore, in A/M Area, heads decline continuously with depth, and there is no head reversal at the Congaree-Ellenton boundary.

A total of nine wells have been installed around the SRL basins. Six water-quality monitoring wells (ASB 1 through 6) immediately adjacent to the basin were drilled in 1981. Three additional water-table wells (ASB 7 through 9) were installed as part of a basin characterization program in 1983 (Branford et al., 1984). The locations of these wells are shown in Figure 7. In

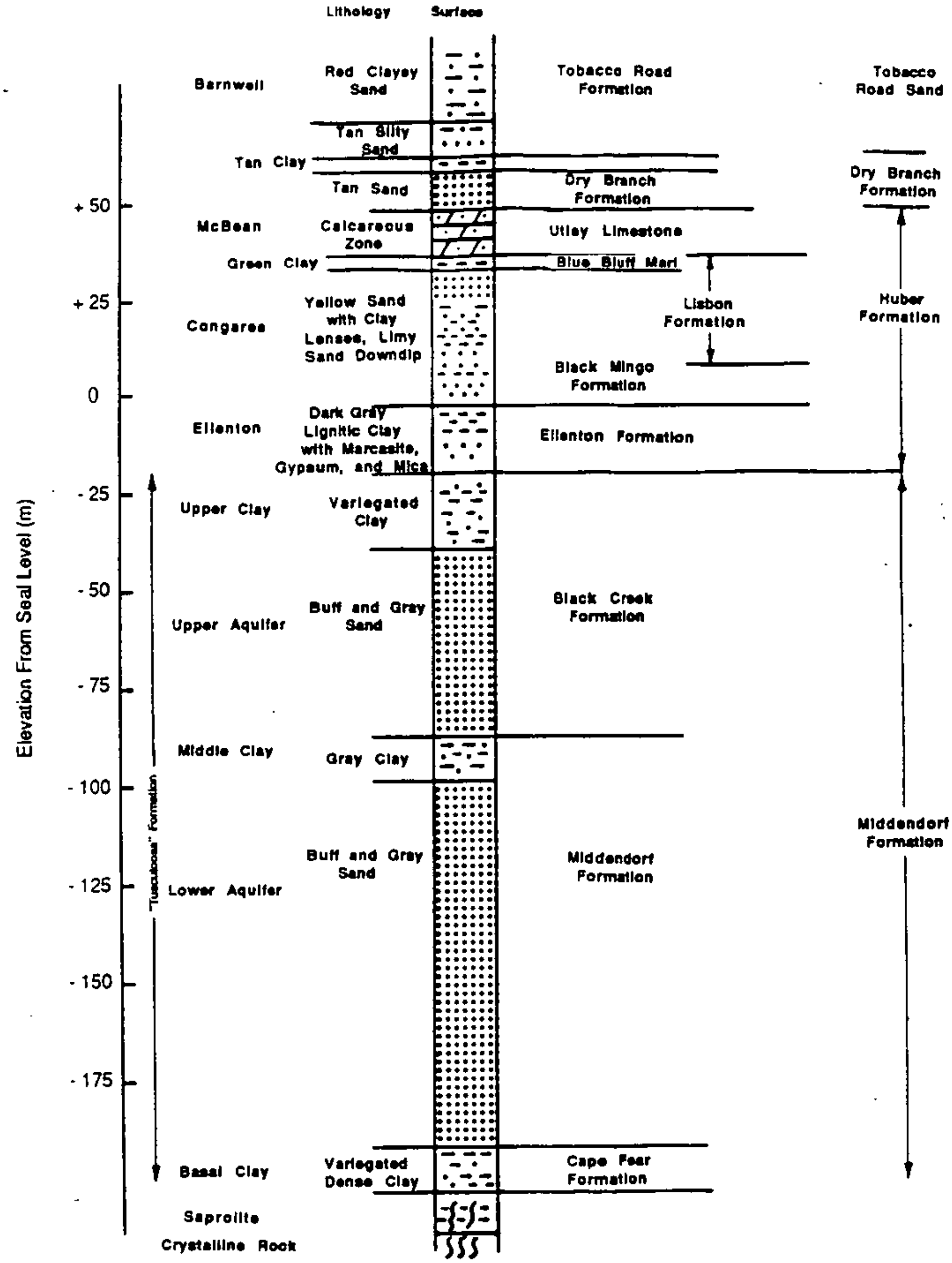


FIGURE 5. **Tentative Correlation of Stratigraphic Terminology of the Southwestern South Carolina Coastal Plain**

TABLE 5

Hydrostratigraphic Units Underlying the Savannah River Plant

Formation	Geologic Age	Outcrop	Description	Water Yield	Thickness (m)
Alluvium	Recent	River and creek bottoms	Fine to coarse sand, silt, and clay	Very little	0 to 9.1
Terrace Deposits	Pleistocene	In flood plains and terraces of stream valleys	Tan to gray sand, clay, silt, and gravel on higher terraces	Moderate to none	0 to 9.1
Hawthorn	Miocene	Interfluvial areas	Tan, red, and purple sandy clay with numerous clastic dikes	Little or none	0 to 24.4
Barnwell	Eocene	Large part of ground surface near streams	Red, brown, yellow, and buff, fine to coarse sand and sandy clay	Limited but sufficient for domestic use	0 to 27.4
McBean Congaree	Eocene	In banks of larger streams	Yellow-brown to green, fine to coarse, glauconite quartz sand, intercalated with green, red, yellow, and tan clay, sandy marl, and lenses of siliceous limestone	Moderate to large	30.5 to 76.2
Ellenton	Paleocene	None on plant	Dark gray to black sandy lignitic micaceous clay containing disseminate crystalline gypsum and coarse quartz sand	Moderate to large from discontinuous sand layers; higher sulfate and iron than water from other formations.	1.5 to 30.5
"Tuscaloosa"	Upper Cretaceous	None on plant	Tan, buff, red, and white; crossbedded, micaceous quartzitic and arkosic sand and gravel imbedded with red, brown, and purple clay and white kaolin	Large, up to 7.6 m^3/min soft, low in total solids	~182.9
Newark Series "Red Beds"	Triassic Period	None on plant	Dark-brown and brick-red sandstone, siltstone, and clay-stone containing gray calcareous patches; fanglomerates near border	Very little	>914.4
Basement rocks of the Slate Belt and Charlotte Group	Precambrian and Paleozoic Eras	None on plant	Hornblende gneiss, chlorite-hornblende schist, lesser amounts of quartzite; covered by saprolite layer derived from basement rock	Very little	Many thousands

Note: Modified from Siple (1967).

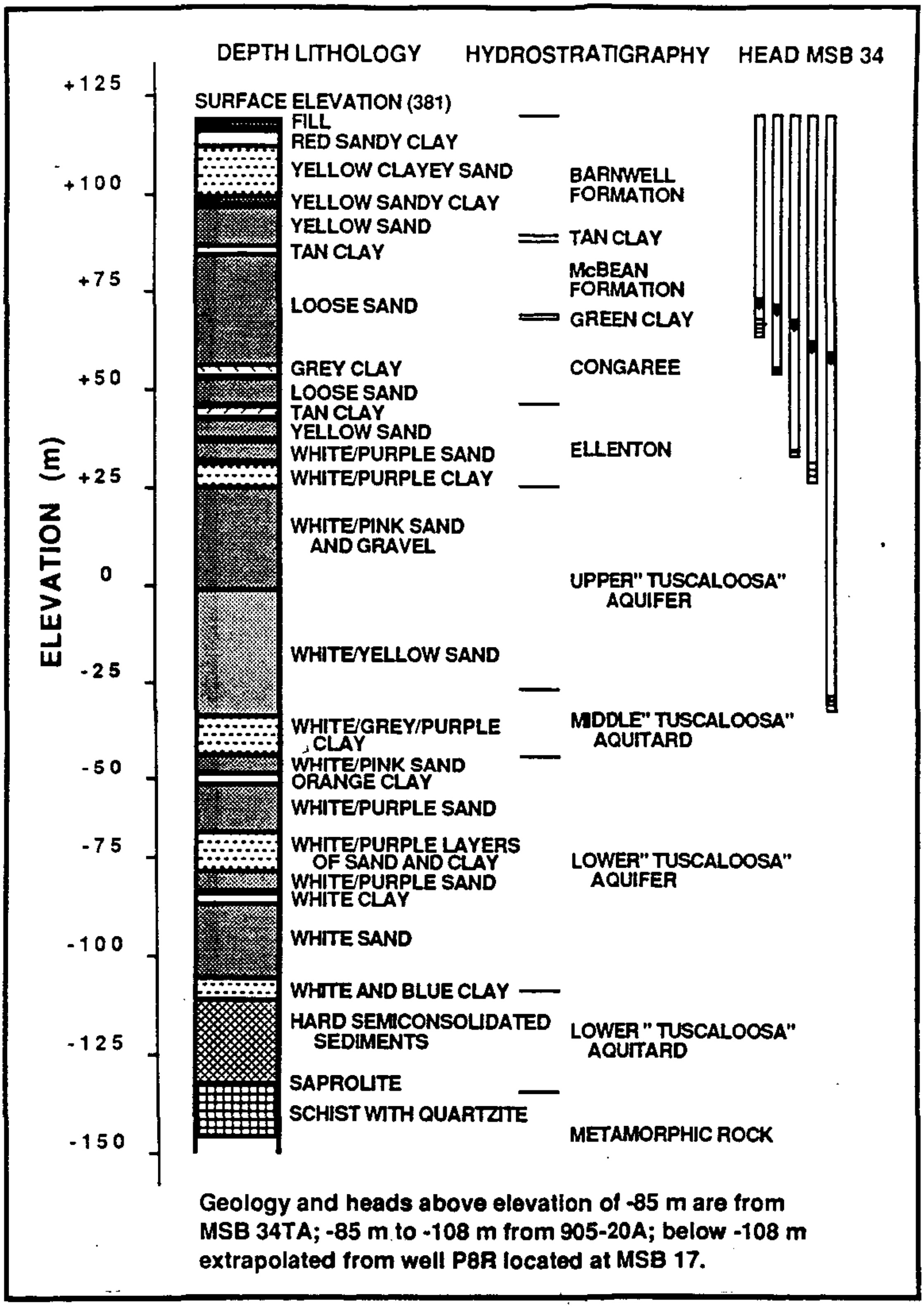
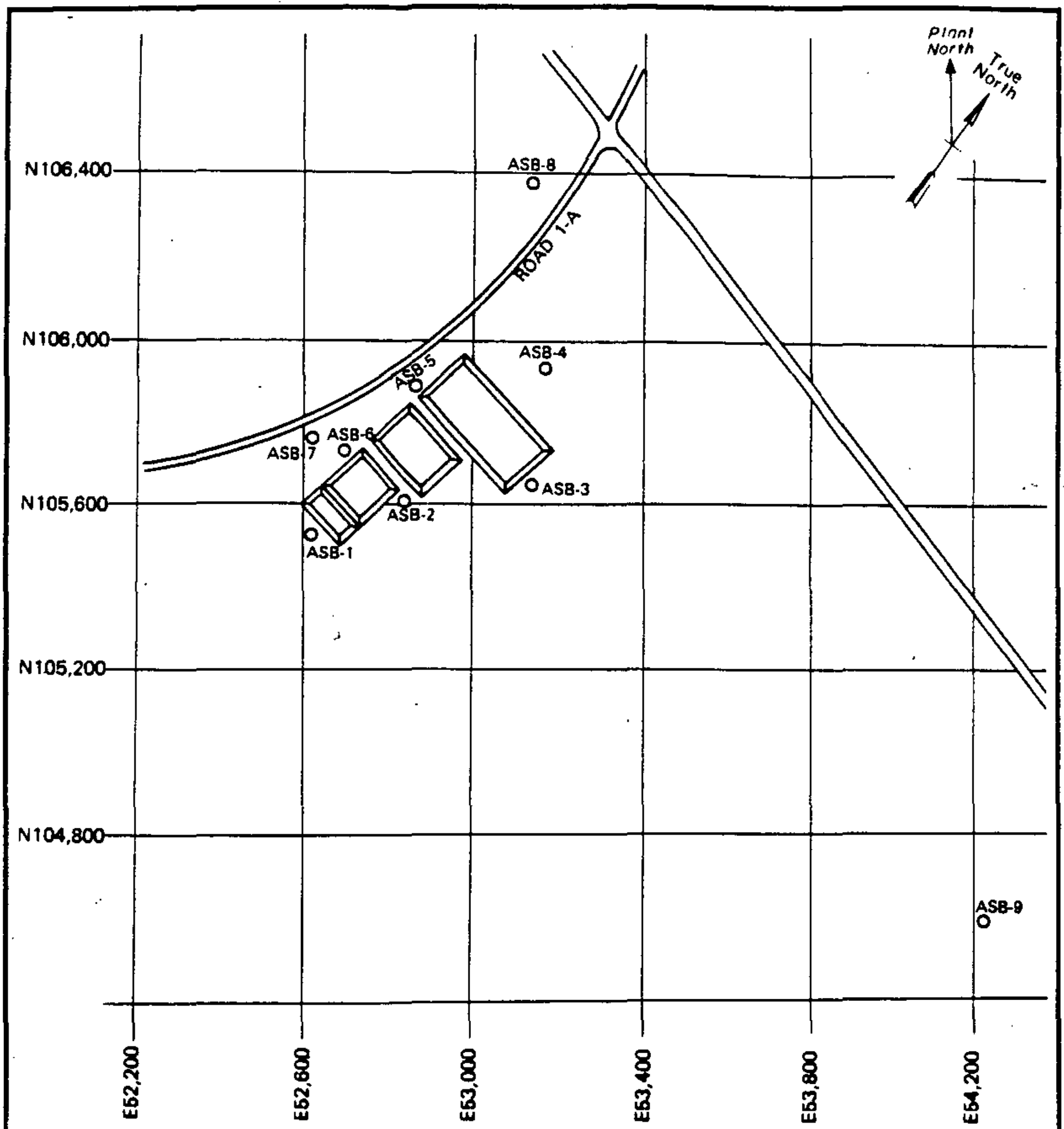


FIGURE 6. Geology and Hydrology Near the Center of A/M Area



Note: Wells ASB 1, ASB 2, ASB 3, ASB 5, and ASB 6 have been replaced by ASB 1A, ASB 2A, ASB 3A, ASB 5A, and ASB 6A, respectively. The new wells are at approximately the same locations.

FIGURE 7. Monitoring Well Location Map for the SRL Seepage Basins

order to obtain additional geologic data, a second boring was drilled at the location of ASB 8 to a depth of approximately 90 m below ground surface and geophysical logs obtained. Once logged, the boring was backgrouted. Well data are presented in the tables in Appendix C. Subsequent to the completion of the 1983 basin characterization program, wells ASB 1, 2, 5, and 6 were replaced by wells (A series) constructed with PVC casing.

Due to lithologic similarity of the geologic sediments in the A/M Area of the plant, especially the near surface formations, the Hawthorne, Barnwell, and McBean formations cannot be easily differentiated and are generally grouped as one unit. These interbedded and intercalated sands, silts, clays, and gravels of Tertiary age overlie the Congaree Formation, also of Tertiary age. The approximate formational controls are shown in Figure 8, which is based on a gamma log from ASB 8. Where present, the Green Clay is found at an elevation of approximately 64 m overlying the Congaree Formation. The sands and clayey sands of the Congaree grade into a basal clay unit at an elevation of approximately 33 m. All combined, these Tertiary age sediments are approximately 76 m in thickness and overlie the Ellenton Formation, which is interpreted to occur at an elevation of approximately 22 m. The Ellenton Formation, which is Paleocene in age, is on the order of 12 to 18 m in thickness and is found between depths of approximately 73 to 91 m below the ground surface. The Ellenton Formation consists characteristically of dark-gray-to-black, sandy, lignitic micaceous clay interbedded with medium-to-coarse sand overlying the "Tuscaloosa," which is found at a depth of approximately 91 m below the ground surface. The "Tuscaloosa" Formation consists of beds of fine-to-coarse-grained quartz sand and gravel interbedded and intercalated with kaolinitic clays and silts. The results of both the geologic sampling and the geophysical logging indicate that the "Tuscaloosa" can be divided into two hydrogeologic units, an upper and lower, separated by relatively thick clay units on the order of 10 to 12 m in thickness.

A water-table map for the A/M Area, based on measurements obtained in July 1984, is presented in Figure 9 (Marine & Bledsoe, 1985). A total of 44 wells was used in the construction of the map. The water table in the vicinity of the SRL Seepage Basins is found at a depth of approximately 30 m below the ground surface or at an average elevation of about 73 m. Due to the closeness of the wells to the basins and to the surface water drainage streams, there probably is a mounding of the water surface as a result of seepage. The water-table map shows that the gradients are relatively flat, averaging about 0.004 m/m.

At this time, there are insufficient data points in the vicinity of the basins to map the potentiometric surface within the Congaree Formation below the Green Clay unit.

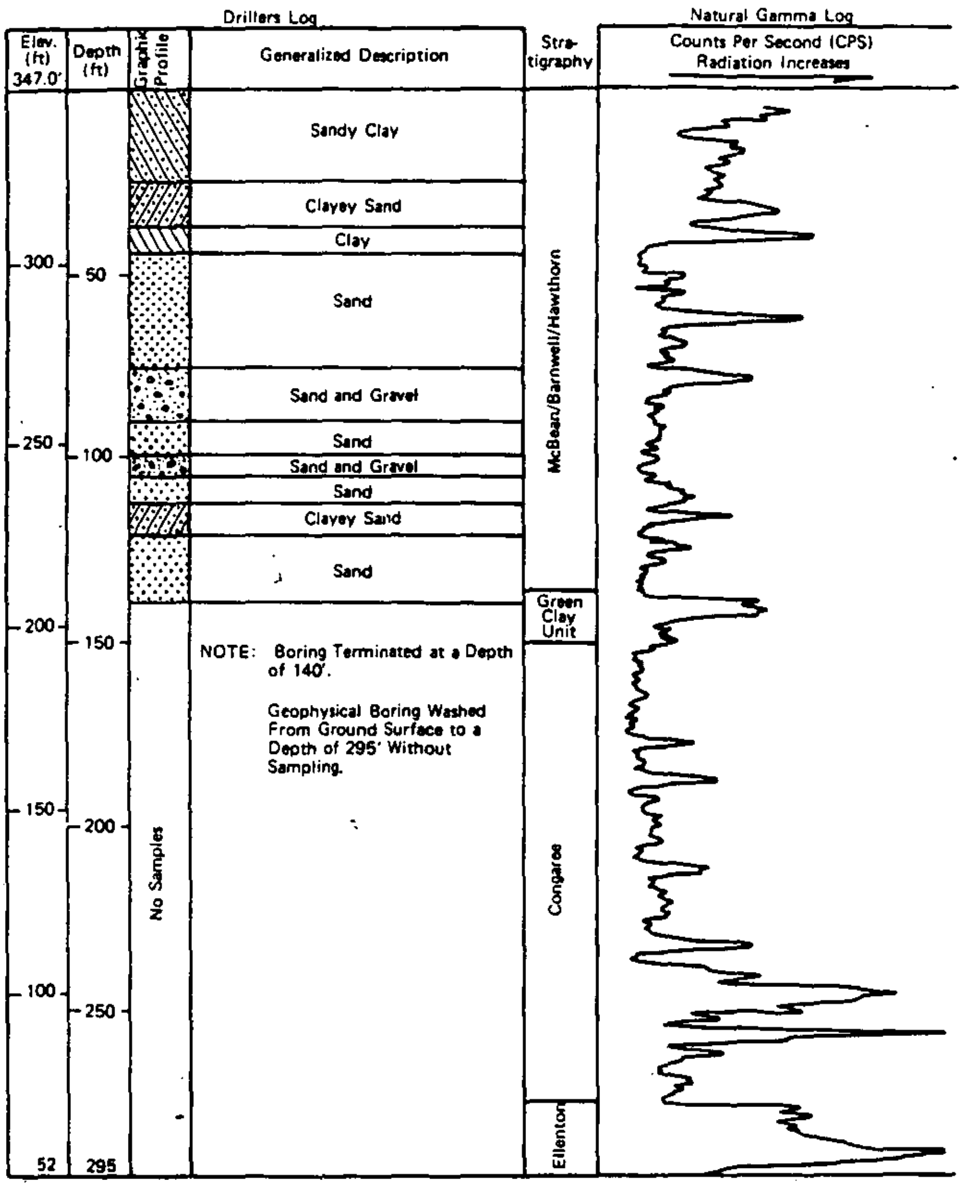


FIGURE 8. Driller's Log for Monitoring Well ASB 8

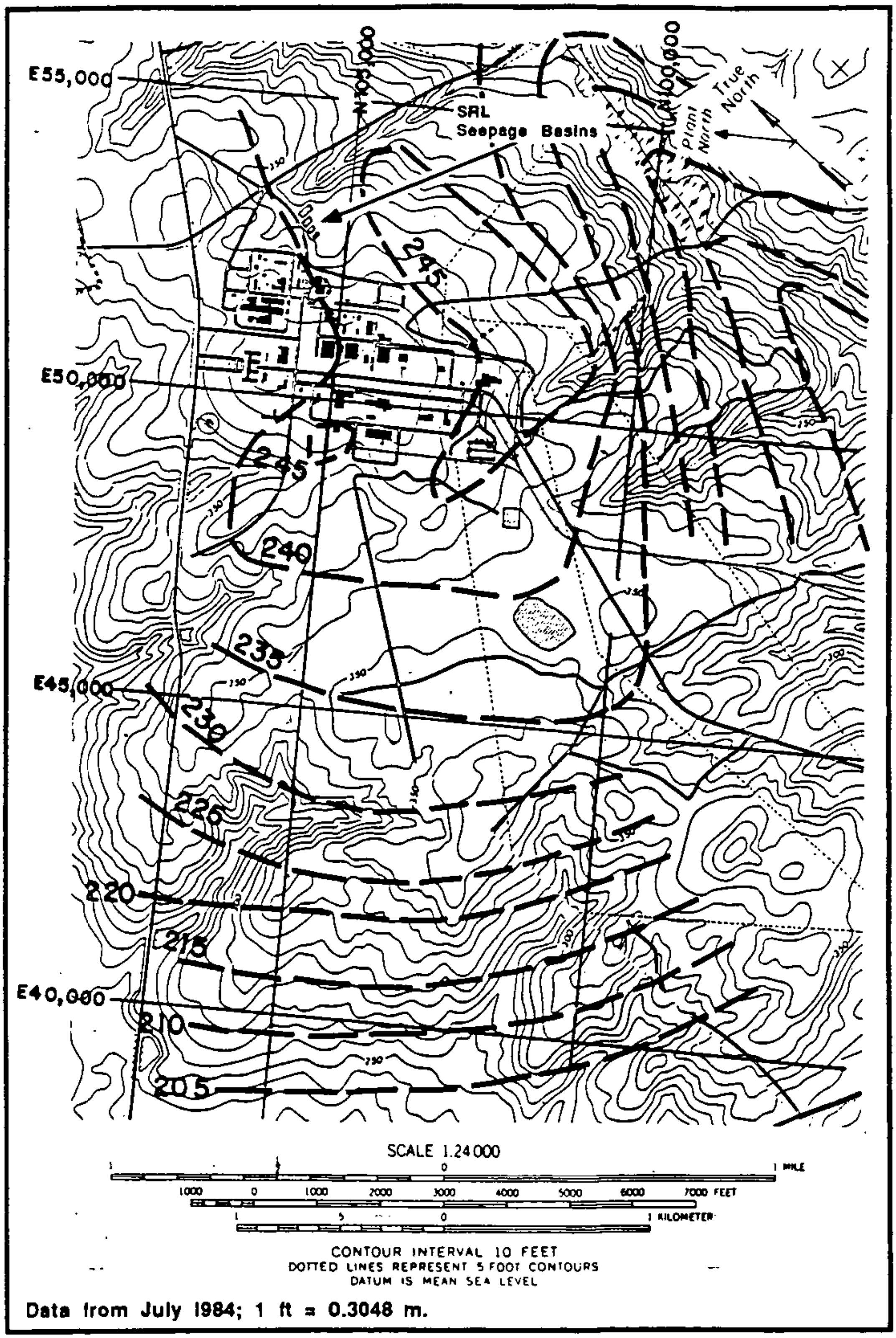


FIGURE 9. Water-Table Map for General A/M Area

The piezometric map of the upper "Tuscaloosa" Formation (Figure 10) indicates a swing back to a more southerly direction under the influence of drainage toward the Savannah River. The nose that is prominent in all of the Tertiary maps caused by drainage to Tims Branch, Upper Three Runs Creek, and the Savannah River swamps is absent from the "Tuscaloosa" map, which is influenced only by the Savannah River Valley. This gradient is consistent with the regional gradient in this area as shown on other upper "Tuscaloosa" piezometric maps (Figure 11).

The vertical gradients (the potential for water to move downward into underlying formations) can be measured by installing wells in different formations and at increasing depths below the water table. Since there are no data available from well clusters in the immediate vicinity of the SRL Seepage Basins screened in each of the different hydrologic units, the head relationships of the different aquifers are not known. However, measurements of water levels taken at different drill sites in the M-Area vicinity show a continuing decrease in head with increasing depth, indicating that A/M Area is located within a potential recharge zone of the "Tuscaloosa" Formation. These measurements show a head difference of 7 to 8 m between the base of the Tertiary (Congaree) sediments and the underlying "Tuscaloosa."

HYDROLOGIC CHARACTERISTICS

The hydraulic properties of the geologic framework determine the ease and the rate at which the groundwater moves through the various formations. The properties of most importance are transmissivity/permeability, porosity, storativity, and leakance. Effective porosity and permeability (hydraulic conductivity) are the most important properties affecting the ability of geologic materials to transmit water. Effective porosity is a measure of the amount of interconnected pore space available for fluid transmission, while hydraulic conductivity is a measure of the ease with which water can be transmitted through a porous material. These hydrologic characteristics are discussed in the paragraphs below for the basins.

Although no test has been conducted in the immediate vicinity of the SRL Seepage Basins, both laboratory and field pumping tests have been conducted within the general A/M Area.

The results of laboratory tests performed on undisturbed samples taken from the clayey units of the Ellenton and upper "Tuscaloosa" formations are presented in Table 6. Parameters measured were unit weight, moisture content, void ratio, specific gravity, porosity (total and effective), permeability (vertical and horizontal), and grain size distribution. Permeabilities of these

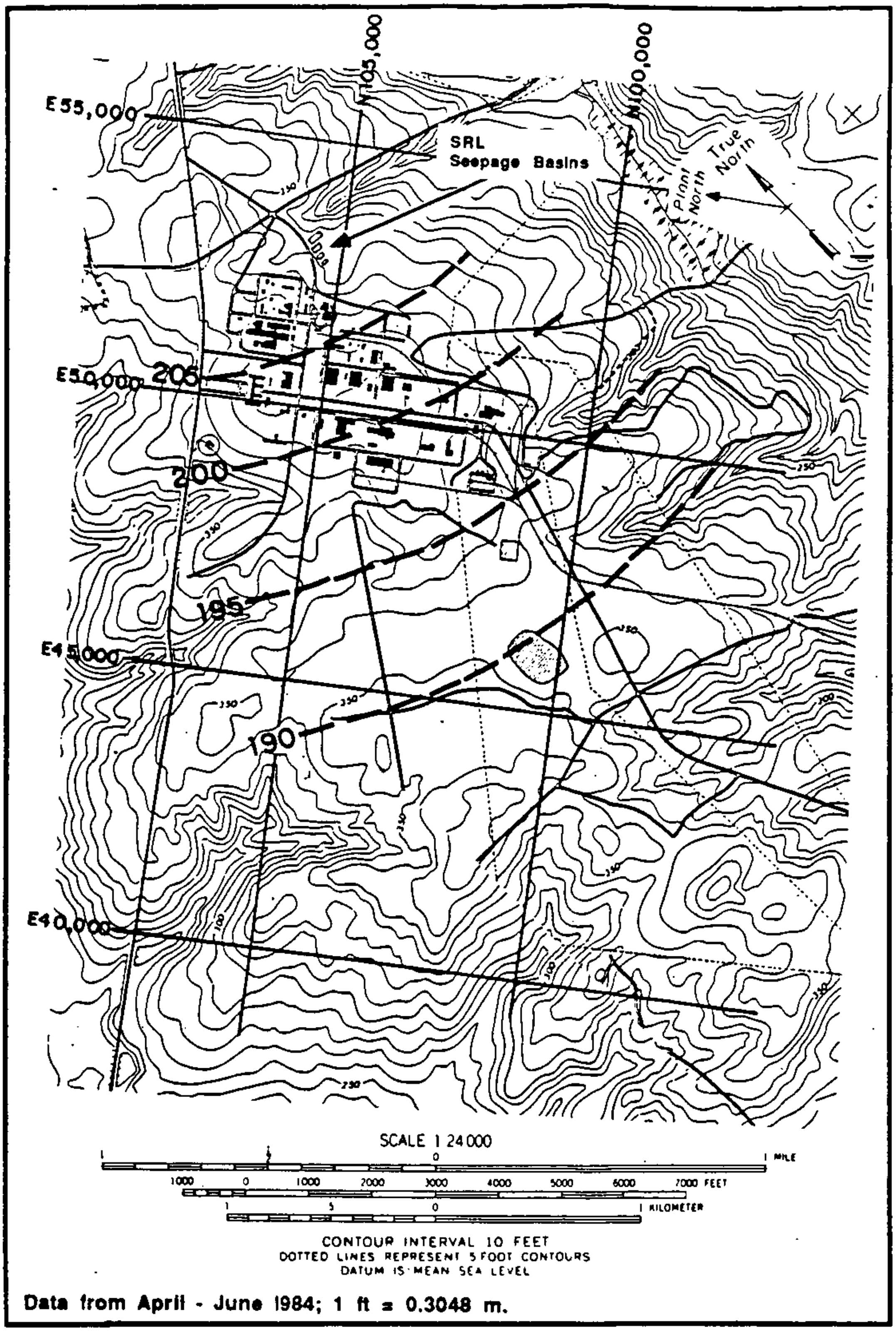
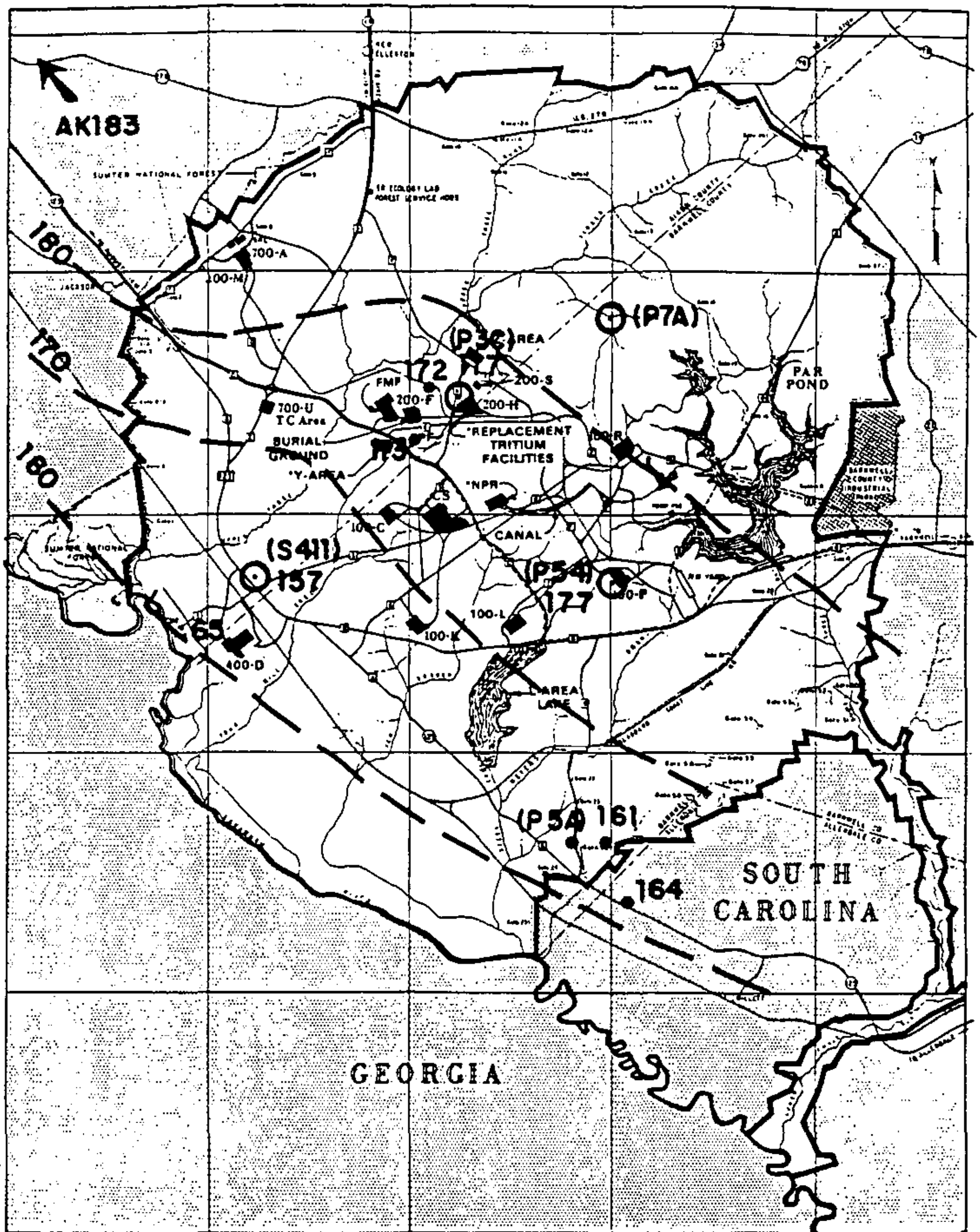


FIGURE 10. Piezometric Map of the Elevation Interval Where the Top of the Screen Is Between 14 and 76 ft (i.e.; Upper "Tuscaloosa" Formation)



Data from May 1982. Contours and water levels in feet above mean sea level; 1 ft = 0.3048 m.

1 0 1 2 3 4 5
Scale in Miles
1 mi = 1.61 km

FIGURE 11. Piezometric Map of the "Tuscaloosa" Formation

TABLE 6

Summary of Soil Test Results

Boring No. or Location	Sample Depth (m)	Visual Description	Unit Weight		Moisture Content (%)	Void Ratio	Initial Saturation (%)	Specific Gravity	Porosity		Falling Head (cm/s)	
			Wet (PCF)	Dry (PCF)					Total	Effective	Vertical	Horizontal
MSB 23A	92.0-92.7	Light tan brown silty	130.9	114.8	14.0	0.447	83.3	2.66			3.2E-07	
		clayey medium to fine	129.1	112.5	14.8	0.476	82.7					5.4E-07
		sand		107.3	19.5				0.370	0.031		
MSB 30A	89.6-90.2	Brown fine sandy silty	134.6	112.9	19.2	0.510	100	2.73			1.5E-08	
		clay	130.5	109.5	19.2	0.556	94.3					1.6E-08
				114.3	17.3				0.362	0.024		
MSB 30A	79.2-79.9	White silty medium to	131.4	112.7	16.7	0.474	93.7	2.66			4.0E-07	
		fine sand	126.1	107.5	17.3	0.545	84.4					5.7E-07
				110.3	16.2				0.326	0.084		
MSB 23A	93.3-93.9	Light grey medium to	132.4	112.6	17.5	0.486	96.5	2.68			5.2E-09	
		fine sandy silty clay	126.2	106.6	18.4	0.570	86.5					1.1E-08
				114.5	12.7				0.306	0.137		
MSB 30A	73.8-74.4	Grey silty clayey medium to fine sand	137.1	121.1	13.2	0.392	90.9	2.70			4.5E-08	
		Average	130.9	112.0	16.6	0.495	90.2	2.69	0.34	0.07	1.5E-07	2.8E-07

Note: No horizontal permeability and porosity test was performed due to limited amount of sample.

clayey soils were low, indicating that they transmit water extremely slowly. For example, vertical permeabilities of 4.0E-07 to 5.2E-09 cm/s and horizontal permeability measurements of 5.7E-07 to 1.1E-08 cm/s were found.

The effective porosities determined for these samples are also low, ranging from 0.024 to 0.137 (dimensionless). These results compare to average effective porosities of 0.20 and 0.30 generally used for the Tertiary and "Tuscaloosa" sands, respectively.

Using an average vertical hydraulic conductivity for the Ellenton/"Tuscaloosa" clays of 1.2E-04 m/day, an average effective porosity of 0.07 (Table 6), a hydraulic head drop of 7.3 m across the Ellenton, and an average clay thickness of 12 m, a calculated vertical groundwater flow velocity of 0.4 m/yr is obtained for flow across the Ellenton Formation.

What cannot be estimated from laboratory measurements is the continuity of the clays; thus, the amount of interconnection or communication that occurs across the Ellenton clays between the Tertiary sediments and the "Tuscaloosa" Formation remains uncertain. This information can only be determined by a pumping test. Analyses of a pumping test conducted by Geraghty & Miller (1983) on wells completed in the "Tuscaloosa" are presented in Table 7. Transmissivity, storage coefficient, and leakance values for the aquifer were determined using both the Hantush-Jacob (1955) and the Cooper-Jacob (1946) method. On the basis of these analyses, it is believed that the representative transmissivity, storage coefficient, and leakance values for this aquifer in the A/M Area are 980 m^2/day, 4.2E-04 (dimensionless), and 1.5E-04/day, respectively. For comparison, Siple (1967) reports a transmissivity of 1,120 m^2/day and a storage coefficient of 3.0E-04 for a test conducted in January 1952. If the Ellenton clay is 12 m in thickness, the leakance would translate to a hydraulic conductivity of 1.8E-03 m/day, which is about an order of magnitude higher than the laboratory values. Using this value, the vertical flow velocity should be about 5.8 m/yr, and water should transverse the Ellenton Formation in about 2 years.

Using the higher conductivity values, the leakage through the Ellenton Formation is at a Darcy velocity of 0.41 m/yr. The general A/M Area is about 1,500 m by 1,500 m, making an area of 2.3 million m^2. Thus, in this area about 950,000 m^3/yr may be recharging the "Tuscaloosa." Pumpage from the "Tuscaloosa" is about 2.5 million m^3/yr. The remainder is made up from lateral flow in the "Tuscaloosa."

The horizontal groundwater velocity in the "Tuscaloosa" is estimated at 52 m/yr, using a hydraulic conductivity of 12.2 m/yr, a gradient of 0.0023 m/m, and an effective porosity of 20%. The horizontal flux in the "Tuscaloosa" through a 1,500-m section of the A/M Area estimated to be 120-m thick would be 1.9 million m^3/yr.

TABLE 7

Summary of Hydraulic Properties of the "Tuscaloosa" Formation as Determined from a Pumping Test on Production Well 905-20A

Well Number	Transmissivity (m^2/day)	Storage Coefficient (dimensionless)	Leakance (day^{-1})	Method Used
905-20A	966.9			Cooper-Jacob (recovery)
905-82A	982.3	4.3E-04	1.55E-04	Hantush-Jacob (drawdown)
	982.3	3.7E-04		Hantush-Jacob (recovery)
	993.2	4.3E-04		Cooper-Jacob (drawdown)
905-31A	1,186	4.7E-04	1.46E-04	Hantush-Jacob (drawdown)
	981.8	4.0E-04		Hantush-Jacob (recovery)
	1,060	4.2E-04		Cooper-Jacob (drawdown)
905-53A	1,052	8.2E-04	4.36E-04	Hantush-Jacob (drawdown)
	981.8	8.7E-04		Hantush-Jacob (recovery)
	1,315	6.8E-04		Cooper-Jacob (drawdown)

A 30-day pumping test of the unconfined Tertiary aquifer was conducted by SRL in 1982 on a recovery well installed in M Area (Bledsoe, 1983). The results of this test yield a calculated transmissivity value of 52 m^2/day and a storage coefficient of 0.27 (Figure 12).

The water-table map (Figure 9) shows that the gradients are relatively flat averaging about 0.004 m/m. The direction of flow at the water table is to the west at an average velocity of about 12 m/yr based on the relationship:

$$V = \frac{I \times K}{E}$$

where: V = flow velocity (m/day)

I = water table pressure gradient (m/m)

E = effective porosity (dimensionless)

K = hydraulic conductivity (m/day)

with the hydraulic conductivity and effective porosity assumed to be 1.58 m/day and 0.20, respectively, based on the 30-day pumping test. For the purposes of transport modeling calculations, a composite horizontal velocity of 20 m/yr was assumed.

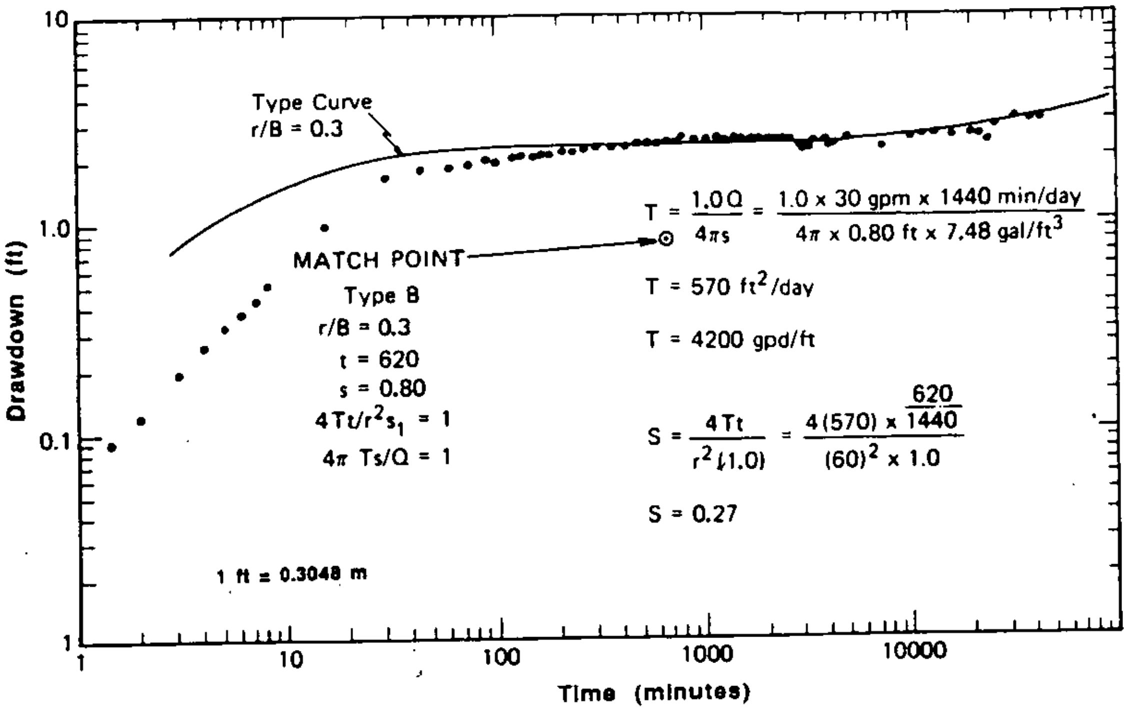


FIGURE 12. **Log-Log Plot of Drawdown for Observation Well MSB 11C During 30-Day Pumping Test**

SOIL CHARACTERIZATION DATA

After the seepage basins were taken out of service, a comprehensive soil sampling program was planned and implemented in early 1983 to determine the present condition of the site and the mobility of any contamination present at the site. The characterization program included analyses of basin sediment samples and groundwater samples.

Figure 13 shows the location of the soil cores within each basin. Cores were taken to a depth of 6.1 m. The cores were segmented at depths of 0.076 m, 0.15 m, 0.23 m, 0.30 m, 0.38 m, 0.46 m, 0.53 m, 0.61 m, 1.5 m, 2.4 m, 3.4 m, 4.3 m, and 5.2 m. Sediments were analyzed for radionuclides, cations, anions, and organic compounds. Typical vertical concentration profiles observed for inorganics and radionuclides in cores from the waste site are presented in Figures 14, 15, and 16. Profiles for tritium and arsenic, which were atypical distributions, are shown in Figures 17 and 18. A summary of the results from the soil analysis program is presented in Appendix A, and the complete data set is in Bransford et al. (1984).

To aid in classifying the seepage basin sediments, EP toxicity tests (metals only) were performed as part of the 1983 characterization study. The results of the EP toxicity test for the most concentrated (0 to 7.6 cm) SRL Seepage Basins sediments are presented in Table 8 and Figure 19.

GROUNDWATER MONITORING DATA

Nine groundwater monitoring wells are located in the vicinity of the SRL Seepage Basins (Figure 7). These wells, with the exception of wells ASB 7 through 9, which are A/M Area plume definition wells, are sampled quarterly and analyzed for a variety of contaminants. All groundwater monitoring data collected from wells ASB 1 through 6 are presented in Appendix C. A summary of well sample analyses performed as part of the 1983 characterization study is presented in Table 9.

STATISTICAL ANALYSIS OF GROUNDWATER DATA

A statistical analysis of the routine Health Protection Department groundwater monitoring program analyses was conducted to determine if wells ASB 1A, ASB 2A, ASB 4, ASB 5A, or ASB 6A are significantly different from well ASB 3A. Results from this

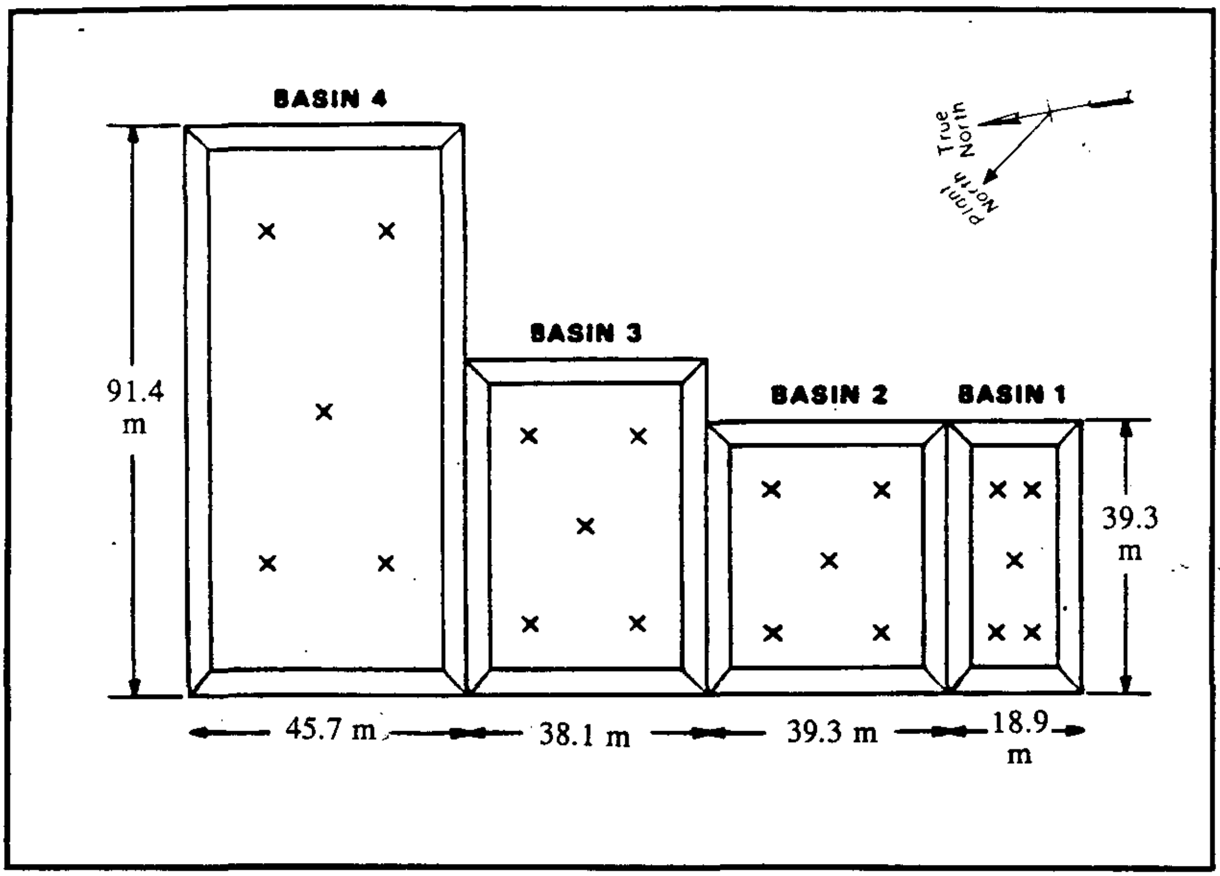


FIGURE 13. Location of Soil Borings in the SRL Seepage Basins

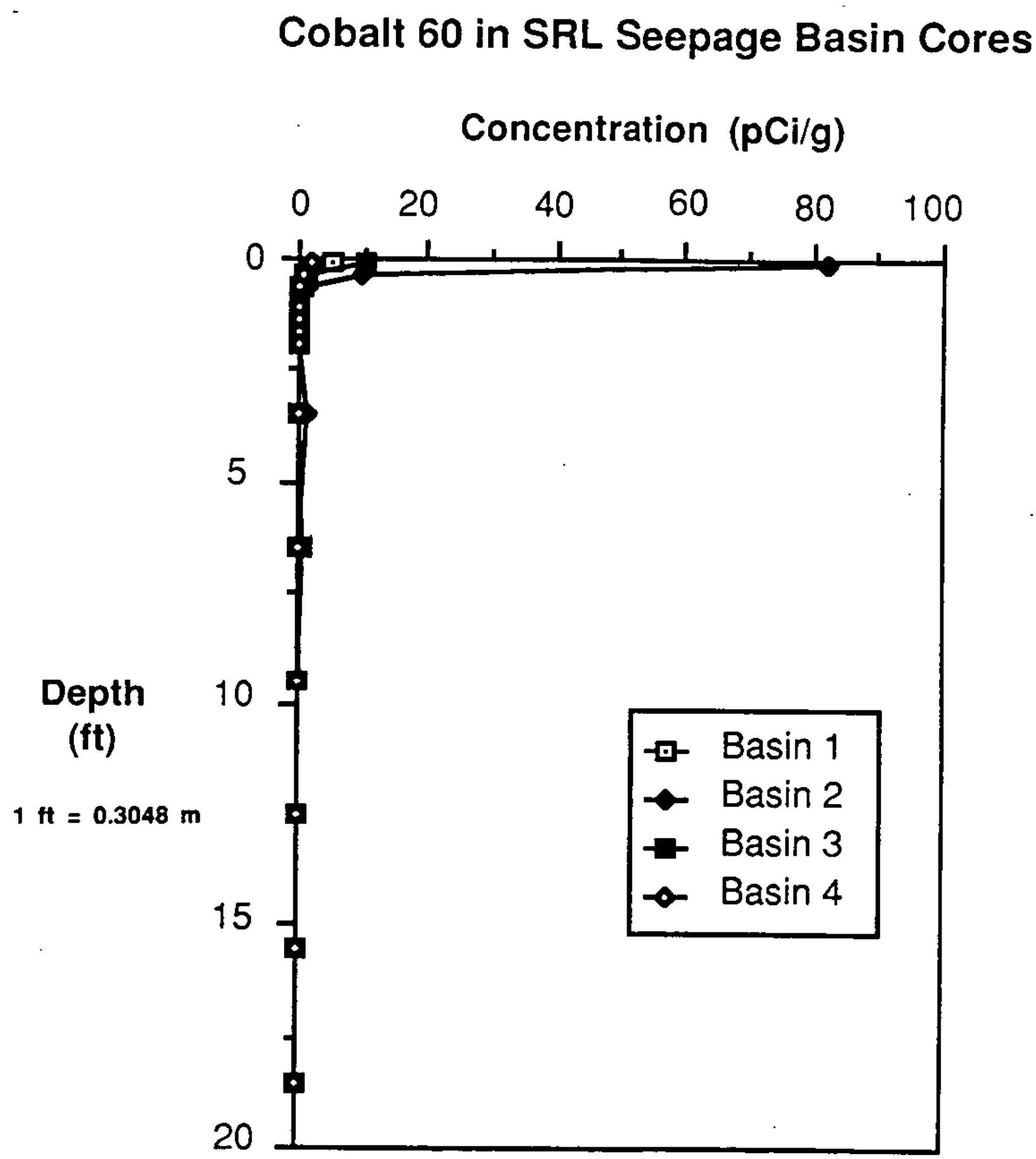


FIGURE 14. ^{60}Co in SRL Seepage Basins Cores

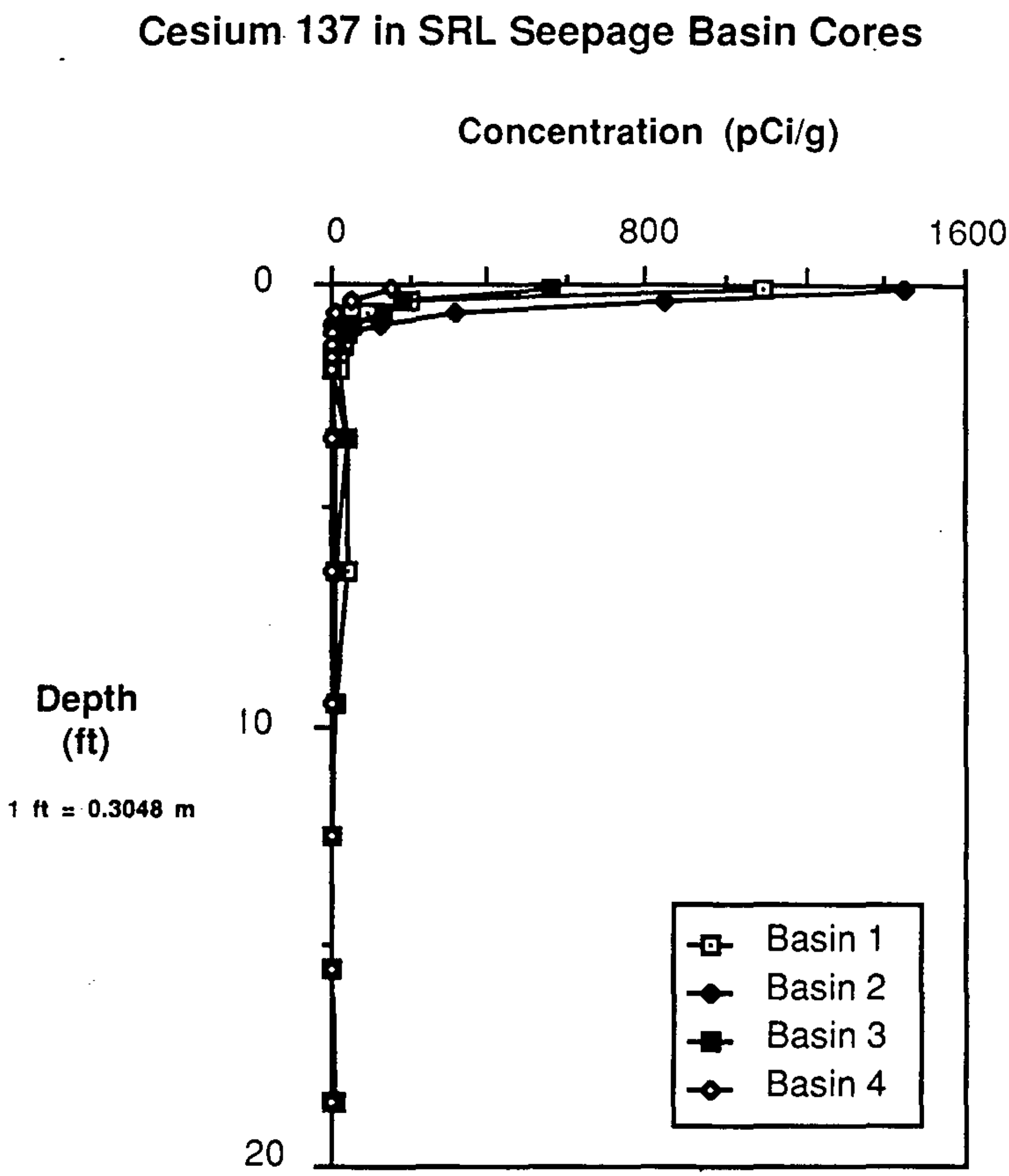


FIGURE 15. ^{137}Cs in SRL Seepage Basins Cores

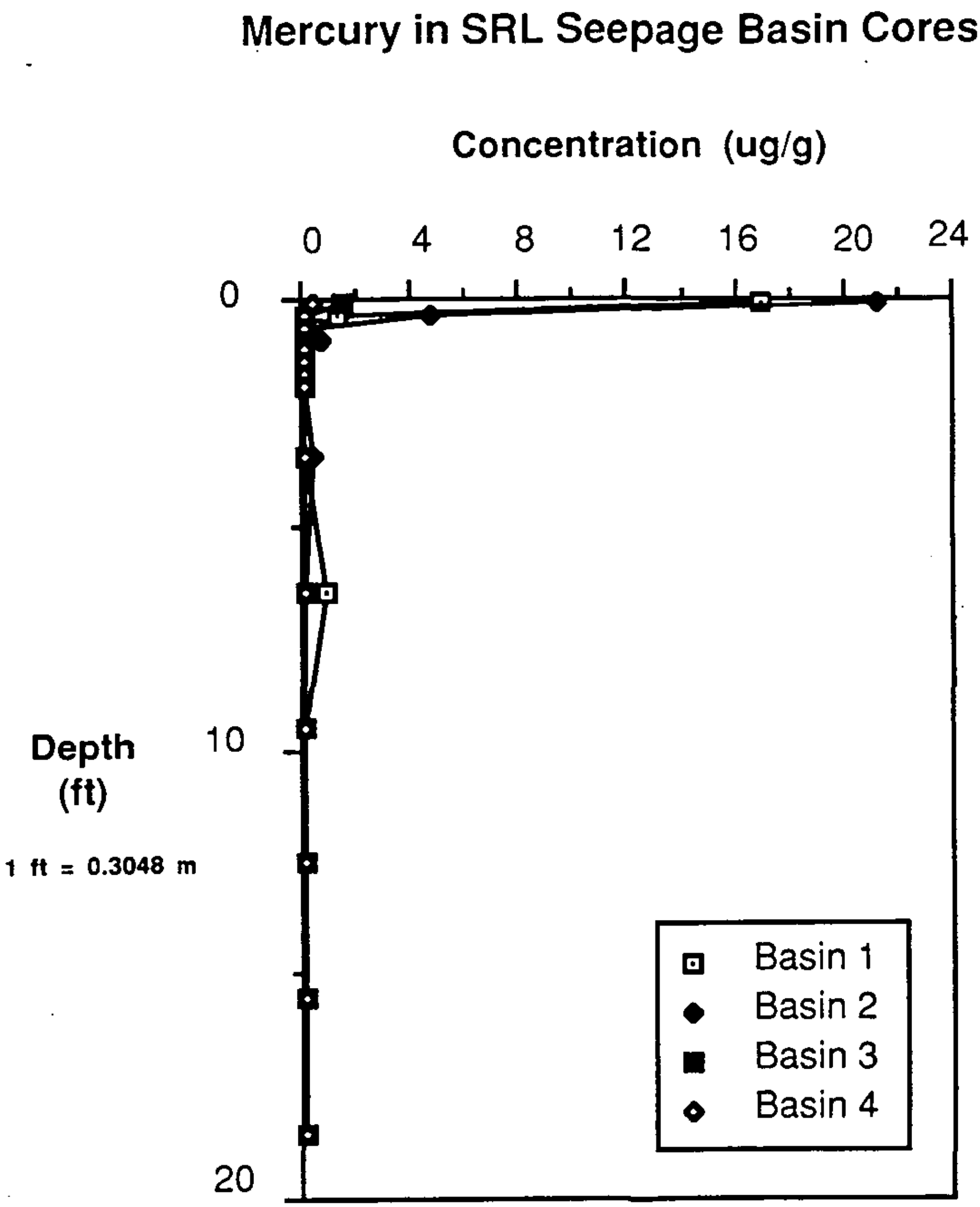


FIGURE 16. Mercury in SRL Seepage Basins Cores

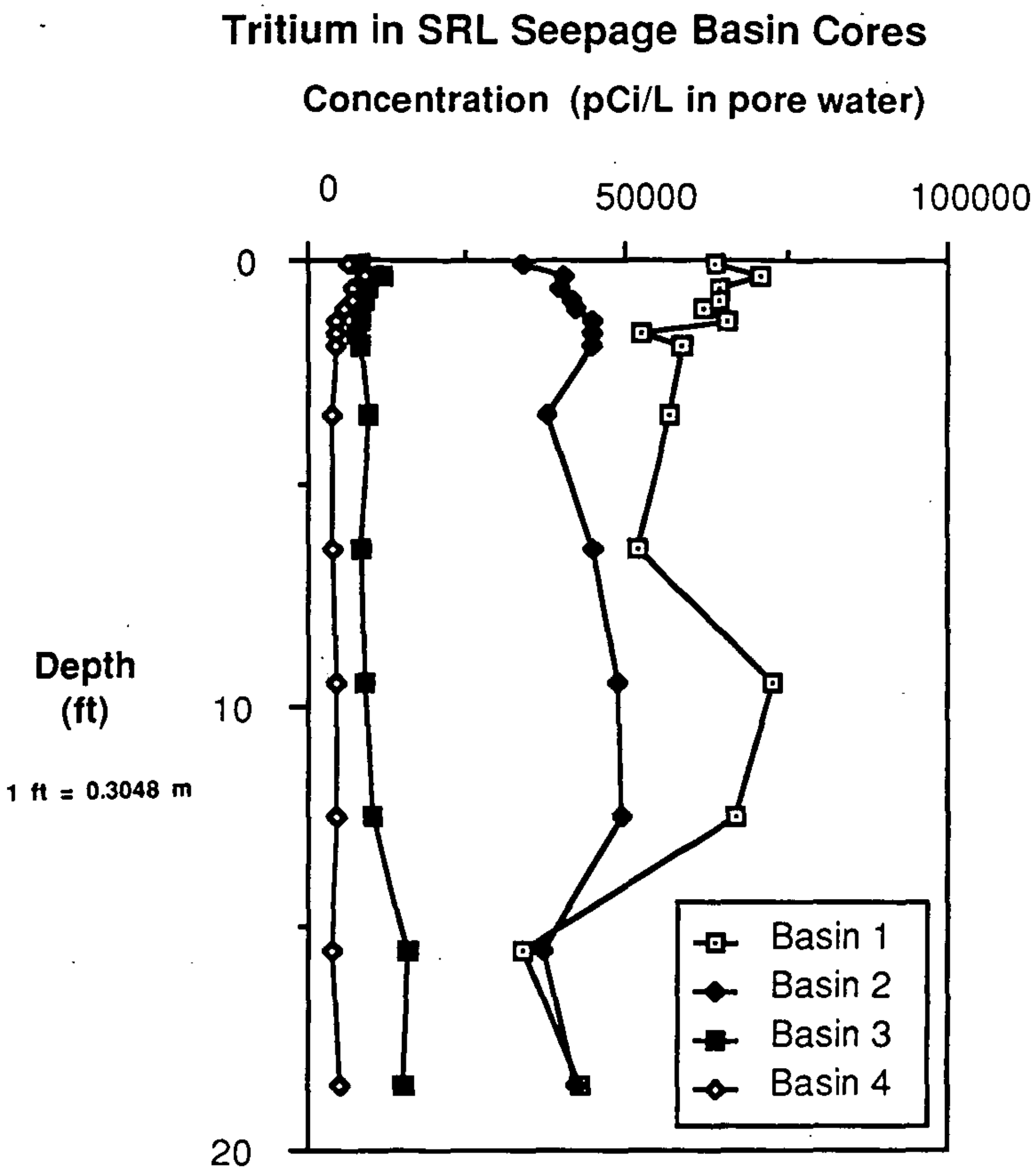


FIGURE 17. Tritium in SRL Seepage Basins Cores

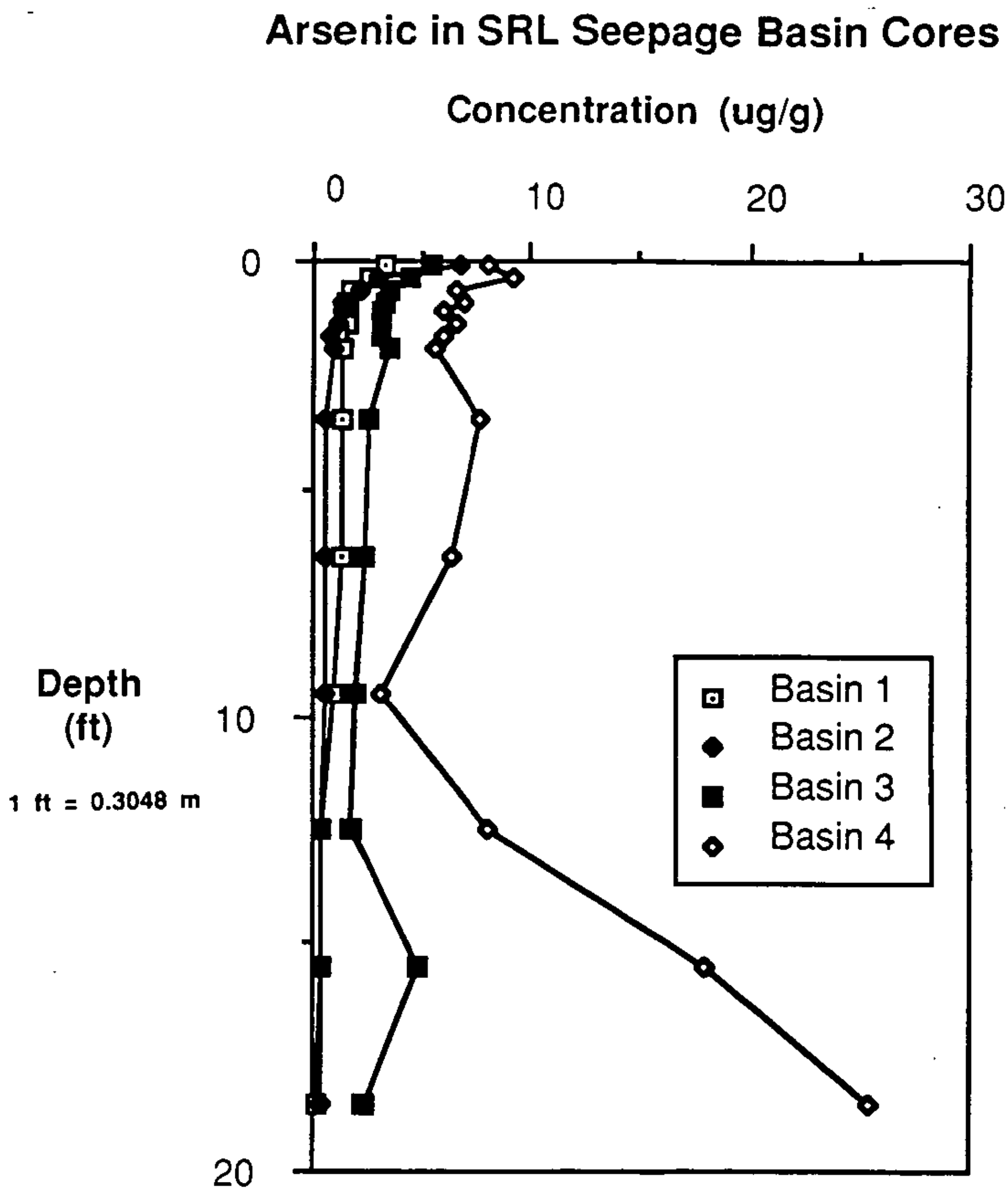


FIGURE 18. Arsenic in SRL Seepage Basins Cores

TABLE 8

EP Toxicity Test Data for SRL Seepage Basins Sediment

	Concentration (mg/L)							
EPA Guideline (100 x MCL)	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
	5.000	100.000	1.000	5.000	5.000	0.2000	1.000	5.0000
Detection Limit	0.001	0.001	0.001	0.005	0.010	0.0002	0.001	0.0005
ASB 101	0.002	0.257	0.015	0.005	0.010	0.0048	0.001	0.0005
ASB 102	0.003	0.373	0.019	0.021	0.010	0.0018	0.001	0.0005
ASB 103	0.001	0.245	0.014	0.005	0.010	0.0009	0.001	0.0005
ASB 104	0.004	0.700	0.072	0.102	0.026	0.1351	0.001	0.0005
ASB 105	0.003	0.219	0.007	0.005	0.010	0.0004	0.001	0.0005
Basin 1 (avg)	0.003	0.359	0.025	0.028	0.013	0.0286	0.001	0.0006
ASB 201	0.031	0.575	0.130	0.028	0.015	0.0005	0.001	0.0008
ASB 202	0.002	0.226	0.006	0.005	0.010	0.0007	0.001	0.0010
ASB 203	0.004	1.660	0.309	0.141	0.263	0.0003	0.001	0.0010
ASB 204	0.002	0.236	0.002	0.005	0.010	0.0002	0.001	0.0005
ASB 205	0.002	0.463	0.021	0.060	0.010	0.0044	0.001	0.0006
Basin 2 (avg)	0.008	0.632	0.094	0.048	0.062	0.0012	0.001	0.0008
ASB 301	0.001	0.268	0.009	0.005	0.010	0.0007	0.001	0.0005
ASB 302	0.001	0.352	0.015	0.005	0.010	0.0003	0.001	0.0005
ASB 303	0.001	0.273	0.023	0.005	0.010	0.0002	0.001	0.0005
ASB 304	0.001	0.245	0.004	0.005	0.010	0.0002	0.001	0.0005
ASB 305	0.001	0.216	0.006	0.005	0.010	0.0008	0.001	0.0005
Basin 3 (avg)	0.001	0.271	0.011	0.005	0.010	0.0004	0.001	0.0005
ASB 401	0.001	0.303	0.013	0.005	0.010	0.0002	0.001	0.0005
ASB 402	0.001	0.160	0.008	0.005	0.010	0.0003	0.001	0.0005
ASB 403	0.001	0.043	0.012	0.006	0.010	0.0008	0.001	0.0005
ASB 404	0.001	0.183	0.007	0.005	0.010	0.0002	0.001	0.0005
ASB 405	0.001	0.218	0.012	0.006	0.010	0.0002	0.001	0.0005
Basin 4 (avg)	0.001	0.181	0.010	0.005	0.010	0.0003	0.001	0.0005

Note: Increments for each core are from 0 to 7.6 cm.

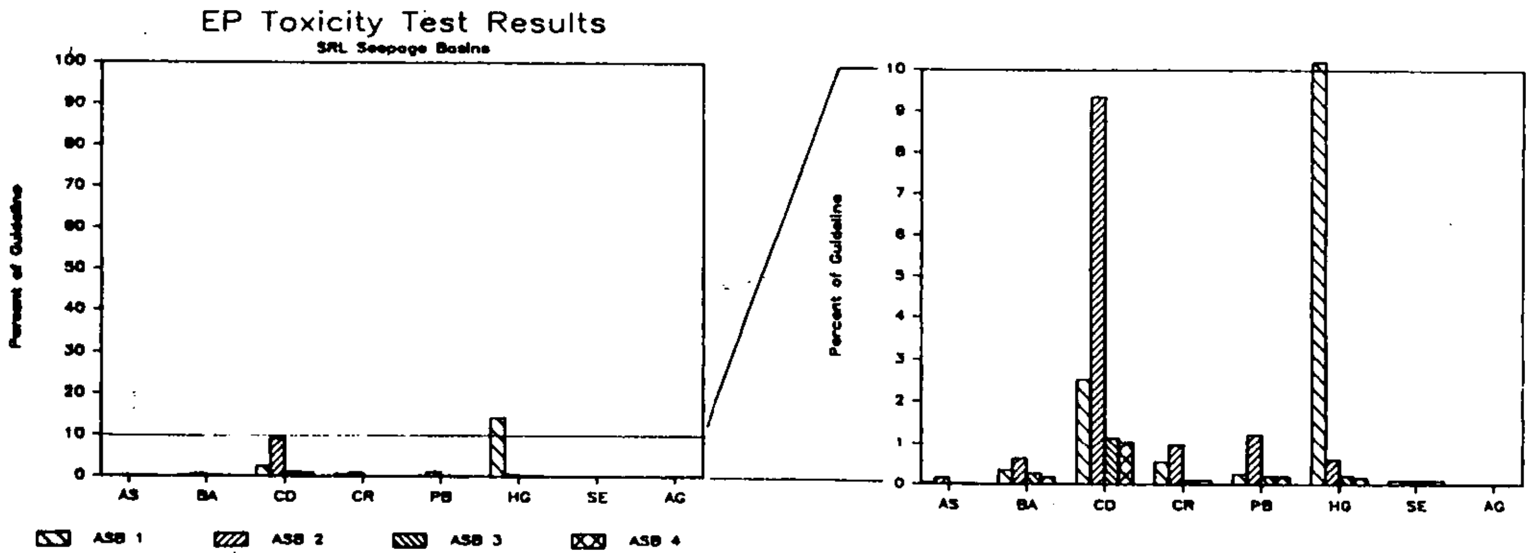


FIGURE 19. EP Toxicity Test Results for the SRL Seepage Basins

TABLE 9

Summary of Groundwater Monitoring Well Sample Analyses at the SRL Seepage Basins

Constituent	Concentration (mg/L) in Monitoring Well								
	ASB 1*	ASB 2*	ASB 3**	ASB 4**	ASB 5*	ASB 6*	ASB 7**	ASB 8**	ASB 9*
Fe	45.64	56.30	6.03	9.93	78.96	91.88	0.09	0.57	0.08
Pb	0.013	0.074	0.007	0.011	0.017	0.007	0.017	0.021	0.008
Cd	0.019	0.028	<0.001	<0.001	0.021	0.010	<0.001	<0.001	<0.001
Cr	0.032	<0.147	0.005	<0.003	0.052	0.037	<0.003	<0.003	<0.003
Trichloroethylene	0.019	<0.005	<0.005	0.014	0.286	0.005	<0.005	1.820	<0.005

Note: The date of this study is 1983.

*Steel casing.
**PVC casing.

analysis are presented in Tables 10 through 14. The surface of the groundwater in the area of the basins is very flat, making it difficult to determine which of the wells is the upgradient well. However, the area water-table map (Figure 9) indicates the overall water-table flow to be in a westerly direction, suggesting that well ASB 2A or ASB 3A is the most upgradient well. Well ASB 3A was selected as the upgradient well because it is upgradient and next to basin 4, which seldom received water. The values for pumped samples reported in Appendix C were used in the statistical analysis for the downgradient wells. Values for 1984 and 1985 were used for ASB 3A.

The tables summarizing the statistical analysis were constructed using the following steps. If an analyte was never detected in the downgradient well, it was so labeled on the table, and the conclusion was drawn that there has been no effect from the basins. If the analyte was detected in the downgradient well, then the means of the resultant values for the upgradient and the downgradient wells were calculated. Values reported as being below detection were included in the mean at that detection limit. If the mean for the analyte (except for pH) in the downgradient well was the same as or lower than the mean in the upgradient well, then the table was so labeled, and it was concluded that there has been no effect from the basins. The means listed in the statistical tables are in the same units as the results in Appendix C. The Statistical Analysis System (SAS) computer procedure TTEST was used to calculate $\underline{t}$ values and probabilities that the populations of analyses for the two wells were the same, assuming unequal variances for the observations from each well. If there is a 95% or greater probability that the means are statistically different, then the conclusion is that the wells are different. If the probability is greater than or equal to 75% but less than 95%, then the analysis is inconclusive. If the probability is less than 75% that the wells are different, then the conclusion is that there has been no effect from the basins.

Differences between wells may be due to natural variability in the groundwater, sampling or analytical variability, or from effects of the basin or other man-made impacts. The measurements of pH, sodium, chloride, and manganese were determined to be statistically different in one or more downgradient wells. All pH values (except ASB 6A) are in the range that is typical for this area--4.5 to 5.5 (Pickett & Looney, 1986). In general, the differences observed are small, and concentrations are well below primary drinking water standards. Total organic halogens, specifically trichloroethylene, were not selected for assessment for reasons discussed earlier. Note, there are a large number of possible chlorocarbon sources in the A/M Area of SRP, and both the upgradient and downgradient wells contain measurable chlorocarbon concentrations.

TABLE 10

Results of t-test Comparison of Downgradient Well ASB 1A and Upgradient Well ASB 3A

Wells:	ASB 1A		ASB 3A				
Parameter	N	Mean	N	Mean	t Value	Prob>t	Difference
pH	6	4.817	8	5.413	-2.714	0.022	Yes
Conductivity	6	49.50	8	56.00	Lower Mean		No
TDS	2	30.00	4	38.50	Lower Mean		No
Turbidity	3	3.033	5	24.34	Lower Mean		No
Ag	Not Detected						No
As	Not Detected						No
Ba	3	0.009	5	0.054	Lower Mean		No
Be	Not Detected						No
Cd	Not Detected						No
Cr	Not Detected						No
Cu	Not Detected						No
Fe	3	0.014	5	6.518	Lower Mean		No
Hg	6	0.0002	8	0.0003	Lower Mean		No
Mn	3	0.079	5	0.018	1.986	0.181	Inconclusive
Na	6	2.417	8	2.876	Lower Mean		No
Ni	Not Detected						No
Pb	6	0.011	8	0.007	0.891	0.410	No
Se	Not Detected						No
Zn	2	0.033	4	0.120	Lower Mean		No
Cl	3	6.600	5	6.780	Lower Mean		No
Cyanide	Not Detected						No
F	3	0.107	5	0.104	0.343	0.752	No
Surfactants	Not Detected						No
H_2S	Not Detected						No
NO_2 (as N)	Not Detected						No
NO_3 (as N)	Not Detected						No
SO_4	Not Detected						No
Gross Alpha	3	6.667	5	8.400	Lower Mean		No
Gross Beta	3	5.000	5	5.000	Same Mean		No
Ra	3	2.667	5	3.600	Lower Mean		No
DOC	Not Detected						No
GC Scan	Not Detected						No
Phenols	3	0.005	5	0.003	0.633	0.583	No
TOC	6	2.141	8	2.701	Lower Mean		No
TOH	6	0.009	8	0.015	Lower Mean		No
Endrin	Not Detected						No
Lindane	Not Detected						No
Methoxychlor	Not Detected						No
Toxaphene	Not Detected						No
24D	Not Detected						No
245TP (Silvex)	Not Detected						No

Note: T value and probability were generated assuming unequal variances between wells. If probability is $\leq$ .05, probability is 95% or greater that the wells are different; if probability is > .25, probability is greater than 75% that the wells are different; if probability is > .05 and $\leq$ .25, probability is between 95% and 75%, and difference is inconclusive. Units of measurement for the means are the same as reported in the tables in Appendix C.

TABLE 11

Results of t-test Comparison of Downgradient Well ASB 2A and Upgradient Well ASB 3A

Wells:	ASB 2A		ASB 3A				
Parameter	N	Mean	N	Mean	t Value	Prob>t	Difference
pH	6	4.767	8	5.413	-3.748	0.003	Yes
Conductivity	6	57.17	8	56.00	0.120	0.907	No
TDS	2	26.00	4	38.50	Lower Mean		No
Turbidity	3	1.100	5	24.34	Lower Mean		No
Ag	Not Detected						No
As	Not Detected						No
Ba	3	0.018	5	0.054	Lower Mean		No
Be	Not Detected						No
Cd	Not Detected						No
Cr	Not Detected						No
Cu	2	0.006	4	0.015	Lower Mean		No
Fe	3	0.047	5	6.518	Lower Mean		No
Hg	6	0.0002	8	0.0003	Lower Mean		No
Mn	3	0.063	5	0.018	4.578	0.018	Yes
Na	6	3.150	8	2.876	1.057	0.315	No
Ni	Not Detected						No
Pb	6	0.013	8	0.007	1.976	0.090	Inconclusive
Se	Not Detected						No
Zn	2	0.070	4	0.120	Lower Mean		No
Cl	3	6.967	5	6.780	0.242	0.819	No
Cyanide	Not Detected						No
F	3	0.110	5	0.104	0.557	0.622	No
Surfactants	2	0.010	4	0.010	Same Mean		No
H_2S	Not Detected						No
NO_2 (as N)	Not Detected						No
NO_3 (as N)	3	0.533	5	0.520	0.343	0.752	No
SO_4	3	7.000	5	6.000	0.447	0.685	No
Gross Alpha	3	6.000	5	8.400	Lower Mean		No
Gross Beta	3	4.000	5	5.000	Lower Mean		No
Ra	3	4.667	5	3.600	1.215	0.277	No
DOC	Not Detected						No
GC Scan	Not Detected						No
Phenols	3	0.003	5	0.003	Same Mean		No
TOC	6	3.153	8	2.701	0.239	0.818	No
TOH	6	0.008	8	0.015	Lower Mean		No
Endrin	Not Detected						No
Lindane	Not Detected						No
Methoxychlor	Not Detected						No
Toxaphene	Not Detected						No
24D	Not Detected						No
245TP (Silvex)	Not Detected						No

Note: T value and probability were generated assuming unequal variances between wells. If probability is $\leq$ .05, probability is 95% or greater that the wells are different; if probability is > .25, probability is greater than 75% that the wells are different; if probability is > .05 and $\leq$ .25, probability is between 95% and 75%, and difference is inconclusive. Units of measurement for the means are the same as reported in the tables in Appendix C.

TABLE 12

Results of t-test Comparison of Downgradient Well ASB 4 and Upgradient Well ASB 3A

Wells:	ASB 4		ASB 3A				
Parameter	N	Mean	N	Mean	t Value	Prob>t	Difference
pH	8	5.288	8	5.413	0.572	0.578	No
Conductivity	8	50.63	8	56.00	Lower Mean		No
TDS	4	929.0	4	38.50	1.022	0.382	No
Turbidity	5	43.40	5	24.34	0.780	0.459	No
Ag	Not Detected						No
As	Not Detected						No
Ba	5	0.051	5	0.054	Lower Mean		No
Be	Not Detected						No
Cd	Not Detected						No
Cr	8	0.009	8	0.005	1.113	0.300	No
Cu	4	0.018	4	0.015	0.246	0.815	No
Fe	5	9.539	5	6.518	0.418	0.687	No
Hg	8	0.0002	8	0.0003	Lower Mean		No
Mn	5	0.041	5	0.018	2.154	0.077	Inconclusive
Na	8	2.130	8	2.876	Lower Mean		No
Ni	4	0.034	4	0.024	0.470	0.664	No
Pb	8	0.010	8	0.007	1.861	0.084	Inconclusive
Se	Not Detected						No
Zn	4	0.085	4	0.120	Lower Mean		No
Cl	5	4.640	5	6.780	Lower Mean		No
Cyanide	Not Detected						No
F	5	0.112	5	0.104	0.956	0.375	No
Surfactants	Not Detected						No
H_2S	Not Detected						No
NO_2 (as N)	Not Detected						No
NO_3 (as N)	5	0.570	5	0.520	0.687	0.525	No
SO_4	5	6.000	5	6.000	Same Mean		No
Gross Alpha	5	8.000	5	8.400	Lower Mean		No
Gross Beta	5	3.800	5	5.000	Lower Mean		No
Ra	5	5.400	5	3.600	1.414	0.196	Inconclusive
DOC	Not Detected						No
GC Scan	4	79.00	4	40.00	1.000	0.391	No
Phenols	5	0.004	5	0.003	0.447	0.671	No
TOC	8	4.724	8	2.701	1.808	0.093	Inconclusive
TOH	8	0.036	8	0.015	1.317	0.220	Inconclusive
Endrin	Not Detected						No
Lindane	Not Detected						No
Methoxychlor	Not Detected						No
Toxaphene	Not Detected						No
24D	Not Detected						No
245TP (Silvex)	Not Detected						No

Note: T value and probability were generated assuming unequal variances between wells. If probability is $\leq .05$, probability is 95% or greater that the wells are different; if probability is $> .25$, probability is greater than 75% that the wells are different; if probability is $> .05$ and $\leq .25$, probability is between 95% and 75%, and difference is inconclusive. Units of measurement for the means are the same as reported in the tables in Appendix C.

TABLE 13

Results of t-test Comparison of Downgradient Well ASB 5A and Upgradient Well ASB 3A

Wells:	ASB 5A		ASB 3A				
Parameter	N	Mean	N	Mean	t Value	Prob>t	Difference
pH	6	4.533	8	5.413	5.557	0.001	Yes
Conductivity	6	64.50	8	56.00	0.779	0.452	No
TDS	2	45.00	4	38.50	0.384	0.750	No
Turbidity	3	46.33	5	24.34	0.469	0.678	No
Ag	Not Detected						No
As	Not Detected						No
Ba	3	0.014	5	0.054	Lower Mean		No
Be	Not Detected						No
Cd	Not Detected						No
Cr	Not Detected						No
Cu	2	0.005	4	0.015	Lower Mean		No
Fe	3	0.033	5	6.518	Lower Mean		No
Hg	6	0.00023	8	0.00026	Lower Mean		No
Mn	3	0.019	5	0.018	0.103	0.924	No
Na	6	6.173	8	2.876	5.859	0.001	Yes
Ni	Not Detected						No
Pb	6	0.008	8	0.007	0.956	0.360	No
Se	Not Detected						No
Zn	2	0.158	4	0.120	0.294	0.803	No
Cl	3	9.967	5	6.780	3.151	0.043	Yes
Cyanide	Not Detected						No
F	3	0.103	5	0.104	Lower Mean		No
Surfactants	Not Detected						No
H_2S	Not Detected						No
NO_2 (as N)	Not Detected						No
NO_3 (as N)	3	0.717	5	0.520	0.904	0.461	No
SO_4	Not Detected						No
Gross Alpha	3	4.000	5	8.400	Lower Mean		No
Gross Beta	3	2.667	5	5.000	Lower Mean		No
Ra	3	2.667	5	3.600	Lower Mean		No
DOC	Not Detected						No
GC Scan	2	47.00	4	40.00	1.000	0.500	No
Phenols	3	0.002	5	0.003	Lower Mean		No
TOC	6	1.991	8	2.701	Lower Mean		No
TOH	6	0.177	8	0.015	3.196	0.023	No
Endrin	Not Detected						No
Lindane	Not Detected						No
Methoxychlor	Not Detected						No
Toxaphene	Not Detected						No
24D	Not Detected						No
245TP (Silvex)	Not Detected						No

Note: T value and probability were generated assuming unequal variances between wells. If probability is $\leq$ .05, probability is 95% or greater that the wells are different; if probability is > .25, probability is greater than 75% that the wells are different; if probability is > .05 and $\leq$ .25, probability is between 95% and 75%, and difference is inconclusive. Units of measurement for the means are the same as reported in the tables in Appendix C.

TABLE 14

Results of t-test Comparison of Downgradient Well ASB 6A and Upgradient Well ASB 3A

Wells:	ASB 6A		ASB 3A				
Parameter	N	Mean	N	Mean	t Value	Prob>t	Difference
pH	6	4.250	8	5.413	6.665	0.001	Yes
Conductivity	6	47.83	8	56.00	Lower Mean		No
TDS	2	13.50	4	38.50	Lower Mean		No
Turbidity	3	52.43	5	24.34	0.549	0.631	No
Ag	Not Detected						No
As	Not Detected						No
Ba	3	0.009	5	0.054	Lower Mean		No
Be	Not Detected						No
Cd	Not Detected						No
Cr	Not Detected						No
Cu	2	0.009	4	0.015	Lower Mean		No
Fe	3	0.027	5	6.518	Lower Mean		No
Hg	Not Detected						No
Mn	3	0.031	5	0.018	1.040	0.384	No
Na	6	3.862	8	2.876	2.690	0.030	Yes
Ni	Not Detected						No
Pb	6	0.014	8	0.007	1.624	0.159	Inconclusive
Se	Not Detected						No
Zn	2	0.037	4	0.120	Lower Mean		No
Cl	3	7.367	5	6.780	0.906	0.400	No
Cyanide	Not Detected						No
F	3	0.107	5	0.104	0.343	0.752	No
Surfactants	Not Detected						No
H_2S	Not Detected						No
NO_2 (as N)	Not Detected						No
NO_3 (as N)	3	0.750	5	0.520	1.578	0.252	No
SO_4	Not Detected						No
Gross Alpha	3	5.333	5	8.400	Lower Mean		No
Gross Beta	3	4.667	5	5.000	Lower Mean		No
Ra	3	3.667	5	3.600	0.040	0.970	No
DOC	Not Detected						No
GC Scan	Not Detected						No
Phenols	3	0.003	5	0.003	Same Mean		No
TOC	6	2.159	8	2.701	Lower Mean		No
TOH	6	0.018	8	0.015	0.411	0.688	No
Endrin	Not Detected						No
Lindane	Not Detected						No
Methoxychlor	Not Detected						No
Toxaphene	Not Detected						No
24D	Not Detected						No
245TP (Silvex)	Not Detected						No

Note: T value and probability were generated assuming unequal variances between wells. If probability is $\leq .05$, probability is 95% or greater that the wells are different; if probability is > .25, probability is greater than 75% that the wells are different; if probability is > .05 and $\leq .25$, probability is between 95% and 75%, and difference is inconclusive. Units of measurement for the means are the same as reported in the tables in Appendix C.

IDENTIFICATION OF CONTAMINANT SUBSTANCES AND ESTIMATED INVENTORIES

Chemical constituents that have been disposed of at existing waste sites at SRP have been identified and their inventories estimated. This information is used to assess the environmental impacts and health risks associated with the various site closure options being considered. All available records have been reviewed to determine which substances were released to the waste sites during their operational histories. Where available, these records include groundwater monitoring data, waste-site characterization studies, influent waste stream measurements, and process chemical records. These inventories provide the source term information required to calculate the transport and potential risk for each material.

The concentrations of chemical constituents released to each waste site were compared to special selection criteria (Looney et al., 1987a). If the groundwater or soil concentration of a given constituent exceeded its selection criterion, the material was designated for inclusion in the transport modeling and risk assessment studies. Additionally, if large amounts of specific chemicals with a health or environmental risk were believed to have been released to a site (based upon inventory or process use), these constituents were also designated for assessment, even if the soil or groundwater characterization data did not indicate their presence.

Based upon available information of substances released to the SRL Seepage Basins during their operational history and soil core data, the following list of contaminants was selected for environmental assessment.

Materials Selected For Environmental Assessment

Selected Constituents	Estimated Disposal Mass (kg)	Selected Constituents	Estimated Disposal Activity (Ci)
Arsenic	230	^{241}Am	0.03
Cadmium	5	^{137}Cs	4
Chromium	320	^{60}Co	0.05
Copper	100	^{244}Cm	0.35
Fluoride	1,000	^{238}Pu	0.02
Lead	70	^{239,240}Pu	0.09
Mercury	10	^{90}Sr	1
Nickel	60	^{235}U	0.007
Phosphate (as P)	4,000	^{238}U	0.08
Silver	5	^{3}H	105
Sodium	24,000		
Zinc	215		

Note: Fractions to groundwater pathway is 1, except for tritium, which is 0.5. Arsenic, cadmium, chromium, copper, fluoride, lead, mercury, nickel, silver, and zinc inventories are based on soil core data, not the historical loadings calculated from a single analysis presented earlier.

Radionuclides, fluoride, and all of the metals (excluding zinc) were selected because of their elevated levels in sediment cores. Sodium, phosphate, and zinc are on the list because the estimated volumes of these chemicals discharged to the SRL Seepage Basins were in amounts significantly greater than normal soil background concentrations. All of the radionuclide activities represent 1985 decayed values. Other chemicals listed in Table 4 and noted in the statistical analysis of groundwater data were not selected because of their low concentrations and minimal potential for environmental effects (Looney et al., 1987a).

CLOSURE OPTIONS

The SRL Seepage Basins will be closed at some future date in accordance with all applicable state and federal regulations. Many closure options for these sites could be developed and evaluated for environmental soundness and cost effectiveness. To establish a range for potential environmental consequences and funding requirements for closure of the sites, three basic options have been examined:

- Waste removal and closure
- No waste removal and closure
- No action

These options were not developed specifically for regulatory compliance, but to bound the potential impact of possible future closure actions.

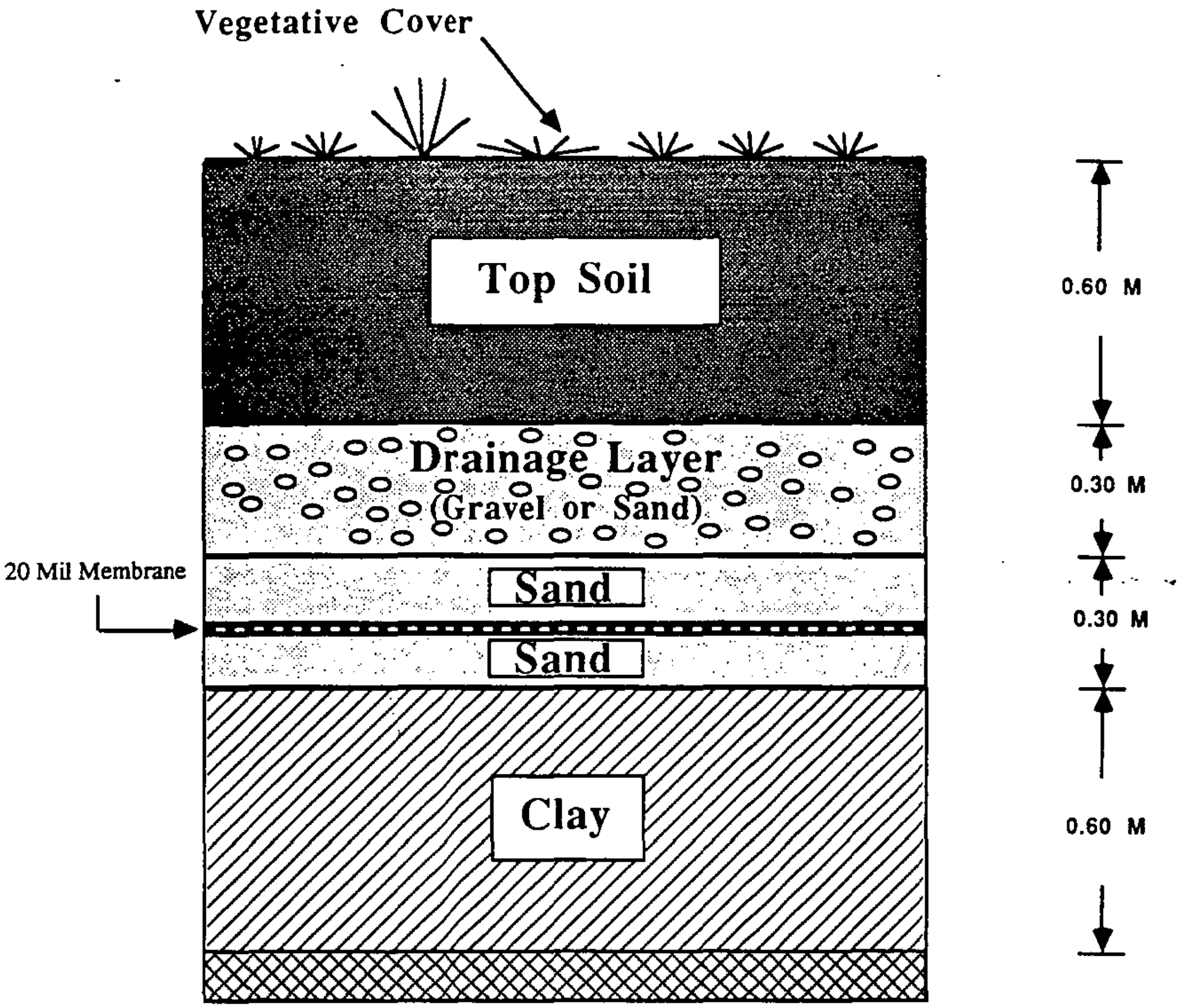
Each closure option except the no action option would require removal of the water in basins 1 through 3 to basin 4. Removal of standing water in basin 4 would be carried out by continued seepage, supplemented by accelerated evaporation if required. The specific details of the commitments to maintenance, monitoring, and cap design in this section were selected primarily for the purpose of deriving reasonable and consistent relative cost estimates.

WASTE REMOVAL AND CLOSURE

Under the waste removal and closure option, the basins would be excavated of waste, backfilled, capped, and the waste disposed of to a waste storage/disposal facility. Approximately 31 cm would be excavated from basins 1 and 2; 16 cm from basin 3; and a scraping of approximately 8 cm from basin 4. The fill would consist of 61 to 122 cm of crushed stone or washed gravel covered by a geotextile filter fabric and at least 61 cm of borrow fill. This fill would be covered by a site cap (Figure 20). Approximately 1,900 m^3 would be excavated from the basins and disposed of in a waste storage/disposal facility. Backfill details are provided in Figures 21 and 22. Groundwater would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance (trimming of vegetation and repair of fencing) would be continued for the entire 30-year period.

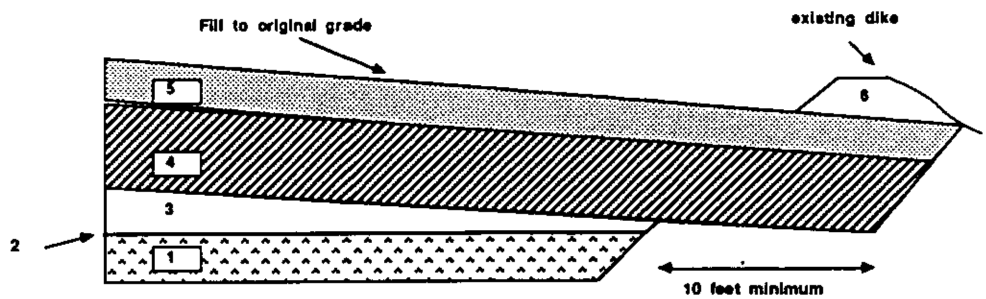
NO WASTE REMOVAL AND CLOSURE

Environmental assessment was performed for two suboptions for the no waste removal and closure option: (1) no waste removal and closure with a cap and (2) no waste removal and closure without a



Note: Permeability of drainage layer is >1.03E-03 cm/s. Permeability of clay is <1.0E-07 cm/s. Infiltration reduction is 99%.

FIGURE 20. Schematic Diagram of Low-Permeability Cap



TYPICAL BASIN BACKFILL DETAILS

LEGEND:

1 Crushed stone or washed gravel (8 to 15 cm uniform size stone). Approximately 0.6 m. thick

2 Geotextile filter fabric.

3 Common borrow fill. Thickness varies from 0 to 1 m.

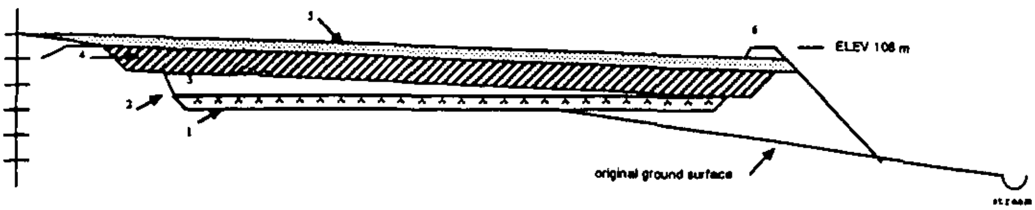
4. Low permeability cap. Group approximately 1.3 m thick (this would be common borrow fill for backfill withot cap;option).

5. Topsoil. Approximately 0.6 m thick.

6. Remove existing dike and use a fill where needed.

1 ft = 0.3048 m

FIGURE 21. Typical Basin Backfill Details of SRL Seepage Basins



BACKFILL DETAILS FOR BASIN 4

LEGEND:

1 Crushed stone or washed gravel (8 to 15 cm uniform size stone). Approximately 0.6 m. thick

2 Geotextile filter fabric.

3 Common borrow fill. Thickness varies from 0 to 1 m.

4. Low permeability cap. Group approximately 1.3 m thick (this would be common borrow fill for backfill without cap option).

5. Topsoil. Approximately 0.6 m thick.

6. Remove existing dike and use a fill.

FIGURE 22. Backfill Details for Basin 4 of SRL Seepage Basins

cap. The results of both suboptions will be presented for this site to aid in assessing the incremental protection resulting from the cap for a typical waste site.

Under the no waste removal and closure with cap option, the basins would be backfilled, and the site capped using the cap shown in Figure 20. There would be no excavation (Figures 21 and 22). The fill and cap would be as described above. Groundwater would be monitored quarterly for 1 year, then annually for 29 years.

There would be no excavation under the no waste removal and closure without cap option. The basins would be backfilled but not capped. The fill would consist of 61 to 122 cm of crushed stone or washed gravel covered by a geotextile filter fabric and a minimum of 180 cm of common borrow fill. The site would be restored to the original ground surface (Figure 23), except basin 4 would be filled and graded, remaining above the original grade to assure that the bottom sediments are covered. Groundwater would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would be continued for the entire 30-year period.

NO ACTION

Under the no action option, the site would be left in its present condition. Groundwater monitoring with existing wells would be continued. Upkeep would consist of maintaining a fence and signs around the basin area and cutting the weeds periodically. Groundwater would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would be continued for the entire 30-year period.

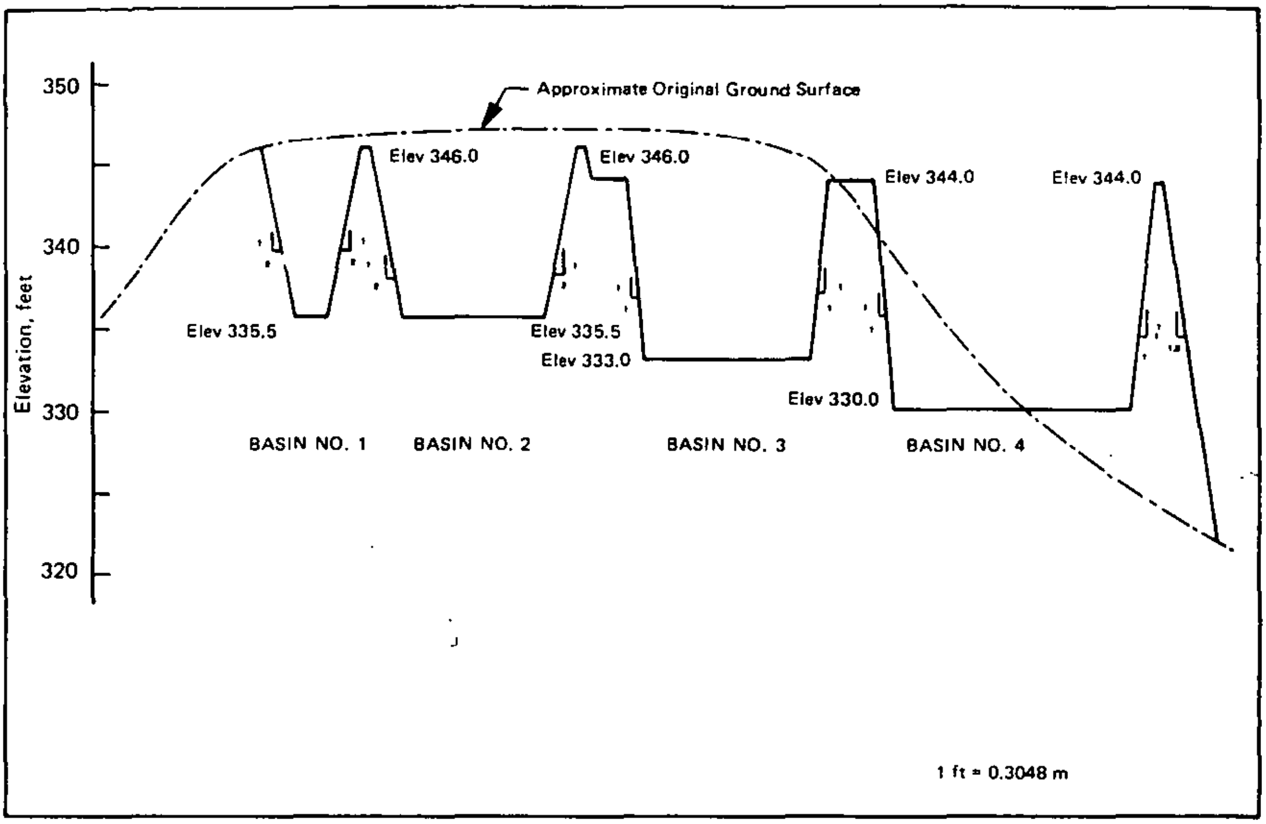


FIGURE 23. Cross Section of the SRL Seepage Basins

ESTIMATES OF ENVIRONMENTAL IMPACTS

The environmental consequences due to closure actions at waste disposal facilities can be grouped into two categories. The first is the relative risk to human health resulting from potential exposure to waste materials transported through groundwater or atmospheric pathways. The second is the potential impact on the aquatic and terrestrial ecosystems due to transport of waste materials into these environments.

Estimates of the environmental impacts in terms of potential human health risk and ecological upsets due to the postulated closure options for the SRL Seepage Basins have been completed. The results of these evaluations are given in the following sections along with the details of analysis.

Three premises are assumed in the analysis of potential environmental consequences. First, it is assumed that the Department of Energy (DOE) will maintain institutional control over the SRP site for 100 years beyond 1985. This assumption is reasonable in light of current production planning and projected scheduling for site decommissioning. Second, the basic time period for the long-term analyses has been set at 1,000 years beyond 1985 because Environmental Protection Agency (EPA) and Nuclear Regulatory Commission (NRC) guidelines specify 1,000 years as a reasonable time for projected calculations. Third, it is assumed that nearly all (99%) of the current waste source is removed in the waste removal and closure option.

HUMAN HEALTH RISKS

Pathway Analysis

In a general sense, exposure of waste materials in a disposal facility to a human population can occur only as a result of transport via surface, subsurface, or atmospheric pathways. At SRP the surface and subsurface pathways of most importance are groundwater movement to water wells, groundwater movement to surface streams, erosion of waste materials and movement to a surface stream, consumption of food produced from farmland reclaimed over a waste site, consumption of crops grown from natural biointrusion into a waste site, and direct exposure to gamma radiation. The relevant atmospheric pathways for human exposure are inhalation of waste particulates or gases in air, ingestion of foodstuffs containing waste materials resulting from deposition of air particulates on the ground surface, and external radiation from air particulates deposited on the ground. Computer codes for simulating transport of waste constituents through surface, subsurface, and atmospheric pathways are described briefly below and in more detail in Stephenson et al. (1987).

Surface and Subsurface Pathways

To calculate the human health risks associated with surface and subsurface transport of radioactive and nonradioactive waste materials, the PATHRAE computer code was chosen. Developed for the EPA for performance assessment calculations of low-level radioactive waste sites, the code has been modified to perform transport and risk calculations for nonradioactive waste materials as well.

The PATHRAE methodology was used to calculate the surface and subsurface pathway scenarios of interest at the SRL Seepage Basins. These pathways are groundwater movement to nearby hypothetical water wells, groundwater movement to surface streams and ultimately to the Savannah River, waste erosion and movement to a surface stream and ultimately to the Savannah River, consumption of food grown on reclaimed farmland over the waste site, consumption of crops grown from natural biointrusion into the waste site, and direct gamma exposure.

For groundwater movement to nearby water wells, the pathway consists of downward migration of the modeled waste components through advection and diffusion or as a result of dissolution in percolating precipitation. The PATHRAE calculations assume that a small fraction of the cationic contaminants will be in a more highly transportable form (K_d =0.001 mL/g) to account for chemical speciation and factors that result in high mobility of cations (low pH, organic and/or inorganic complexation). This fraction is termed the facilitated transport fraction. This assumption results in a conservative calculation of the transport of cations through the hydrologic system in the time period of interest and is in agreement with groundwater monitoring results. These waste components move downward through the unsaturated zone to the aquifer below the disposal site. They mix with water in the saturated zone of the aquifer and move to nearby wells located downgradient (in the sense of aquifer flow). Two hypothetical well scenarios are analyzed: one immediately adjacent to the waste disposal facility (at 1 m) and one downstream from the edge of the facility (at 100 m). The models for both vertical and horizontal movement of waste materials account for chemical retardation by the soils. Once withdrawn from the well, the water is assumed to be consumed directly by individuals or used to irrigate crops that are then consumed by these same individuals.

For groundwater movement to surface streams, the pathway is similar to the one described above, but the modeled waste components are assumed to continue to move through the aquifer until released to surface waters. For the purpose of analyzing the potential impacts of releases through this pathway, the release is assumed to be into nearby surface streams and ultimately into the Savannah River, with its downstream consumer populations. For modeling purposes, the waste components are assumed to be transported instantaneously to the Savannah River without further dilution and to be completely mixed with water in the Savannah River.

The scenario for erosion and movement to a surface stream involves the gradual removal of the cover over the disposed waste by erosion and eventually the slow removal of the waste itself. The time required for erosion of the total cover depth is calculated. Then erosion operates on the waste materials by removing a given amount (specific depth) from the top of the waste each year. A conservative assumption is made that the modeled eroded waste components flow over the ground surface and into the surface stream in the same year they are removed from the disposed waste volume. Once the waste components reach the surface stream, they are assumed to be transported instantaneously to the Savannah River without further dilution and to be completely mixed with water in the Savannah River.

The pathway for consumption of food grown on reclaimed farmland accounts for potential exposure of individuals to waste materials through the human food chain. This pathway assumes that reclamation activities are required to cause exposure to waste materials. The means for disturbing the waste materials are modeled as drilling wells through the waste and excavating basements for homes. A volume of waste excavated by these activities is assumed to be completely mixed with a volume of soil down to 1 m. The soil mixture then is assumed to be used to grow a representative set of edible crops and forage for milk- and meat-producing animals. Individuals are assumed to get some fraction of their food needs from contaminated crops, meat, and milk.

A slightly different pathway involves consumption of crops whose roots have grown through subsurface sediments by natural biointrusion. Vegetation roots are presumed to take up waste constituents, and these crops, contaminated by root uptake, are directly consumed by humans. The distinction here is that no reclamation activities are imposed, only crops are consumed, and then only directly.

The direct gamma exposure pathway calculates the external radiation dose to an individual standing directly over a waste site. The cover material over the waste is allowed to erode at a specified rate, so the degree of shielding provided by the cover may decrease in time. For this pathway the conservative assumption is made that no loss of contaminants occurs by leaching to the groundwater pathways. The time dependence of the source term is described solely by radioactive decay.

Atmospheric Pathway

Modeling calculations to determine potential risk to human populations due to atmospheric transport of waste materials have been made using a variety of computer codes. The pathway scenarios considered for the SRL Seepage Basins are inhalation of polluted air, ingestion of contaminated foodstuffs, and exposure to direct gamma radiation.

Atmospheric source terms for the site must first be estimated from soil inventories. Atmospheric source terms account for volatilization of select contaminants (i.e., organics), dust generated by suspension of contaminated soil due to wind erosion (saltation), and dust generated as a consequence of excavation of contaminated soil from the site. The time-dependent nature of atmospheric source terms must also be estimated to account for the time period of interest in this analysis (1,000 years). SESOIL, an EPA soil layer model, is used to estimate the soil contaminant concentration profiles as a function of time. The model accounts for potential upward transport (volatilization) and downward movement (infiltration) of each contaminant for each closure option. Airborne contaminant loadings are estimated using SESOIL and MARIAH (a newly developed computer code that employs a National Oceanographic and Atmospheric Administration box model and EPA source term equations). SESOIL estimates the amount of contamination entering the atmosphere over time from the site via volatilization. MARIAH estimates suspended dust loading to the atmosphere and excavation-generated dust loading due to digging, vehicular movement, and dumping. The source term for potential atmospheric transport away from the site--the contaminant loading due to dust--is the product of the dust loading and the contaminant concentration in the top soil layer.

The transport of contaminants from a waste disposal facility to potential receptor sites through atmospheric dispersion is modeled using the XOQDOQ computer code (Sagendorf et al., 1982), an NRC model used for routine atmospheric dispersion calculations at SRP. The calculated dispersion has been verified by environmental measurements of tritium (Marter, 1984). The XOQDOQ transport code uses a modified Gaussian plume model to estimate contaminant concentration as a function of distance and direction from a waste site. Time-dependent contaminant source strength and meteorological conditions are also input parameters.

Calculation of the transport of materials from SRP by the atmosphere is based on meteorological conditions that are measured continuously at seven on-plant meteorological towers and at a 366-m television transmitting tower 30 km northwest of the geometric center of SRP. For this analysis, meteorological dispersion and deposition were calculated with meteorological measurements over a 5-year period (1975 through 1979) collected at a meteorological tower located near the center of the SRP site (H Area).

After waste contaminant concentrations at potential receptor locations are determined, the results are translated into individual and population exposures. The maximum exposed individual at the site boundary and general population exposures to airborne contaminants via inhalation, ingestion, and direct gamma radiation pathways are estimated for nonradioactive and radioactive constituents.

Nonradioactive Constituents

The CONEX computer code uses XOQDOQ transport results and local population demographics to estimate time-dependent population exposures to nonradioactive constituents. The TERREX computer code also uses XOQDOQ transport results along with local crop production data and local population demographics to estimate population exposures to contaminated foodstuffs. The population demographics used in the CONEX and TERREX codes are estimated using a population growth model. Using census data from 1980 as the initial basis, the population growth model estimates the surrounding population from 1980 to 2050. After 2050, the population is assumed to be constant. After the end of the assumed period of institutional control (2085), it is assumed that the SRP reservation is inhabited by the public. Hence, the air receptor is closer to the waste site at the end of the period of institutional control.

Risk posed to the public population from nonradioactive constituents is calculated using a newly developed computer code called MILENIUM. For each potentially airborne contaminant, the MILENIUM code translates time-dependent exposure results into a population dose and into a maximum exposed individual dose. Calculated doses are then converted to risk estimates in the MILENIUM code.

Radioactive Constituents

To calculate the human health risks associated with atmospheric transport of radioactive waste materials, transport and dosimetry models developed by the NRC and others for assessing the effects of operations of licensed commercial nuclear facilities were chosen (NRC, 1977a, 1977b; ICRP, 1978). The radioactive transport and dose models have been implemented in the computer codes MAXIGASP and POPGASP as well as XOQDOQ. MAXIGASP is a computer program to calculate maximum and average doses to offsite individuals from atmospheric releases. POPGASP is a computer program to calculate population doses from atmospheric releases. Both of these codes are SRL-modified versions of the NRC program GASPAR (Eckerman et al., 1980). The modifications are those needed to meet the requirements for input of specific SRP physical and biological data. The basic calculational methods used in the GASPAR program were not modified.

Radioactive materials released to the environment generally become involved in a complex series of physical, chemical, and biological processes. Some of these processes involve dilution while others involve physical or biological reconcentration, followed by transfer through various pathways to man.

Annual average concentration and deposition factors calculated with the XOQDOQ program are used in the MAXIGASP and POPGASP programs along with data on population distribution, vegetable crop production, milk production, and meat production to calculate offsite radiation exposure. The major exposure pathways considered in the calculation of atmospheric doses are briefly described as follows:

Pathway	Description
Plume	External dose from radioactive materials transported by the atmosphere
Ground	External dose from radioactive material deposited on the ground
Inhalation	Internal dose from inhalation of radioactive materials transported by the atmosphere
Vegetation	Internal dose from consumption of vegetable food crops that contain radioactive material deposited from the atmosphere.
Milk	Internal dose from consumption of milk that contains radioactive material deposited from the atmosphere into the human food chain through livestock
Meat	Internal dose from consumption of meat products that contain radioactive material deposited from the atmosphere into the human food chain through livestock

Occupational Exposure

Risk posed to the worker involved in waste excavation activities of nonradioactive constituents is estimated using the MARIAH and MILENIUM computer codes. The MARIAH code estimates the amount of dust generated during the excavation of a waste site and the time required to complete the activity. The MILENIUM code uses these results and appropriate conversion factors to estimate worker risk. A conservative assumption built into these models is that the occupational work force would not use any special protective clothing during waste excavation operations. Calculated risks for workers using standard respiratory equipment at sites with significant exposure potential were assumed to be reduced by a factor of 50.

Radiation exposure pathways are evaluated to calculate risks attributable to closure activities. Exposure from the following pathways are considered: internal dose (from inhalation) to personnel directly involved in cleanup activities; external dose to personnel directly involved in cleanup activities; and external dose to personnel involved in transportation of contaminated waste.

For the inhalation pathway, parameters such as the size of the work force, volume of waste to be excavated, and the number of work days required to excavate the waste are estimated. Concentrations of waste constituents in the air to which workers are exposed at the waste site are calculated with dust generation and resuspension models described previously and combined with work-force parameters to estimate worker inhalation exposure (no respiratory protection is assumed), dose commitment, and risk.

Exposures due to external irradiation of site workers are estimated using the DECOM computer code (Till & Moore, 1986), a pathway analysis methodology that calculates the quantity of contaminated soil that must be removed in order to keep exposures from all potential pathways below a value selected by the user. External dose rate is calculated using the dose factors of Kocher and Sjoreen (1985). The model employed in DECOM accounts for radionuclide contamination in 15-cm increments of depth and estimates exposure from the top 15 cm as well as the contribution from contaminated soil beneath the exposed layer. Worker exposure is estimated for the work crew (excluding truck drivers) by assuming workers are exposed to the external radiation field at each area for the period of cleanup required for the area. Exposure of drivers to external radiation is assumed to occur during transport of excavated waste from the site to a waste storage/disposal facility. The total time of exposure for each driver is assumed to be 4 hr/day for the period of cleanup required for the area. The exposure rate is conservatively assumed to be equal to the external exposure rate at 1 m above the ground as calculated by DECOM. No credit for shielding provided by the metal boxes is taken into account.

It is assumed there will be no release of radioactive materials from the metal boxes during routine transport. Further, because the material is being transported within the boundary of the Savannah River Plant, it is assumed there will be no exposure to the public and no significant exposure to employees on site involved in activities not related to the cleanup of this area.

Risk Assessment Procedure

Risk assessment may be divided into three major components: (1) hazard assessment, consisting of hazard identification and dose-response assessment; (2) exposure assessment; and (3) risk characterization. These fundamental steps are common to all assessments of the risk of exposure to pollutants, regardless of the substances under investigation; the species, populations, or environmental systems at risk; the medium (or media) in which exposure occurs; the route of exposure; or the adverse effects under consideration.

Hazard assessment involves the identification of waste contaminants of concern (i.e., subjects of the risk assessment) and an initial determination of the intrinsic toxicity of these contaminants under consideration (dose-response assessment). Exposure assessment is the process of measuring or estimating the intensity, duration, and frequency of exposure to these contaminants. Other elements critical to the exposure assessment are the identification of routes of exposure and the determination of human and/or nonhuman receptors at risk. The final component of the risk assessment process, risk characterization, can be defined as the process of estimating the incidence of an adverse effect under the various conditions of exposure described in the exposure assessment. Risk characterization is conducted by combining the results of the exposure and hazard (dose-response) assessments.

Risk assessment procedures for radioactive constituents are briefly described below and are treated in more detail in King et al. (1987).

Nonradioactive Constituents

It is common practice to consider risk characterization for carcinogens and noncarcinogens separately because of a fundamental difference in the way organisms typically respond to these classes of compounds. For noncarcinogens, toxicologists recognize the existence of a threshold of exposure below which there is only a very small likelihood of adverse health effects in an exposed population. Exposure to carcinogenic compounds, however, is not characterized by the existence of a threshold. Rather, all levels of exposure are considered to carry a risk of adverse effects.

The procedure for calculating risk of exposure to carcinogenic compounds is well documented (EPA, 1985a; National Research Council, 1983; Rodricks, 1984). A nonthreshold dose-response model is used to calculate a unit risk value (risk per unit dose) for each chemical. The risk per unit dose (unit carcinogenic risk) is then multiplied by the estimated average daily lifetime dose experienced by the exposed individual or population to derive an estimate of risk (R) as follows:

$$R = D \times UCR$$

where D = average daily lifetime dose (mg/kg body weight/day). A 50-year exposure lifetime and 70-kg body weight are assumed.

UCR = unit carcinogenic risk estimate $[(\text{mg/kg body weight/day})^{-1}]$

The risk value is an explicit estimate of risk and will have a value between 0 and 1. In this environmental analysis, this risk is called chemical carcinogenic risk and for an exposed individual has units of health effects (HE) per lifetime; for an exposure population the units are simply health effects. In evaluating risk of exposure to more than one carcinogen, the risk values for each compound may be summed to give an overall estimate of total carcinogenic risk (EPA, 1985a; Rodricks, 1984). This summing is done for each source of environmental release, for each associated exposure pathway, and for each receptor group at risk of exposure.

The traditionally accepted practice of evaluating exposure to noncarcinogenic compounds has been to determine a no-observable-effect-level (NOEL) experimentally and to divide this level by a safety factor in order to establish an acceptable human dose. This acceptable human dose has been labeled as an acceptable daily intake (ADI) by the National Research Council (1983). The ADI is then compared to the average daily dose experienced by an exposed individual to obtain a measure of risk (R) as follows:

$$R = D/ADI$$

where D = average daily dose (mg/kg body weight/day). A one-year exposure period and 70-kg body weight are assumed.

ADI = acceptable daily intake for chronic exposure (mg/kg body weight/day)

The method of developing acceptable limits of exposure implies that the application of safety factors of various magnitudes to an experimentally derived NOEL will ensure minimal risk. The acceptable exposure levels (e.g., ADIs) are typically derived by making assumptions about the nature of dose-response relationships at low doses and drawing inferences based upon the available data (National Research Council, 1983).

The risk values derived for noncarcinogens will vary from <1 to >1. This risk is called noncarcinogenic risk and for an exposed individual has units of ADI fraction. Unlike the estimates of R derived for carcinogens, however, R values for noncarcinogens cannot be meaningfully summed to obtain an overall estimate of noncarcinogenic risk from a given waste site for a given exposure pathway and receptor group. However, as a method of estimating the relative hazard of a mixture of noncarcinogenic chemicals, the noncarcinogenic risk values for an exposed individual will be summed and called the EPA Hazard Index (a unitless parameter). The basis for such treatment of risk results is the EPA Guidelines (EPA, 1985b) for health risk assessment of chemical mixtures, in which EPA defines a hazard index of the mixture based on the assumption of additivity. Because a threshold dose-response model is used in calculating noncarcinogenic risk, it is not meaningful to extrapolate noncarcinogenic population risks. The ADI fraction and EPA Hazard Index are not mathematical predictions of incidence of effects or severity, but are only numerical indicators of the transition between acceptable and possibly unacceptable exposure levels.

It is important to emphasize that the proposed methods for evaluating carcinogenic and noncarcinogenic hazards have been used only in evaluating the relative risk of adverse effects from postulated closure options at a given waste site or from one site to the next at the Savannah River Plant. The methods as proposed by EPA and the National Research Council are not to be assumed to be a quantitative evaluation and prediction of the incidence of adverse effects in exposed populations. The proposed methods are a tool for relative assessment of risk (i.e., comparison across sites or across closure options).

The data base (King et al., 1987) for UCRs and ADIs for inhalation and ingestion pathways was derived from the EPA Superfund Public Health Evaluation Manual (EPA, 1985a), which was designed to conform to EPA's proposed risk assessment guidelines (EPA, 1985b; Federal Register, 1984) and to serve as a framework for analyzing public health risks and for developing design goals for closure options.

Radioactive Constituents

The risk associated with exposure to radioactive materials is typically characterized by a linear no-threshold model for establishing the likelihood of adverse health effects. Most scientists generally acknowledge the lack of a threshold of exposure; that is, all levels of exposure are considered to carry a finite risk of adverse effects.

Estimates of health risks associated with calculated exposures to radioactivity were made using the guidelines of the International Commission on Radiological Protection (ICRP, 1975, 1977). The detrimental health effects against which radiation protection is required are known as somatic and hereditary. Radiation effects are called somatic if they become manifest in the exposed individual and hereditary if they affect the individual's descendants. Carcinogenesis is considered to be the chief somatic risk of irradiation at low doses and, therefore, the main problem in radiation protection.

The units of radiation dose to an individual are usually expressed in millirem (mrem). To put this in perspective, an individual receives an average annual radiation dose of 93 mrem from natural sources of radiation in the vicinity of SRP. Population dose commitment is the sum of individual dose commitments in a population group and is expressed in units of person-rem.

Radiological doses are calculated with dose factors (King et al., 1987) based on methodology developed by the ICRP as reported in its Publication 30 (ICRP, 1978) and recently implemented by DOE. These dose factors relate intake of radioactive materials through ingestion and inhalation to the dose commitment received for 50 years following intake.

The procedure for determining the risk of exposure to a radionuclide requires two basic calculations. First, the radionuclide intake in a given year is multiplied by a dose conversion factor for the specific radionuclide of interest to establish a dose equivalent value. Mathematically this is represented as follows:

$$CEDE = C \times DCF$$

where CEDE = committed effective dose equivalent for a given environmental pathway (mrem/yr)

C = calculated annual intake of radioactivity for a given environmental pathway (pCi)

DCF = dose conversion factor for a given radionuclide based on ICRP guidelines (mrem/pCi)

Second, the risk of radiation exposure is found by multiplying the committed effective dose equivalent by the risk conversion factor. This equation is as follows:

$$R = CEDE \times RCF$$

where R = radioactive risk (health effects/yr of intake)

RCF = risk conversion factor (health effects/mrem)

For this environmental analysis, radioactive risk to an individual is the incremental probability of a health effect (somatic and genetic) over the 50-year lifetime of an adult male resulting from chronic intake in the first year. The units for individual radioactive risk are health effects (HE) per year of intake. Radioactive risk to the exposed population is an estimate of the projected number of incremental health effects (somatic and genetic) for the exposed population. The units for radioactive risk to a population are health effects for the receptor group during the time period of interest.

Although the frequency of effects resulting from radiation exposure is dependent on age, sex, type of radiation, and other factors, a review of reports by the Committee on the Biological Effects of Ionizing Radiation (NAS, 1980), the ICRP (ICRP, 1977), and the Office of Radiation Programs of the Environmental Protection Agency (EPA, 1985c) indicates that, for average populations, a reasonable range for the risk conversion factor is 1.65E-04 to 2.80E-04 adverse effects per rem of dose. For this assessment, a conservative value reflecting the upper limit of the above range has been chosen to convert dose to health effects for water, terrestrial, atmospheric, and occupational pathways.

The dose and health risk data should be used with caution since they are not presented for the purpose of calculating projected cancer deaths or other health-effect assessments, but are presented solely to provide a basis for evaluation and comparison of waste-site closure action alternatives. Although the codes used in the risk assessment process represent state-of-the-art technology in risk estimation, they necessarily involve numerous assumptions and generalizations that may be highly uncertain under some conditions. Hence, their application is more reliable for comparing relative risks from exposures via similar environmental pathways than for estimating absolute risks of human health effects.

Results

Surface and Subsurface Pathways

The surface and subsurface pathways for transport of waste materials, the resulting potential exposures to the human population, and the excess risk posed to human health for the postulated closure options for the SRL Seepage Basins have been calculated using the PATHRAE code. Standard options in the code are used to represent both the current waste-site condition and its potential configurations covered in the closure options. The pathways modeled are groundwater movement to hypothetical water wells nearby, groundwater movement to surface streams, waste erosion and movement to a surface stream, consumption of food grown on reclaimed farmland, consumption of crops grown through natural biointrusion, and direct gamma exposure. All scenarios with the exception of groundwater movement and waste erosion to surface streams are assumed to occur immediately after the 100 years of institutional control. The groundwater movement and waste erosion pathways to surface streams may occur before the end of the assumed 100-year period of institutional control. It should be noted that the events may not occur for many hundreds of years, if at all, even without institutional control.

The four seepage basins are represented as if they are a single larger basin with the combined areas, volume capacities, and waste inventories of the four. This approximation is made for economy of analysis effort and because the results of the analyses of the four basins will ultimately be used as a unit. The grouping of the four is justified by several considerations: they were interconnected to receive the same liquid wastes; they operated simultaneously for 22 of their 28 years of service; they are located adjacent to each other; their size scale is small relative to the dimensions of known variations of geohydrological parameters in the SRL region; and their hydraulic heads were similar throughout their period of service. Possible limitations in the combined grouping are chemical precipitation or other selective removal of certain species in one basin relative to the others and changes in waste composition during the first 4 to 6 years when the third and fourth basins were not in service. These limitations are of minor importance, however, since they should have relatively small effects on the ultimate spatial and temporal distributions of the waste contaminants in the exposure pathways. The average facility parameters are defined in Table 15.

In modeling the basins for the no action option the operating lifetime of the basins was set equal to 28 years, assuming that the wastes were deposited in the basins uniformly over the 28-year operating period. The water seepage rate is estimated to be 1.10 m/yr during operation of the basins. This rate leads to a vertical water velocity of approximately 5.5 m/yr.

For any of the closure options in which the basin is backfilled with soil, several parameters would change. The infiltration rate would be reduced, and this, in turn, would reduce the vertical water velocity in the unsaturated zone. If the basin is backfilled, the added soil would also serve to alter parameters defining the surface erosion, reclaimed-farmland, and biointrusion pathways.

TABLE 15

SRL Seepage Basin Facility Parameters for PATHRAE Calculations

Parameter	Value (m)
Facility length (parallel to aquifer)	142
Facility width	60
Waste thickness	1

For the waste excavation option, the inventory is reduced to account for the removal of sediments and soil below the basin. The amounts of contaminants removed are calculated using the vertical water velocity and contaminant retardation factors to determine the vertical extent of migration relative to the depth of excavation. For contaminants with low mobility, which remain almost entirely in the top few centimeters of soil, it is assumed that 99% of the contaminant is removed by excavation (i.e., 1% is assumed to remain, even if removal is calculated to be 100%).

Source terms are defined in terms of the total inventories of each of the hazardous and radioactive contaminants contained in the seepage basins. The criteria for selecting contaminants for analysis and the inventories are given in Looney et al. (1987a). The inventory for the analyses is given in Table 16.

General pathway parameters are given in Table 17. The parameters defining the contaminant pathways through groundwater and other environmental paths were defined from the geohydrological data discussed earlier and are presented in Table 18 as they were used in the PATHRAE analyses. The geohydrologic information indicates that the water flow pattern in the vicinity of the basin is complex; water flows laterally to the west from this site and vertically into the Congaree Formation. The PATHRAE model assumes a single flow path and calculates the groundwater and outcrop concentration along the path. The flow path assumed for this site is based on westerly flow in the water-table aquifer towards the truncation of the McBean and Congaree formations. The water then enters the "Tuscaloosa" Formation at this point and flows to the Savannah River where the assumed outcrop is located. A complete flow path is shown schematically in Figure 24. An average flow velocity of 20 m/yr was assumed for the PATHRAE analysis.

Many of the parameters used in the PATHRAE code are specific to given chemicals or radionuclides. They include dose conversion factors (DCF), unit carcinogenic risk (UCR) factors, acceptable daily intakes (ADI), sorption coefficients (K_d), soil-plant transfer factors, solubilities, and facilitated transport fractions. Table 19 presents these parameters for the radionuclides, and Table 20 presents corresponding parameters for the chemical species.

One set of PATHRAE analyses was performed for each closure option for analyzing the environmental transport, exposures, and human health risks from the SRL Seepage Basins. Each set consisted of four computer runs. The first run identified the times (years) at which peak doses occurred for human exposures and only addressed the groundwater pathways. The second analyzed the exposures and risks from all pathways at selected times. The third analysis calculated total releases to the Savannah River, and the fourth analysis calculated the contaminant concentrations in groundwater fluxes at the outcrop location.

TABLE 16

Inventory for the SRL Seepage Basins

Radionuclide Inventory		Nonradioactive Inventory	
Radionuclide	Inventory (Ci)	Chemical	Inventory (kg)
^{3}H	100*	Arsenic	230
^{60}Co	0.05	Cadmium	5
^{90}Sr	1	Chromium	320
^{90}Y	1	Copper	100
^{137}Cs	4	Fluoride	1,000
^{235}U	0.007	Lead	70
^{238}U	0.08	Mercury	10
^{238}Pu	0.02	Nickel	60
^{239}Pu	0.09	Phosphate	12,300
^{241}Am	0.03	Silver	5
^{244}Cm	0.35	Sodium	24,000
		Zinc	215

* Undecayed, accounts for volatilization.

TABLE 17

General Pathway Parameters for PATHRAE Calculations

Parameter	Value
River flow rate	9.1E+09 m^3/yr
Aquifer density	1,600 kg/m^3
Aquifer porosity	0.2 (dimensionless)
Soil residual saturation	0.1 (dimensionless)
Vertical permeability of unsaturated zone	2.2 m/yr
Soil index	0.25 (dimensionless)
Plant root depth	1.0 m
Areal density of plants	1.0 kg/m^2

TABLE 18

Hydrological Pathway Parameters for PATHRAE Calculations

Parameter	Value
Distance of groundwater flow to river	13,000 m
Distance from basin to water table	30 m
Distance to wells	1 m, 100 m
Length of perforated well casing in water table	10 m
Water seepage rate (no action)	1.1 m/yr
Horizontal groundwater velocity	20 m/yr

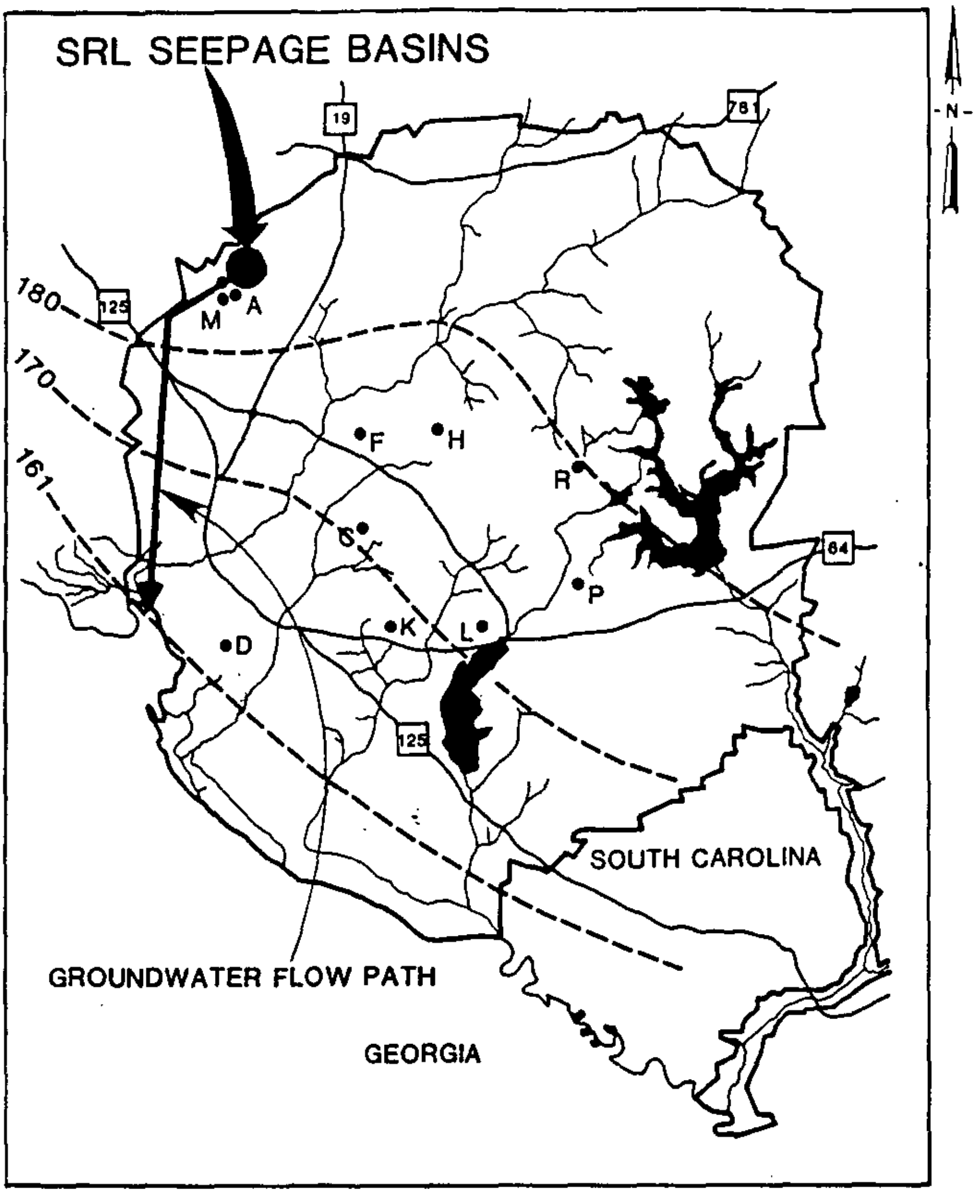


FIGURE 24. Piezometric Surface of the "Tuscaloosa" Formation With Groundwater Flow Path From the SRL Seepage Basins

TABLE 19

Radionuclide-Specific Data for PATHRAE Analyses

Radionuclide	DCF for Ingestion* (mrem/pCi)	K_d** (mL/g)	Soil-Plant Transfer Factor*	Solubility** (moles/L)	Facilitated Transport Fraction**
^{3}H	6.3E-08	1.0E-03	4.8E+00	†	-
^{60}Co	2.6E-05	1.0E+01	9.4E-03	1.0E-02	2.0E-06
^{90}Sr	1.3E-04	8.0E+00	1.7E-02	†	1.0E-04
^{90}Y	1.0E-05	8.0E+00	1.7E-02	†	1.0E-03
^{137}Cs	5.0E-05	5.0E+02	1.0E-02	†	1.0E-04
^{235}U	2.5E-04	4.0E+01	2.5E-03	†	1.0E-03
^{238}U	2.3E-04	4.0E+01	2.5E-03	†	1.0E-03
^{238}Pu	3.8E-04	1.0E+02	2.5E-04	1.0E-13	2.0E-04
^{239}Pu	4.3E-04	1.0E+02	2.5E-04	1.0E-13	2.0E-04
^{241}Am	2.2E-03	1.0E+02	2.5E-04	1.0E-01	-
^{244}Cm	1.1E-03	3.0E+03	2.5E-03	1.0E-14	-

* Date from King et al. (1987).
** Data from Looney et al. (1987b).
† Transport not limited by solubility.

TABLE 20

Chemical-Specific Data for PATHRAE Analyses

Chemical	ADI* (mg/kg/day)	K_d** (mL/g)	Soil-Plant Transfer Factor*	Solubility** (mg/L)	Facilitated Transport Fraction**
Arsenic	2.8E-03	3.0E+00	1.0E-02	†	-
Cadmium	2.9E-04	6.0E+00	3.0E-01	†	2.0E-03
Chromium	5.0E-03	4.0E+01	2.5E-04	5.2E+02	5.0E-03
Copper	3.7E-02	2.5E+01	1.2E-01	6.4E+00	4.0E-02
Fluoride	5.0E-02	1.0E-03	6.5E-04	†	-
Lead	1.4E-03	1.0E+02	6.8E-02	†	3.0E-02
Mercury	2.8E-04	1.0E+04	3.8E-01	†	1.0E-03
Nickel	1.0E-01	1.0E+02	1.9E-02	5.9E+02	2.0E-03
Phosphate	1.1E+02	3.5E+00	3.5E+00	†	-
Silver	3.0E-03	1.0E+02	1.5E-01	†	1.0E-02
Sodium	2.9E+01	1.0E-03	5.2E-02	†	-
Zinc	2.1E-01	1.5E+01	4.0E-01	6.5E-08	-

* Data from King et al. (1987).
** Data from Looney et al. (1987b).
† Transport not limited by solubility.

The PATHRAE concentration, dose, and risk calculations for each of the closure options are presented in the following sections. In reporting concentrations (and corresponding doses and risks) the cutoff value has been set arbitrarily at 1.0E-20. Values smaller than this are reported as zero (0.0) in the tables. Time is measured in years since (or before) 1985 in all tables. Because of the assumed period of institutional control, analysis of the pathways for groundwater to wells, reclaimed farmland, and direct gamma exposure is not applicable prior to 100 years.

Waste Removal and Closure

During the operational life and 3-year dormancy of the basins, constituents leached downward with infiltrating water, the amount depending on the retention of each individual constituent by the soil medium. For the waste removal and closure with cap option, 99% of the constituents that would not have leached out of the 1-m waste layer are assumed to be removed by the excavation process. For several of the most mobile contaminants, none of the inventory remains to receive benefit from excavation.

The PATHRAE analyses of the groundwater pathways to identify peak doses for human exposure for the waste removal and closure option are summarized in Table 21 for radionuclides and Table 22 for chemical constituents. All of the radionuclide doses are low, less than 25 mrem/yr, and the peak dose of approximately 14 mrem/yr (groundwater to well at 1 m pathway) occurs during the period of institutional control. Similarly, the peak doses for chemical constituents are low (no ADI fraction is greater than 1 except fluoride which has an ADI fraction of 3.7 at the well at 1 m during the period of institutional control). The time dependence of the well at 1 m pathway analyses for the radioactive and chemical constituents is summarized in Tables 23 and 24, respectively. Similar results for the well at 100 m pathway are presented in Tables 25 and 26. The time dependence of the groundwater-to-river pathway analyses is summarized in Tables 27 and 28. Constituent fluxes at the assumed groundwater outcrop and concentrations in the groundwater for use in wetlands assessment are given in Tables 29 and 30. Tables 31 and 32 contain the results for the reclaimed-farmland pathway, and Table 33 contains the results for the direct gamma exposure pathway.

No Waste Removal and Closure

Under this option, two suboptions were examined: (1) no waste removal and closure with cap and (2) no waste removal and closure without cap. Both scenarios assume that infiltration of wastewater associated with basin operation has passed through the waste prior

TABLE 21

Peak Radionuclide Calculations for the Waste Removal and Closure Option

Pathway	Radio-nuclide	Peak Concentration (Ci/m^3)	Peak Year Since 1985	Dose (mrem/yr)	Radioactive Risk (HE/yr)
Groundwater to well at 1 m	^{3}H	3.2E-04	-23	1.6E+01	4.5E-06
	^{60}Co	4.9E-34	420	8.0E-27	2.2E-33
	^{60}Co*	5.4E-13	-23	8.8E-06	2.5E-12
	^{90}Sr	3.4E-11	340	2.2E-03	6.0E-10
	^{90}Sr*	4.1E-10	-22	2.6E-02	7.2E-09
	^{90}Y	3.4E-11	340	1.7E-04	4.6E-11
	^{90}Y*	4.1E-10	-22	2.0E-03	5.5E-10
	^{137}Cs*	1.6E-09	-22	5.7E-02	1.6E-08
	^{235}U*	1.3E-11	30	1.6E-03	4.5E-10
	^{238}U*	1.5E-10	30	1.7E-02	4.7E-09
	^{238}Pu*	1.5E-11	-19	2.6E-03	7.3E-10
	^{239}Pu*	3.5E-11	27	6.9E-03	1.9E-09
Groundwater to well at 100 m	^{3}H	2.0E-04	-17	1.0E+01	2.8E-06
	^{60}Co*	2.5E-13	-20	4.1E-06	1.1E-12
	^{90}Sr	2.0E-12	400	1.2E-04	3.5E-11
	^{90}Sr*	3.1E-10	-14	2.0E-02	5.5E-09
	^{90}Y	2.0E-12	400	9.5E-06	2.7E-12
	^{90}Y*	3.1E-10	-14	1.5E-03	4.2E-10
	^{137}Cs*	1.2E-09	-14	4.4E-02	1.2E-08
	^{235}U*	1.3E-11	31	1.6E-03	4.5E-10
	^{238}U*	1.5E-10	31	1.7E-02	4.7E-09
	^{238}Pu*	1.3E-11	-6	2.3E-03	6.5E-10
	^{239}Pu*	3.4E-11	31	6.9E-03	1.9E-09
Groundwater to river	^{235}U*	3.7E-18	650	4.6E-10	1.3E-16
	^{238}U*	4.3E-17	650	4.8E-09	1.3E-15
	^{238}Pu*	1.3E-20	600	2.5E-12	7.0E-19
	^{239}Pu*	9.4E-18	650	2.0E-09	5.5E-16

* Facilitated transport fraction.

TABLE 22

Peak Chemical Calculations for the Waste Removal and Closure Option

Pathway	Chemical	Peak Concentration (mg/L)	Peak Year Since 1985	Noncarcinogenic Risk (ADI fraction)
Groundwater to well at 1 m	Arsenic	7.3E-02	420	6.0E-01
	Cadmium	1.5E-03	550	9.8E-02
	Cadmium*	1.9E-05	30	1.2E-03
	Chromium*	3.1E-03	30	1.3E-02
	Copper*	7.7E-03	30	6.4E-03
	Fluoride	1.9E+00	30	3.7E+00
	Lead*	4.0E-03	30	5.4E-02
	Mercury*	1.9E-05	30	1.1E-02
	Nickel*	2.3E-04	30	5.7E-05
	Phosphate	3.8E+00	460	1.9E-03
	Silver*	9.6E-05	30	1.9E-03
	Sodium	4.6E+01	30	9.2E-02
Groundwater to well at 100 m	Arsenic	6.6E-02	440	5.4E-01
	Cadmium	1.2E-03	580	7.6E-02
	Cadmium*	1.9E-05	31	1.2E-03
	Chromium*	3.1E-03	31	1.3E-02
	Copper*	7.7E-03	31	6.4E-03
	Fluoride	1.9E+00	31	3.7E+00
	Lead*	4.0E-03	31	5.4E-02
	Mercury*	1.9E-05	31	1.1E-02
	Nickel*	2.3E-04	31	5.7E-05
	Phosphate	3.3E+00	460	1.7E-03
	Silver*	9.6E-05	31	1.9E-03
	Sodium	4.6E+01	31	9.2E-02
Groundwater to river	Cadmium*	5.4E-12	650	1.3E-09
	Chromium*	8.6E-10	650	1.3E-08
	Copper*	2.1E-09	650	2.6E-09
	Fluoride	5.4E-07	650	1.1E-06
	Lead*	1.1E-09	650	3.7E-08
	Mercury*	5.4E-12	650	8.3E-09
	Nickel*	6.4E-11	650	3.3E-11
	Silver*	2.7E-11	650	5.3E-10
	Sodium	1.3E-05	650	3.7E-08

* Facilitated transport fraction.

TABLE 23

Radionuclide Results for Groundwater to Well at 1 m Pathway for the Waste Removal and Closure Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (Ci/m^3)							
^{3}H	2.0E-11	1.5E-16	0.0	0.0	0.0	0.0	0.0
^{90}Sr	1.3E-15	2.4E-19	0.0	1.1E-11	1.1E-12	1.8E-15	1.5E-19
^{90}Y	1.3E-15	2.4E-19	0.0	1.1E-11	1.1E-12	1.8E-15	1.5E-19
^{137}Cs	5.9E-15	1.3E-18	0.0	0.0	0.0	0.0	0.0
^{235}U	1.5E-15	3.2E-18	1.2E-20	0.0	0.0	0.0	0.0
^{238}U	1.7E-14	3.7E-17	1.3E-19	0.0	0.0	0.0	0.0
^{238}Pu	3.4E-16	3.3E-19	0.0	0.0	0.0	0.0	0.0
^{239}Pu	3.9E-15	8.2E-18	3.0E-20	0.0	0.	0.0	0.0
Dose (mrem/yr)							
^{3}H	1.0E-06	7.6E-12	0.0	0.0	0.0	0.0	0.0
^{90}Sr	8.2E-08	1.5E-11	0.0	7.1E-04	6.9E-05	1.1E-07	9.6E-12
^{90}Y	6.3E-09	1.2E-12	0.0	5.5E-05	5.3E-06	8.7E-09	7.4E-13
^{137}Cs	2.1E-07	4.5E-11	0.0	0.0	0.0	0.0	0.0
^{235}U	1.8E-07	3.8E-10	1.4E-12	0.0	0.0	0.0	0.0
^{238}U	1.9E-06	4.0E-09	1.5E-11	0.0	0.0	0.0	0.0
^{238}Pu	6.0E-08	5.8E-11	0.0	0.0	0.0	0.0	0.0
^{239}Pu	7.7E-07	1.6E-09	5.9E-12	0.0	0.0	0.0	0.0
Total Dose	4.2E-06	6.1E-09	2.2E-11	7.6E-04	7.4E-05	1.2E-07	1.0E-11
Radioactive Risk (HE/yr)							
	1.2E-12	1.7E-15	6.1E-18	2.1E-10	2.1E-11	3.4E-14	2.9E-18

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 24

Chemical Results for Groundwater to Well at 1 m Pathway for the Waste Removal and Closure Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (mg/L)							
Arsenic	0.0	6.9E-02	7.2E-02	7.3E-02	5.8E-03	9.7E-04	2.2E-04
Cadmium	2.2E-09	4.6E-12	1.4E-03	1.5E-03	1.5E-03	9.8E-05	2.1E-05
Chromium	3.5E-07	7.3E-10	2.7E-12	1.2E-14	5.9E-17	0.0	0.0
Copper	8.6E-07	1.8E-09	6.7E-12	3.0E-14	1.5E-16	0.0	0.0
Fluoride	2.2E-04	4.6E-07	1.7E-09	7.5E-12	3.7E-14	1.1E-18	0.0
Lead	4.5E-07	9.6E-10	3.5E-12	1.6E-14	7.8E-17	0.0	0.0
Mercury	2.2E-09	4.6E-12	1.7E-14	7.5E-17	3.7E-19	0.0	0.0
Nickel	2.6E-08	5.5E-11	2.0E-13	8.9E-16	4.4E-18	0.0	0.0
Phosphate	0.0	3.5E+00	3.7E+00	3.8E+00	4.9E-01	6.9E-02	1.6E-02
Silver	1.1E-08	2.3E-11	8.4E-14	3.7E-16	1.8E-18	0.0	0.0
Sodium	5.2E-03	1.1E-05	4.0E-08	1.8E-10	8.9E-13	2.6E-17	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	4.9E-08	6.0E-08
Noncarcinogenic Risk (ADI fraction)							
Arsenic	0.0	5.7E-01	5.9E-01	5.9E-01	4.7E-02	8.0E-03	1.8E-03
Cadmium	1.4E-07	2.9E-10	8.7E-02	9.5E-02	9.8E-02	6.2E-03	1.3E-03
Chromium	1.4E-06	3.0E-09	1.1E-11	4.9E-14	2.4E-16	0.0	0.0
Copper	7.2E-07	1.5E-09	5.6E-12	2.5E-14	1.2E-16	0.0	0.0
Fluoride	4.1E-04	8.8E-07	3.2E-09	1.4E-11	7.1E-14	2.1E-18	0.0
Lead	6.0E-06	1.3E-08	4.7E-11	2.1E-13	1.0E-15	0.0	0.0
Mercury	1.3E-06	2.7E-09	9.8E-12	4.4E-14	2.2E-16	0.0	0.0
Nickel	6.5E-09	1.4E-11	5.0E-14	2.2E-16	1.1E-18	0.0	0.0
Phosphate	0.0	1.8E-03	1.9E-03	1.9E-03	2.5E-04	3.5E-05	8.2E-06
Silver	2.1E-07	4.5E-10	1.6E-12	7.3E-15	3.6E-17	0.0	0.0
Sodium	1.0E-05	2.2E-08	8.1E-11	3.5E-13	1.8E-15	5.1E-20	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	1.3E-08	1.7E-08
EPA Hazard Index	4.3E-04	5.7E-01	6.8E-01	6.9E-01	1.5E-01	1.4E-02	3.1E-03

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 25

Radionuclide Results for Groundwater to Well at 100 m Pathway for the Waste Removal and Closure Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (Ci/m^3)							
^{3}H	1.9E-10	1.5E-15	1.9E-20	0.0	0.0	0.0	0.0
^{90}Sr	1.3E-14	2.4E-18	0.0	2.0E-12	5.1E-13	6.1E-15	1.2E-18
^{90}Y	1.3E-14	2.4E-18	0.0	2.0E-12	5.1E-13	6.1E-15	1.2E-18
^{137}Cs	5.7E-14	1.2E-17	0.0	0.0	0.0	0.0	0.0
^{235}U	1.5E-14	3.1E-17	1.1E-19	0.0	0.0	0.0	0.0
^{238}U	1.7E-13	3.6E-16	1.3E-18	0.0	0.0	0.0	0.0
^{238}Pu	3.3E-15	3.2E-18	0.0	0.0	0.0	0.0	0.0
^{239}Pu	3.7E-14	8.0E-17	2.9E-19	0.0	0.0	0.0	0.0
Dose (mrem/yr)							
^{3}H	9.7E-06	7.4E-11	9.7E-16	0.0	0.0	0.0	0.0
^{90}Sr	7.9E-07	1.5E-10	0.0	1.2E-04	3.2E-05	3.8E-07	7.4E-11
^{90}Y	6.1E-08	1.2E-11	0.0	9.5E-06	2.5E-06	2.9E-08	5.7E-12
^{137}Cs	2.0E-06	4.4E-10	0.0	0.0	0.0	0.0	0.0
^{235}U	1.7E-06	3.7E-09	1.4E-11	0.0	0.0	0.0	0.0
^{238}U	1.8E-05	3.9E-08	1.4E-10	0.0	0.0	0.0	0.0
^{238}Pu	5.8E-07	5.6E-10	0.0	0.0	0.0	0.0	0.0
^{239}Pu	7.5E-06	1.6E-08	5.8E-11	0.0	0.0	0.0	0.0
Total Dose	4.1E-05	6.0E-08	2.2E-10	1.3E-04	3.4E-05	4.1E-07	8.0E-11
Radioactive Risk (HE/yr)							
	1.1E-11	1.7E-14	6.0E-17	3.7E-11	9.6E-12	1.2E-13	2.2E-17

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 26

Chemical Results for Groundwater to Well at 100 m Pathway for the Waste Removal and Closure Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (mg/L)							
Arsenic	0.0	4.0E-02	5.7E-02	6.4E-02	3.9E-02	8.5E-03	2.0E-03
Cadmium	2.1E-08	4.5E-11	2.8E-04	8.1E-04	1.1E-03	6.5E-04	1.7E-04
Chromium	3.3E-06	7.2E-09	2.6E-11	1.2E-13	5.8E-16	1.7E-20	0.0
Copper	8.3E-06	1.8E-08	6.6E-11	2.9E-13	1.5E-15	4.3E-20	0.0
Fluoride	2.1E-03	4.5E-06	1.6E-08	7.3E-11	3.6E-13	1.1E-17	0.0
Lead	4.4E-06	9.4E-09	3.4E-11	1.5E-13	7.6E-16	2.2E-20	0.0
Mercury	2.1E-08	4.5E-11	1.6E-13	7.3E-16	3.6E-18	0.0	0.0
Nickel	2.5E-07	5.4E-10	2.0E-12	8.8E-15	4.4E-17	0.0	0.0
Phosphate	0.0	1.5E+00	2.7E+00	3.2E+00	2.7E+00	5.9E-01	1.5E-01
Silver	1.0E-07	2.2E-10	8.2E-13	3.7E-15	1.8E-17	0.0	0.0
Sodium	5.0E-02	1.1E-04	3.9E-07	1.8E-09	8.7E-12	2.6E-16	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	1.8E-09	3.1E-08
Noncarcinogenic Risk (ADI fraction)							
Arsenic	0.0	3.3E-01	4.7E-01	5.3E-01	3.2E-01	7.0E-02	1.7E-02
Cadmium	1.3E-06	2.9E-09	1.8E-02	5.1E-02	6.8E-02	4.1E-02	1.1E-02
Chromium	1.4E-05	3.0E-08	1.1E-10	4.8E-13	2.4E-15	7.0E-20	0.0
Copper	7.0E-06	1.5E-08	5.5E-11	2.5E-13	1.2E-15	3.6E-20	0.0
Fluoride	4.0E-03	8.6E-06	3.2E-08	1.4E-10	7.0E-13	2.0E-17	0.0
Lead	5.8E-05	1.3E-07	4.6E-10	2.1E-12	1.0E-14	3.0E-19	0.0
Mercury	1.2E-05	2.6E-08	9.6E-11	4.3E-13	2.1E-15	0.0	0.0
Nickel	6.2E-08	1.3E-10	4.9E-13	2.2E-15	1.1E-17	0.0	0.0
Phosphate	0.0	7.6E-04	1.4E-03	1.6E-03	1.4E-03	3.0E-04	7.4E-05
Silver	2.0E-06	4.4E-09	1.6E-11	7.2E-14	3.6E-16	0.0	0.0
Sodium	1.0E-04	2.2E-07	7.9E-10	3.5E-12	1.7E-14	5.1E-19	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	5.0E-10	8.4E-09
EPA Hazard Index	4.2E-03	3.3E-01	4.9E-01	5.8E-01	3.9E-01	1.1E-01	2.8E-02

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 27

Radionuclide Results for Groundwater-to-River Pathway for the Waste Removal and Closure Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration (Ci/m^3)								
^{235}U	0.0	0.0	0.0	0.0	0.0	4.6E-19	3.1E-18	0.0
^{238}U	0.0	0.0	0.0	0.0	3.3E-20	5.3E-18	3.5E-17	8.7E-20
^{239}Pu	0.0	0.0	0.0	0.0	0.0	1.2E-18	7.8E-18	1.9E-20
Dose (mrem/yr)								
^{235}U	0.0	0.0	0.0	0.0	0.0	5.7E-11	3.8E-10	0.0
^{238}U	0.0	0.0	0.0	0.0	3.7E-12	6.0E-10	4.0E-09	9.8E-12
^{239}P	0.0	0.0	0.0	0.0	0.0	2.5E-10	1.6E-09	4.0E-12
Total Dose	0.0	0.0	0.0	0.0	3.7E-12	9.0E-10	6.0E-09	1.4E-11
Radioactive Risk (HE/yr)								
	0.0	0.0	0.0	0.0	1.0E-18	2.5E-16	1.7E-15	3.9E-18

TABLE 28

Chemical Results for Groundwater-to-River Pathway for the Waste Removal and Closure Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration (mg/L)								
Cadmium	0.0	0.0	0.0	6.9E-20	4.2E-15	6.6E-13	4.4E-12	1.1E-14
Chromium	0.0	0.0	0.0	1.1E-17	6.7E-13	1.1E-10	7.1E-10	1.7E-12
Copper	0.0	0.0	0.0	2.8E-17	1.7E-12	2.6E-10	1.8E-09	4.4E-12
Fluoride	0.0	0.0	0.0	6.9E-15	4.2E-10	6.6E-08	4.4E-07	1.1E-09
Lead	0.0	0.0	0.0	1.5E-17	8.7E-13	1.4E-10	9.3E-10	2.3E-12
Mercury	0.0	0.0	0.0	6.9E-20	4.2E-15	6.6E-13	4.4E-12	1.1E-14
Nickel	0.0	0.0	0.0	8.3E-19	5.0E-14	7.9E-12	5.3E-11	1.3E-13
Silver	0.0	0.0	0.0	3.5E-19	2.1E-14	3.3E-12	2.2E-11	5.5E-14
Sodium	0.0	0.0	0.0	1.7E-13	1.0E-08	1.6E-06	1.1E-05	2.6E-08
Noncarcinogenic Risk (ADI fraction)								
Cadmium	0.0	0.0	0.0	1.7E-17	1.0E-12	1.7E-10	1.1E-09	2.7E-12
Chromium	0.0	0.0	0.0	1.7E-16	9.9E-12	1.6E-09	1.1E-08	2.6E-11
Copper	0.0	0.0	0.0	3.3E-17	2.0E-12	3.2E-10	2.1E-09	5.2E-12
Fluoride	0.0	0.0	0.0	1.4E-14	8.2E-10	1.3E-07	8.7E-07	2.2E-09
Lead	0.0	0.0	0.0	4.7E-16	2.8E-11	4.5E-09	3.0E-08	7.5E-11
Mercury	0.0	0.0	0.0	1.1E-16	6.4E-12	1.0E-09	6.8E-09	1.7E-11
Nickel	0.0	0.0	0.0	4.3E-19	2.6E-14	4.1E-12	2.8E-11	6.8E-14
Silver	0.0	0.0	0.0	6.8E-18	4.1E-13	6.5E-11	4.4E-10	1.1E-12
Sodium	0.0	0.0	0.0	4.9E-16	2.9E-11	4.7E-09	3.1E-08	7.7E-11
EPA Hazard Index	0.0	0.0	0.0	1.5E-14	9.0E-10	1.4E-07	9.5E-07	2.4E-09

TABLE 29

Radionuclide Activity Outcrop Data for the Waste Removal and Closure Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration in Groundwater at Outcrop (Ci/m^3)								
^{235}U	0.0	0.0	0.0	0.0	0.0	2.5E-14	1.4E-13	0.0
^{238}U	0.0	0.0	0.0	0.0	2.2E-15	2.9E-13	1.6E-12	3.6E-15
^{239}Pu	0.0	0.0	0.0	0.0	0.0	6.4E-14	3.5E-13	7.9E-16
Contaminant Flux at Outcrop (Ci/yr)								
^{235}U	0.0	0.0	0.0	0.0	0.0	4.2E-09	2.8E-08	0.0
^{238}U	0.0	0.0	0.0	0.0	3.0E-10	4.8E-08	3.2E-07	8.0E-10
^{239}Pu	0.0	0.0	0.0	0.0	0.0	1.1E-08	7.1E-08	1.7E-10

TABLE 30

Chemical Concentration Outcrop Data for the Waste Removal and Closure Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration in Groundwater at Outcrop (mg/L)								
Cadmium	0.0	0.0	0.0	5.8E-15	2.7E-10	3.6E-08	2.0E-07	4.5E-10
Chromium	0.0	0.0	0.0	9.3E-13	4.4E-08	5.8E-06	3.2E-05	7.2E-08
Copper	0.0	0.0	0.0	2.3E-12	1.1E-07	1.5E-05	7.9E-05	1.8E-07
Fluoride	0.0	0.0	0.0	5.8E-10	2.7E-05	3.6E-03	2.0E-02	4.5E-05
Lead	0.0	0.0	0.0	1.2E-12	5.7E-08	7.6E-06	4.2E-05	9.5E-08
Mercury	0.0	0.0	0.0	5.8E-15	2.7E-10	3.6E-08	2.0E-07	4.5E-10
Nickel	0.0	0.0	0.0	6.9E-14	3.3E-09	4.4E-07	2.4E-06	5.4E-09
Silver	0.0	0.0	0.0	2.9E-14	1.4E-09	1.8E-07	9.9E-07	2.3E-09
Sodium	0.0	0.0	0.0	1.4E-08	6.5E-04	8.7E-02	4.7E-01	1.1E-03
Contaminant Flux at Outcrop (kg/yr)								
Cadmium	0.0	0.0	0.0	6.3E-13	3.8E-08	6.0E-06	4.0E-05	9.9E-01
Chromium	0.0	0.0	0.0	1.0E-10	6.1E-06	9.6E-04	6.4E-03	1.6E-05
Copper	0.0	0.0	0.0	2.5E-10	1.5E-05	2.4E-03	1.6E-02	4.0E-05
Fluoride	0.0	0.0	0.0	6.3E-08	3.8E-03	6.0E-01	4.0E+00	9.9E-03
Lead	0.0	0.0	0.0	1.3E-10	7.9E-06	1.3E-03	8.5E-03	2.1E-05
Mercury	0.0	0.0	0.0	6.3E-13	3.8E-08	6.0E-06	4.0E-05	9.9E-08
Nickel	0.0	0.0	0.0	7.6E-12	4.5E-07	7.2E-05	4.8E-04	1.2E-06
Silver	0.0	0.0	0.0	3.1E-12	1.9E-07	3.0E-05	2.0E-04	5.0E-07
Sodium	0.0	0.0	0.0	1.5E-06	9.1E-02	1.4E+01	9.7E+01	2.4E-01

TABLE 31

Radionuclide Results for Reclaimed-Farmland Pathway for the Waste Removal and Closure Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Dose (mrem/yr)							
^{60}Co	5.3E-11	7.2E-17	9.9E-23	1.3E-28	1.8E-34	0.0	0.0
^{90}Sr	4.8E-02	3.2E-03	2.1E-04	1.4E-05	9.0E-07	3.9E-09	1.1E-12
^{90}Y	3.7E-03	2.4E-04	1.6E-05	1.1E-06	6.9E-08	3.0E-10	8.4E-14
^{137}Cs	1.7E-04	1.5E-05	1.3E-06	1.1E-07	9.8E-09	7.4E-11	4.9E-14
^{235}U	8.2E-05	6.1E-05	4.5E-05	3.3E-05	2.5E-05	1.4E-05	5.5E-06
^{238}U	8.8E-04	6.5E-04	4.8E-04	3.6E-04	2.6E-04	1.4E-04	5.9E-05
^{238}Pu	4.0E-08	1.3E-08	4.5E-09	1.5E-09	5.1E-10	5.7E-11	2.2E-12
^{239}Pu	5.1E-07	3.8E-07	2.8E-07	2.1E-07	1.5E-07	8.3E-08	3.4E-08
^{241}Am	3.6E-06	2.3E-06	1.5E-06	9.3E-07	5.9E-07	2.4E-07	6.2E-08
^{244}Cm	1.7E-07	3.3E-09	6.2E-11	1.2E-12	2.2E-14	8.1E-18	5.6E-23
Total Dose	5.3E-02	4.1E-03	7.5E-04	4.1E-04	2.9E-04	1.6E-04	6.4E-05
Radioactive Risk (HE/yr)							
	1.5E-08	1.2E-09	2.1E-10	1.1E-10	8.1E-11	4.4E-11	1.8E-11

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 32

Chemical Results for Reclaimed-Farmland Pathway for the Waste Removal and Closure Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Noncarcinogenic Risk (ADI fraction)							
Arsenic	3.9E-04	2.9E-04	2.1E-04	1.6E-04	1.2E-04	6.4E-05	2.6E-05
Cadmium	8.0E-04	5.9E-04	4.4E-04	3.2E-04	2.4E-04	1.3E-04	5.4E-05
Chromium	1.3E-04	1.0E-04	7.4E-05	5.5E-05	4.1E-05	2.2E-05	9.1E-06
Copper	2.4E-04	1.8E-04	1.3E-04	9.6E-05	7.1E-05	3.9E-05	1.6E-05
Lead	5.7E-06	4.2E-06	3.1E-06	2.3E-06	1.7E-06	9.5E-07	3.9E-07
Mercury	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.1E-03	2.0E-03
Nickel	7.0E-08	5.2E-08	3.9E-08	2.9E-08	2.1E-08	1.2E-08	4.7E-09
Phosphate	1.5E-03	1.1E-03	8.2E-04	6.0E-04	4.6E-04	2.5E-04	1.0E-04
Silver	7.5E-06	5.5E-06	4.1E-06	3.0E-06	2.2E-06	1.2E-06	5.0E-07
Zinc	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03
EPA Hazard Index	6.8E-03	6.0E-03	5.3E-03	4.8E-03	4.6E-03	4.2E-03	3.8E-03

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 33

Radionuclide Results for Direct Gamma Exposure Pathway for the Waste Removal and Closure Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Dose (mrem/yr)							
^{60}Co	2.5E-13	5.5E-19	1.2E-24	2.6E-30	5.7E-36	0.0	0.0
^{137}Cs	1.1E-10	1.4E-11	1.7E-12	2.1E-13	2.7E-14	4.2E-16	8.3E-19
^{235}U	1.2E-20	1.8E-20	2.8E-20	4.2E-20	6.4E-20	1.4E-19	5.0E-19
^{238}Pu	5.1E-17	3.0E-17	1.8E-17	1.1E-17	6.3E-18	2.2E-18	4.6E-19
^{241}Am	6.3E-15	7.1E-15	7.9E-15	8.9E-15	1.0E-14	1.3E-14	1.8E-14
^{244}Cm	2.2E-17	5.7E-19	1.5E-20	3.7E-22	9.4E-24	6.1E-27	1.0E-31
Total Dose	1.1E-10	1.4E-11	1.7E-12	2.3E-13	3.7E-14	1.3E-14	1.8E-14
Radioactive Risk (HE/yr)							
	3.1E-17	3.8E-18	4.8E-19	6.3E-20	1.0E-20	3.7E-21	5.0E-21

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

to the subject closure action. More than half the inventories of contaminants with low retardation coefficients will have been transported downward to the water table by this time. Some reduction in radionuclide transport does occur after emplacement of the cap because infiltration rates and leach rates are reduced. Therefore, the dose from the groundwater pathways are reduced and peak doses and risks occur at later times compared to the no action option.

The results for the no waste removal and closure with cap option are presented in Tables 34 through 46. Note that the peak radionuclide doses are low (approximately 16 mrem/yr) and that they occur during the period of assumed institutional control. The peak noncarcinogenic risks are all below ADI fractions of 1 except fluoride, which has an ADI fraction of 3.7 at the well at 1 m during the period of institutional control.

The results for the no waste removal and closure without cap option are presented in Tables 47 through 59. The doses and risks fall between the no action option and the no waste removal and closure with cap option. The peak calculated radioactive doses and risks are low (approximately 16 mrem/yr), and they occur during the assumed period of institutional control, therefore no persons are exposed because the water is not consumed. Note that arsenic has a peak noncarcinogenic risk (ADI fraction) of 3.4 in Year 160 after 1985 at the well at 1 m. Fluoride has a peak ADI fraction of 7.0 at the well at 1 m during the period of institutional control. The results for the groundwater-to-river, reclaimed-farmland, and direct gamma exposure pathways are low for both suboptions. The slower leach rate due to the closure actions results in higher doses for the reclaimed-farmland pathway than those calculated for the no action option.

No Action

The results of the PATHRAE analyses for the no action option are presented in Tables 60 through 72. As with the other options, the peak radionuclide doses are low (approximately 16 mrem/yr), and they occur during the period of assumed institutional control. Arsenic has a peak noncarcinogenic risk (ADI fraction) of 6.1 in Year 130 after 1985 at the well at 1 m. Fluoride has a peak ADI fraction of 7.5 during the period of institutional control.

Summary

The total calculated releases of constituents to the Savannah River are presented in Tables 73 through 75. Assuming a population of 100,000, the total radioactive risk calculated to correspond to all closure options is approximately 4.2E-08 health effects. The maximum radiological and chemical doses are summarized in Table 76.

TABLE 34

Peak Radionuclide Calculations for the No Waste Removal and Closure With Cap Option

Pathway	Radio-nuclide	Peak Concentration (Ci/m^3)	Peak Year Since 1985	Dose (mrem/yr)	Radioactive Risk (HE/yr)
Groundwater to well at 1 m	^{3}H	3.2E-04	-23	1.6E+01	4.5E-06
	^{60}Co	5.2E-34	420	8.4E-27	2.4E-33
	^{60}Co*	5.4E-13	-23	8.8E-06	2.5E-12
	^{90}Sr	3.4E-11	340	2.2E-03	6.0E-10
	^{90}Sr*	4.1E-10	-22	2.6E-02	7.2E-09
	^{90}Y	3.4E-11	340	1.7E-04	4.6E-11
	^{90}Y*	4.1E-10	-22	2.0E-03	5.5E-10
	^{137}Cs*	1.6E-09	-22	5.7E-02	1.6E-08
	^{235}U*	1.3E-11	30	1.6E-03	4.5E-10
	^{238}U*	1.5E-10	30	1.7E-02	4.7E-09
	^{238}Pu*	1.5E-11	-19	2.6E-03	7.3E-10
	^{239}Pu*	3.5E-11	27	6.9E-03	1.9E-09
Groundwater to well at 100 m	^{3}H	2.0E-04	-17	1.0E+01	2.8E-06
	^{60}Co*	2.5E-13	-20	4.1E-06	1.1E-12
	^{90}Sr	2.0E-12	400	1.2E-04	3.5E-11
	^{90}Sr*	3.1E-10	-14	2.0E-02	5.5E-09
	^{90}Y	2.0E-12	400	9.5E-06	2.7E-12
	^{90}Y*	3.1E-10	-14	1.5E-03	4.2E-10
	^{137}Cs*	1.2E-09	-14	4.4E-02	1.2E-08
	^{235}U*	1.3E-11	31	1.6E-03	4.5E-10
	^{238}U*	1.5E-10	31	1.7E-02	4.7E-09
	^{238}Pu*	1.3E-11	-6	2.3E-03	6.5E-10
	^{239}Pu*	3.4E-11	31	6.9E-03	1.9E-09
Groundwater to river	^{3}H	2.3E-24	430	1.2E-19	3.3E-26
	^{90}Sr*	2.7E-23	530	2.4E-15	6.8E-22
	^{90}Y*	2.7E-23	530	1.9E-16	5.2E-23
	^{137}Cs*	2.1E-22	530	1.5E-13	4.3E-20
	^{235}U*	3.7E-18	650	4.6E-10	1.3E-16
	^{238}U*	4.3E-17	650	4.8E-09	1.3E-15
	^{238}Pu*	1.3E-20	600	2.5E-12	7.0E-19
	^{239}Pu*	9.4E-18	650	2.0E-09	5.5E-16

* Facilitated transport fraction.

TABLE 35

Peak Chemical Calculations for the No Waste Removal and Closure With Cap Option

Pathway	Chemical	Peak Concentration (mg/L)	Peak Years Since 1985	Noncarcinogenic Risk (ADI fraction)
Groundwater	Arsenic	7.3E-02	450	6.0E-01
to well	Cadmium	1.5E-03	580	9.8E-02
at 1 m	Cadmium*	1.9E-05	30	1.2E-03
	Chromium*	3.1E-03	30	1.3E-02
	Copper*	7.7E-03	30	6.4E-03
	Fluoride	1.9E+00	30	3.7E+00
	Lead*	4.0E-03	30	5.4E-02
	Mercury*	1.9E-05	30	1.1E-02
	Nickel*	2.3E-04	30	5.7E-05
	Phosphate	3.8E+00	460	1.9E-03
	Silver*	9.6E-05	30	1.9E-03
	Sodium	4.6E+01	30	9.2E-02
Groundwater	Arsenic	6.6E-02	440	5.4E-01
to well	Cadmium	1.2E-03	580	7.6E-02
at 100 m	Cadmium*	1.9E-05	31	1.2E-03
	Chromium*	3.1E-03	31	1.3E-02
	Copper*	7.7E-03	31	6.4E-03
	Fluoride	1.9E+00	31	3.7E+00
	Lead*	4.0E-03	31	5.4E-02
	Mercury*	1.9E-05	31	1.1E-02
	Nickel*	2.3E-04	31	5.7E-05
	Phosphate	3.3E+00	460	1.7E-03
	Silver*	9.6E-05	31	1.9E-03
	Sodium	4.6E+01	31	9.2E-02
Groundwater	Cadmium*	5.4E-12	650	1.3E-09
to river	Chromium*	8.6E-10	650	1.3E-08
	Copper*	2.1E-09	650	2.6E-09
	Fluoride	5.4E-07	650	1.1E-06
	Lead*	1.1E-09	650	3.7E-08
	Mercury*	5.4E-12	650	8.3E-09
	Nickel*	6.4E-11	650	3.3E-11
	Silver*	2.7E-11	650	5.3E-10
	Sodium	1.3E-05	650	3.7E-08

* Facilitated transport fraction.

TABLE 36

Radionuclide Results for Groundwater to Well at 1 m Pathway for the No Waste Removal and Closure With Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (Ci/m^3)							
^{3}H	2.0E-11	1.5E-16	0.0	0.0	0.0	0.0	0.0
^{90}Sr	1.3E-15	2.4E-19	0.0	1.1E-11	1.1E-12	1.8E-15	1.5E-19
^{90}Y	1.3E-15	2.4E-19	0.0	1.1E-11	1.1E-12	1.8E-15	1.5E-19
^{137}Cs	5.9E-15	1.3E-18	0.0	0.0	0.0	0.0	0.0
^{235}U	1.5E-15	3.2E-18	1.2E-20	0.0	0.0	0.0	0.0
^{238}U	1.7E-14	3.7E-17	1.3E-19	0.0	0.0	0.0	0.0
^{238}Pu	3.4E-16	3.3E-19	0.0	0.0	0.0	0.0	0.0
^{239}Pu	3.9E-15	8.2E-18	3.0E-20	0.0	0.0	0.0	0.0
Dose (mrem/yr)							
^{3}H	1.0E-06	7.6E-12	0.0	0.0	0.0	0.0	0.0
^{90}Sr	8.2E-08	1.5E-11	0.0	7.1E-04	6.9E-05	1.1E-07	9.6E-12
^{90}Y	6.3E-09	1.2E-12	0.0	5.5E-05	5.3E-06	8.7E-09	7.4E-13
^{137}Cs	2.1E-07	4.5E-11	0.0	0.0	0.0	0.0	0.0
^{235}U	1.8E-07	3.8E-10	1.4E-12	0.0	0.0	0.0	0.0
^{238}U	1.9E-06	4.0E-09	1.5E-11	0.0	0.0	0.0	0.0
^{238}Pu	6.0E-08	5.8E-11	0.0	0.0	0.0	0.0	0.0
^{239}Pu	7.7E-07	1.6E-09	5.9E-12	0.0	0.0	0.0	0.0
Total Dose	4.2E-06	6.1E-09	2.2E-11	7.6E-04	7.4E-05	1.2E-07	1.0E-11
Radioactive Risk (HE/yr)							
	1.2E-12	1.7E-15	6.1E-18	2.1E-10	2.1E-11	3.4E-14	2.9E-18

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 37

Chemical Results for Groundwater to Well at 1 m Pathway for the No Waste Removal and Closure With Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (mg/L)							
Arsenic	0.0	6.9E-02	7.2E-02	7.3E-02	5.8E-03	9.7E-04	2.2E-04
Cadmium	2.2E-09	4.6E-12	1.4E-03	1.5E-03	1.5E-03	9.8E-05	2.1E-05
Chromium	3.5E-07	7.3E-10	2.7E-12	1.2E-14	5.9E-17	0.0	0.0
Copper	8.6E-07	1.8E-09	6.7E-12	3.0E-14	1.5E-16	0.0	0.0
Fluoride	2.2E-04	4.6E-07	1.7E-09	7.5E-12	3.7E-14	1.1E-18	0.0
Lead	4.5E-07	9.6E-10	3.5E-12	1.6E-14	7.8E-17	0.0	0.0
Mercury	2.2E-09	4.6E-12	1.7E-14	7.5E-17	3.7E-19	0.0	0.0
Nickel	2.6E-08	5.5E-11	2.0E-13	8.9E-16	4.4E-18	0.0	0.0
Phosphate	0.0	3.5E+00	3.7E+00	3.8E+00	4.9E-01	6.9E-02	1.6E-02
Silver	1.1E-08	2.3E-11	8.4E-14	3.7E-16	1.8E-18	0.0	0.0
Sodium	5.2E-03	1.1E-05	4.0E-08	1.8E-10	8.9E-13	2.6E-17	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	4.9E-08	6.0E-08
Noncarcinogenic Risk (ADI fraction)							
Arsenic	0.0	5.7E-01	5.9E-01	5.9E-01	4.7E-02	8.0E-03	1.8E-03
Cadmium	1.4E-07	2.9E-10	8.7E-02	9.5E-02	9.8E-02	6.2E-03	1.3E-03
Chromium	1.4E-06	3.0E-09	1.1E-11	4.9E-14	2.4E-16	0.0	0.0
Copper	7.2E-07	1.5E-09	5.6E-12	2.5E-14	1.2E-16	0.0	0.0
Fluoride	4.1E-04	8.8E-07	3.2E-09	1.4E-11	7.1E-14	2.1E-18	0.0
Lead	6.0E-06	1.3E-08	4.7E-11	2.1E-13	1.0E-15	0.0	0.0
Mercury	1.3E-06	2.7E-09	9.8E-12	4.4E-14	2.2E-16	0.0	0.0
Nickel	6.5E-09	1.4E-11	5.0E-14	2.2E-16	1.1E-18	0.0	0.0
Phosphate	0.0	1.8E-03	1.9E-03	1.9E-03	2.5E-04	3.5E-05	8.2E-06
Silver	2.1E-07	4.5E-10	1.6E-12	7.3E-15	3.6E-17	0.0	0.0
Sodium	1.0E-05	2.2E-08	8.1E-11	3.5E-13	1.8E-15	5.1E-20	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	1.3E-08	1.7E-08
EPA Hazard Index	4.3E-04	5.7E-01	6.8E-01	6.9E-01	1.5E-01	1.4E-02	3.1E-03

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 38

Radionuclide Results for Groundwater to Well at 100 m Pathway for the No Waste Removal and Closure With Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (Ci/m^3)							
^{3}H	1.9E-10	1.5E-15	1.9E-20	0.0	0.0	0.0	0.0
^{90}Sr	1.3E-14	2.4E-18	0.0	2.0E-12	5.1E-13	6.1E-15	1.2E-18
^{90}Y	1.3E-14	2.4E-18	0.0	2.0E-12	5.1E-13	6.1E-15	1.2E-18
^{137}Cs	5.7E-14	1.2E-17	0.0	0.0	0.0	0.0	0.0
^{235}U	1.5E-14	3.1E-17	1.1E-19	0.0	0.0	0.0	0.0
^{238}U	1.7E-13	3.6E-16	1.3E-18	0.0	0.0	0.0	0.0
^{238}Pu	3.3E-15	3.2E-18	0.0	0.0	0.0	0.0	0.0
^{239}Pu	3.7E-14	8.0E-17	2.9E-19	0.0	0.0	0.0	0.0
Dose (mrem/yr)							
^{3}H	9.7E-06	7.4E-11	9.7E-16	0.0	0.0	0.0	0.0
^{90}Sr	7.9E-07	1.5E-10	0.0	1.2E-04	3.2E-05	3.8E-07	7.4E-11
^{90}Y	6.1E-08	1.2E-11	0.0	9.5E-06	2.5E-06	2.9E-08	5.7E-12
^{137}Cs	2.0E-06	4.4E-10	0.0	0.0	0.0	0.0	0.0
^{235}U	1.7E-06	3.7E-09	1.4E-11	0.0	0.0	0.0	0.0
^{238}U	1.8E-05	3.9E-08	1.4E-10	0.0	0.0	0.0	0.0
^{238}Pu	5.8E-07	5.6E-10	0.0	0.0	0.0	0.0	0.0
^{239}Pu	7.5E-06	1.6E-08	5.8E-11	0.0	0.0	0.0	0.0
Total Dose	4.1E-05	6.0E-08	2.2E-10	1.3E-04	3.4E-05	4.1E-07	8.0E-11
Radioactive Risk (HE/yr)							
	1.1E-11	1.7E-14	6.0E-17	3.7E-11	9.6E-12	1.2E-13	2.2E-17

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 39

Chemical Results for Groundwater to Well at 100 m Pathway for the No Waste Removal and Closure With Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (mg/L)							
Arsenic	0.0	4.0E-02	5.7E-02	6.4E-02	3.9E-02	8.5E-03	2.0E-03
Cadmium	2.1E-08	4.5E-11	2.8E-04	8.1E-04	1.1E-03	6.5E-04	1.7E-04
Chromium	3.3E-06	7.2E-09	2.6E-11	1.2E-13	5.8E-16	1.7E-20	0.0
Copper	8.3E-06	1.8E-08	6.6E-11	2.9E-13	1.5E-15	4.3E-20	0.0
Fluoride	2.1E-03	4.5E-06	1.6E-08	7.3E-11	3.6E-13	1.1E-17	0.0
Lead	4.4E-06	9.4E-09	3.4E-11	1.5E-13	7.6E-16	2.2E-20	0.0
Mercury	2.1E-08	4.5E-11	1.6E-13	7.3E-16	3.6E-18	0.0	0.0
Nickel	2.5E-07	5.4E-10	2.0E-12	8.8E-15	4.4E-17	0.0	0.0
Phosphate	0.0	1.5E+00	2.7E+00	3.2E+00	2.7E+00	5.9E-01	1.5E-01
Silver	1.0E-07	2.2E-10	8.2E-13	3.7E-15	1.8E-17	0.0	0.0
Sodium	5.0E-02	1.1E-04	3.9E-07	1.8E-09	8.7E-12	2.6E-16	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	1.8E-09	3.1E-08
Noncarcinogenic Risk (ADI fraction)							
Arsenic	0.0	3.3E-01	4.7E-01	5.3E-01	3.2E-01	7.0E-02	1.7E-02
Cadmium	1.3E-06	2.9E-09	1.8E-02	5.1E-02	6.8E-02	4.1E-02	1.1E-02
Chromium	1.4E-05	3.0E-08	1.1E-10	4.8E-13	2.4E-15	7.0E-20	0.0
Copper	7.0E-06	1.5E-08	5.5E-11	2.5E-13	1.2E-15	3.6E-20	0.0
Fluoride	4.0E-03	8.6E-06	3.2E-08	1.4E-10	7.0E-13	2.0E-17	0.0
Lead	5.8E-05	1.3E-07	4.6E-10	2.1E-12	1.0E-14	3.0E-19	0.0
Mercury	1.2E-05	2.6E-08	9.6E-11	4.3E-13	2.1E-15	0.0	0.0
Nickel	6.2E-08	1.3E-10	4.9E-13	2.2E-15	1.1E-17	0.0	0.0
Phosphate	0.0	7.6E.04	1.4E-03	1.6E-03	1.4E-03	3.0E-04	7.4E-05
Silver	2.0E-06	4.4E-09	1.6E-11	7.2E-14	3.6E-16	0.0	0.0
Sodium	1.0E-04	2.2E-07	7.9E-10	3.5E-12	1.7E-14	5.1E-19	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	5.0E-10	8.4E-09
EPA Hazard Index	4.2E-03	3.3E-01	4.9E-01	5.8E-01	3.9E-01	1.1E-01	2.8E-02

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 40

Radionuclide Results for Groundwater-to-River Pathway for the No Waste Removal and Closure With Cap Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration (Ci/m^3)								
^{235}U	0.0	0.0	0.0	0.0	0.0	4.6E-19	3.1E-18	0.0
^{238}U	0.0	0.0	0.0	0.0	3.3E-20	5.3E-18	3.5E-17	8.7E-20
^{239}Pu	0.0	0.0	0.0	0.0	0.0	1.2E-18	7.8E-18	1.9E-20
Dose (mrem/yr)								
^{235}U	0.0	0.0	0.0	0.0	0.0	5.7E-11	3.8E-10	0.0
^{238}U	0.0	0.0	0.0	0.0	3.7E-12	6.0E-10	4.0E-09	9.8E-12
^{239}Pu	0.0	0.0	0.0	0.0	0.0	2.5E-10	1.6E-09	4.0E-12
Total Dose	0.0	0.0	0.0	0.0	3.7E-12	9.0E-10	6.0E-09	1.4E-11
Radioactive Risk (HE/yr)								
	0.0	0.0	0.0	0.0	1.0E-18	2.5E-16	1.7E-15	3.9E-18

TABLE 41

Chemical Results for Groundwater-to-River Pathway for the No Waste Removal and Closure With Cap Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration (mg/L)								
Cadmium	0.0	0.0	0.0	6.9E-20	4.2E-15	6.6E-13	4.4E-12	1.1E-14
Chromium	0.0	0.0	0.0	1.1E-17	6.7E-13	1.1E-10	7.1E-10	1.7E-12
Copper	0.0	0.0	0.0	2.8E-17	1.7E-12	2.6E-10	1.8E-09	4.4E-12
Fluoride	0.0	0.0	0.0	6.9E-15	4.2E-10	6.6E-08	4.4E-07	1.1E-09
Lead	0.0	0.0	0.0	1.5E-17	8.7E-13	1.4E-10	9.3E-10	2.3E-12
Mercury	0.0	0.0	0.0	6.9E-20	4.2E-15	6.6E-13	4.4E-12	1.1E-14
Nickel	0.0	0.0	0.0	8.3E-19	5.0E-14	7.9E-12	5.3E-11	1.3E-13
Silver	0.0	0.0	0.0	3.5E-19	2.1E-14	3.3E-12	2.2E-11	5.5E-14
Sodium	0.0	0.0	0.0	1.7E-13	1.0E-08	1.6E-06	1.1E-05	2.6E-08
Noncarcinogenic Risk (ADI fraction)								
Cadmium	0.0	0.0	0.0	1.7E-17	1.0E-12	1.7E-10	1.1E-09	2.7E-12
Chromium	0.0	0.0	0.0	1.7E-16	9.9E-12	1.6E-09	1.1E-08	2.6E-11
Copper	0.0	0.0	0.0	3.3E-17	2.0E-12	3.2E-10	2.1E-09	5.2E-12
Fluoride	0.0	0.0	0.0	1.4E-14	8.2E-10	1.3E-07	8.7E-07	2.2E-09
Lead	0.0	0.0	0.0	4.7E-16	2.8E-11	4.5E-09	3.0E-08	7.5E-11
Mercury	0.0	0.0	0.0	1.1E-16	6.4E-12	1.0E-09	6.8E-09	1.7E-11
Nickel	0.0	0.0	0.0	4.3E-19	2.6E-14	4.1E-12	2.8E-11	6.8E-14
Silver	0.0	0.0	0.0	6.8E-18	4.1E-13	6.5E-11	4.4E-10	1.1E-12
Sodium	0.0	0.0	0.0	4.9E-16	2.9E-11	4.7E-09	3.1E-08	7.7E-11
EPA Hazard Index	0.0	0.0	0.0	1.5E-14	9.0E-10	1.4E-07	9.5E-07	2.4E-09

TABLE 42

Radionuclide Activity Outcrop Data for the No Waste Removal and Closure With Cap Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration in Groundwater at Outcrop (Ci/m^3)								
^{235}U	0.0	0.0	0.0	0.0	0.0	2.5E-14	1.4E-13	0.0
^{238}U	0.0	0.0	0.0	0.0	2.2E-15	2.9E-13	1.6E-12	3.6E-15
^{239}Pu	0.0	0.0	0.0	0.0	0.0	6.4E-14	3.5E-13	7.9E-16
Contaminant Flux at Outcrop (Ci/yr)								
^{235}U	0.0	0.0	0.0	0.0	0.0	4.2E-09	2.8E-08	0.0
^{238}U	0.0	0.0	0.0	0.0	3.0E-10	4.8E-08	3.2E-07	8.0E-10
^{239}Pu	0.0	0.0	0.0	0.0	0.0	1.1E-08	7.1E-08	1.7E-10

TABLE 43

Chemical Concentration Outcrop Data for the No Waste Removal and Closure With Cap Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration in Groundwater at Outcrop (mg/L)								
Cadmium	0.0	0.0	0.0	5.8E-15	2.7E-10	3.6E-08	2.0E-07	4.5E-10
Chromium	0.0	0.0	0.0	9.3E-13	4.4E-08	5.8E-06	3.2E-05	7.2E-08
Copper	0.0	0.0	0.0	2.3E-12	1.1E-07	1.5E-05	7.9E-05	1.8E-07
Fluoride	0.0	0.0	0.0	5.8E-10	2.7E-05	3.6E-03	2.0E-02	4.5E-05
Lead	0.0	0.0	0.0	1.2E-12	5.7E-08	7.6E-06	4.2E-05	9.5E-08
Mercury	0.0	0.0	0.0	5.8E-15	2.7E-10	3.6E-08	2.0E-07	4.5E-10
Nickel	0.0	0.0	0.0	6.9E-14	3.3E-09	4.4E-07	2.4E-06	5.4E-09
Silver	0.0	0.0	0.0	2.9E-14	1.4E-09	1.8E-07	9.9E-07	2.3E-09
Sodium	0.0	0.0	0.0	1.4E-08	6.5E-04	8.7E-02	4.7E-01	1.1E-03
Contaminant Flux at Outcrop (kg/yr)								
Cadmium	0.0	0.0	0.0	6.3E-13	3.8E-08	6.0E-06	4.0E-05	9.9E-08
Chromium	0.0	0.0	0.0	1.0E-10	6.1E-06	9.6E-04	6.4E-03	1.6E-05
Copper	0.0	0.0	0.0	2.5E-10	1.5E-05	2.4E-03	1.6E-02	4.0E-05
Fluoride	0.0	0.0	0.0	6.3E-08	3.8E-03	6.0E-01	4.0E+00	9.9E-03
Lead	0.0	0.0	0.0	1.3E-10	7.9E-06	1.3E-03	8.5E-03	2.1E-05
Mercury	0.0	0.0	0.0	6.3E-13	3.8E-08	6.0E-06	4.0E-05	9.9E-08
Nickel	0.0	0.0	0.0	7.6E-12	4.5E-07	7.2E-05	4.8E-04	1.2E-06
Silver	0.0	0.0	0.0	3.1E-12	1.9E-07	3.0E-05	2.0E-04	5.0E-07
Sodium	0.0	0.0	0.0	1.5E-06	9.1E-02	1.4E+01	9.7E+01	2.4E-01

TABLE 44

Radionuclide Results for Reclaimed-Farmland Pathway for the No Waste Removal and Closure With Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Dose (mrem/yr)							
^{60}Co	5.6E-11	7.6E-17	1.0E-22	1.4E-28	1.9E-34	0.0	0.0
^{90}Sr	4.8E-02	3.2E-03	2.1E-04	1.4E-05	9.0E-07	3.9E-09	1.1E-12
^{90}Y	3.7E-03	2.4E-04	1.6E-05	1.1E-06	6.9E-08	3.0E-10	8.4E-14
^{137}Cs	1.7E-02	1.5E-03	1.3E-04	1.1E-05	9.8E-07	7.4E-09	4.9E-12
^{235}U	1.8E-04	1.3E-04	9.9E-05	7.3E-05	5.4E-05	3.0E-05	1.2E-05
^{238}U	1.9E-03	1.4E-03	1.0E-03	7.7E-04	5.7E-04	3.1E-04	1.3E-04
^{238}Pu	4.0E-06	1.3E-06	4.5E-07	1.5E-07	5.1E-08	5.7E-09	2.2E-10
^{239}Pu	7.4E-05	7.3E-05	7.1E-05	7.0E-05	6.9E-05	6.6E-05	6.3E-05
^{241}Am	3.6E-04	2.3E-04	1.5E-04	9.3E-05	5.9E-05	2.4E-05	6.2E-06
^{244}Cm	1.7E-05	3.3E-07	6.2E-09	1.2E-10	2.2E-12	8.1E-16	5.6E-21
Total Dose	7.1E-02	6.7E-03	1.7E-03	1.0E-03	7.5E-04	4.3E-04	2.1E-04
Radioactive Risk (HE/yr)							
	2.0E-08	1.9E-09	4.8E-10	2.9E-10	2.1E-10	1.2E-10	5.8E-11

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 45

Chemical Results for Reclaimed Farmland Pathway for the No Waste Removal and Closure With Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Noncarcinogenic Risk (ADI fraction)							
Arsenic	3.9E-04	2.9E-04	2.1E-04	1.6E-04	1.2E-04	6.4E-05	2.6E-05
Cadmium	8.0E-04	5.9E-04	4.4E-04	3.2E-04	2.4E-04	1.3E-04	5.4E-05
Chromium	2.9E-04	2.1E-04	1.6E-04	1.2E-04	8.7E-05	4.8E-05	1.9E-05
Copper	3.4E-04	2.5E-04	1.9E-04	1.4E-04	1.0E-04	5.6E-05	2.3E-05
Lead	5.7E-04	4.2E-04	3.1E-04	2.3E-04	1.7E-04	9.5E-05	3.9E-05
Mercury	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.0E-01
Nickel	7.0E-06	5.2E-06	3.9E-06	2.9E-06	2.1E-06	1.2E-06	4.7E-07
Phosphate	1.5E-03	1.1E-03	8.2E-04	6.0E-04	4.6E-04	2.5E-04	1.0E-04
Silver	7.5E-04	5.5E-04	4.1E-04	3.0E-04	2.2E-04	1.2E-04	5.0E-05
Zinc	1.8E-03	1.8E-03	1.8E-03	1.8E-03	1.8E-03	1.8E-03	1.8E-03
EPA Hazard Index	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.0E-01

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 46

Radionuclide Results for Direct Gamma Exposure Pathway for the No Waste Removal and Closure With Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Dose (mrem/yr)							
^{60}Co	2.6E-13	5.8E-19	1.3E-24	2.8E-30	6.0E-36	0.0	0.0
^{137}Cs	1.1E-08	1.4E-09	1.7E-10	2.1E-11	2.7E-12	4.2E-14	8.3E-17
^{235}U	2.7E-20	4.0E-20	6.1E-20	9.2E-20	1.4E-19	3.2E-19	1.1E-18
^{238}Pu	5.1E-15	3.0E-15	1.8E-15	1.1E-15	6.3E-16	2.2E-16	4.6E-17
^{241}Am	6.3E-13	7.1E-13	7.9E-13	8.9E-13	1.0E-12	1.3E-12	1.8E-12
^{244}Cm	2.2E-15	5.7E-17	1.5E-18	3.7E-20	9.4E-22	6.1E-25	1.0E-29
Total Dose	1.1E-08	1.4E-09	1.7E-10	2.2E-11	3.7E-12	1.3E-12	1.8E-12
Radioactive Risk (HE/yr)							
	3.0E-15	3.8E-16	4.8E-17	6.2E-18	1.0E-18	3.7E-19	5.0E-19

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 47

Peak Radionuclide Calculations for the No Waste Removal and Closure Without Cap Option

Pathway	Radio-nuclide	Peak Concentration (Ci/m^3)	Peak Year Since 1985	Dose (mrem/yr)	Radioactive Risk (HE/yr)
Groundwater to well at 1 m	^{3}H	3.2E-04	-23	1.6E+01	4.5E-06
	^{60}Co	3.3E-33	420	5.3E-26	1.5E-32
	^{60}Co*	5.4E-13	-23	8.8E-06	2.5E-12
	^{90}Sr	2.2E-10	340	1.4E-02	3.8E-09
	^{90}Sr*	4.1E-10	-22	2.6E-02	7.2E-09
	^{90}Y	2.2E-10	340	1.1E-03	2.9E-10
	^{90}Y*	4.1E-10	-22	2.0E-03	5.5E-10
	^{137}Cs*	1.6E-09	-22	5.7E-02	1.6E-08
	^{235}U*	2.5E-11	5	3.0E-03	8.4E-10
	^{238}U*	2.9E-10	5	3.2E-02	8.9E-09
	^{238}Pu*	1.5E-11	-19	2.6E-03	7.3E-10
	^{239}Pu*	6.5E-11	5	1.3E-02	3.6E-09
Groundwater to well at 100 m	^{3}H	2.0E-04	-17	1.0E+01	2.8E-06
	^{60}Co*	2.5E-13	-20	4.1E-06	1.1E-12
	^{90}Sr	1.2E-11	390	7.8E-04	2.2E-10
	^{90}Sr*	3.1E-10	-14	2.0E-02	5.5E-09
	^{90}Y	1.2E-11	390	6.0E-05	1.7E-11
	^{90}Y*	3.1E-10	-14	1.5E-03	4.2E-10
	^{137}Cs*	1.2E-09	-14	4.4E-02	1.2E-08
	^{235}U*	2.5E-11	4	2.9E-03	8.3E-10
	^{238}U*	2.8E-10	4	3.1E-02	8.7E-09
	^{238}Pu*	1.3E-11	-6	2.3E-03	6.5E-10
	^{239}Pu*	6.4E-11	4	1.3E-02	3.6E-09
Groundwater to river	^{3}H	3.8E-24	430	1.9E-19	5.4E-26
	^{90}Sr*	3.6E-23	520	3.2E-15	9.1E-22
	^{90}Y*	3.6E-23	520	2.5E-16	7.0E-23
	^{137}Cs*	2.8E-22	520	2.0E-13	5.6E-20
	^{235}U*	3.8E-18	630	4.7E-10	1.3E-16
	^{238}U*	4.3E-17	630	4.9E-09	1.4E-15
	^{238}Pu*	1.5E-20	590	2.8E-12	7.8E-19
	^{239}Pu*	9.6E-18	630	2.0E-09	5.6E-16

* Facilitated transport fraction.

TABLE 48

Peak Chemical Calculations for the No Waste Removal and Closure Without Cap Option

Pathway	Chemical	Peak Concentration (mg/L)	Peak Year Since 1985	Noncarcinogenic Risk (ADI fraction)
Groundwater to well at 1 m	Arsenic	4.2E-01	160	3.4E+00
	Cadmium	8.5E-03	290	5.4E-01
	Cadmium*	3.6E-05	5	2.3E-03
	Chromium*	5.8E-03	5	2.4E-02
	Copper*	1.4E-02	5	1.2E-02
	Fluoride	3.6E+00	5	7.0E+00
	Lead*	7.6E-03	5	1.0E-01
	Mercury*	3.6E-05	5	2.1E-02
	Nickel*	4.3E-04	5	1.1E-04
	Phosphate	2.2E+01	180	1.1E-02
	Silver*	1.8E-04	5	3.5E-03
	Sodium	8.7E+01	5	1.7E-01
Groundwater to well at 100 m	Arsenic	1.9E-01	170	1.5E+00
	Cadmium	2.3E-03	330	1.5E-01
	Cadmium*	3.5E-05	4	2.3E-03
	Chromium*	5.7E-03	4	2.3E-02
	Copper*	1.4E-02	4	1.2E-02
	Fluoride	3.5E+00	4	6.8E+00
	Lead*	7.4E-03	4	9.9E-02
	Mercury*	3.5E-05	4	2.1E-02
	Nickel*	4.3E-04	4	1.1E-04
	Phosphate	8.7E+00	200	4.4E-03
	Silver*	1.8E-04	4	3.5E-03
	Sodium	8.5E+01	4	1.7E-01
Groundwater to river	Cadmium*	5.4E-12	630	1.4E-09
	Chromium*	8.7E-10	630	1.3E-08
	Copper*	2.2E-09	630	2.6E-09
	Fluoride	5.4E-07	630	1.1E-06
	Lead*	1.1E-09	630	3.7E-08
	Mercury*	5.4E-12	630	8.4E-09
	Nickel*	6.5E-11	630	3.4E-11
	Silver*	2.7E-11	630	5.3E-10
	Sodium	1.3E-05	630	3.7E-08

* Facilitated transport fraction.

TABLE 49

Radionuclide Results for Groundwater to Well at 1 m Pathway for the No Waste Removal and Closure Without Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (Ci/m^3)							
^{3}H	5.9E-12	5.4E-17	0.0	0.0	0.0	0.0	0.0
^{90}Sr	3.8E-16	8.7E-20	0.0	1.5E-11	2.1E-13	4.0E-16	8.7E-20
^{90}Y	3.8E-16	8.7E-20	0.0	1.5E-11	2.1E-13	4.0E-16	8.7E-20
^{137}Cs	1.8E-15	4.5E-19	0.0	0.0	0.0	0.0	0.0
^{235}U	4.5E-16	1.1E-18	0.0	0.0	0.0	0.0	0.0
^{238}U	5.1E-15	1.3E-17	5.1E-20	0.0	0.0	0.0	0.0
^{238}Pu	1.0E-16	1.2E-19	0.0	0.0	0.0	0.0	0.0
^{239}Pu	1.1E-15	2.9E-18	1.1E-20	0.0	0.0	0.0	0.0
Dose (mrem/yr)							
^{3}H	3.0E-07	2.7E-12	0.0	0.0	0.0	0.0	0.0
^{90}Sr	2.4E-08	5.5E-12	0.0	9.2E-04	1.3E-05	2.5E-08	5.5E-12
^{90}Y	1.9E-09	4.2E-13	0.0	7.1E-05	1.0E-06	1.9E-09	4.2E-13
^{137}Cs	6.2E-08	1.6E-11	0.0	0.0	0.0	0.0	0.0
^{235}U	5.3E-08	1.4E-10	0.0	0.0	0.0	0.0	0.0
^{238}U	5.6E-07	1.4E-09	5.6E-12	0.0	0.0	0.0	0.0
^{238}Pu	1.8E-08	2.1E-11	0.0	0.0	0.0	0.0	0.0
^{239}Pu	2.3E-07	5.8E-10	2.3E-12	0.0	0.0	0.0	0.0
Total Dose	1.2E-06	2.2E-09	7.8E-12	9.9E-04	1.4E-05	2.7E-08	5.9E-12
Radioactive Risk (HE/yr)							
	3.5E-13	6.2E-16	2.2E-18	2.8E-10	4.0E-12	7.5E-15	1.6E-18

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 50

Chemical Results for Groundwater to Well at 1 m Pathway for the No Waste Removal and Closure Without Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (mg/L)							
Arsenic	0.0	2.9E-02	5.6E-03	2.3E-03	1.1E-03	4.0E-04	1.2E-04
Cadmium	6.4E-10	1.6E-12	2.9E-03	2.8E-04	1.1E-04	3.6E-05	1.2E-05
Chromium	1.0E-07	2.6E-10	1.0E-12	4.7E-15	2.3E-17	0.0	0.0
Copper	2.5E-07	6.6E-10	2.5E-12	1.2E-14	5.9E-17	0.0	0.0
Fluoride	6.4E-05	1.6E-07	6.3E-10	2.9E-12	1.5E-14	4.4E-19	0.0
Lead	1.3E-07	3.4E-10	1.3E-12	6.1E-15	3.1E-17	0.0	0.0
Mercury	6.4E-10	1.6E-12	6.3E-15	2.9E-17	1.5E-19	0.0	0.0
Nickel	7.6E-09	2.0E-11	7.6E-14	3.5E-16	1.8E-18	0.0	0.0
Phosphate	0.0	3.4E+00	4.2E-01	1.6E-01	8.1E-02	2.9E-02	8.9E-03
Silver	3.2E-09	8.2E-12	3.2E-14	1.5E-16	7.3E-19	0.0	0.0
Sodium	1.5E-03	3.9E-06	1.5E-08	7.0E-11	3.5E-13	1.0E-17	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	4.9E-08	6.0E-08
Noncarcinogenic Risk (ADI fraction)							
Arsenic	0.0	2.4E-01	4.6E-02	1.8E-02	9.4E-03	3.3E-03	9.5E-04
Cadmium	4.1E-08	1.0E-10	1.8E-01	1.8E-02	7.0E-03	2.3E-03	7.7E-04
Chromium	4.2E-07	1.1E-09	4.2E-12	1.9E-14	9.7E-17	0.0	0.0
Copper	2.1E-07	5.5E-10	2.1E-12	9.7E-15	4.9E-17	0.0	0.0
Fluoride	1.2E-04	3.1E-07	1.2E-09	5.6E-12	2.8E-14	8.4E-19	0.0
Lead	1.8E-06	4.6E-09	1.8E-11	8.1E-14	4.1E-16	0.0	0.0
Mercury	3.7E-07	9.6E-10	3.7E-12	1.7E-14	8.6E-17	0.0	0.0
Nickel	1.9E-09	4.9E-12	1.9E-14	8.7E-17	4.4E-19	0.0	0.0
Phosphate	0.0	1.7E-03	2.1E-04	8.2E-05	4.1E-05	1.4E-05	4.4E-06
Silver	6.2E-08	1.6E-10	6.2E-13	2.8E-15	1.4E-17	0.0	0.0
Sodium	3.1E-06	7.9E-09	2.9E-11	1.4E-13	7.1E-16	2.2E-20	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	1.3E-08	1.7E-08
EPA Hazard Index	1.2E-04	2.4E-01	2.3E-01	3.6E-02	1.6E-02	5.6E-03	1.7E-03

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 51

Radionuclide Results for Groundwater to Well at 100 m Pathway for the No Waste Removal and Closure Without Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (Ci/m^3)							
^{3}H	5.7E-11	5.3E-16	0.0	0.0	0.0	0.0	0.0
^{90}Sr	3.7E-15	8.5E-19	0.0	1.2E-11	9.7E-13	2.8E-15	7.2E-19
^{90}Y	3.7E-15	8.5E-19	0.0	1.2E-11	9.7E-13	2.8E-15	7.2E-19
^{137}Cs	1.7E-14	4.4E-18	0.0	0.0	0.0	0.0	0.0
^{235}U	4.3E-15	1.1E-17	4.4E-20	0.0	0.0	0.0	0.0
^{238}U	4.9E-14	1.3E-16	5.0E-19	0.0	0.0	0.0	0.0
^{238}Pu	9.7E-16	1.1E-18	0.0	0.0	0.0	0.0	0.0
^{239}Pu	1.1E-14	2.9E-17	1.1E-19	0.0	0.0	0.0	0.0
Dose (mrem/yr)							
^{3}H	2.9E-06	2.7E-11	0.0	0.0	0.0	0.0	0.0
^{90}Sr	2.3E-07	5.4E-11	0.0	7.6E-04	6.1E-05	1.8E-07	4.5E-11
^{90}Y	1.8E-08	4.1E-12	0.0	5.9E-05	4.7E-06	1.4E-08	3.5E-12
^{137}Cs	6.0E-07	1.6E-10	0.0	0.0	0.0	0.0	0.0
^{235}U	5.1E-07	1.3E-09	5.2E-12	0.0	0.0	0.0	0.0
^{238}U	5.4E-06	1.4E-08	5.4E-11	0.0	0.0	0.0	0.0
^{238}Pu	1.7E-07	2.0E-10	0.0	0.0	0.0	0.0	0.0
^{239}Pu	2.2E-06	5.7E-09	2.2E-11	0.0	0.0	0.0	0.0
Total Dose	1.2E-05	2.2E-08	8.2E-11	8.2E-04	6.6E-05	1.9E-07	4.9E-11
Radioactive Risk (HE/yr)							
	3.4E-12	6.0E-15	2.3E-17	2.3E-10	1.8E-11	5.4E-14	1.4E-17

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 52

Chemical Results for Groundwater to Well at 100 m Pathway for the No Waste Removal and Closure Without Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (mg/L)							
Arsenic	0.0	1.4E-01	4.3E-02	1.9E-02	1.0E-02	3.7E-03	1.1E-03
Cadmium	6.2E-09	1.6E-11	1.8E-03	1.5E-03	7.6E-04	2.9E-04	1.1E-04
Chromium	9.9E-07	2.6E-09	1.0E-11	4.6E-14	2.3E-16	0.0	0.0
Copper	2.5E-06	6.4E-09	2.5E-11	1.1E-13	5.8E-16	1.7E-20	0.0
Fluoride	6.2E-04	1.6E-06	6.2E-09	2.9E-11	1.4E-13	4.3E-18	0.0
Lead	1.3E-06	3.4E-09	1.3E-11	6.0E-14	3.0E-16	0.0	0.0
Mercury	6.2E-09	1.6E-11	6.2E-14	2.9E-16	1.4E-18	0.0	0.0
Nickel	7.4E-08	1.9E-10	7.5E-13	3.4E-15	1.7E-17	0.0	0.0
Phosphate	0.0	8.6E+00	2.9E+00	1.3E+00	6.9E-01	2.6E-01	8.3E-02
Silver	3.1E-08	8.0E-11	3.1E-13	1.4E-15	7.2E-18	0.0	0.0
Sodium	1.5E-02	3.9E-05	1.5E-07	6.9E-10	3.5E-12	1.0E-16	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	1.8E-09	3.1E-08
Noncarcinogenic Risk (ADI fraction)							
Arsenic	0.0	1.1E+00	3.5E-01	1.6E-01	8.2E-02	3.0E-02	8.9E-03
Cadmium	3.9E-07	1.0E-09	1.1E-01	9.3E-02	4.8E-02	1.9E-02	6.7E-03
Chromium	4.1E-06	1.1E-08	4.1E-11	1.9E-13	9.5E-16	0.0	0.0
Copper	2.1E-06	5.4E-09	2.1E-11	9.6E-14	4.8E-16	1.4E-20	0.0
Fluoride	1.2E-03	3.1E-06	1.2E-08	5.5E-11	2.8E-13	8.3E-18	0.0
Lead	1.7E-05	4.5E-08	1.7E-10	8.0E-13	4.0E-15	0.0	0.0
Mercury	3.6E-06	9.4E-09	3.7E-11	1.7E-13	8.5E-16	0.0	0.0
Nickel	1.8E-08	4.8E-11	1.9E-13	8.6E-16	4.3E-18	0.0	0.0
Phosphate	0.0	4.4E-03	1.5E-03	6.5E-04	3.5E-04	1.3E-04	4.1E-05
Silver	6.0E-07	1.6E-09	6.1E-12	2.8E-14	1.4E-16	0.0	0.0
Sodium	2.9E-05	7.7E-08	2.9E-10	1.4E-12	6.9E-15	2.2E-19	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	5.0E-10	8.4E-09
EPA Hazard Index	1.2E-03	1.1E+00	4.6E-01	2.5E-01	1.3E-01	4.9E-02	1.6E-02

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 53

Radionuclide Results for Groundwater-to-River Pathway for the No Waste Removal and Closure Without Cap Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration (Ci/m^3)								
^{235}U	0.0	0.0	0.0	0.0	0.0	6.5E-19	2.8E-18	0.0
^{238}U	0.0	0.0	0.0	0.0	5.8E-20	7.5E-18	3.2E-17	5.5E-20
^{239}Pu	0.0	0.0	0.0	0.0	1.3E-20	1.7E-18	7.1E-18	1.2E-20
Dose (mrem/yr)								
^{235}U	0.0	0.0	0.0	0.0	0.0	8.0E-11	3.4E-10	0.0
^{238}U	0.0	0.0	0.0	0.0	6.5E-12	8.4E-10	3.6E-09	6.2E-12
^{239}Pu	0.0	0.0	0.0	0.0	2.7E-12	3.5E-10	1.5E-09	2.5E-12
Total Dose	0.0	0.0	0.0	0.0	9.2E-12	1.3E-09	5.4E-09	8.7E-12
Radioactive Risk (HE/yr)								
	0.0	0.0	0.0	0.0	2.6E-18	3.5E-16	1.5E-15	2.4E-18

TABLE 54

Chemical Results for Groundwater-to-River Pathway for the No Waste Removal and Closure Without Cap Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration (mg/L)								
Cadmium	0.0	0.0	0.0	1.3E-19	7.2E-15	9.3E-13	4.0E-12	6.9E-15
Chromium	0.0	0.0	0.0	2.1E-17	1.2E-12	1.5E-10	6.4E-10	1.1E-12
Copper	0.0	0.0	0.0	5.2E-17	2.9E-12	3.7E-10	1.6E-09	2.8E-12
Fluoride	0.0	0.0	0.0	1.3E-14	7.2E-10	9.3E-08	4.0E-07	6.9E-10
Lead	0.0	0.0	0.0	2.7E-17	1.5E-12	2.0E-10	8.4E-10	1.4E-12
Mercury	0.0	0.0	0.0	1.3E-19	7.2E-15	9.3E-13	4.0E-12	6.9E-15
Nickel	0.0	0.0	0.0	1.6E-18	8.6E-14	1.1E-11	4.8E-11	8.3E-14
Silver	0.0	0.0	0.0	6.5E-19	3.6E-14	4.7E-12	2.0E-11	3.4E-14
Sodium	0.0	0.0	0.0	3.1E-13	1.7E-08	2.2E-06	9.6E-06	1.7E--8
Noncarcinogenic Risk (ADI fraction)								
Cadmium	0.0	0.0	0.0	3.2E-17	1.8E-12	2.3E-10	1.0E-09	1.7E-12
Chromium	0.0	0.0	0.0	3.1E-16	1.7E-11	2.2E-09	9.6E-09	1.6E-11
Copper	0.0	0.0	0.0	6.2E-17	3.5E-12	4.5E-10	1.9E-09	3.3E-12
Fluoride	0.0	0.0	0.0	2.6E-14	1.4E-09	1.8E-07	7.9E-07	1.4E-09
Lead	0.0	0.0	0.0	8.9E-16	4.9E-11	6.4E-09	2.7E-08	4.7E-11
Mercury	0.0	0.0	0.0	2.0E-16	1.1E-11	1.4E-09	6.2E-09	1.1E-11
Nickel	0.0	0.0	0.0	8.1E-19	4.5E-14	5.8E-12	2.5E-11	4.3E-14
Silver	0.0	0.0	0.0	1.3E-17	7.1E-13	9.2E-11	3.9E-10	6.8E-13
Sodium	0.0	0.0	0.0	9.0E-16	5.1E-11	6.5E-09	2.8E-08	4.9E-11
EPA Hazard Index	0.0	0.0	0.0	2.8E-14	1.5E-09	2.0E-07	8.6E-07	1.5E-09

TABLE 55

Radionuclide Activity Outcrop Data for the No Waste Removal and Closure Without Cap Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration in Groundwater at Outcrop (Ci/m^3)								
^{235}U	0.0	0.0	0.0	0.0	0.0	3.6E-14	1.2E-13	0.0
^{238}U	0.0	0.0	0.0	0.0	3.8E-15	4.1E-13	1.4E-12	2.3E-15
^{239}Pu	0.0	0.0	0.0	0.0	8.4E-16	9.0E-14	3.1E-13	5.0E-16
Contaminant Flux at Outcrop (Ci/yr)								
^{235}U	0.0	0.0	0.0	0.0	0.0	5.9E-09	2.6E-08	0.0
^{238}U	0.0	0.0	0.0	0.0	5.2E-10	6.8E-08	2.9E-07	5.0E-10
^{239}Pu	0.0	0.0	0.0	0.0	1.2E-10	1.5E-08	6.4E-08	1.1E-10

TABLE 56

Chemical Concentration Outcrop Data for the No Waste Removal and Closure Without Cap Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration in Groundwater at Outcrop (mg/L)								
Cadmium	0.0	0.0	0.0	1.1E-14	4.7E-10	5.1E-08	1.8E-07	2.8E-10
Chromium	0.0	0.0	0.0	1.7E-12	7.5E-08	8.1E-06	2.9E-05	4.6E[illegible]
Copper	0.0	0.0	0.0	4.3E-12	1.9E-07	2.0E-05	7.1E-05	1.1E-07
Fluoride	0.0	0.0	0.0	1.1E-09	4.7E-05	5.1E-03	1.8E-02	2.8E-05
Lead	0.0	0.0	0.0	2.3E-12	9.9E-08	1.1E-05	3.7E-05	6.0E-08
Mercury	0.0	0.0	0.0	1.1E-14	4.7E-10	5.1E-08	1.8E-07	2.8E-10
Nickel	0.0	0.0	0.0	1.3E-13	5.7E-09	6.1E-07	2.1E-06	3.4E-09
Silver	0.0	0.0	0.0	5.4E-14	2.4E-09	2.5E-07	8.9E-07	1.4E-09
Sodium	0.0	0.0	0.0	2.6E-08	1.1E-03	1.2E-01	4.3E-01	6.8E-04
Contaminant Flux at Outcrop (kg/yr)								
Cadmium	0.0	0.0	0.0	1.2E-12	6.6E-08	8.5E-06	3.6E-05	6.3E-08
Chromium	0.0	0.0	0.0	1.9E-10	1.0E-05	1.4E-03	5.8E-03	1.0E-05
Copper	0.0	0.0	0.0	4.7E-10	2.6E-05	3.4E-03	1.5E-02	2.5E-05
Fluoride	0.0	0.0	0.0	1.2E-07	6.6E-03	8.5E-01	3.6E+00	6.3E-03
Lead	0.0	0.0	0.0	2.5E-10	1.4E-05	1.8E-03	7.7E-03	1.3E-05
Mercury	0.0	0.0	0.0	1.2E-12	6.6E-08	8.5E-06	3.6E-05	6.3E-08
Nickel	0.0	0.0	0.0	1.4E-11	7.9E-07	1.0E-04	4.4E-04	7.5E-07
Silver	0.0	0.0	0.0	5.9E-12	3.3E-07	4.2E-05	1.8E-04	3.1E-07
Sodium	0.0	0.0	0.0	2.8E-06	1.6E-01	2.0E+01	8.7E+01	1.5E-01

TABLE 57

Radionuclide Results for Reclaimed-Farmland Pathway for the No Waste Removal and Closure Without Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Dose (mrem/yr)							
^{60}Co	1.2E-11	3.2E-18	8.8E-25	2.4E-31	6.7E-38	0.0	0.0
^{90}Sr	1.0E-02	1.3E-04	1.8E-06	2.3E-08	3.1E-10	5.4E-14	1.3E-19
^{90}Y	7.7E-04	1.0E-05	1.4E-07	1.8E-09	2.4E-11	4.2E-15	9.8E-21
^{137}Cs	2.8E-02	2.5E-03	2.1E-04	1.9E-05	1.6E-06	1.2E-08	8.2E-12
^{235}U	4.8E-05	8.6E-06	1.6E-06	2.8E-07	5.0E-08	1.6E-09	9.6E-12
^{238}U	5.0E-04	9.1E-05	1.6E-05	2.9E-06	5.3E-07	1.7E-08	1.0E-10
^{238}Pu	4.0E-06	9.1E-07	2.1E-07	4.8E-08	1.1E-08	5.7E-10	6.7E-12
^{239}Pu	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.1E-04	1.1E-04	1.0E-04
^{241}Am	3.6E-04	1.6E-04	6.8E-05	2.9E-05	1.3E-05	2.4E-06	1.9E-07
^{244}Cm	2.8E-05	5.4E-07	1.0E-08	2.0E-10	3.7E-12	1.4E-15	9.4E-21
Total Dose	4.0E-02	3.0E-03	4.2E-04	1.7E-04	1.3E-04	1.1E-04	1.0E-04
Radioactive Risk (HE/yr)							
	1.1E-08	8.3E-10	1.2E-10	4.7E-11	3.6E-11	3.2E-11	2.9E-11

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 58

Chemical Results for Reclaimed Farmland Pathway for the No Waste Removal and Closure Without Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Noncarcinogenic Risk (ADI fraction)							
Arsenic	8.1E-05	1.2E-05	1.8E-06	2.7E-07	4.0E-08	9.0E-10	3.0E-12
Cadmium	1.7E-04	2.5E-05	3.7E-06	5.6E-07	8.3E-08	1.9E-09	6.2E-12
Chromium	7.6E-05	1.4E-05	2.5E-06	4.5E-07	8.1E-08	2.6E-09	1.5E-11
Copper	7.0E-05	1.1E-05	1.6E-06	2.4E-07	3.5E-08	7.9E-10	2.6E-12
Lead	5.8E-04	2.9E-04	1.5E-04	7.4E-05	3.7E-05	9.4E-06	1.2E-06
Mercury	3.6E-01	3.6E-01	3.5E-01	3.5E-01	3.5E-01	3.4E-01	3.4E-01
Nickel	7.1E-06	3.6E-06	1.8E-06	9.0E-07	4.5E-07	1.2E-07	1.5E-08
Phosphate	3.0E-04	4.6E-05	7.1E-06	1.0E-06	1.6E-07	3.5E-09	1.2E-11
Silver	7.5E-04	3.8E-04	1.9E-04	9.6E-05	4.8E-05	1.2E-05	1.6E-06
Zinc	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03
EPA Hazard Index	3.6E-01	3.6E-01	3.6E-01	3.5E-01	3.5E-01	3.5E-01	3.4E-01

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 59

Radionuclide Results for Direct Gamma Exposure Pathway for the No Waste Removal and Closure Without Cap Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Dose (mrem/yr)							
^{60}Co	7.9E-12	1.7E-17	3.8E-23	8.3E-29	1.8E-34	0.0	0.0
^{137}Cs	1.0E-06	1.3E-07	1.6E-08	2.0E-09	2.5E-10	3.8E-12	7.5E-15
^{235}U	9.9E-17	1.5E-16	2.3E-16	3.4E-16	5.1E-16	1.2E-15	4.0E-15
^{238}Pu	1.0E-12	6.2E-13	3.6E-13	2.2E-13	1.3E-13	4.4E-14	9.2E-15
^{241}Am	1.3E-10	1.4E-10	1.6E-10	1.8E-10	2.0E-10	2.5E-10	3.6E-10
^{244}Cm	4.6E-13	1.2E-14	3.0E-16	7.5E-18	1.9E-19	1.2E-22	2.0E-27
Total Dose	1.0E-06	1.3E-07	1.6E-08	2.1E-09	4.5E-10	2.6E-10	3.6E-10
Radioactive Risk (HE/yr)							
	2.8E-13	3.5E-14	4.4E-15	6.0E-16	1.3E-16	7.2E-17	1.0E-16

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 60

Peak Radionuclide Calculations for the No Action Option

Pathway	Radio-nuclide	Peak Concentration (Ci/m^3)	Peak Year Since 1985	Dose (mrem/yr)	Radioactive Risk (HE/yr)
Groundwater to well at 1 m	^{3}H	3.2E-04	-23	1.6E+01	4.5E-06
	^{60}Co	6.2E-33	420	1.0E-25	2.8E-32
	^{60}Co*	5.4E-13	-23	8.8E-06	2.5E-12
	^{90}Sr	4.1E-10	340	2.6E-02	7.2E-09
	^{90}Sr*	4.1E-10	-22	2.6E-02	7.2E-09
	^{90}Y	4.1E-10	340	2.0E-03	5.6E-10
	^{90}Y*	4.1E-10	-22	2.0E-03	5.5E-10
	^{137}Cs*	1.6E-09	-22	5.7E-02	1.6E-08
	^{235}U*	2.7E-11	2	3.2E-03	8.9E-10
	^{238}U*	3.1E-10	2	3.4E-02	9.4E-09
	^{238}Pu*	1.5E-11	-19	2.6E-03	7.3E-10
	^{239}Pu*	6.9E-11	2	1.4E-02	3.8E-09
Groundwater to well at 100 m	^{3}H	2.0E-04	-17	1.0E+01	2.8E-06
	^{60}Co*	2.5E-13	-20	4.1E-06	1.1E-12
	^{90}Sr	1.8E-11	380	1.2E-03	3.2E-10
	^{90}Sr*	3.1E-10	-14	2.0E-02	5.5E-09
	^{90}Y	1.8E-11	380	8.9E-05	2.5E-11
	^{90}Y*	3.1E-10	-14	1.5E-03	4.2E-10
	^{137}Cs*	1.2E-09	-14	4.4E-02	1.2E-08
	^{235}U*	2.6E-11	3	3.1E-03	8.7E-10
	^{238}U*	3.0E-10	3	3.3E-02	9.2E-09
	^{238}Pu*	1.3E-11	-6	2.3E-03	6.5E-10
	^{239}Pu*	6.7E-11	3	1.3E-02	3.8E-09
Groundwater to river	^{3}H	3.9E-24	430	2.0E-19	5.6E-26
	^{90}Sr*	3.7E-23	520	3.3E-15	9.3E-22
	^{90}Y*	3.7E-23	520	2.5E-16	7.1E-23
	^{137}Cs*	2.8E-22	520	2.0E-13	5.7E-20
	^{235}U*	3.8E-18	630	4.7E-10	1.3E-16
	^{238}U*	4.4E-17	630	4.9E-09	1.4E-15
	^{238}Pu*	1.5E-20	590	2.8E-12	7.9E-19
	^{239}Pu*	9.6E-18	630	2.0E-09	5.6E-16

* Facilitated transport fraction.

TABLE 61

Peak Chemical Calculations for the No Action Option

Pathway	Chemical	Peak Concentration (mg/L)	Peak Year Since 1985	Noncarcinogenic Risk (ADI fraction)
Groundwater to well at 1 m	Arsenic	7.4E-01	130	6.1E+00
	Cadmium	1.4E-02	260	9.2E-01
	Cadmium*	3.8E-05	2	2.4E-03
	Chromium*	6.1E-03	2	2.5E-02
	Copper*	1.5E-02	2	1.3E-02
	Fluoride	3.8E+00	2	7.4E+00
	Lead*	8.0E-03	2	1.1E-01
	Mercury*	3.8E-05	2	2.2E-02
	Nickel*	4.6E-04	2	1.1E-04
	Phosphate	3.8E+01	160	1.9E-02
	Silver*	1.9E-04	2	3.7E-03
	Sodium	9.2E+01	2	1.8E-01
Groundwater to well at 100 m	Arsenic	2.1E-01	150	1.7E+00
	Cadmium	2.4E-03	310	1.5E-01
	Cadmium*	3.7E-05	3	2.4E-03
	Chromium*	6.0E-03	3	2.5E-02
	Copper*	1.5E-02	3	1.3E-02
	Fluoride	3.7E+00	3	7.2E+00
	Lead*	7.9E-03	3	1.0E-01
	Mercury*	3.7E-05	3	2.2E-02
	Nickel*	4.5E-04	3	1.1E-04
	Phosphate	9.5E+00	180	4.6E-03
	Silver*	1.9E-04	3	3.7E-03
	Sodium	9.0E+01	3	1.8E-01
Groundwater to river	Cadmium*	5.4E-12	630	1.4E-09
	Chromium*	8.7E-10	630	1.3E-08
	Copper*	2.2E-09	630	2.6E-09
	Fluoride	5.4E-07	630	1.1E-06
	Lead*	1.1E-09	630	3.7E-08
	Mercury*	5.4E-12	630	8.4E-09
	Nickel*	6.5E-11	630	3.4E-11
	Silver*	2.7E-11	630	5.4E-10
	Sodium	1.3E-05	630	3.7E-08

* Facilitated transport fraction.

TABLE 62

Radionuclide Results for Groundwater to Well at 1 m Pathway for the No Action Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (Ci/m^3)							
^{3}H	5.5E-12	5.1E-17	0.0	0.0	0.0	0.0	0.0
^{90}Sr	3.6E-16	8.2E-20	0.0	9.1E-12	1.8E-13	3.7E-16	8.3E-20
^{90}Y	3.6E-16	8.2E-20	0.0	9.1E-12	1.8E-13	3.7E-16	8.3E-20
^{137}Cs	1.6E-15	4.3E-19	0.0	0.0	0.0	0.0	0.0
^{235}U	4.2E-16	1.1E-18	0.0	0.0	0.0	0.0	0.0
^{238}U	4.8E-15	1.2E-17	4.8E-20	0.0	0.0	0.0	0.0
^{238}Pu	9.4E-17	1.1E-19	0.0	0.0	0.0	0.0	0.0
^{239}Pu	1.1E-15	2.8E-18	1.1E-20	0.0	0.0	0.0	0.0
Dose (mrem/yr)							
^{3}H	2.8E-07	2.6E-12	0.0	0.0	0.0	0.0	0.0
^{90}Sr	2.3E-08	5.2E-12	0.0	5.7E-04	1.1E-05	2.3E-08	5.2E-12
^{90}Y	1.7E-09	4.0E-13	0.0	4.4E-05	8.8E-07	1.8E-09	4.0E-13
^{137}Cs	5.8E-08	1.5E-11	0.0	0.0	0.0	0.0	0.0
^{235}U	5.0E-08	1.3E-10	0.0	0.0	0.0	0.0	0.0
^{238}U	5.2E-07	1.4E-09	5.2E-12	0.0	0.0	0.0	0.0
^{238}Pu	1.6E-08	1.9E-11	0.0	0.0	0.0	0.0	0.0
^{239}Pu	2.1E-07	5.5E-10	2.1E-12	0.0	0.0	0.0	0.0
Total Dose	1.2E-06	2.1E-09	7.4E-12	6.2E-04	1.2E-05	2.5E-08	5.7E-12
Radioactive Risk (HE/yr)							
	3.2E-13	5.8E-16	2.1E-18	1.7E-10	3.4E-12	7.0E-15	1.6E-18

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 63

Chemical Results for Groundwater to Well at 1 m Pathway for the No Action Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (mg/L)							
Arsenic	0.0	2.0E-02	4.8E-03	2.0E-03	1.1E-03	3.8E-04	1.1E-04
Cadmium	6.0E-10	1.5E-12	1.4E-03	2.4E-04	1.0E-04	3.4E-05	1.2E-05
Chromium	9.5E-08	2.5E-10	9.6E-13	4.4E-15	2.2E-17	0.0	0.0
Copper	2.4E-07	6.2E-10	2.4E-12	1.1E-14	5.6E-17	0.0	0.0
Fluoride	6.0E-05	1.5E-07	6.0E-10	2.8E-12	1.4E-14	4.2E-19	0.0
Lead	1.2E-07	3.2E-10	1.3E-12	5.8E-15	2.9E-17	0.0	0.0
Mercury	6.0E-10	1.5E-12	6.0E-15	2.8E-17	1.4E-19	0.0	0.0
Nickel	7.1E-09	1.9E-11	7.2E-14	3.3E-16	1.7E-18	0.0	0.0
Phosphate	0.0	1.9E+00	3.6E-01	1.5E-01	7.5E-02	2.7E-02	8.6E-03
Silver	3.0E-09	7.7E-12	3.0E-14	1.4E-16	7.0E-19	0.0	0.0
Sodium	1.4E-03	3.7E-06	1.4E-08	6.6E-11	3.3E-13	1.0E-17	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	4.9E-08	6.0E-08
Noncarcinogenic Risk (ADI fraction)							
Arsenic	0.0	1.6E-01	4.0E-02	1.7E-02	8.7E-03	3.1E-03	9.1E-04
Cadmium	3.8E-08	9.8E-11	8.7E-02	1.5E-02	6.3E-03	2.1E-03	7.4E-04
Chromium	3.9E-07	1.0E-09	4.0E-12	1.8E-14	9.2E-17	0.0	0.0
Copper	2.0E-07	5.2E-10	2.0E-12	9.2E-15	4.7E-17	0.0	0.0
Fluoride	1.1E-04	3.0E-07	1.2E-09	5.3E-12	2.7E-14	8.0E-19	0.0
Lead	1.7E-06	4.3E-09	1.7E-11	7.7E-14	3.9E-16	0.0	0.0
Mercury	3.5E-07	9.1E-10	3.5E-12	1.6E-14	8.2E-17	0.0	0.0
Nickel	1.8E-09	4.6E-12	1.8E-14	8.2E-17	4.2E-19	0.0	0.0
Phosphate	0.0	9.5E-04	1.8E-04	7.4E-05	3.8E-05	1.4E-05	4.4E-06
Silver	5.8E-08	1.5E-10	5.9E-13	2.7E-15	1.4E-17	0.0	0.0
Sodium	2.9E-06	7.5E-09	2.9E-11	1.3E-13	6.7E-16	2.0E-20	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	1.3E-08	1.7E-08
EPA Hazard Index	1.1E-04	1.6E-01	1.3E-01	3.2E-02	1.5E-02	5.2E-03	1.6E-03

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 64

Radionuclide Results for Groundwater to Well at 100 m Pathway for the No Action Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (Ci/m^3)							
^{3}H	5.3E-11	5.0E-16	0.0	0.0	0.0	0.0	0.0
^{90}Sr	3.5E-15	8.0E-19	0.0	1.5E-11	9.0E-13	2.7E-15	7.0E-19
^{90}Y	3.5E-15	8.0E-19	0.0	1.5E-11	9.0E-13	2.7E-15	7.0E-19
^{137}Cs	1.6E-14	4.2E-18	0.0	0.0	0.0	0.0	0.0
^{235}U	4.0E-15	1.1E-17	4.1E-20	0.0	0.0	0.0	0.0
^{238}U	4.6E-14	1.2E-16	4.7E-19	0.0	0.0	0.0	0.0
^{238}Pu	9.1E-16	1.1E-18	0.0	0.0	0.0	0.0	0.0
^{239}Pu	1.0E-14	2.7E-17	1.1E-19	0.0	0.0	0.0	0.0
Dose (mrem/yr)							
^{3}H	2.7E-06	2.5E-11	0.0	0.0	0.0	0.0	0.0
^{90}Sr	2.2E-07	5.1E-11	0.0	9.3E-04	5.7E-05	1.7E-07	4.4E-11
^{90}Y	1.7E-08	3.9E-12	0.0	7.2E-05	4.4E-06	1.3E-08	3.4E-12
^{137}Cs	5.6E-07	1.5E-10	0.0	0.0	0.0	0.0	0.0
^{235}U	4.8E-07	1.3E-09	4.9E-12	0.0	0.0	0.0	0.0
^{238}U	5.1E-06	1.3E-08	5.2E-11	0.0	0.0	0.0	0.0
^{238}Pu	1.6E-07	1.9E-10	0.0	0.0	0.0	0.0	0.0
^{239}Pu	2.1E-06	5.4E-09	2.1E-11	0.0	0.0	0.0	0.0
Total Dose	1.1E-05	2.0E-08	7.7E-11	1.0E-03	6.1E-05	1.8E-07	4.7E-11
Radioactive Risk (HE/yr)							
	3.1E-12	5.7E-15	2.2E-17	2.8E-10	1.7E-11	5.1E-14	1.3E-17

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 65

Chemical Results for Groundwater to Well at 100 m Pathway for the No Action Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Concentration (mg/L)							
Arsenic	0.0	1.1E-01	3.8E-02	1.7E-02	9.3E-03	3.5E-03	1.0E-03
Cadmium	5.8E-09	1.5E-11	2.4E-03	1.3E-03	7.0E-04	2.8E-04	1.0E-04
Chromium	9.2E-07	2.4E-09	9.4E-12	4.3E-14	2.2E-16	0.0	0.0
Copper	2.3E-06	6.1E-09	2.4E-11	1.1E-13	5.5E-16	1.6E-20	0.0
Fluoride	5.8E-04	1.5E-06	5.9E-09	2.7E-11	1.4E-13	4.1E-18	0.0
Lead	1.2E-06	3.2E-09	1.2E-11	5.7E-14	2.9E-16	0.0	0.0
Mercury	5.8E-09	1.5E-11	5.9E-14	2.7E-16	1.4E-18	0.0	0.0
Nickel	6.9E-08	1.8E-10	7.1E-13	3.3E-15	1.6E-17	0.0	0.0
Phosphate	0.0	7.9E+00	2.6E+00	1.2E+00	6.4E-01	2.5E-01	8.0E-02
Silver	2.9E-08	7.6E-11	2.9E-13	1.4E-15	6.8E-18	0.0	0.0
Sodium	1.4E-02	3.6E-05	1.4E-07	6.5E-10	3.3E-12	9.8E-17	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	1.8E-09	3.1E-08
Noncarcinogenic Risk (ADI fraction)							
Arsenic	0.0	9.4E-01	3.1E-01	1.4E-01	7.7E-02	2.8E-02	8.5E-03
Cadmium	3.7E-07	9.6E-10	1.5E-01	8.5E-02	4.5E-02	1.8E-02	6.5E-03
Chromium	3.8E-06	1.0E-08	3.9E-11	1.8E-13	9.0E-16	0.0	0.0
Copper	1.9E-06	5.1E-09	2.0E-11	9.1E-14	4.6E-16	1.4E-20	0.0
Fluoride	1.1E-03	2.9E-06	1.1E-08	5.2E-11	2.6E-13	7.9E-18	0.0
Lead	1.6E-05	4.2E-08	1.6E-10	7.6E-13	3.8E-15	0.0	0.0
Mercury	3.4E-06	8.9E-09	3.5E-11	1.6E-13	8.0E-16	0.0	0.0
Nickel	1.7E-08	4.5E-11	1.8E-13	8.1E-16	4.1E-18	0.0	0.0
Phosphate	0.0	3.8E-03	1.3E-03	6.0E-04	3.3E-04	1.2E-04	4.1E-05
Silver	5.6E-07	1.5E-09	5.8E-12	2.6E-14	1.3E-16	0.0	0.0
Sodium	2.8E-05	7.3E-08	2.8E-10	1.3E-12	6.5E-15	2.0E-19	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	5.0E-10	8.4E-09
EPA Hazard Index	1.1E-03	9.4E-01	4.6E-01	2.3E-01	1.2E-01	4.6E-01	1.5E-02

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 66

Radionuclide Results for Groundwater-to-River Pathway for the No Action Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration (Ci/m^3)								
^{235}U	0.0	0.0	0.0	0.0	0.0	6.7E-19	2.8E-18	0.0
^{238}U	0.0	0.0	0.0	0.0	6.0E-20	7.6E-18	3.2E-17	5.4E-20
^{239}Pu	0.0	0.0	0.0	0.0	1.3E-20	1.7E-18	7.0E-18	1.2E-20
Dose (mrem/yr)								
^{235}U	0.0	0.0	0.0	0.0	0.0	8.2E-11	3.4E-10	0.0
^{238}U	0.0	0.0	0.0	0.0	6.8E-12	8.6E-10	3.6E-09	6.0E-12
^{239}Pu	0.0	0.0	0.0	0.0	2.8E-12	3.5E-10	1.5E-09	2.5E-12
Total Dose	0.0	0.0	0.0	0.0	9.6E-12	1.3E-09	5.4E-09	8.5E-12
Radioactive Risk (HE/yr)								
	0.0	0.0	0.0	0.0	2.7E-18	3.6E-16	1.5E-15	2.4E-18

TABlE 67

Chemical Results for Groundwater-to-River Pathway for the No Action Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration (mg/L)								
Cadmium	0.0	0.0	0.0	1.4E-19	7.5E-15	9.5E-13	4.0E-12	6.7E-15
Chromium	0.0	0.0	0.0	2.2E-17	1.2E-12	1.5E-10	6.4E-10	1.1E-12
Copper	0.0	0.0	0.0	5.5E-17	3.0E-12	3.8E-10	1.6E-09	2.7E-12
Fluoride	0.0	0.0	0.0	1.4E-14	7.5E-10	9.5E-08	4.0E-07	6.7E-10
Lead	0.0	0.0	0.0	2.9E-17	1.6E-12	2.0E-10	8.3E-10	1.4E-12
Mercury	0.0	0.0	0.0	1.4E-19	7.5E-15	9.5E-13	4.0E-12	6.7E-15
Nickel	0.0	0.0	0.0	1.6E-18	9.0E-14	1.1E-11	4.8E-11	8.0E-14
Silver	0.0	0.0	0.0	6.9E-19	3.8E-14	4.8E-12	2.0E-11	3.4E-14
Sodium	0.0	0.0	0.0	3.3E-13	1.8E-08	2.3E-06	9.5E-06	1.6E-08
Noncarcinogenic Risk (ADI fraction)								
Cadmium	0.0	0.0	0.0	3.4E-17	1.9E-12	2.4E-10	9.9E-10	1.7E-12
Chromium	0.0	0.0	0.0	3.3E-16	1.8E-11	2.3E-09	9.5E-09	1.6E-11
Copper	0.0	0.0	0.0	6.6E-17	3.6E-12	4.6E-10	1.9E-09	3.2E-12
Fluoride	0.0	0.0	0.0	2.7E-14	1.5E-09	1.9E-07	7.9E-07	1.3E-09
Lead	0.0	0.0	0.0	9.4E-16	5.1E-11	6.5E-09	2.7E-08	4.6E-11
Mercury	0.0	0.0	0.0	2.1E-16	1.2E-11	1.5E-09	6.1E-09	1.0E-11
Nickel	0.0	0.0	0.0	8.6E-19	4.7E-14	5.9E-12	2.5E-11	4.2E-14
Silver	0.0	0.0	0.0	1.4E-17	7.4E-13	9.4E-11	3.9E-10	6.6E-13
Sodium	0.0	0.0	0.0	9.6E-16	5.3E-11	6.7E-09	2.8E-08	4.7E-11
EPA Hazard Index	0.0	0.0	0.0	2.9E-14	1.6E-09	2.1E-07	8.6E-07	1.4E-09

TABLE 68

Radionuclide Activity Outcrop Data for the No Action Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration in Groundwater at Outcrop (Ci/m^3)								
^{235}U	0.0	0.0	0.0	0.0	0.0	3.6E-14	1.2E-13	0.0
^{238}U	0.0	0.0	0.0	0.0	3.9E-15	4.2E-13	1.4E-12	2.2E-15
^{239}Pu	0.0	0.0	0.0	0.0	8.7E-16	9.2E-14	3.1E-13	4.8E-16
Contaminant Flux at Outcrop (Ci/yr)								
^{235}U	0.0	0.0	0.0	0.0	0.0	6.1E-09	2.5E-08	0.0
^{238}U	0.0	0.0	0.0	0.0	5.5E-10	6.9E-08	2.9E-07	4.9E-10
^{239}Pu	0.0	0.0	0.0	0.0	1.2E-10	1.5E-08	6.4E-08	1.1E-10

TABLE 69

Chemical Concentration Outcrop Data for the No Action Option

	Years Since 1985							
	0	100	200	300	400	500	700	1000
Concentration in Groundwater at Outcrop (mg/L)								
Cadmium	0.0	0.0	0.0	1.1E-14	4.9E-10	5.2E-08	1.8E-07	2.8E-10
Chromium	0.0	0.0	0.0	1.8E-12	7.9E-08	8.3E-06	2.8E-05	4.4E-08
Copper	0.0	0.0	0.0	4.6E-12	2.0E-07	2.1E-05	7.1E-05	1.1E-07
Fluoride	0.0	0.0	0.0	1.1E-09	4.9E-05	5.2E-03	1.8E-02	2.8E-05
Lead	0.0	0.0	0.0	2.4E-12	1.0E-07	1.1E-05	3.7E-05	5.8E-08
Mercury	0.0	0.0	0.0	1.1E-14	4.9E-10	5.2E-08	1.8E-07	2.8E-10
Nickel	0.0	0.0	0.0	1.4E-13	5.9E-09	6.2E-07	2.1E-06	3.3E-09
Silver	0.0	0.0	0.0	5.7E-14	2.5E-09	2.6E-07	8.8E-07	1.4E-09
Sodium	0.0	0.0	0.0	2.8E-08	1.2E-03	1.2E-01	4.2E-01	6.6E-04
Contaminant Flux at Outcrop (kg/yr)								
Cadmium	0.0	0.0	0.0	1.2E-12	6.8E-08	8.7E-06	3.6E-05	6.1E-08
Chromium	0.0	0.0	0.0	2.0E-10	1.1E-05	1.4E-03	5.8E-03	9.8E-06
Copper	0.0	0.0	0.0	5.0E-10	2.7E-05	3.5E-03	1.4E-02	2.4E-05
Fluoride	0.0	0.0	0.0	1.2E-07	6.8E-03	8.7E-01	3.6E+00	6.1E-03
Lead	0.0	0.0	0.0	2.6E-10	1.4E-05	1.8E-03	7.6E-03	1.3E-05
Mercury	0.0	0.0	0.0	1.2E-12	6.8E-08	8.7E-06	3.6E-05	6.1E-08
Nickel	0.0	0.0	0.0	1.5E-11	8.2E-07	1.0E-04	4.3E-04	7.3E-07
Silver	0.0	0.0	0.0	6.2E-12	3.4E-07	4.3E-05	1.8E-04	3.1E-07
Sodium	0.0	0.0	0.0	3.0E-06	1.6E-01	2.1E+01	8.7E+01	1.5E-01

TABLE 70

Radionuclide Results for Reclaimed-Farmland Pathway for the No Action Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Dose (mrem/yr)							
^{60}Co	1.3E-12	6.4E-20	3.2E-27	1.6E-34	0.0	0.0	0.0
^{90}Sr	1.1E-03	2.7E-06	6.5E-09	1.6E-11	3.8E-14	2.2E-19	3.2E-27
^{90}Y	8.5E-05	2.1E-07	5.0E-10	1.2E-12	2.9E-15	1.7E-20	2.4E-28
^{137}Cs	2.8E-02	2.5E-03	2.1E-04	1.9E-05	1.6E-06	1.2E-08	8.2E-12
^{235}U	4.8E-05	8.6E-06	1.6E-06	2.8E-07	5.0E-08	1.6E-09	9.6E-12
^{238}U	5.0E-04	9.1E-05	1.6E-05	2.9E-06	5.3E-07	1.7E-08	1.0E-10
^{238}Pu	4.0E-06	9.1E-07	2.1E-07	4.8E-08	1.1E-08	5.7E-10	6.7E-12
^{239}Pu	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.1E-04	1.1E-04	1.0E-04
^{241}Am	3.6E-04	1.6E-04	6.8E-05	2.9E-05	1.3E-05	2.4E-06	1.9E-07
^{244}Cm	2.8E-05	5.4E-07	1.0E-08	2.0E-10	3.7E-12	1.4E-15	9.4E-21
Total Dose	3.0E-02	2.8E-03	4.2E-04	1.7E-04	1.3E-04	1.1E-04	1.0E-04
Radioactive Risk (HE/yr)							
	8.5E-09	7.9E-10	1.2E-10	4.7E-11	3.6E-11	3.2E-11	2.9E-11

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 71

Chemical Results for Reclaimed-Farmland Pathway for the No Action Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Noncarcinogenic Risk (ADI fraction)							
Arsenic	8.8E-06	2.4E-07	6.6E-09	1.8E-10	4.9E-12	3.7E-15	7.5E-20
Cadmium	1.8E-05	5.0E-07	1.4E-08	3.7E-10	1.0E-11	7.6E-15	1.5E-19
Chromium	7.6E-05	1.4E-05	2.5E-06	4.5E-07	8.1E-08	2.6E-09	1.5E-11
Copper	2.4E-05	1.5E-06	1.0E-07	6.4E-09	4.2E-10	1.8E-12	4.8E-16
Lead	5.8E-04	2.9E-04	1.5E-04	7.4E-05	3.7E-05	9.4E-06	1.2E-06
Mercury	3.6E-01	3.6E-01	3.5E-01	3.5E-01	3.5E-01	3.4E-01	3.4E-01
Nickel	7.1E-06	3.6E-06	1.8E-06	9.0E-07	4.5E-07	1.2E-07	1.5E-08
Phosphate	3.5E-05	9.3E-07	2.6E-08	7.1E-10	1.9E-11	1.4E-14	3.0E-19
Silver	7.5E-04	3.8E-04	1.9E-04	9.6E-05	4.8E-05	1.2E-05	1.6E-06
Zinc	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03
EPA Hazard Index	3.6E-01	3.6E-01	3.6E-01	3.5E-01	3.5E-01	3.5E-01	3.4E-01

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 72

Radionuclide Results for Direct Gamma Exposure Pathway for the No Action Option

	Years Since 1985						
	100	200	300	400	500	700	1000
Dose (mrem/yr)							
^{60}Co	2.8E-08	6.0E-14	1.3E-19	2.8E-25	6.0E-31	0.0	0.0
^{137}Cs	5.7E-02	7.0E-03	8.7E-04	1.1E-04	1.3E-05	2.0E-07	3.7E-10
^{235}U	6.5E-08	9.8E-08	1.5E-07	2.2E-07	3.2E-07	7.2E-07	2.3E-06
^{238}U	4.1E-21	1.1E-20	2.9E-20	7.7E-20	2.1E-19	1.5E-18	2.7E-17
^{238}Pu	4.4E-07	2.5E-07	1.5E-07	8.6E-08	5.0E-08	1.7E-08	3.3E-09
^{239}Pu	7.9E-12	1.3E-11	2.2E-11	3.7E-11	6.3E-11	1.8E-10	8.2E-10
^{241}Am	5.4E-05	6.0E-05	6.6E-05	7.3E-05	8.0E-05	9.7E-05	1.3E-04
^{244}Cm	1.9E-07	4.8E-09	1.2E-10	3.0E-12	7.5E-14	4.7E-17	7.2E-22
Total Dose	5.7E-02	7.1E-03	9.3E-04	1.8E-04	9.3E-05	9.8E-05	1.3E-04
Radioactive Risk (HE/yr)							
	1.6E-08	2.0E-09	2.6E-10	5.0E-11	2.6E-11	2.7E-11	3.6E-11

Note: Analysis of this pathway is not applicable prior to 100 years because of assumed period of institutional control.

TABLE 73

Cumulative Release Over 1,000-Year Period to the Savannah River for the Waste Removal and Closure and the No Waste Removal and Closure With Cap Options

Radionuclide	Total Release (Ci)
^{3}H	2.5E-12
^{90}Sr	3.8E-11
^{90}Y	3.8E-11
^{137}Cs	3.0E-10
^{235}U	7.0E-06
^{238}U	8.0E-05
^{238}Pu	2.3E-08
^{239}Pu	1.8E-05

Chemical	Total Release (kg)
Cadmium	1.0E-02
Chromium	1.6E+00
Copper	4.0E+00
Fluoride	1.0E+03
Lead	2.1E+00
Mercury	1.0E-02
Nickel	1.2E-01
Silver	5.0E-02
Sodium	2.4E+04

TABLE 74

Cumulative Release Over 1,000-Year Period to the Savannah River for the No Waste Removal and Closure Without Cap Option

Radionuclide	Total Release (Ci)
^{3}H	4.0E-12
^{90}Sr	5.0E-11
^{90}Y	5.0E-11
^{137}Cs	3.8E-10
^{235}U	7.0E-06
^{238}U	8.0E-05
^{238}Pu	2.5E-08
^{239}Pu	1.8E-05

Chemical	Total Release (kg)
Cadmium	1.0E-02
Chromium	1.6E+00
Copper	4.0E+00
Fluoride	1.0E+03
Lead	2.1E+00
Mercury	1.0E-02
Nickel	1.2E-01
Silver	5.0E-02
Sodium	2.4E+04

TABLE 75

Cumulative Release Over 1,000-Year Period to the Savannah River for the No Action Option

Radionuclide	Total Release (Ci)
^{3}H	4.1E-12
^{90}Sr	5.1E-11
^{90}Y	5.1E-11
^{137}Cs	3.9E-10
^{235}U	7.0E-06
^{238}U	8.0E-05
^{238}Pu	2.5E-08
^{239}Pu	1.8E-05

Chemical	Total Release (kg)
Cadmium	1.0E-02
Chromium	1.6E+00
Copper	4.0E+00
Fluoride	1.0E+03
Lead	2.1E+00
Mercury	1.0E-02
Nickel	1.2E-01
Silver	5.0E-02
Sodium	2.4E+04

TABLE 76

Comparison of Maximum Risks and Dominant Constituents

	Waste Removal and Closure Option			
Pathway	Peak Year Since 1985	Dominant Constituent	Radioactive Risk (HE/yr)	Noncarcinogenic Risk (EPA Hazard Index)
Groundwater to well at 1 m	340	^{90}Sr	6.5E-10	-
	420	Arsenic	-	7.0E-01
Groundwater to well at 100 m	400	^{90}Sr	3.8E-11	-
	440	Arsenic	-	6.0E-01
Groundwater to river	650	^{238}U	2.0E-15	-
	650	Fluoride	-	1.2E-06
Reclaimed farmland	100	^{90}Sr	1.5E-08	-
	100-1,000	Mercury	-	6.8E-03
Direct gamma	100	^{137}Cs	3.1E-17	-

Note: Analysis of the pathways for groundwater to wells, reclaimed farmland, and direct gamma is not applicable prior to Year 100 because of the assumed period of institutional control.

TABLE 76, Contd

Pathway	No Waste Removal and Closure With Cap Option			
	Peak Year Since 1985	Dominant Constituent	Radioactive Risk (HE/yr)	Noncarcinogenic Risk (EPA Hazard Index)
Groundwater to well at 1 m	340	^{90}Sr	6.5E-10	-
	420	Arsenic	-	7.0E-01
Groundwater to well at 100 m	400	^{90}Sr	3.8E-11	-
	440	Arsenic	-	6.0E-01
Groundwater to river	650	^{238}U	2.0E-15	-
	650	Fluoride	-	1.2E-06
Reclaimed farmland	100	^{90}Sr	2.0E-08	-
	100-1,000	Mercury	-	2.1E-01
Direct gamma	100	^{137}Cs	3.0E-15	-

Note: Analysis of the pathways for groundwater to wells, reclaimed farmland, and direct gamma is not applicable prior to Year 100 because of the assumed period of institutional control.

TABLE 76, Contd

	No Waste Removal and Closure Without Cap Option			
Pathway	Peak Year Since 1985	Dominant Constituent	Radioactive Risk (HE/yr)	Noncarcinogenic Risk (EPA Hazard Index)
Groundwater to well at 1 m	340	^{90}Sr	4.1E-09	-
	160	Arsenic	-	3.4E+00
Groundwater to well at 100 m	390	^{90}Sr	2.4E-10	-
	170	Arsenic	-	1.5E+00
Groundwater to river	630	^{238}U	2.1E-15	-
	630	Fluoride	-	1.2E-06
Reclaimed farmland	100	^{137}Cs	1.1E-08	-
	100	Mercury	-	3.7E-01
Direct gamma	100	^{137}Cs	2.8E-13	-

Note: Analysis of the pathways for groundwater to wells, reclaimed farmland, and direct gamma is not applicable prior to Year 100 because of the assumed period of institutional control.

TABLE 76, Contd

	No Action Option			
Pathway	Peak Year Since 1985	Dominant Constituent	Radioactive Risk (HE/yr)	Noncarcinogenic Risk (EPA Hazard Index)
Groundwater to well at 1 m	340	^{90}Sr	7.8E-09	-
	130	Arsenic	-	6.1E+00
Groundwater to well at 100 m	380	^{90}Sr	3.4E-10	-
	150	Arsenic	-	1.7E+00
Groundwater to river	630	^{238}U	2.1E-15	-
	630	Fluoride	-	1.2E-06
Reclaimed farmland	100	^{137}Cs	8.5E-09	-
	100-300	Mercury	-	3.6E-01
Direct gamma	100	^{137}Cs	1.6E-08	-

* Analysis of the pathways for groundwater to wells, reclaimed farmland, and direct gamma is not applicable prior to Year 100 because of the assumed period of institutional control.

Releases of chemical and radiological contaminants to the environment were characterized for the SRL Seepage Basins by using pathway analysis. Analyses of contaminant transport and human exposures via six environmental pathways were performed for four options: no action, closure with a soil cover, closure with a low-permeability cap, and waste removal and closure with a low-permeability cap. For waste removal and closure, 99% of the contaminants presently in the basins were considered removed, and transport calculations considered only the contaminants that had already been leached beyond the zone of excavation via the groundwater pathways. Pathways analyzed for human exposure are groundwater to a river and to wells, erosion of cover, natural biointrusion, onsite reclaimed farmland, and direct gamma exposure.

The PATHRAE analyses indicate that no doses or risks occur for the erosion or natural biointrusion pathways for any of the options for either chemical or radioactive constituents. For the groundwater pathways similar maximum doses were computed for all options. The groundwater pathways are dominated by tritium during the period of institutional control. Following the assumed period of institutional control, the maximum radioactive risk results from ^{90}Sr (these risks are less than 4.1E-09 HE/yr). For the reclaimed-farmland pathway, doses increase for the closure action options because the decrease in infiltration causes constituents to remain in the soil for a longer time.

Tritium is completely leached out of the waste zone prior to closure action. For the direct gamma pathway, the progessively more complete closure actions (closure without cap, closure with cap, and waste removal) reduce the peak health effects by 5, 7, and 9 orders of magnitude, respectively. However, doses for this pathway are already insignificant for the no action option. The no waste removal and closure with cap option and the waste removal and closure option are significantly better than the other options with respect to noncarcinogenic risk, reducing the ADI fraction of arsenic to values less than one following the assumed period of institutional control. Fluoride has an ADI fraction greater than one during the period of institutional control for all options. Note, however, the ADI selected for fluoride is based on the health effect "dental fluorosis" and is set at a level of only 2 times the optimum level suggested for water by the Surgeon General. The levels of fluoride predicted for groundwater beneath the SRL Seepage Basins would result in insignificant numbers of health effects more severe than dental fluorosis.

Atmospheric Pathway

Estimates of public risk attributable to exposure of atmospherically transported contaminants resulting from the postulated closure options at the SRL Seepage Basins have been calculated. As discussed earlier, the general pathways for exposure to atmospherically dispersed chemical or radioactive constituents are inhalation of polluted air, ingestion of contaminated foodstuffs, and direct gamma radiation. The data, assumptions, and models discussed previously were used to estimate the quantities of airborne contaminants released from the waste site and to quantify public exposure and risk via the inhalation, ingestion, and gamma radiation pathways.

The chemical and radionuclide constituents selected for this environmental analysis of risk were identified by Looney et al. (1986a) as discussed previously. Soil inventory profiles for each closure option for the estimates of disposed mass and radioactivity were determined using a four-layer soil model (SESOIL). These concentration profiles for the SRL Seepage Basins were determined for each constituent of concern for each site cleanup option. Tables 77 and 78 contain these data. For the waste removal and closure option, the tables also list the volume of soil and mass of each constituent that would be excavated from the site. Inventory profiles for tritium were calculated using averaged soil core data.

For each of the three options considered, all 12 nonradioactive contaminants (arsenic, cadmium, chromium, copper, fluoride, lead, mercury, nickel, phosphate, silver, sodium, and zinc) were analyzed to estimate public exposure and risk attributable to atmospheric contaminant releases from the SRL Seepage Basins. Arsenic and chromium were modeled as both carcinogenic and toxic materials. The risk due to inhalation of arsenic was included in the calculations of carcinogenic risk; the risk due to ingestion of arsenic was included in the calculations of noncarcinogenic risk. The risk due to ingestion of chromium was modeled as chromium III, a noncarcinogen; the risk due to inhalation was calculated with 90% of the dose modeled as chromium III and 10% of the dose modeled as chromium VI, a carcinogen. This approach was taken to recognize both the carcinogenic and toxic properties of these contaminants.

Nonradioactive Constituents

Twenty-four one-year risk assessments were performed spanning a 1,000-year period. Analyses were performed for every year for the period 1986-1990, for every 5th year for the period 1990-2035, and for every 100th year for the period 2085-2985. Doses and risks for the population and for a maximum exposed individual were estimated. The risks associated with carcinogens and noncarcinogens were analyzed separately by closure option. Figures 25 and 26 are graphs of total risk versus time for nonradioactive constituents. Figure 25 is a graph of lifetime population carcinogenic risk versus-time for all closure options. Figure 26 is a graph of the maximum exposed individual carcinogenic risk versus time for all

TABLE 77

Soil Inventory Profile for Radionuclide Constituents at the SRL Seepage Basins

Option	Layer Number	Thickness (m)	Constituent Inventory (Ci) ^{241}Am	^{243}Cm ^{244}Cm	^{60}Co	^{137}Cs	^{3}H
Waste removal and closure	1	0.5	0.0	0.0	0.0	0.0	0.0
	2	2.8	0.0	0.0	0.0	0.0	0.0
	3	0.3	3.00E-04	3.50E-03	5.00E-04	4.00E-02	5.82E-03
	4	28.5	0.0	0.0	0.0	0.0	5.20E-01
	Inventory excavated		2.97E-02	3.47E-01	4.95E-02	3.96E+00	3.20E-03
No waste removal and closure	1	0.5	0.0	0.0	0.0	0.0	0.0
	2	2.8	0.0	0.0	0.0	0.0	0.0
	3	0.3	3.00E-02	3.50E-01	5.00E-02	4.00E+00	9.02E-03
	4	28.5	0.0	0.0	0.0	0.0	5.20E-01
No action	1	0.5	3.00E-02	3.50E-01	5.00E-02	4.00E+00	1.50E-02
	2	2.8	0.0	0.0	0.0	0.0	4.97E-02
	3	0.3	0.0	0.0	0.0	0.0	6.21E-03
	4	28.5	0.0	0.0	0.0	0.0	4.58E-01

Note: The waste removal and closure option includes excavating 1,900 m^3 of contaminated soil.

TABLE 77, Contd

Option	Layer Number	Thickness (m)	Constituent Inventory (Ci)				
			^{238}Pu	^{239}Pu ^{240}Pu	^{90}Sr	^{235}U	^{238}U
Waste removal and closure	1	0.5	0.0	0.0	0.0	0.0	0.0
	2	2.8	0.0	0.0	0.0	0.0	0.0
	3	0.3	2.00E-04	9.00E-04	1.00E-02	7.00E-05	8.00E-04
	4	28.5	0.0	0.0	0.0	0.0	0.0
	Inventory excavated		1.98E-02	8.91E-02	9.90E-01	6.93E-03	7.92E-02
No waste removal and closure	1	0.5	0.0	0.0	0.0	0.0	0.0
	2	2.8	0.0	0.0	0.0	0.0	0.0
	3	0.3	2.00E-02	9.00E-02	1.00E+00	7.00E-03	8.00E-02
	4	28.5	0.0	0.0	0.0	0.0	0.0
No action	1	0.5	2.00E-02	9.00E-02	1.00E+00	7.00E-03	8.00E-02
	2	2.8	0.0	0.0	0.0	0.0	0.0
	3	0.3	0.0	0.0	0.0	0.0	0.0
	4	28.5	0.0	0.0	0.0	0.0	0.0

Note: The waste removal and closure option includes excavating 1,900 m^3 of contaminated soil.

TABLE 78

Soil Inventory Profile for Chemical Constituents at the SRL Seepage Basins

Option	Layer Number	Thickness (m)	Constituent Inventory (kg) Arsenic	Cadmium	Chromium	Copper	Fluoride	Lead	Mercury	Nickel	Phosphate as (P)	Silver	Sodium	Zinc
Waste removal and closure	1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	0.3	2.30E+00	5.00E-02	3.20E+00	1.00E+00	1.00E+01	7.00E-01	1.00E-01	6.00E-01	4.00E+01	5.00E-02	2.40E+02	2.15E+00
	4	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inventory excavated			2.28E-02	4.95E+00	3.17E+02	9.9E+01	9.9E+02	6.93E+01	9.9E+00	5.94E+01	3.96E+03	4.95E+01	2.38E+04	2.13E+02
No waste removal and closure	1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	0.3	2.30E+02	5.00E+00	3.20E+02	1.00E+02	1.00E+03	7.00E+01	1.00E+01	6.00E+01	4.00E+03	5.00E+00	2.40E+04	2.15E+02
	4	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No action	1	0.5	2.30E+02	5.00E+00	3.20E+02	1.00E+02	1.00E+03	7.00E+01	1.00E+01	6.00E+01	4.00E+03	5.00E+00	2.40E+04	2.15E+02
	2	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: The waste removal and closure option includes excavating 1,900 m^3 of contaminated soil.

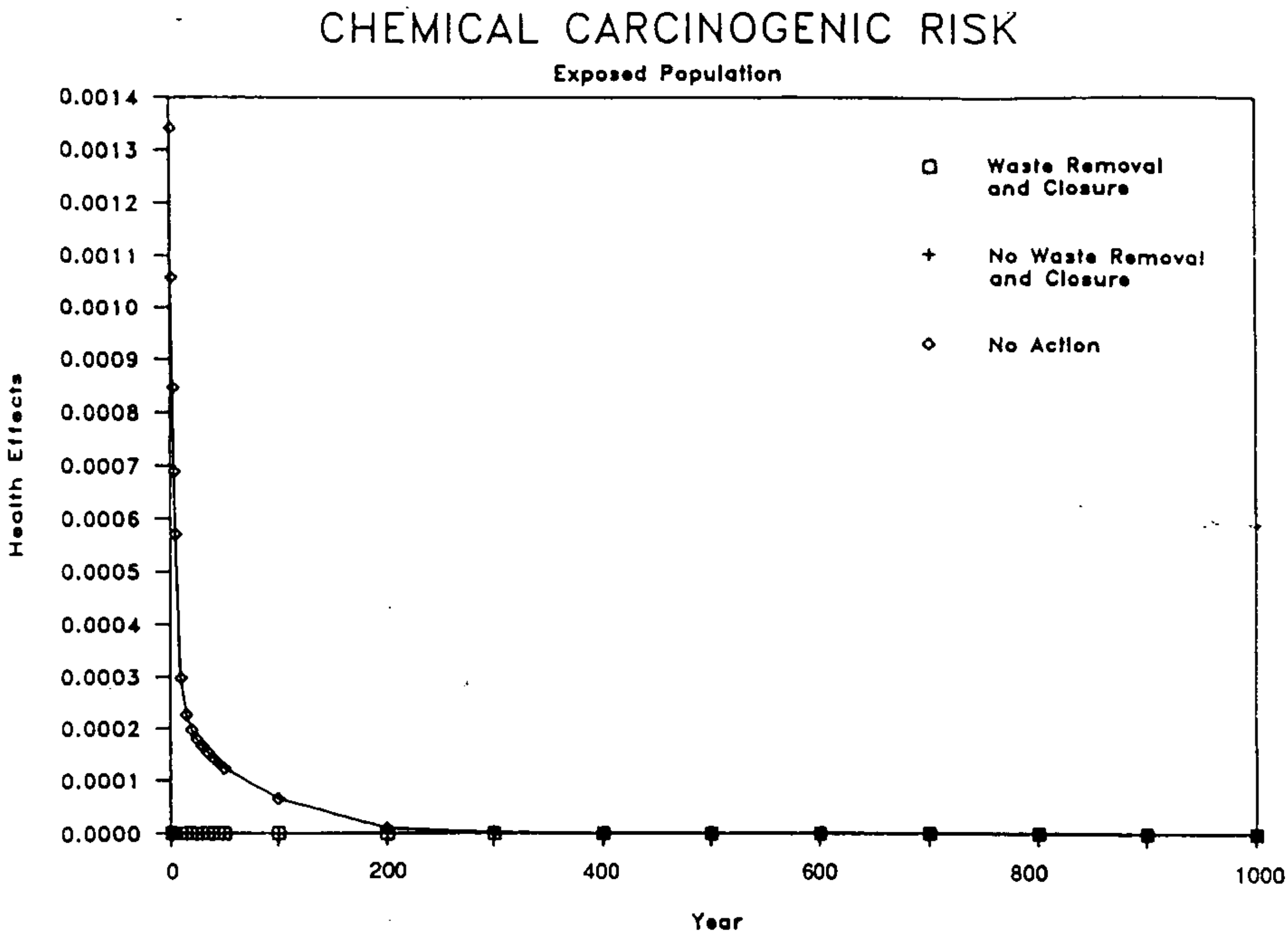


FIGURE 25. Chemical Carcinogenic Risk for the Exposed Population Due to Atmospherically Released Carcinogens

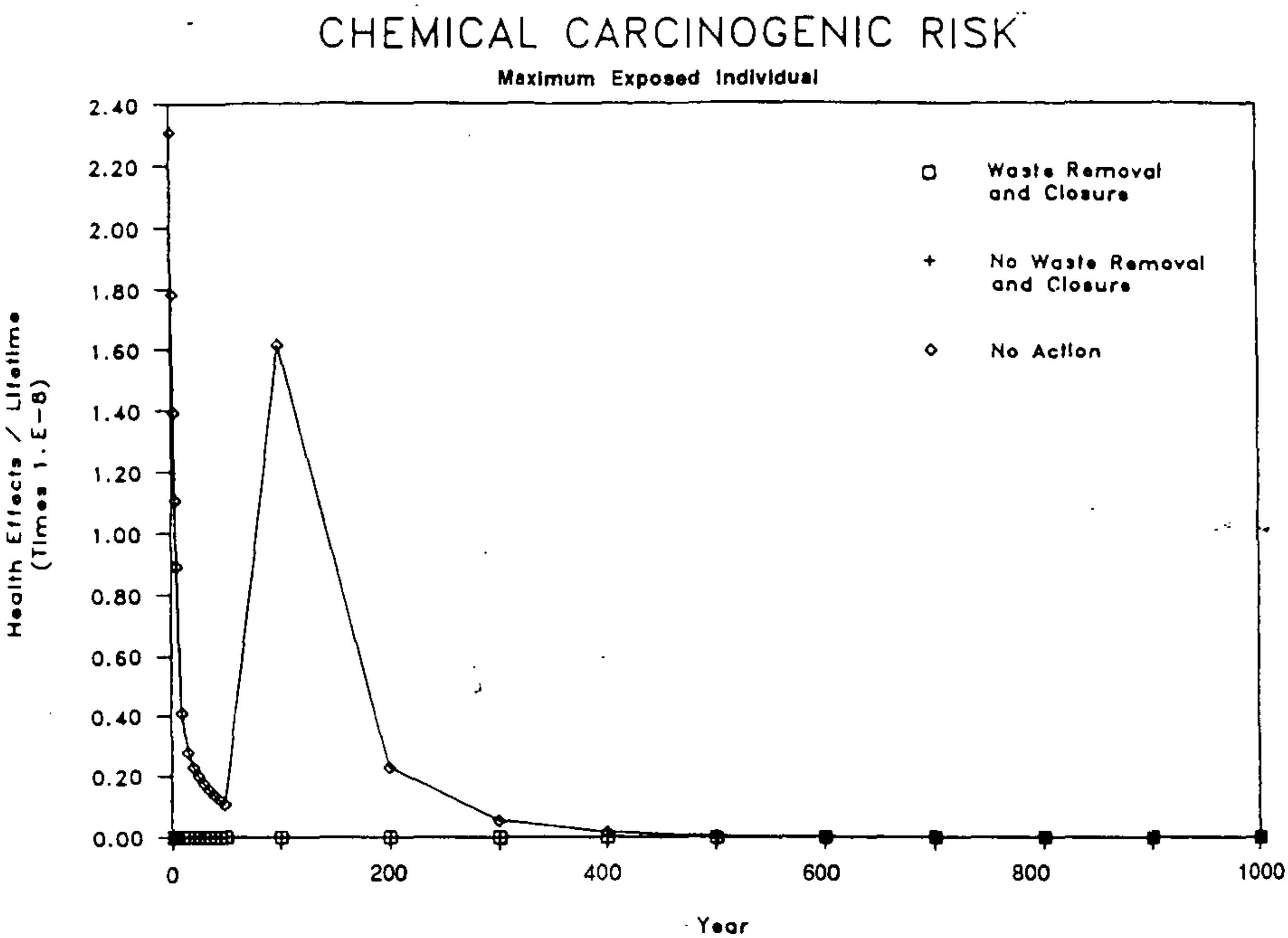


FIGURE 26. Chemical Carcinogenic Risk for the Exposed Individual Due to Atmospherically Released Carcinogens

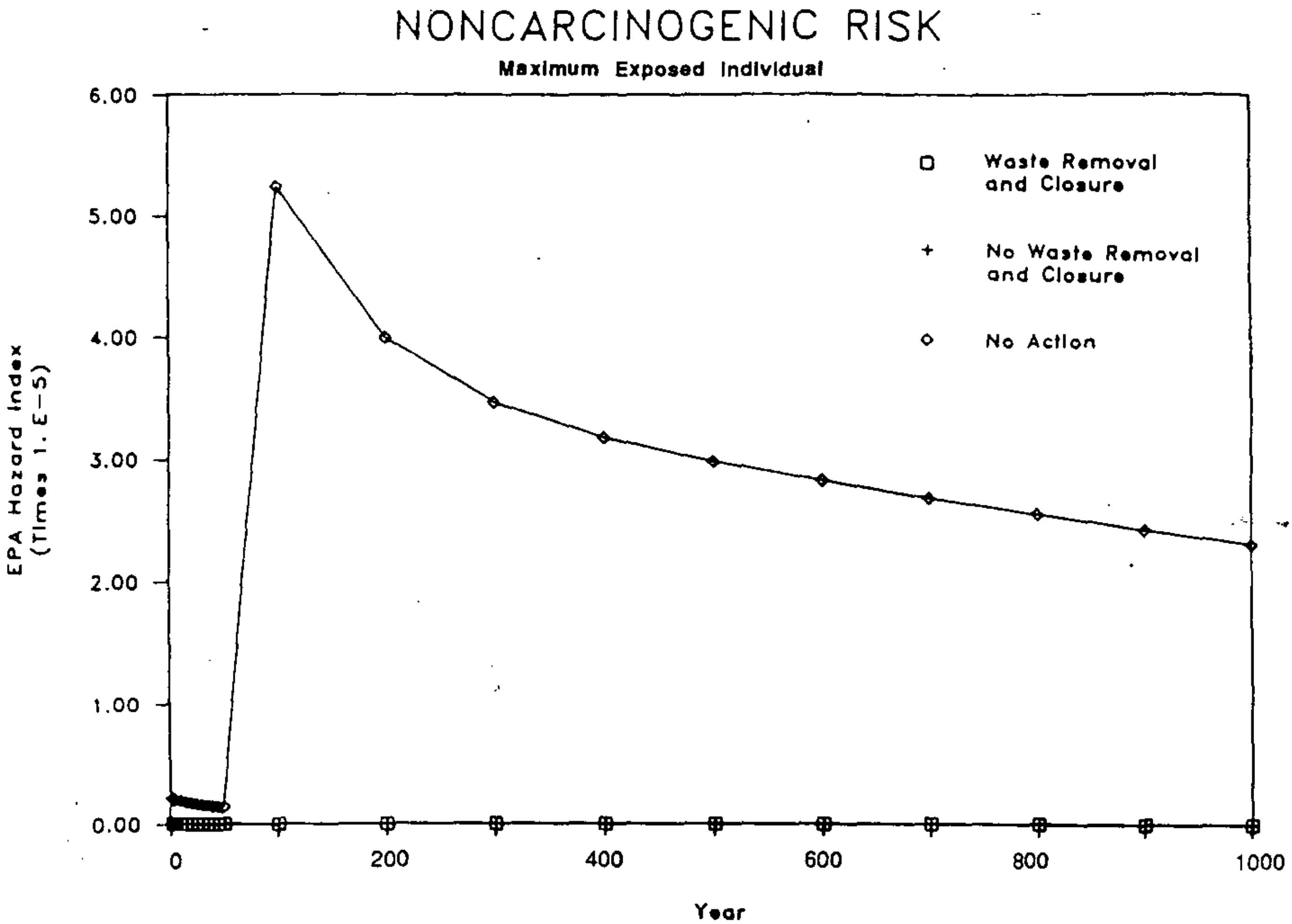


FIGURE 27. Noncarcinogenic Risk for the Exposed Individual Due to Atmospherically Released Noncarcinogens

closure options. And Figure 27 is a graph of the maximum exposed individual noncarcinogenic risk (EPA Hazard Index) versus time for all closure options. The starting time for each of these graphs is Year 1. A salient feature of Figure 25 is the exponential decay with time of population risk. Shown best by the no action option, the lifetime population carcinogenic risk declines with time. The risks associated with the other closure options also decline exponentially, but their magnitudes appear as zero on the plotted scale. The risks decline because, even though the population is increasing, the source term declines slightly faster due to leaching. At Year 100, an inflection point in the risk curve occurs because of a forecasted step population increase resulting from the public occupation of SRP. This step increase in population results in a step increase in population risk beginning in Year 100. After Year 100, the population is fixed, and risk declines again as the source terms decay.

The behavior of the risk posed to the maximum exposed individual through time from both carcinogens and noncarcinogens is quite similar (Figures 26 and 27). From Year 1 through Year 99, the location of the maximum exposed individual is assumed to be approximately 8 km from the center of SRP in a northwest direction. Consequently, the risk posed to this individual varies directly with the source term strength; as the source term strength declines due to leaching, so does the risk to the maximum exposed individual. Thus, there is an exponential decay in the maximum exposed individual risk from Year 1 to Year 99. At Year 100, SRP is assumed to be occupied by homesteaders, and the location of the maximum exposed individual shifts much closer to a location directly east of, and adjacent to, the waste site. Consequently, the risk increases at this time (a step increase) and then decreases with succeeding years as the source strength decays.

Generally, public health risks decrease as more extensive remedial options are applied. Tables 79 and 80 show carcinogenic and noncarcinogenic risks for three selected years--1, 100, and 1,000. For both carcinogens and noncarcinogens, the risk associated with no action is higher than for other closure options in all three years. In Year 1, the risk associated with the waste removal and closure option is higher than the risk associated with the no waste removal and closure option because waste removal creates risks attributable to Year 1 excavation activities.

In Year 1, the dominant contributors to carcinogenic population risks for the waste removal and closure option are arsenic (89%) and chromium VI (10%). The dominant contributors for the no action option in Year 1 are also arsenic (81%) and chromium VI (17%).

TABLE 79

Risks Due to Atmospherically Released Chemical Carcinogens for Years 1, 100, and 1,000 for the Closure Options

	Waste Removal and Closure		No Waste Removal and Closure		No Action	
Chemical	Population Risk (HE)	Maximum Exposed Indiv. Risk (HE/lifetime)	Population Risk (HE)	Maximum Exposed Indiv. Risk (HE/lifetime)	Population Risk (HE)	Maximum Exposed Indiv. Risk (HE/lifetime)
Year 1						
Arsenic	5.61E-07	9.98E-12	0.0	0.0	1.09E-03	1.94E-08
Cadmium	1.90E-09	3.38E-14	0.0	0.0	4.05E-06	7.20E-11
Chromium VI	6.40E-08	1.14E-12	0.0	0.0	2.26E-04	3.34E-09
Nickel	3.51E-09	6.24E-14	0.0	0.0	1.76E-05	2.31E-10
Total Risk	6.31E-07	1.12E-11	0.0	0.0	1.34E-03	2.31E-08
Year 100						
Arsenic	0.0	0.0	0.0	0.0	1.94E-16	4.82E-20
Cadmium	0.0	0.0	0.0	0.0	2.11E-12	5.24E-16
Chromium VI	0.0	0.0	0.0	0.0	4.97E-05	1.23E-08
Nickel	0.0	0.0	0.0	0.0	1.54E-05	3.81E-09
Total Risk	0.0	0.0	0.0	0.0	6.50E-05	1.61E-08
Year 1,000						
Arsenic	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	0.0	0.0	0.0	0.0	0.0	0.0
Chromium VI	0.0	0.0	0.0	0.0	4.46E-15	1.11E-18
Nickel	0.0	0.0	0.0	0.0	1.14E-09	2.82E-13
Total Risk	0.0	0.0	0.0	0.0	1.14E-09	2.82E-13

TABLE 80

Risks Due to Atmospherically Released Noncarcinogens for Years 1, 100, and 1,000 for the Closure Options

Chemical	Noncarcinogenic Risk (ADI fraction) Waste Removal and Closure	No Waste Removal and Closure	No Action
	Year 1		
Arsenic	3.33E-13	0.0	2.59E-11
Chromium	2.45E-09	0.0	2.25E-07
Copper	4.33E-10	0.0	3.94E-08
Fluoride	8.67E-10	0.0	8.06E-08
Lead	7.05E-09	0.0	6.54E-07
Mercury	8.50E-09	0.0	7.98E-07
Phosphate	3.45E-13	0.0	4.55E-11
Silver	7.23E-11	0.0	6.72E-09
Sodium	3.70E-11	0.0	3.42E-09
Zinc	9.32E-10	0.0	8.39E-08
EPA Hazard Index	2.22E-08	0.0	2.07E-06
	Year 100		
Arsenic	0.0	0.0	3.10E-25
Chromium	0.0	0.0	8.31E-07
Copper	0.0	0.0	3.38E-08
Fluoride	0.0	0.0	1.86E-06
Lead	0.0	0.0	1.09E-05
Mercury	9.83E-15	9.83E-13	3.58E-05
Phosphate	0.0	0.0	2.00E-21
Silver	0.0	0.0	1.08E-07
Sodium	0.0	0.0	5.76E-08
Zinc	0.0	0.0	7.27E-09
EPA Hazard Index	9.83E-15	9.83E-13	5.24E-05
	Year 1,000		
Arsenic	0.0	0.0	0.0
Chromium	0.0	0.0	7.46E-17
Copper	0.0	0.0	5.16E-24
Fluoride	0.0	0.0	2.82E-09
Lead	0.0	0.0	8.52E-10
Mercury	6.42E-11	6.42E-09	2.32E-05
Phosphate	0.0	0.0	0.0
Silver	0.0	0.0	6.26E-12
Sodium	0.0	0.0	5.46E-12
Zinc	0.0	0.0	0.0
EPA Hazard Index	6.42E-11	6.42E-09	2.32E-05

As indicated in Table 80, the major contributors to noncarcinogenic population risks in Year 1 are mercury (38%), lead (32%), and chromium III (11%). Mercury, due to volatilization and movement to the surface, is the sole contributor to noncarcinogenic risk in all years for the no waste removal and closure option and in all years after Year 1 for the waste removal and closure option. Mercury is also the dominant contributor to noncarcinogenic risk for the no action option in later years.

Radioactive Constituents

Atmospheric dust terms were estimated for radionuclide contaminants for each of the closure options at the SRL Seepage Basins and are summarized in Table 81. Nonzero dust terms are calculated in the first year due to soil excavation and tritium volatilization. Dust terms are zero in later years for the options that include backfill due to covering the contamination with backfill and the decay of tritium. Dust terms are finite but small for the no action option throughout the time period of interest due to surface contamination and suspension of contaminated dust and the conservative assumption of no benefit derived from a vegetative cover to minimize dust generation. No action dust terms decrease in later years because of downward movement of contamination and radioactive decay.

The dose due to inhalation of suspended dust and the assumption of radionuclides deposited to the ground entering the human food chain is 1.34E-02 mrem to the maximum exposed individual for the waste removal and closure option in the first year. The dose is zero in later years for the no waste removal and closure option due to backfilling the site and the nonvolatile properties of any residual contamination. The significant contributors to potential offsite exposure during excavation are ^{243}Cm (~51%) and ^{239}Pu (~16%).

For the no waste removal and closure option, only tritium contributes to potential offsite exposure due to its volatility. The calculated dose occurs only in the first year and is insignificant (2.8E-15 mrem). Other radionuclides do not make a contribution to offsite dose due to their nonvolatility and the backfilling of the site, which eliminates potential saltation (dust suspension).

For the no action option, resuspension of contaminated dust due to wind erosion and the conservative assumption of no benefit from vegetative cover leads to potential offsite exposure to the maximum exposed individual throughout the time period of analysis. The dose does not exceed 6.88E-01 mrem (Year 1) due to ^{243}Cm (~51%), ^{239}Pu (~16%), and ^{137}Cs (~14%). The exposure decreases in later years due to depletion of the atmospheric source term associated

TABLE 81

Radionuclide Atmospheric Source Terms Used to Assess Public Risk for Years 1, 100, and 1,000 for the Closure Options

Radionuclide (Ci/yr)	Waste Removal and Closure			No Waste Removal and Closure			No Action		
	1	100	1000	1	100	1000	1	100	1000
^{241}Am	2.67E-06	0.0	0.0	0.0	0.0	0.0	1.38E-04	6.57E-05	7.84E-08
^{243}Cm	3.12E-05	0.0	0.0	0.0	0.0	0.0	1.60E-03	1.41E-04	3.60E-14
^{60}Co	4.45E-06	0.0	0.0	0.0	0.0	0.0	2.09E-04	2.18E-12	0.0
^{137}Cs	3.56E-04	0.0	0.0	0.0	0.0	0.0	1.82E-02	1.69E-03	7.08E-13
^{3}H	2.88E-07	0.0	0.0	0.0	0.0	0.0	3.79E-07	0.0	0.0
^{238}Pu	1.78E-06	0.0	0.0	0.0	0.0	0.0	9.19E-05	2.44E-05	1.41E-10
^{239}Pu	8.02E-06	0.0	0.0	0.0	0.0	0.0	4.14E-04	2.31E-04	1.17E-06
^{90}Sr	8.91E-05	0.0	0.0	0.0	0.0	0.0	4.36E-03	4.16E-07	0.0
^{235}U	6.23E-07	0.0	0.0	0.0	0.0	0.0	3.21E-05	7.78E-06	2.00E-11
^{238}U	7.13E-06	0.0	0.0	0.0	0.0	0.0	3.66E-04	9.18E-05	3.14E-10

with downward movement (hydrologic transport) and radioactive decay. At longer time periods the radionuclide of significance is ^{239}Pu due to its long half-life and low soil mobility.

Dose and health effects are summarized in Table 82 for the maximum exposed individual and the population surrounding the Savannah River Plant. Incremental health effects to the maximum individual do not exceed 1.93E-07 health effects for any closure option in any year. Backfill of the site would greatly decrease calculated incremental health effects to the individual due to elimination of suspendable atmospheric source terms.

Total health effects to the exposed population surrounding the Savannah River Plant do not exceed 1.88E-04 (6.7E-01 person-rem) for any closure option in any given year. This total corresponds to an extremely small calculated absolute health effect to the affected population of ~585,000 (1986) in the vicinity of the Savannah River Plant. The population results can be placed into perspective relative to exposure to background radiation. For the exposed population of 585,000 (1986 estimate) surrounding the Savannah River Plant, the average individual receives 93 mrem of background radiation corresponding to a population dose of 5.42E+04 person-rem of radiation exposure. This dose results in a estimate of 15 absolute adverse health effects to the exposed population over a lifetime due to natural background radiation. The no waste removal and closure option would decrease calculated health effects to the population (6.0E-19) due to the elimination of suspendable atmospheric source terms.

For radionuclide atmospheric pathways, the risk of offsite exposure does not exceed acceptable criteria for any closure option for the SRL Seepage Basins.

Occupational Exposure

Cleanup of the sites under the waste removal and closure option would expose workers to airborne radioactive and nonradioactive contaminants. Approximately 1,900 m^3 of soil would be excavated if the waste removal option is selected. Therefore, the site excavation would require approximately 10 days (Table 83). Approximately 274 kg of contaminated dust would be generated as a result of excavation activities. No respiratory protection of workers was assumed for the inhalation doses.

Nonradioactive Constituents

The calculated nonradioactive risks for the waste removal and closure option, assuming an average individual works at the site for 8 hr each day, are summarized in Tables 84 and 85.

TABLE 82

Summary of Public Risk from Atmospheric Transport of Radionuclides for Years 1, 100, and 1,000

Dose	Waste Removal and Closure			No Waste Removal and Closure			No Action		
	1	100	1000	1	100	1000	1	100	1000
Maximum Individual (mrem)									
	1.34E-02	0.0	0.0	2.76E-15	0.0	0.0	6.88E-01	1.63E-01	3.93E-04
Population (person-rem)									
	1.31E-02	0.0	0.0	2.14E-15	0.0	0.0	6.73E-01	4.51E-01	1.16E-03

Radioactive Risk	Waste Removal and Closure			No Waste Removal and Closure			No Action		
	1	100	1000	1	100	1000	1	100	1000
Maximum Individual (HE/yr)									
	3.75E-09	0.0	0.0	7.73E-22	0.0	0.0	1.93E-07	4.56E-08	1.10E-10
Population (HE)									
	3.67E-06	0.0	0.0	5.99E-19	0.0	0.0	1.88E-04	1.26E-04	3.25E-07

TABLE 83

Parameters for the Assessment of Occupational Exposure

Work crew composition	One supervisor One health physics technician One crane operator One loader operator Two handlers Three truck drivers
Work day	8 hours for crew 4 hours for drivers
Truck volume	12 metal boxes per trip 2 m^3 per box
Loading rate	8 truckloads (192 m^3/day)
Volume of material removed	1,900 m^3
Exposure time	10 work days
Distance waste is transported	16 km (one way)
Transport speed	32 km/hr

TABLE 84

Occupational Risk Due to Atmospherically Released Carcinogens for the Waste Removal and Closure Option

Constituent	Source Term ($g/m^2/s$)	Inhalation Dose (mg/kg/day)	Exposure Time (days)	Chemical Carcinogenic Risk (HE/lifetime)
Arsenic	1.07E-07	5.54E-06	10	1.52E-07
Cadmium	2.33E-09	1.20E-07	10	5.13E-10
Chromium VI	1.49E-08	7.70E-07	10	1.73E-08
Nickel	2.80E-08	1.44E-06	10	9.48E-10
Total				1.71E-07

TABLE 85

Occupational Risk Due to Atmospherically Released Noncarcinogens for the Waste Removal and Closure Option

Constituent	Source Term ($g/m^2/s$)	Inhalation Dose (mg/kg/day)	Exposure Time (days)	Noncarcinogenic Risk (ADI fraction)
Chromium	1.34E-07	6.92E-06	10	1.36E-03
Copper	4.66E-08	2.40E-06	10	2.40E-04
Fluoride	4.66E-07	2.40E-05	10	4.81E-04
Lead	3.26E-08	1.68E-06	10	3.91E-03
Mercury	4.66E-09	2.40E-07	10	4.71E-03
Phosphate	1.41E-07	7.29E-06	10	2.43E-05
Silver	2.33E-09	1.20E-07	10	4.01E-05
Sodium	1.14E-05	5.90E-04	10	1.04E-03
Zinc	1.00E-07	5.17E-06	10	5.17E-04
EPA Hazard Index				1.23E-02

(Note that the average worker and maximum exposed worker are the same in this model of worker risk.) These results indicate that arsenic is the dominant contributor to chemical carcinogenic risk via inhalation. Combined with the other carcinogenic contaminants modeled, total chemical carcinogenic risk due to excavation operations for an unprotected worker is 1.71E-07 HE/lifetime. Assuming workers wear a full face piece, air, purifying negative pressure respirator, this risk is reduced to 3.41E-09 HE/lifetime.

For the noncarcinogenic contaminants modeled, the average unprotected worker is exposed to an EPA Hazard Index of 1.13E-02.

While the results presented in Table 84 are for an average individual worker excavating the site, they can be easily translated to worker population risks. To estimate a worker population risk for a particular contaminant, multiply the risk value in Table 84 by the time-on-site-weighted average number of workers. Excavating the SRL Seepage Basins is estimated to require an average of nine workers for 10 days. Thus, for workers the chemical carcinogenic risk associated with the inhalation of carcinogens released during the excavation of this site is 1.54E-06 HE. The risk for protected workers is 3.07E-08 HE.

Radioactive Constituents

For each of the three closure options considered (no action, no waste removal and closure, and waste removal and closure), radioactive constituents were analyzed to estimate occupational exposure and risk attributable to closure activities for the SRL Seepage Basins. Radiation exposures from the following pathways were considered: internal dose (from inhalation) to personnel directly involved in cleanup activities, external dose to personnel directly involved in cleanup activities, and external dose to personnel involved in transportation of contaminated waste. Table 86 summarizes the inhalation exposure for the waste removal and closure option. For a cleanup period lasting 10 work days, each crew member would receive a total external dose of 5.5 mrem.

Exposure of drivers to external radiation is assumed to occur during transport of excavated waste from the site to the disposal facility. The total time of exposure for each driver is assumed to be 4 hr/day for the period of cleanup. The exposure rate was conservatively assumed to be equal to the highest external exposure rate at 1 m above the ground calculated by DECOM (mrem/hr). This value is below the allowable Department of Transportation limit for exposure in the occupied cab of 2 mrem/hr unless the drive is wearing dosimeters under a radiation protection program (CFR, 1984) No credit for shielding provided by the metal boxes is taken into account. The total dose due to external exposure for each driver while involved in transportation of excavated waste (10 work days) would be 18 mrem.

TABLE 86

Internal Dose to Each Crew Worker Due to Inhalation

Radionuclide	Inhalation Dose Factor (mrem/μCi)	Air Concentration (μCi/m³)	Total Intake (μCi)	Dose Commitment (mrem)
^{3}H	9.5E-02	7.2E-10	6.9E-08	6.6E-09
^{60}Co	1.5E+02	1.1E-08	1.1E-06	1.6E-04
^{90}Sr	1.3E+03	2.2E-07	2.1E-05	2.7E-02
^{137}Cs	3.2E+01	8.9E-07	8.5E-05	2.7E-03
^{235}U	1.2E+05	1.6E-09	1.5E-07	1.8E-02
^{238}U	1.2E+05	1.8E-08	1.7E-06	2.1E-01
^{238}Pu	4.6E+05	4.4E-09	4.2E-07	1.9E-01
^{239}Pu	5.1E+05	2.0E-08	1.9E-06	9.8E-01
^{241}Am	5.2E+05	6.6E-09	6.3E-07	3.3E-01
^{243}Cm	3.5E+05	7.8E-08	7.5E-06	2.6E+00
			Total	4.4E+00

It is assumed there will be no release of radioactive materials from the metal boxes during routine transport. Further, since the material is being transported within the boundary of the Savannah River Plant, it is assumed there will be no exposures to the public and no significant exposure to employees on site involved in activities not related to the cleanup of this area.

The total estimated exposures to the work crew and drivers during excavation activities are given in Table 87. Total worker dose due to internal and external exposure is 113 person-mrem.

The no waste removal and closure option assumes the site will be covered with uncontaminated soil without removal of any of the waste. It is assumed that there are no truck drivers involved in this option.

The only significant exposures will be those from external radiation of workers while the site is being covered with uncontaminated soil. It is assumed that the maximum dose rate will be that calculated for the top layer (0-15 cm) for each basin. Further, it is assumed that a total of 10 hours are required for the crew to complete the job. For example, in basin 1 the surface exposure is estimated to be 0.24 mrem. This procedure does not account for shielding afforded by layers of soil being put over the waste site.

Table 88 lists individual worker exposure for the four basins during no waste removal and closure. Assuming six workers are involved in the remedial action, the total worker exposure is 8.7 mrem. Applying a risk factor of 2.8E-07 health effects/mrem yields 2.4E-06 health effects. It is assumed no risk to occupational workers exists for the no action option.

ECOLOGICAL ASSESSMENT

Surface Water Quality Impacts

Radioactive and nonradioactive constituents were identified as contaminant substances of potential environmental concern in the assessment of closure options for the SRL Seepage Basins. Groundwater beneath the SRL Seepage Basins ultimately outcrops to the Savannah River. Simple dilution modeling of instream water chemistry in the Savannah River and outcropping of organic, inorganic, and radioactive constituents gives a result of no calculated adverse environmental impacts on Savannah River water quality for all closure options through 1,000 years following 1985.

Simple dilution modeling of organic and inorganic contaminants in groundwater associated with SRL Seepage Basins closure options with existing Savannah River water chemistry was completed according to

TABLE 87

Summary of Occupational Exposure and Risk for the Waste Removal and Closure Option

Worker	Internal Dose Due to Inhalation (mrem)	External Dose (mrem)	Total Dose (mrem)
Supervisor	4.4E+00	5.5E+00	9.9E+00
Health physics	4.4E+00	5.5E+00	9.9E+00
Crane operator	4.4E+00	5.5E+00	9.9E+00
Loader	4.4E+00	5.5E+00	9.9E+00
Handler #1	4.4E+00	5.5E+00	9.9E+00
Handler #2	4.4E+00	5.5E+00	9.9E+00
Driver #1	0.0	1.8E+01	1.8E+01
Driver #2	0.0	1.8E+01	1.8E+01
Driver #3	0.0	1.8E+01	1.8E+01
Total			1.13E+02

Note: Radioactive risk = 1.13E+02 mrem x 2.8E-07 health effects/mrem
= 3.2E-05 health effects.

TABLE 88

Summary of Occupational Exposure and Risk for the No Waste Removal and Closure Option

Basin	Exposure Rate (mrem/hr)	Total Dose (mrem)	Radioactive Risk (HE)
Basin #1	2.4E-01	2.4E+00	6.7E-07
Basin #2	4.5E-01	4.5E+00	1.3E-06
Basin #3	1.4E-01	1.4E+00	3.9E-07
Basin #4	4.1E-02	4.1E-01	1.1E-07
Total			2.4E-06

$$C_3 = \frac{Q_1C_1 + Q_2C_2}{Q_1 + Q_2}$$

where

C_1 = instream water chemistry data (stream reach)

C_2 = outcrop water chemistry data (influent)

Q_1 = instream flow rate

Q_2 = influent flow from outcrops

C_3 = resultant mixed concentration (calculated mixture)

The groundwater migrating from the SRL Seepage Basins is assumed to outcrop into the Savannah River near the southwestern boundary of SRP (Figure 23). The mean Savannah River flow rate is estimated at 9.1E+09 m^3/yr. The groundwater flux into the river within the flow path is estimated at 2.2E+05 m^3/yr. The concentrations of chemical contaminants outcropping into the Savannah River have been calculated using the PATHRAE code.

Tables 89 and 90 employ this simple dilution equation for all pertinent organic, inorganic, and radioactive constituents for all closure options. Year 700 was chosen for dilution modeling in Tables 89 and 90 because, of the years assessed, this year represents the time at which outcropping of all contaminants to the Savannah River would approach or reach a maximum concentration. The comparison criteria for chemicals are based on EPA ambient water quality criteria documents or upstream unimpacted measurements (whichever are greater). The comparison criteria for radionuclides are based on National Interim Primary Drinking Water Standards (EPA-570/9-76-003) for beta and gamma emitters (EPA, 1977). Comparison criteria for alpha emitters are based on the activity of the radionuclide yielding an effective dose equivalent rate of 4 mrem/yr.

The results of the calculations indicate that outcropping of organic, inorganic, and radioactive materials from groundwaters encompassing the SRL Seepage Basins would have no adverse effects on the existing water chemistry of the Savannah River for any of the closure options offered. Because influent concentrations of metals are low (<0.011 µg/L), no change in existing Savannah River water quality is expected. Outcropping radionuclide concentrations were all less than 1.6E-03 pCi/L and were very small relative to known Savannah River concentrations. Calculated mixtures indicate that none of the contaminants exceeds its respective stream/aquatic water quality comparison criterion.

A summary of instream water quality effects associated with the closure of the SRL Seepage Basins for eight time scenarios up to 1,000 years following 1985 for the closure options is given in Tables 91 through 93. Again, no degradation of existing Savannah River water quality is evidenced.

TABLE 89

Savannah River Water Quality Impacts for the Waste Removal and Closure and the No Waste Removal and Closure With Cap Options

Parameter	Units	Stream Reach	Calculated Mixture	Comparison Criteria	Criterion Exceeded
Cadmium	μg/L	0.26	0.26	3	No
Chromium	μg/L	12	12	40	No
Copper	μg/L	3.4	3.4	5	No
Fluoride	μg/L	<100	<100	NS	--
Lead	μg/L	2.5	2.5	90	No
Mercury	μg/L	<0.05	<0.05	0.1	No
Nickel	μg/L	5.2	5.2	10	No
Silver	μg/L	NA	NA	NS	--
Sodium	μg/L	7,000	7,000	NS	--
^{235}U	pCi/L	<0.02	<0.02	22	No
^{238}U	pCi/L	≤0.20	<0.20	24	No
^{239}Pu	pCi/L	<0.02	<0.02	13	No

Note: This model run represents Year 700 after 1985. NS = no standard. NA = not available.

TABLE 90

Savannah River Water Quality Impacts for the No Waste Removal and Closure Without Cap and the No Action Options

Parameter	Units	Stream Reach	Calculated Mixture	Comparison Criteria	Criterion Exceeded
Cadmium	µg/L	0.26	0.26	3	No
Chromium	µg/L	12	12	40	No
Copper	µg/L	3.4	3.4	5	No
Fluoride	µg/L	<100	<100	NS	--
Lead	µg/L	2.5	2.5	90	No
Mercury	µg/L	<0.05	<0.05	0.1	No
Nickel	µg/L	5.2	5.2	10	No
Silver	µg/L	NA	NA	NS	--
Sodium	µg/L	7,000	7,000	NS	--
^{235}U	pCi/L	<0.02	<0.02	22	No
^{238}U	pCi/L	<0.20	<0.20	24	No
^{239}Pu	pCi/L	<0.02	<0.02	13	No

Note: This model run represents Year 700 after 1985. NS = no standard. NA = not available.

TABLE 91

Instream Ecological Effects in the Savannah River for the Waste Removal and Closure and the No Waste Removal and Closure With Cap Options

		Existing Savannah River	Incremental Increase in Concentration For Years Since 1985							
Parameter	Units	Concentration*	0	100	200	300	400	500	700	1000
Cadmium	µg/L	0.26	0.0	0.0	0.0	6.9E-17	4.2E-12	6.6E-10	4.4E-09	1.1E-04
Chromium	µg/L	12	0.0	0.0	0.0	1.1E-14	6.7E-10	1.1E-07	7.0E-07	1.8E-09
Copper	µg/L	3.4	0.0	0.0	0.0	2.7E-14	1.6E-09	2.6E-07	1.8E-06	4.4E-09
Fluoride	µg/L	<100	0.0	0.0	0.0	6.9E-12	4.2E-07	6.6E-05	4.4E-04	1.1E-06
Lead	µg/L	2.5	0.0	0.0	0.0	1.4E-14	8.7E-10	1.4E-07	9.3E-07	2.3E-09
Mercury	µg/L	<0.05	0.0	0.0	0.0	6.9E-17	4.2E-11	6.6E-10	4.4E-09	1.1E-11
Nickel	µg/L	5.2	0.0	0.0	0.0	8.4E-11	4.9E-11	7.9E-09	5.3E-08	1.3E-10
Silver	µg/L	-	0.0	0.0	0.0	3.4E-16	2.1E-11	3.3E-09	2.2E-08	5.5E-11
Sodium	µg/L	7,000	0.0	0.0	0.0	1.6E-10	1.0E-05	1.5E-03	1.1E-02	2.6E-05
^{235}U	pCi/L	<0.02	0.0	0.0	0.0	0.0	0.0	4.6E-10	3.1E-03	0.0
^{238}U	pCi/L	<0.20	0.0	0.0	0.0	0.0	3.3E-11	5.3E-09	3.5E-08	8.8E-11
^{239}U	pCi/L	<0.02	0.0	0.0	0.0	0.0	0.0	1.2E-09	7.8E-09	1.9E-11

* In vicinity of outcrop (Looney & Holmes, 1987).

TABLE 92

Instream Ecological Effects in the Savannah River for the No Waste Removal and Closure Without Cap Option

Parameter	Units	Existing Savannah River Concentration*	Incremental Increase in Concentration for Years Since 1985: 0	100	200	300	400	500	700	1000
Cadmium	µg/L	0.26	0.0	0.0	0.0	1.3E-16	7.3E-12	9.3E-10	4.0E-09	6.9E-12
Chromium	µg/L	12	0.0	0.0	0.0	2.1E-14	1.1E-09	1.5E-07	6.4E-07	1.1E-09
Copper	µg/L	3.4	0.0	0.0	0.0	5.2E-14	2.9E-09	3.7E-07	1.6E-06	2.7E-09
Fluoride	µg/L	<100	0.0	0.0	0.0	1.3E-11	7.3E-07	9.3E-05	4.0E-04	6.9E-07
Lead	µg/L	2.5	0.0	0.0	0.0	2.7E-14	1.5E-09	2.0E-07	8.5E-07	1.4E-09
Mercury	µg/L	<0.05	0.0	0.0	0.0	1.3E-16	7.3E-12	9.3E-10	4.0E-09	6.9E-12
Nickel	µg/L	5.2	0.0	0.0	0.0	1.5E-15	8.7E-11	1.1E-08	4.8E-08	8.2E-11
Silver	µg/L	-	0.0	0.0	0.0	6.5E-16	3.6E-11	4.6E-09	2.0E-08	3.4E-11
Sodium	µg/L	7,000	0.0	0.0	0.0	3.1E-10	1.8E-05	2.2E-03	9.6E-03	1.6E-05
^{235}U	pCi/L	<0.02	0.0	0.0	0.0	0.0	0.0	6.5E-10	2.9E-09	0.0
^{238}U	pCi/L	<0.20	0.0	0.0	0.0	0.0	5.7E-11	7.5E-09	3.2E-08	5.5E-11
^{239}Pu	pCi/L	<0.02	0.0	0.0	0.0	0.0	1.3E-11	1.6E-09	7.0E-09	1.2E-11

* In vicinity of outcrop (Looney & Holmes, 1987).

TABLE 93

Instream Ecological Effects in the Savannah River for the No Action Option

Parameter	Units	Existing Savannah River Concentration*	Incremental Increase in Concentration for Years Since 1985 0	100	200	300	400	500	700	1000
Cadmium	µg/L	0.26	0.0	0.0	0.0	1.3E-16	7.5E-12	9.6E-10	4.0E-09	6.7E-12
Chromium	µg/L	12	0.0	0.0	0.0	2.2E-14	1.2E-09	1.5E-07	6.4E-07	1.1E-09
Copper	µg/L	3.4	0.0	0.0	0.0	5.5E-14	3.0E-09	3.8E-07	1.5E-06	2.6E-09
Fluoride	µg/L	<100	0.0	0.0	0.0	1.3E-11	7.5E-07	9.6E-05	4.0E-04	6.7E-07
Lead	µg/L	2.5	0.0	0.0	0.0	2.9E-14	1.5E-09	2.0E-07	8.4E-07	1.4E-09
Mercury	µg/L	<0.05	0.0	0.0	0.0	1.3E-16	7.5E-12	9.6E-10	4.0E-09	6.7E-12
Nickel	µg/L	5.2	0.0	0.0	0.0	1.6E-15	9.0E-11	1.1E-08	4.7E-08	8.0E-11
Silver	µg/L	-	0.0	0.0	0.0	6.8E-16	3.7E-11	4.7E-09	2.0E-08	3.4E-11
Sodium	µg/L	7,000	0.0	0.0	0.0	3.3E-10	1.8E-05	2.3E-03	9.6E-03	1.6E-05
^{235}U	pCi/L	<0.02	0.0	0.0	0.0	0.0	0.0	6.7E-10	2.7E-09	0.0
^{238}U	pCi/L	<0.20	0.0	0.0	0.0	0.0	6.0E-11	7.6E-09	3.2E-08	5.4E-11
^{239}Pu	pCi/L	<0.02	0.0	0.0	0.0	0.0	1.3E-11	1.6E-09	7.0E-09	1.2E-11

* In vicinity of outcrop (Looney & Holmes, 1987).

Aquatic and Terrestrial Impacts

For the aquatic and terrestrial impacts assessment, four pathways through which waste-site constituents can reach the environment were identified: (1) biointrusion, (2) surface erosion of waste constituents due to water and subsequent transport to surface waters, (3) movement of waste constituents through the unsaturated zone to the groundwater and subsequent transport to a surface outcrop, and (4) consumption of contaminated basin waters and, at some sites, aquatic plants.

The exposure concentrations were screened by comparing them to various ecological benchmark criteria. The first benchmark for each constituent, a lower screening level, represents ecologically protective concentration (SAIC, 1987) and is based on EPA Water Quality Criteria for the Protection of Aquatic Life or equivalent numbers from the technical literature. Any constituent that exceeded the lower screening level by more than a factor of 10 was compared to additional ecological benchmarks to define further the extent (if any) of the potential ecological effects. These additional benchmarks are based on either (1) LC-50s and EC-50s for taxa specific to the SRP ecosystem to assess effects on the aquatic community; (2) the EPA National Interim Primary Drinking Water Standards (DWS) and, if the DWS are exceeded, chronic no-effect concentrations of metals and organics (except volatile solvents) in mammalian diets to screen for possible effects from consumption of surface waters by terrestrial wildlife; or (3) dietary concentrations shown to be toxic to birds and mammals to assess consumption of contaminated aquatic biota. For those waste sites with radionuclide constituents, EPA National Interim Drinking Water Standards were used as first-level benchmarks for comparison of potential exposure concentrations in surface waters. For tritium, known no-effect concentrations in fish were used as second-level benchmarks. Benchmarks for soil are based on the Department of Energy's Threshold Guidance Limits (DOE, 1985) as presented in Looney et al. (1987a). These soil and water criteria are based on human health concerns and so are conservative. The various quotients (comparing calculated concentrations to benchmarks) form the basis for quantification of potential ecological impacts from each waste site.

At the Savannah River Laboratory Seepage Basins, the groundwater transport to a surface outcrop, biointrusion, and consumption of contaminated basin waters and aquatic plants pathways are applicable under the no action option. The groundwater transport to a surface outcrop pathway would remain under all closure options. The waste removal and closure or no waste removal and closure options would remove the biointrusion and consumption of contaminated basin waters and aquatic plants pathways.

No aquatic impacts are expected from the implementation of any of the closure options. The levels of groundwater outcrop contamination predicted by the PATHRAE model are ecologically insignificant for all closure options, indicating no potential for adverse impacts on the aquatic biota of the Savannah River or adjacent wetlands and no adverse impacts on wildlife consuming the undiluted groundwater at the outcrop.

Based on the available data, limited terrestrial impacts are anticipated under the no action option. The maximum concentrations in the basin soils for ^{241}Am, ^{244}Cm, ^{60}Co, ^{137}Cs, ^{3}H, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{90}Sr, ^{235}U, and ^{238}U exceed the first-level benchmark criteria. The maximum concentrations in the basin soils for cadmium, chromium, copper, mercury, nickel, and silver exceed the phytotoxic benchmarks, indicating that these concentrations could cause vegetation impacts such as reduced plant growth and increased plant mortalities via the biointrusion pathway. However, food chain uptake calculations indicate that the predicted vegetation concentrations are below the levels considered toxic to consuming wildlife. Any terrestrial impacts would be limited to the area (approximately 2.15 acres) occupied by the basins. Either of the other closure options would eliminate these potential impacts.

Endangered Species

No endangered species have been identified in the vicinity of the SRL Seepage Basins from previous surveys at SRP. The habitats in the vicinity of this waste site are not suitable for any federally endangered species that have been identified at SRP, including the American alligator, the red-cockaded woodpecker, the wood stork, and the short-nose sturgeon (Dukes, 1984; Gladden et al., 1985). Therefore, none of the actions postulated for this site would have any effect on endangered species or their critical habitats.

Wetlands

Wetlands found within 1,000 m of the SRL Seepage Basins are summarized in Table 94 (Mackey et al., 1985; Shields et al., 1982). The bottomland hardwood communities occur along Tims Branch, which drains to Upper Three Runs Creek (Figure 28). These wetlands are sufficiently close to the waste site so that remedial actions should use appropriate erosion control to eliminate potential runoff and sedimentation to nearby tributaries. No other effects are expected from the postulated actions at the SRL Seepage Basins.

TABLE 94

Wetlands Within 1,000 m of the SRL Seepage Basins

	Distance to Wetlands (m)				
Type of Wetlands (acres)	0-200	201-400	401-600	601-800	801-1000
Open water	0	0	0	0	0
Cypress/tupelo	0	0	0	0	0
Emergent marsh	0	0	0	0	0
Scrub/shrub	0	0	0	0	0
Bottomland hardwood	7.1	5.4	4.6	11.9	6.2
Total	7.1	5.4	4.6	11.9	6.2

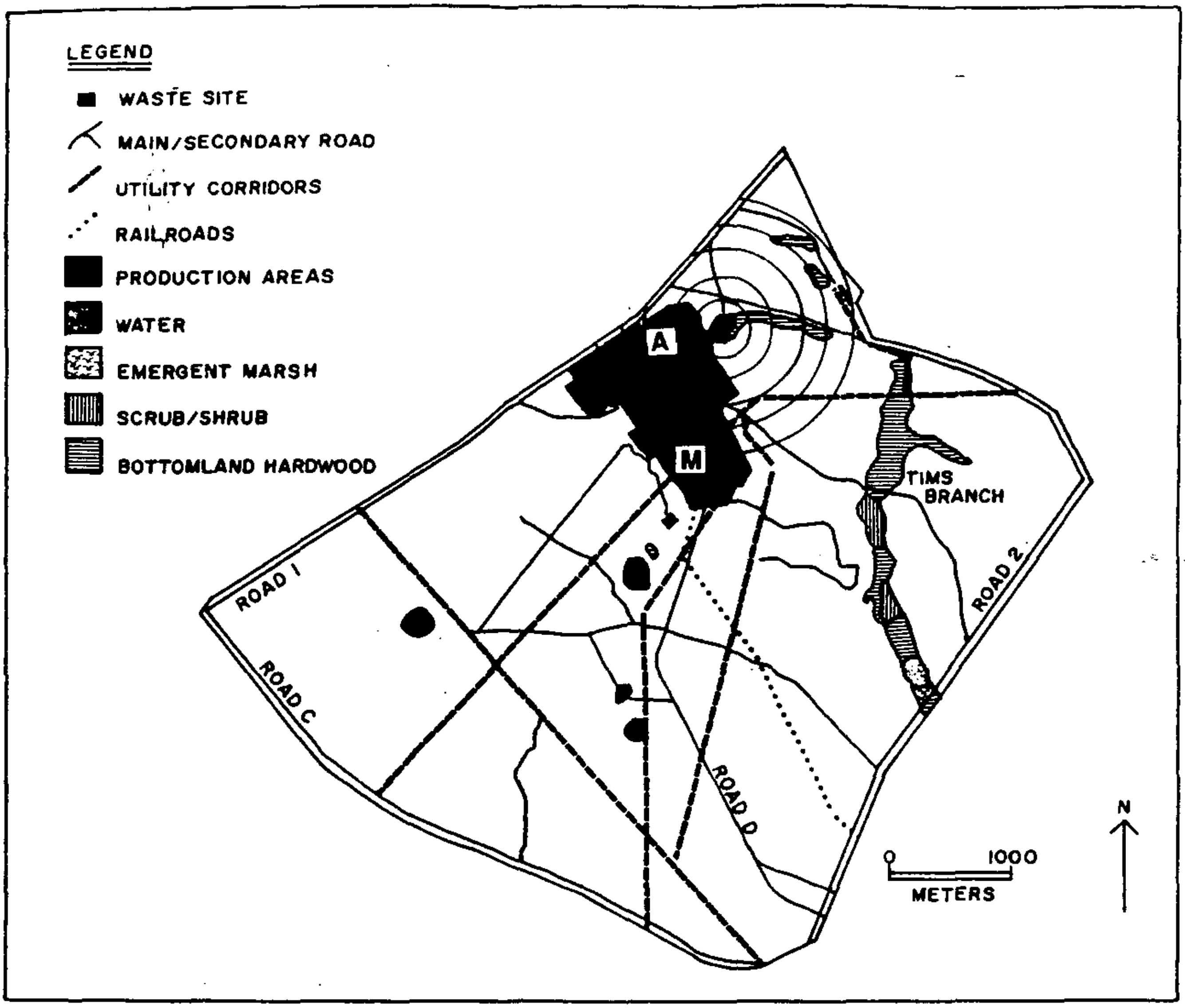


Figure 28. Location of Wetlands Within 1,000 m of the SRL Seepage Basins

ACCIDENT ANALYSIS

The environmental impacts and risk of potential accidents occurring during the closure options for the SRL Seepage Basins have been analyzed. The selected closure option would be implemented in such a manner that the risk to the public and to workers from accidental releases of or exposure to site materials/contaminants would be minimal.

Pertinent environmental and safety documents were reviewed to identify potential accidents. The potential accidents and consequences associated with each waste-site closure alternative are related to the materials at the site. The potential accident scenarios are based on the hazards associated with these materials. The SRL Seepage Basins only received liquid effluents. There are no waste containers or pieces of contaminated equipment in the basin to be considered. Therefore, the possible closure options would involve primarily excavating, earthmoving, and backfilling.

The accidents considered for the closure options are natural events such as earthquakes, tornadoes, and straight winds and industrial accidents such as injuries, fires, cave-ins, and container spills. The natural events were analyzed using historical data on probability and severity. Industrial accidents were analyzed using man-hour estimates based on construction industry cost-estimating handbooks and industrial accident rate tabulations. The number of construction labor man-days required to accomplish the postulated options was estimated. This estimate was used to calculate the frequency of each potential accident. The contaminants considered in the accident analysis are those selected for this site in Looney et al. (1987a).

Tables 95 through 98 identify the potential accidents germane to the basins. The frequencies for the closure options of waste removal and no waste removal are based on events per closure operation to facilitate comparison among the various sites and options. The accident with the greatest likelihood of occurring at the SRL Seepage Basins would be falls or equipment-related mishaps resulting in personnel injury. Further explanation of the methodology, analyses, and appropriate calculations of consequences is supplied in separate documentation (Palmiotto & Comiskey, 1986).

TABLE 95

Accident Analysis for the Waste Removal and Closure Option

Initiator	Accident	Frequency	Consequences
Natural Events			
Tornado	High winds disperse soil during excavation.	1.94E-05	Potential for serious injury to personnel. Dispersion of waste off waste site but not beyond SRP boundary.
Straight winds	High winds disperse soil during excavation.	1.40E-04	Dispersion of soil off waste site but not beyond SRP boundary.
Earthquake	Failure of basin walls.	4.00E-06	Dispersion of basin contents onsite in vicinity of basin.
Industrial Accidents			
Container puncture	Waste containers in site.	N/A	N/A
Equipment collision	Mobile equipment collides. Possible puncture of waste boxes.	1.22E-02	Potential for serious injury to personnel. Releases confined to the immediate area of the waste site. Equipment damaged.
Large equipment toppling	Failure of equipment.	6.35E-03	Potential for serious injury to personnel. Dispersion of waste material at site.
Employee injury	Falls/ equipment-related injuries.	2.73E-01	Potential for serious injury to personnel.
Contamination	Inadvertent contamination to workers at site.	5.57E-02	Potential for minor injury to personnel.

Note: N/A = not applicable due to the nature of the closure option or the waste site.

TABLE 95, Contd

Initiator	Accident	Frequency	Consequences
Drop & breach	Waste box dropped and puncture or lid opening occurs.	1.25E-03	Potential for minor injury to personnel. Release of waste at waste site. Cleanup initiated.
Equipment fire	Fuel or hydraulic fluid catches fire.	3.15E-03	Onsite fire team response. Potential for minor injury to personnel. Some equipment damage.
Cave-In	During excavation of material with equipment in basin.	8.47E-05	Releases confined to basin vicinity. No personnel injury anticipated.
Waste truck accident and fire	Accident resulting in fire.	1.90E-05	Onsite fire department response. Potential for serious injury to personnel. Damaged equipment.
Waste truck accident and spill	Waste truck accident during transport. Waste container damaged and breached.	1.14E-03	Waste release confined to accident site. Site cleanup initiated. Potential for serious injury to personnel.
Waste truck accident and fatality	Truck accident while in transit to disposal area.	6.08E-04	Fatality to driver.
Waste box falls off truck	Rigging or driving error results in spillage of waste box contents.	3.04E-03	Release of waste at site of accident. Cleanup initiated.
Fill truck accident	Truck with fill and another vehicle collide, or single vehicle accident occurs.	3.47E-02	Potential for serious injury to personnel. Fill material released at accident site. Cleanup initiated.
Fatal construction accident	Accident resulting in fatality.	2.00E-05	Fatality.

TABLE 96

Accident Analysis for the No Waste Removal and Closure Options With Cap Option

Initiator	Accident	Frequency	Consequences
Natural Events			
Tornado	High winds disperse soil during excavation.	1.75E-05	Potential for serious injury to personnel. Dispersion of waste off basin site but not off SRP site.
Straight winds	High winds disperse soil during excavation.	1.26E-04	Dispersion of wet soil off basin but not off SRP site.
Earthquake	Failure of basin walls.	4.00E-06	Dispersion of basin contents in vicinity of basin.
Industrial Accidents			
Container puncture	Waste containers in site punctured.	N/A	N/A
Equipment collision	Mobile equipment collides. Possible puncture of waste boxes.	1.16E-02	Potential for serious injury to personnel. Releases confined to the immediate area.
Large equipment toppling	Failure of equipment.	6.05E-03	Potential for serious injury to personnel.
Employee injury	Falls/ equipment-related injuries.	2.28E-01	Potential for minor injury to personnel.
Contamination	Inadvertent contamination to workers at site	5.02E-02	Potential for minor injury to personnel.

Note: N/A = not applicable due to the nature of the closure option or the waste site.

TABLE 96, Contd

Initiator	Accident	Frequency	Consequences
Drop & breach	Waste box dropped and punctured or lid opening occurs.	N/A	N/A
Equipment fire	Fuel or hydraulic fluid catches fire.	2.63E-03	Potential for minor injury to personnel. Damage to equipment.
Cave-In	During movement of material with equipment in basin.	7.72E-05	Releases confined to basin vicinity. No personnel injury anticipated.
Waste truck accident and fire	Accident resulting in fire.	N/A	N/A
Waste truck accident and spill	Truck accident during transport. Waste box damaged and breached.	N/A	N/A
Waste truck accident and fatality	Truck accident while in transit to disposal area.	N/A	N/A
Waste box falls off truck	Rigging or driving error results in spillage of waste box contents.	N/A	N/A
Fill truck accident	Truck with fill and another vehicle collide, or single accident occurs.	3.31E-02	Potential for serious injury to personnel. Fill material released at accident site. Cleanup initiated.
Fatal construction accident	Construction accident resulting in fatality.	1.66E-05	Fatality.

Note: N/A = not applicable due to the nature of the closure option or the waste site.

TABLE 97

Accident Analysis for the No Waste Removal and Closure Without Cap Option

Initiator	Accident	Frequency	Consequences
Natural Events			
Tornado	High winds disperse sediments in basin.	8.92E-06	Potential for serious injury to personnel or dispersion of wet soil/waste off waste site but not beyond SRP boundaries.
Straight winds	High winds disperse soil in basin.	6.43E-05	Dispersion of wet soil/waste off waste site but not beyond SRP boundaries.
Earthquake	Failure of basin walls.	4.00E-06	Dispersion of basin contents in vicinity of basin.
Industrial Accidents			
Container puncture	Waste containers in site punctured.	N/A	N/A
Equipment collision	Mobile equipment collides. Possible puncture of waste boxes.	7.03E-03	Potential for serious personnel injury. Releases confined to the area of the waste site.
Large equipment topping	Failure of equipment.	3.40E-03	Potential for serious injury to personnel.
Employee injury	Falls/ equipment-related injuries.	1.08E-01	Potential for minor injury to personnel.
Contamination	Inadvertent contamination to workers at site.	2.56E-02	Potential for minor injury to personnel.
Drop & breach	Waste box dropped and punctured or lid opening occurs.	N/A	N/A

Note: N/A = not applicable due to the nature of the closure option or the waste site.

TABLE 97, Contd

Initiator	Accident	Frequency	Consequences
Equipment fire	Fuel or hydraulic fluid catches fire.	1.25E-03	Potential for minor injury to personnel. Some equipment damage.
Cave-In	During excavation of material with equipment.	1.38E-04	Releases confined to basin area. No personnel injury anticipated.
Waste truck accident and fire	Accident resulting in fire.	N/A	N/A
Waste truck accident and spill	Truck accident during transport. Waste box damaged and breached.	N/A	N/A
Waste truck accident and fatality	Truck accident while in transit to disposal area.	N/A	N/A
Waste box falls off truck	Rigging or driving error results in spillage of waste box contents.	N/A	N/A
Fill truck accident	Truck with fill and another vehicle collide, or single vehicle accident occurs.	2.96E-02	Potential for serious injury to personnel. Fill material released at accident site. Cleanup initiated.
Fatal construction accident	Construction accident resulting in fatality.	7.89E-06	Fatality.

Note: N/A = not applicable due to the nature of the closure option or the waste site.

TABLE 98

Accident Analysis for the No Action Option

Initiator	Accident	Frequency	Consequences
Natural Events			
Tornado	High winds disperse soil during excavation.	N/A	N/A
Straight winds	High winds disperse soil in basin.	N/A	N/A
Earthquake	Failure of basin walls.	1.44E-03	Dispersion of basin contents in vicinity of basin.
Industrial Accidents			
Container puncture	Waste containers in site punctured.	N/A	N/A
Equipment collision	Mobile equipment collides. Possible puncture of waste boxes.	N/A	N/A
Large equipment topping	Failure of equipment.	N/A	N/A
Employee injury	Falls/ equipment-related injuries.	N/A	N/A
Contamination	Inadvertent contamination to workers at site.	N/A	N/A
Drop & breach	Waste box dropped and punctured or lid opening occurs.	N/A	N/A

Note: N/A = not applicable due to the nature of the closure option or the waste site.

TABLE 98, Contd

Initiator	Accident	Frequency	Consequences
Equipment fire	Fuel or hydraulic fluid catches fire.	N/A	N/A
Cave-in	During excavation of material with equipment in basin.	N/A	N/A
Waste truck accident and fire	Accident resulting in fire.	N/A	N/A
Waste truck accident and spill	Truck accident during transport. Waste box damaged and breached.	N/A	N/A
Waste truck accident and fatality	Truck accident while in transit to disposal area.	N/A	N/A
Waste box fall of truck	Rigging or driving error results in spillage of waste box contents.	N/A	N/A
Fill truck accident	Truck with fill and another vehicle collide, or single vehicle accident occurs.	N/A	N/A
Fatal construction accident	Construction accident resulting in fatality.	N/A	N/A

Note: N/A = not applicable due to the nature of the closure option or the waste site.

ARCHEOLOGICAL AND HISTORICAL SURVEY

Archeological surveying and testing of the Savannah River Laboratory Seepage Basins have been performed by the University of South Carolina's Institute of Archeology and Anthropology (Brooks, 1986). These sites were surveyed by surface inspection and their conditions documented by one general area photograph and one photograph of each seepage basin. One hundred percent of the area was found to be disturbed by basin construction. The survey located no archeological or historical sites. Therefore, no further archeological work is warranted or required as part of the closure actions for the Savannah River Laboratory Seepage Basins. It is recommended that a request be made to the South Carolina State Historic Preservation Officer for concurrence with this determination of no effect.

UNAVOIDABLE/IRREVERSIBLE IMPACTS

Environmental impacts that cannot be avoided by reasonable mitigation measures are described in this section. These impacts are based upon the alternative closure options developed for the Savannah River Laboratory Seepage Basins. Also assessed are the irreversible and irretrievable commitments of resources, short-term land uses, and long-term environmental implications for the alternative closure options considered.

Many of the unavoidable adverse impacts expected from the closure of the SRL Seepage Basins have been experienced during the past use of the land. One impact is the loss of alternative land uses while the subject area (approximately 10,800 m^2) remains under the control of the Department of Energy. Application of the no action option would require some future action (i.e., site preparation) before alternative land uses such as agriculture could be implemented. Other adverse environmental impacts may include minimal wildlife habitat loss during revegetation of the site and temporary air pollution associated with activities such as field work (i.e., excavation, backfilling, grading) and transportation of materials to and from the site. If it is determined that additional study of the site is required, soil and groundwater analyses of the subject area would need to be completed before additional adverse impacts could be defined.

Energy, raw materials, and other resources would be used for the closure of these basins. Resources that would be irreversibly or irretrievably committed during closure actions include (1) materials that cannot be recovered or recycled (i.e., backfill material) and (2) materials consumed or reduced to unrecoverable forms (i.e., energy).

Closure of the site would involve land area already committed. Disposal of soils and any contaminated equipment from the site (approximately 1,900 m^3) would require use of additional land at a waste storage/disposal facility. Other committed resources would include backfill and capping materials, clean topsoil, and packaging materials (i.e., metal boxes). Irretrievable energy loss would result from the use of machinery to work the site, transport materials, process wastes at the disposal facility, and operate the floating aerators. Continued grounds maintenance and groundwater monitoring of the subject area would require a 30-year commitment of manpower and other resources.

In the short term, implementation of basin closure options would minimally affect local wildlife habitat and natural productivity. The long-term impact of these effects would be no greater than the impacts of existing land use. Following closure actions, the site would probably revert to its natural state and productivity with minimal long-term effects. Implementation of the no action option, however, may adversely affect the area's long-term productivity.

CONTROL AND SECURITY

Access to the Savannah River Plant site is controlled at primary roads by permanently manned barricades. Other roads entering the site are closed to traffic by gates or other barriers. The plant, except along the Savannah River, is fenced. Additionally, the site is posted against trespass under South Carolina and federal statutes. Operating areas are separately fenced and continuously patrolled by armed security personnel.

The SRL Seepage Basins are fenced. The basin area is periodically patrolled by security personnel. The Savannah River Laboratory is responsible for the care and maintenance of the SRL Seepage Basins.

COST ANALYSIS

The relative costs for each of the postulated closure options for the Savannah River Laboratory Seepage Basins have been estimated. The Du Pont Engineering Department has prepared Venture Guidance Appraisal (VGA) cost estimates for each option.

SCOPES OF WORK

Scopes of work based upon the various closure options described earlier in this document have been developed and are detailed below. The specific details of the commitments to maintenance, monitoring, and cap design in this section were selected for the primary purpose of deriving reasonable and consistent relative cost estimates.

Waste Removal And Closure

Under the waste removal and closure option, after removal of the security fence, basins 1, 2, and 3 would be dewatered by pumping liquid wastes into basin 4 (approximate total volume 2,500 m^3). Liquid wastes in basin 4 would be removed by seepage into the soil column and surface evaporation enhanced by 10 floating aerators, if necessary. Approximately 5,355 m^3 of soil would be excavated from the basins (assume 1 year delay in basin 4 closure), with 3,508 m^3 being stockpiled for subsequent fill operations. For cost estimating purposes, 2,000 m^3 of contaminated soils and other materials are assumed to be transported in metal boxes to a waste storage/disposal facility. The basins would be backfilled with common borrow fill, capped with a low-permeability clay layer, graded, seeded, and allowed to return to their natural state. Nine groundwater monitoring wells would be sampled and analyzed quarterly for 1 year, then annually for 29 years. There would be site maintenance (maintaining well signs, cutting grass) for the full 30-year period.

No Waste Removal And Closure

Under the no waste removal and closure with cap option, after removal of the security fence, basins 1, 2, and 3 would be dewatered by pumping liquid wastes into basin 4 (approximate total volume 2,500 m^3). Liquid wastes in basin 4 would be removed by seepage into the soil column and surface evaporation enhanced by 10 floating aerators, if necessary. The basins would be then backfilled with common borrow fill. Under the no waste removal and closure with cap option, the facility would be graded, seeded, and

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APPENDIX A

ANALYTICAL RESULTS FOR SEDIMENT CORES

Tritium concentrations were determined by Teledyne isotopes method PRO-052-57 followed by method PRO-052-2. Using these methods, water is extracted from the samples, converted to hydrogen gas, then counted by gas counting.

Chemical Determination

Both the groundwater and sediment samples were analyzed for chemical compounds. Sediment samples, however, were predigested before any chemical analyses were made.

Metals

The concentrations of all the metals except Hg were determined by atomic absorption analysis using EPA section 200.0. Ag, As, Pb, and Se were determined by flameless atomic absorption; and Al, Ba, Cd, Cu, Fe, Mg, Mn, Ni, and Zn were determined by flame atomic absorption. In flame atomic absorption a flame is used to atomize the sample whereas in flameless atomic absorption a furnace is used to atomize the sample. In these methods filtration and chelation-extraction steps are used to remove interferences.

Hg concentrations were determined by colorimetry using EPA Method 212.3. In this method the Hg is isolated by passing the solution through a membrane filter. Curcumin is added to form a colored derivative of Hg allowing the concentration of Hg to be determined by an autoanalyzer.

Inorganic Ions

Ammonia concentrations were determined by colorimetry using EPA Method 350.1. In this method, an EDTA solution is added to prevent precipitation of Ca and Mg, and turbidity is removed by filtration. Then alkaline phenol and hypochlorite are added to the samle solution to form a color derivative of ammonia, indophenol blue.

Chloride concentrations were determined by titrimetric methods (EPA Method 325.3). In this method, interferences are removed by precipitation-filtration, and mercuric nitrate is the titrant.

Cyanide concentrations were determined by colorimetry using EPA Method 335.2. In this method, acidification is used for releasing the cyanide in the cyanide complexes as HCN gas. The gas is absorbed in sodium hydroxide, and color is formed by converting the CN to CNCl and adding pyridine-pyrazolone.

TABLE A-1

Soil Core Data For The Savannah River Laboratory Seepage Basins (Summary)

Basin 1

Concentrations (μg/g)

	Top 3.6 cm			0.6 to 6.1 m	
	Minimum	Maximum	Mean	Minimum	Maximum
Arsenic	2.52	4.05	3.31	0.13	2.83
Barium	11.6	25.8	24.5	<2.0	7.3
Cadmium	1.30	4.30	2.64	<0.20	0.40
Chromium	69.5	249.0	136.1	1.2	53.4
Copper	31.72	79.68	49.39	0.84	12.82
Lead	32.2	84.3	55.0	1.5	17.2
Mercury	8.8	26.7	16.9	<0.2	3.5
Nickel	22.8	142.7	64.4	0.5	11.2
Selenium	<0.05	<0.05	<0.05	<0.05	<0.05
Silver	1.31	28.60	16.47	<0.02	5.12
Zinc	33.0	160.0	77.2	1.0	16.6

Concentrations (pCi/g)

	Top 3.6 cm Minimum	Top 3.6 cm Maximum	Top 3.6 cm Mean	0.6 to 6.1 m Minimum	0.6 to 6.1 m Maximum
^{241}Am	0.19	100.0	25.9	0.02	1.8
^{137}Cs	670	2,060	1,086	0.25	107
^{60}Co	1.37	8.69	4.92	<0.02	0.17
^{242}Cm	<0.04	5.4	1.66	<0.01	0.22
$^{243/244}Cm$	13.0	1300	400	0.25	22.0
^{238}Pu	0.05	61.0	16.8	0.09	2.4
$^{239/240}Pu$	0.06	330	75.5	0.13	61.0
^{90}Sr	43.0	360	141	<0.07	48.0
Tritium*	6.8	18.5	11.9	2.0	27.0
^{235}U	2.3	53.0	16.7	<0.01	2.3
^{238}U	22.0	420	159	0.1	22.0

* Assumes moisture content of 0.3 and bulk density of 1.6 g/cm^3.

TABLE A-1, Contd

Basin 3

Concentrations (μg/g)

	Top 7.6 cm			0.6 to 6.1 m	
	Minimum	Maximum	Mean	Minimum	Maximum
Arsenic	2.80	9.20	5.44	0.36	15.03
Barium	4.1	11.5	6.5	<2.0	2.6
Cadmium	0.22	0.85	0.62	<0.20	0.25
Chromium	12.4	35.8	24.6	1.8	35.5
Copper	3.20	14.00	9.56	0.90	4.30
Lead	4.5	13.8	8.0	1.6	7.7
Mercury	<0.2	2.9	1.5	<0.2	<0.2
Nickel	4.0	18.1	11.2	<0.8	4.0
Selenium	<0.10	<0.10	<0.10	<0.10	0.22
Silver	0.06	0.57	0.23	<0.02	0.06
Zinc	4.7	34.6	24.0	0.2	36.5

Concentrations (pCi/g)

^{241}Am	0.14	4.2	1.3	0.05	0.57
^{137}Cs	311	867	559	<0.05	42.0
^{60}Co	2.7	19.0	10.4	<0.02	1.6
^{242}Cm	<0.01	0.11	0.06	<0.01	0.12
$^{243/244}Cm$	1.9	75.0	35.0	<0.03	8.0
^{238}Pu	0.11	7.6	2/3	0.005	0.46
$^{239/240}Pu$	0.03	3/8	1.1	<0.001	0.48
^{90}Sr	39	6,900	1,435	<0.05	5.5
Tritium*	1.1	2.0	1.6	1.0	3.1
^{235}U	1.7	9.9	4.2	0.004	0.22
^{238}U	11.0	30.0	15.7	0.08	2.2

* Assumes moisture content of 0.3 and bulk density of 1.6 g/cm^3.

APPENDIX B

RESULTS OF BASIN WATER ANALYSIS FOR THE SRL SEEPAGE BASINS AND HISTORICAL pH AND DISCHARGE DATA TO THE SRL SEEPAGE BASINS

TABLE B-2

pH and Discharge to the SRL Seepage Basins

Year	Average Discharge (gal/month)	pH Maximum	pH Minimum	pH Average
74	92,800	7.3	2.4	4.1
75	101,300	9.3	1.95*	4.4
76	104,000	8.3	2.3	3.8
77	100,500	9.3	2.4	4.3
78	70,000	8.2	2.1	3.3
79	69,000	11	2.3	3.7
80	79,800	11	2*	4.6
81	53,000	9	3	4.3
82**	10,000	10	3	4.1

Note: No records are available before July 1974. Average is the arithmetic mean. Median pH values for four years are 3.4 (1974), 3.6 (1975), 3.2 (1976), and 3.4 (1977).

* A single measurement of 1.95 was made in 1975; the next lowest pH value in that year was 2.1. Three measurements of pH 2 were made in 1980, all in January. Neutralization to pH 3 was begun in March 1980 and continued until use of the basins was discontinued.

** Calculated from discharge and pH data through 10/5/82, at which time use of the basins was discontinued.

APPENDIX C

SRL SEEPAGE BASINS GROUNDWATER MONITORING DATA

\- Analysis not performed

< Less than detection limits

TABLE C-2

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 1

			meters	feet
SRP Grid Coordinates	N 105530.8 E 52621.8	Screen Zone Elev.	78.5-72.4	257.6-237.6
		Screen Zone Depth	27.2-33.3	89.1-109.1
		Drill Depth	33.25	109.1
Latitude	33.345024°N	Casing Elevation	106.28	348.7
Longitude	81.733277°W	Casing Material Steel		

Parameter	Units	1/25/83	4/20/83	8/6/83	12/21/83
Sampling Method		Bail	Bail	Bail	Bail
Water Table	meters	73.9	74.0	74.0	74.2
Elevation	feet	242.3	242.7	242.7	243.5
Coliform B	#/100 ml	0	0	-	<2
Color	CU	2	10	-	380
Corrosivity		No	No	-	-
Odor		3	160	-	-
pH	pH	4.4	4.0	6.0	4.5
Conductivity	umho/cm	28	31	51	80
TDS	mg/L	14	78	80	108
Temperature	°C	17.6	19.2	25.9	17.0
Turbidity	NTU	0.2	1.4	-	2
Ag	mg/L	<0.001	<0.001	-	-
As	mg/L	<0.002	<0.002	-	-
Ba	mg/L	<0.05	<0.05	-	-
Be	mg/L	<0.005	<0.005	-	-
Cd	mg/L	0.002	0.011	-	-
Cr	mg/L	0.007	0.061	0.028	0.104
Cu	mg/L	0.002	0.010	-	-
Fe	mg/L	9.49	74.66	-	-
Hg	mg/L	0.0003	<0.0002	-	-
Mn	mg/L	0.20	0.274	-	-
Na	mg/L	2.26	2.94	-	-
Ni	mg/L	0.005	0.024	-	-
Pb	mg/L	0.029	0.033	0.076	0.026
Se	mg/L	<0.002	<0.002	-	-
Zn	mg/L	1.840	2.159	-	-
Cl	mg/L	5.1	10.1	6.8	6.0
Cyanide	mg/L	<0.005	<0.005	-	-
F	mg/L	0.02	<0.01	0.08	<0.10
Surfactants	mg/L	<0.01	<0.01	-	-
H_2S	mg/L	<1.0	<1.0	-	-
NO_2 (as N)	mg/L	<0.01	<0.01	-	<0.5
NO_3 (as N)	mg/L	0.2	0.1	-	<0.5
SO_4	mg/L	<5	<5	<5	<5
Gross Alpha	pCi/L	0.7	17.1	1.71	239
Gross Beta	pCi/L	0.5	25.2	4.59	99
Ra	pCi/L	1.31	2.0	-	-
DOC	mg/L	4.0	6.0	-	6
GC Scan	ug/L	<40	<40	-	-
Phenols	mg/L	<0.002	<0.002	-	-
TOC	mg/L	3.0	51.0	-	16
TOH	mg/L	0.019	0.044	0.030	1.100
Endrin	ug/L	<0.04	<0.04	-	-
Lindane	ug/L	<1	<1	-	-
Methoxychlor	ug/L	<20	<20	-	-
Toxaphene	ug/L	<1	<1	-	-
24D	ug/L	<20	<20	-	-
245TP (Silvex)	ug/L	<2	<2	-	-

TABLE C-4

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 1A

				meters	feet
SRP Grid	N	105535.0	Screen Zone Elev.	75.3-66.2	247.2-217.2
Coordinates	E	52614.0	Screen Zone Depth	30.5-39.6	100.0-130.0
			Drill Depth	39.62	130.0
Latitude		33.345021°N	Casing Elevation	106.40	349.1
Longitude		81.733306°W	Casing Material PVC		

Parameter	Units	02/25/85	04/23/85	08/13/85	10/29/85
Sampling Method		Pump	Pump	Pump	Pump
Water Table	meters	74.4	74.3	73.9	74.1
Elevation	feet	244.2	243.9	242.3	243.0
Coliform B	#/100 ml	<2	-	-	-
Color	CU	-	-	-	-
Corrosivity		-	-	-	-
Odor		-	-	-	-
pH	pH	5.5	5.0	5.0	4.6
Conductivity	umho/cm	75	47	43	35
TDS	mg/L	-	-	-	-
Temperature	°C	19.8	20.0	19.8	19.8
Turbidity	NTU	1.6	-	-	-
Ag	mg/L	<0.0020	-	-	-
As	mg/L	<0.001	-	-	-
Ba	mg/L	0.012	-	-	-
Be	mg/L	-	-	-	-
Cd	mg/L	<0.002	-	-	-
Cr	mg/L	<0.004	<0.004	<0.004	<0.004
Cu	mg/L	-	-	-	-
Fe	mg/L	<0.004	-	-	-
Hg	mg/L	0.0002	<0.0002	<0.0002	<0.0002
Mn	mg/L	0.020	-	-	-
Na	mg/L	2.25	2.05	3.71	2.29
Ni	mg/L	-	-	-	-
Pb	mg/L	<0.004	0.008	<0.010	<0.005
Se	mg/L	<0.001	-	-	-
Zn	mg/L	-	-	-	-
Cl	mg/L	7.8	-	-	-
Cyanide	mg/L	-	-	-	-
F	mg/L	<0.10	-	-	-
Surfactants	mg/L	-	-	-	-
H_2S	mg/L	-	-	-	-
NO_2 (as N)	mg/L	-	-	-	-
NO_3 (as N)	mg/L	<0.50	-	-	-
SO_4	mg/L	<5.0	-	-	-
Gross Alpha	pCi/L	8.0	-	-	-
Gross Beta	pCi/L	5.0	-	-	-
Ra	pCi/L	2.0	-	-	-
DOC	mg/L	-	-	-	-
GC Scan	ug/L	-	-	-	-
Phenols	mg/L	<0.002	-	-	-
TOC	mg/L	0.415	0.688	0.350	1.390
TOH	mg/L	<0.005	0.008	0.013	0.011
Endrin	ug/L	<0.04	-	-	-
Lindane	ug/L	<1.00	-	-	-
Methoxychlor	ug/L	<20.0	-	-	-
Toxaphene	ug/L	<1.0	-	-	-
24D	ug/L	<20	-	-	-
245TP (Silvex)	ug/L	<2.0	-	-	-

TABLE C-6

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 2

			meters	feet
SRP Grid Coordinates	N 105608.3 E 52845.6	Screen Zone Elev.	78.0-71.9	255.9-235.9
		Screen Zone Depth	27.6-33.7	90.6-110.6
		Drill Depth	33.71	110.6
Latitude	33.345558°N	Casing Elevation	106.22	348.5
Longitude	81.732838°W	Casing Material Steel		

Parameter	Units	1/25/83	4/20/83	8/6/83	12/21/83
Sampling Method		Bail	Bail	Bail	Bail
Water Table	meters	73.8	73.9	74.1	74.2
Elevation	feet	242.2	242.5	243.0	243.4
Coliform B	#/100 ml	0	0	-	>16
Color	CU	2	8	-	0
Corrosivity		No	No	-	-
Odor		6	10	-	-
pH	pH	5.2	5.1	5.5	5.2
Conductivity	umho/cm	129	103	122	120
TDS	mg/L	88	100	82	130
Temperature	°C	17.0	19.8	20.8	17.3
Turbidity	NTU	0.7	1.9	-	0
Ag	mg/L	<0.001	<0.001	-	-
As	mg/L	<0.002	<0.002	-	-
Ba	mg/L	<0.05	<0.05	-	-
Be	mg/L	<0.005	<0.005	-	-
Cd	mg/L	0.004	0.012	-	-
Cr	mg/L	0.012	0.096	0.069	0.066
Cu	mg/L	0.022	0.055	-	-
Fe	mg/L	12.75	64.98	-	-
Hg	mg/L	0.0008	<0.0002	-	-
Mn	mg/L	0.14	0.265	-	-
Na	mg/L	20.0	18.70	-	-
Ni	mg/L	0.011	0.017	-	-
Pb	mg/L	0.019	0.046	0.131	0.009
Se	mg/L	<0.002	<0.002	-	-
Zn	mg/L	2.470	3.128	-	-
Cl	mg/L	5.4	7.6	5.5	6.5
Cyanide	mg/L	<0.005	<0.005	-	-
F	mg/L	0.06	<0.01	0.06	0.15
Surfactants	mg/L	<0.01	<0.01	-	-
H_2S	mg/L	<1.0	3	-	-
NO_2 (as N)	mg/L	<0.01	<0.01	-	<0.5
NO_3 (as N)	mg/L	0.3	0.3	-	<0.5
SO_4	mg/L	<5	<5	<5	10
Gross Alpha	pCi/L	0.5	8.0	3.04	200
Gross Beta	pCi/L	4.3	26.2	13.11	75
Ra	pCi/L	0.86	6.2	-	-
DOC	mg/L	2.0	6.0	-	7
GC Scan	ug/L	<40	<40	-	-
Phenols	mg/L	<0.002	<0.002	-	-
TOC	mg/L	10.0	98.0	-	22
TOH	mg/L	0.028	0.146	0.049	0.015
Endrin	ug/L	<0.04	<0.04	-	-
Lindane	ug/L	<1	<1	-	-
Methoxychlor	ug/L	<20	<20	-	-
Toxaphene	ug/L	<1	<1	-	-
24D	ug/L	<20	<20	-	-
245TP (Silvex)	ug/L	<2	<2	-	-

TABLE C-8

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 2A

				meters	feet
SRP Grid Coordinates	N 105608.8	Screen Zone Elev.		75.3-66.1	247.0-217.0
	E 52856.9	Screen Zone Depth		30.5-39.6	100.0-130.0
		Drill Depth		39.62	130.0
Latitude	33.345578°N	Casing Elevation		106.37	349.0
Longitude	81.732810°W	Casing Material	PVC		

Parameter	Units	02/25/85	04/23/85	08/13/85	10/29/85
Sampling Method		Pump	Pump	Pump	Pump
Water Table	meters	74.6	74.5	73.9	74.2
Elevation	feet	244.6	244.4	242.5	243.5
Coliform B	#/100 ml	<2	-	-	-
Color	CU	-	-	-	-
Corrosivity		-	-	-	-
Odor		-	-	-	-
pH	pH	4.6	5.1	4.9	4.3
Conductivity	umho/cm	69	48	50	38
TDS	mg/L	-	-	-	-
Temperature	°C	19.1	19.2	19.1	19.1
Turbidity	NTU	2.2	-	-	-
Ag	mg/L	<0.0020	-	-	-
As	mg/L	<0.001	-	-	-
Ba	mg/L	0.017	-	-	-
Be	mg/L	-	-	-	-
Cd	mg/L	<0.002	-	-	-
Cr	mg/L	<0.004	<0.004	<0.004	<0.004
Cu	mg/L	-	-	-	-
Fe	mg/L	0.068	-	-	-
Hg	mg/L	0.0003	<0.0002	<0.0002	<0.0002
Mn	mg/L	0.046	-	-	-
Na	mg/L	3.26	3.14	2.47	4.00
Ni	mg/L	-	-	-	-
Pb	mg/L	0.014	0.011	<0.010	0.006
Se	mg/L	<0.001	-	-	-
Zn	mg/L	-	-	-	-
Cl	mg/L	6.3	-	-	-
Cyanide	mg/L	-	-	-	-
F	mg/L	<0.10	-	-	-
Surfactants	mg/L	-	-	-	-
H_2S	mg/L	-	-	-	-
NO_2 (as N)	mg/L	-	-	-	-
NO_3 (as N)	mg/L	0.60	-	-	-
SO_4	mg/L	<5.0	-	-	-
Gross Alpha	pCi/L	9.0	-	-	-
Gross Beta	pCi/L	5.0	-	-	-
Ra	pCi/L	5.0	-	-	-
DOC	mg/L	-	-	-	-
GC Scan	ug/L	-	-	-	-
Phenols	mg/L	<0.002	-	-	-
TOC	mg/L	0.354	0.485	2.080	0.300
TOH	mg/L	<0.005	<0.005	0.013	0.010
Endrin	ug/L	<0.04	-	-	-
Lindane	ug/L	<1.00	-	-	-
Methoxychlor	ug/L	<20.0	-	-	-
Toxaphene	ug/L	<1.0	-	-	-
24D	ug/L	<20	-	-	-
245TP (Silvex)	ug/L	<2.0	-	-	-

TABLE C-10

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 3A

			meters	feet
SRP Grid Coordinates	N 105606.6 E 53153.7	Screen Zone Elev.	75.6-66.5	248.2-218.2
		Screen Zone Depth	29.0-38.1	95.0-125.0
		Drill Depth	38.10	125.0
Latitude	33.346058°N	Casing Elevation	105.21	345.2
Longitude	81.732024°W	Casing Material PVC		

Parameter	Units	1/25/83	4/20/83	8/6/83	11/27/83
Sampling Method		Bail	Bail	Bail	Pump
Water Table	meters	73.9	73.8	74.4	74.0
Elevation	feet	242.4	242.2	244.2	242.7
Coliform B	#/100 ml	4	2	-	<2
Color	CU	2	7	-	80
Corrosivity		No	No	-	-
Odor		0	24	-	-
pH	pH	5.3	4.4	5.4	5.3
Conductivity	umho/cm	36	30	53	40
TDS	mg/L	26	38	51	44
Temperature	°C	17.1	17.5	20.5	18.1
Turbidity	NTU	0.9	3.4	-	0
Ag	mg/L	<0.001	<0.001	-	-
As	mg/L	<0.002	<0.002	-	-
Ba	mg/L	<0.05	<0.05	-	-
Be	mg/L	<0.005	<0.005	-	-
Cd	mg/L	0.002	0.003	-	-
Cr	mg/L	0.024	0.079	0.002	0.027
Cu	mg/L	0.011	0.021	-	-
Fe	mg/L	7.58	39.84	-	-
Hg	mg/L	0.0008	0.0009	-	-
Mn	mg/L	0.07	0.098	-	-
Na	mg/L	3.76	3.37	-	-
Ni	mg/L	0.010	0.032	-	-
Pb	mg/L	0.013	0.011	0.008	0.014
Se	mg/L	<0.002	<0.002	-	-
Zn	mg/L	0.167	0.110	-	-
Cl	mg/L	5.1	7.0	3.6	6.0
Cyanide	mg/L	<0.005	<0.005	-	-
F	mg/L	0.02	<0.01	0.08	0.07
Surfactants	mg/L	<0.01	<0.01	-	-
H_2S	mg/L	<1.0	<1.0	-	-
NO_2 (as N)	mg/L	<0.01	<0.01	-	<0.5
NO_3 (as N)	mg/L	0.2	0.1	-	<0.5
SO_4	mg/L	<5	<5	<5	<5
Gross Alpha	pCi/L	1.7	6.4	0.95	33.0
Gross Beta	pCi/L	2.2	8.2	3.74	15.0
Ra	pCi/L	2.12	1.7	-	-
DOC	mg/L	4.0	3.0	-	<5
GC Scan	ug/L	<40	<40	-	-
Phenols	mg/L	<0.002	<0.002	-	-
TOC	mg/L	5.0	8.0	-	<5
TOH	mg/L	0.013	0.079	0.066	0.012
Endrin	ug/L	<0.04	<0.04	-	-
Lindane	ug/L	<1	<1	-	-
Methoxychlor	ug/L	<20	<20	-	-
Toxaphene	ug/L	<1	<1	-	-
24D	ug/L	<20	<20	-	-
245TP (Silvex)	ug/L	<2	<2	-	-

TABLE C-12

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 3A

				meters	feet
SRP Grid	N	105657.4	Screen Zone Elev.	75.6-66.5	248.2-218.2
Coordinates	E	53152.7	Screen Zone Depth	28.9-38.0	94.7-124.7
			Drill Depth	38.10	125.0
Latitude		33.346169°N	Casing Elevation	105.15	345.0
Longitude		81.732125°W	Casing Material PVC		

Parameter	Units	02/25/85	04/23/85	08/13/85	10/29/85
Sampling Method		Pump	Pump	Pump	Pump
Water Table	meters	74.4	74.4	73.9	74.0
Elevation	feet	244.2	244.1	242.4	242.7
Coliform B	#/100 ml	<2	-	-	-
Color	CU	-	-	-	-
Corrosivity		-	-	-	-
Odor		-	-	-	-
pH	pH	4.9	5.4	5.4	5.0
Conductivity	umho/cm	70	42	45	35
TDS	mg/L	-	-	-	-
Temperature	°C	18.3	18.6	19.3	18.5
Turbidity	NTU	2.2	-	-	-
Ag	mg/L	<0.0020	-	-	-
As	mg/L	<0.001	-	-	-
Ba	mg/L	0.026	-	-	-
Be	mg/L	-	-	-	-
Cd	mg/L	<0.002	-	-	-
Cr	mg/L	<0.004	<0.004	<0.004	<0.004
Cu	mg/L	-	-	-	-
Fe	mg/L	0.085	-	-	-
Hg	mg/L	0.0004	<0.0002	<0.0002	<0.0002
Mn	mg/L	0.006	-	-	-
Na	mg/L	3.08	2.52	2.20	3.38
Ni	mg/L	-	-	-	-
Pb	mg/L	<0.004	<0.004	<0.010	<0.005
Se	mg/L	<0.001	-	-	-
Zn	mg/L	-	-	-	-
Cl	mg/L	7.3	-	-	-
Cyanide	mg/L	-	-	-	-
F	mg/L	<0.10	-	-	-
Surfactants	mg/L	-	-	-	-
H_2S	mg/L	-	-	-	-
NO_2 (as N)	mg/L	-	-	-	-
NO_3 (as N)	mg/L	<0.50	-	-	-
SO_4	mg/L	<5.0	-	-	-
Gross Alpha	pCi/L	15.0	-	-	-
Gross Beta	pCi/L	11.0	-	-	-
Ra	pCi/L	4.0	-	-	-
DOC	mg/L	-	-	-	-
GC Scan	ug/L	-	-	-	-
Phenols	mg/L	<0.002	-	-	-
TOC	mg/L	0.295	0.536	0.350	0.430
TOH	mg/L	0.025	<0.005	0.010	<0.005
Endrin	ug/L	<0.04	-	-	-
Lindane	ug/L	<1.00	-	-	-
Methoxychlor	ug/L	<20.0	-	-	-
Toxaphene	ug/L	<1.0	-	-	-
24D	ug/L	<20	-	-	-
245TP (Silvex)	ug/L	<2.0	-	-	-

TABLE C-14

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 4

				meters	feet
SRP Grid Coordinates	N 105935.7 E 53177.2	Screen Zone Elev.		78.2-69.1	256.6-226.6
		Screen Zone Depth		23.5-32.6	77.0-107.0
		Drill Depth		32.61	107.0
Latitude	33.346827°N	Casing Elevation		102.29	335.6
Longitude	81.732602°W	Casing Material PVC			

Parameter	Units	1/25/83	4/19/83	8/6/83	11/28/83
Sampling Method		Bail	Bail	Bail	Bail
Water Table	meters	73.5	73.6	74.3	73.7
Elevation	feet	241.1	241.6	243.9	241.8
Coliform B	#/100 ml	>80	-	-	<2
Color	CU	3	30	-	80
Corrosivity		No	No	-	-
Odor		5	32	-	-
pH	pH	4.8	4.7	5.3	4.9
Conductivity	umho/cm	40	41	74	26
TDS	mg/L	26	60	142	46
Temperature	°C	17.3	18.8	22.8	19.2
Turbidity	NTU	2.4	41.0	-	5
Ag	mg/L	<0.001	<0.001	-	-
As	mg/L	<0.002	<0.002	-	-
Ba	mg/L	<0.05	<0.05	-	-
Be	mg/L	<0.005	<0.005	-	-
Cd	mg/L	0.002	0.018	-	-
Cr	mg/L	0.010	0.059	<0.002	0.001
Cu	mg/L	0.008	0.040	-	-
Fe	mg/L	11.92	63.72	-	-
Hg	mg/L	<0.0002	0.0002	-	-
Mn	mg/L	0.08	0.499	-	-
Na	mg/L	3.10	3.03	-	-
Ni	mg/L	0.015	0.012	-	-
Pb	mg/L	0.029	0.047	0.026	0.012
Se	mg/L	<0.002	<0.002	-	-
Zn	mg/L	0.158	0.206	-	-
Cl	mg/L	3.5	5.5	14.5	4.0
Cyanide	mg/L	<0.005	<0.005	-	-
F	mg/L	0.02	<0.01	0.06	0.01
Surfactants	mg/L	<0.01	0.02	-	-
H_2S	mg/L	<1.0	<1.0	-	-
NO_2 (as N)	mg/L	<0.01	<0.01	-	<0.5
NO_3 (as N)	mg/L	0.7	0.5	-	<0.5
SO_4	mg/L	<5	<5	<5	7.5
Gross Alpha	pCi/L	0.2	8.8	1.71	4.0
Gross Beta	pCi/L	1.3	11.4	4.29	<3.0
Ra	pCi/L	1.0	1.4	-	-
DOC	mg/L	3.0	9.0	-	6
GC Scan	ug/L	<40	<40	-	-
Phenols	mg/L	<0.002	<0.002	-	-
TOC	mg/L	4.0	9.0	-	7
TOH	mg/L	0.038	0.039	0.020	0.012
Endrin	ug/L	<0.04	<0.04	-	-
Lindane	ug/L	<1	<1	-	-
Methoxychlor	ug/L	<20	<20	-	-
Toxaphene	ug/L	<1	<1	-	-
24D	ug/L	<20	<20	-	-
245TP (Silvex)	ug/L	<2	<2	-	-

TABLE C-16

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 4

				meters	feet
SRP Grid Coordinates	N 105935.7 E 53177.2	Screen Zone Elev.		78.2-69.1	256.6-226.6
		Screen Zone Depth		23.5-32.6	77.0-107.0
		Drill Depth		32.61	107.0
Latitude	33.346827°N	Casing Elevation		102.29	335.6
Longitude	81.732602°W	Casing Material	PVC		

Parameter	Units	02/27/85	04/23/85	07/15/85	10/29/85
Sampling Method		Pump	Pump	Pump	Pump
Water Table	meters	74.0	74.0	73.5	73.7
Elevation	feet	242.8	242.9	241.3	241.7
Coliform B	#/100 ml	5	-	-	-
Color	CU	-	-	-	-
Corrosivity		-	-	-	-
Odor		-	-	-	-
pH	pH	5.3	5.4	5.0	4.8
Conductivity	umho/cm	69	50	42	38
TDS	mg/L	-	-	-	-
Temperature	°C	18.8	19.2	20.0	18.7
Turbidity	NTU	15.0	-	-	-
Ag	mg/L	<0.0020	-	-	-
As	mg/L	<0.001	-	-	-
Ba	mg/L	0.018	-	-	-
Be	mg/L	-	-	-	-
Cd	mg/L	<0.002	-	-	-
Cr	mg/L	<0.004	<0.004	<0.004	<0.004
Cu	mg/L	-	-	-	-
Fe	mg/L	0.445	-	-	-
Hg	mg/L	0.0003	<0.0002	<0.0002	<0.0002
Mn	mg/L	0.013	-	-	-
Na	mg/L	2.29	1.76	2.09	2.55
Ni	mg/L	-	-	-	-
Pb	mg/L	0.009	0.006	0.011	0.011
Se	mg/L	<0.001	-	-	-
Zn	mg/L	-	-	-	-
Cl	mg/L	3.4	-	-	-
Cyanide	mg/L	-	-	-	-
F	mg/L	<0.10	-	-	-
Surfactants	mg/L	-	-	-	-
H_2S	mg/L	-	-	-	-
NO_2 (as N)	mg/L	-	-	-	-
NO_3 (as N)	mg/L	<0.50	-	-	-
SO_4	mg/L	5.0	-	-	-
Gross Alpha	pCi/L	6.0	-	-	-
Gross Beta	pCi/L	4.0	-	-	-
Ra	pCi/L	4.0	-	-	-
DOC	mg/L	-	-	-	-
GC Scan	ug/L	-	-	-	-
Phenols	mg/L	<0.002	-	-	-
TOC	mg/L	4.360	4.450	4.080	0.900
TOH	mg/L	0.011	0.011	0.026	0.061
Endrin	ug/L	<0.04	-	-	-
Lindane	ug/L	<1.00	-	-	-
Methoxychlor	ug/L	<20.0	-	-	-
Toxaphene	ug/L	<1.0	-	-	-
24D	ug/L	<20	-	-	-
245TP (Silvex)	ug/L	<2.0	-	-	-

TABLE C-18

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 5

				meters	feet
SRP Grid Coordinates	N 105891.8 E 52875.3	Screen Zone Elev.		74.0-67.9	242.7-222.7
		Screen Zone Depth		30.5-36.6	100.1-120.1
		Drill Depth		36.60	120.1
Latitude	33.346236°N	Casing Elevation		105.09	344.8
Longitude	81.733312°W	Casing Material	Steel		

Parameter	Units	1/25/83	4/20/83	8/31/83	11/27/83
Sampling Method		Bail	Bail	Bail	Pump
Water Table	meters	73.5	73.7	73.9	74.0
Elevation	feet	241.3	241.8	242.6	242.7
Coliform B	#/100 ml	38	0	-	<2
Color	CU	2	10	-	0
Corrosivity		No	No	-	-
Odor		2	0	-	-
pH	pH	5.2	5.3	5.3	5.1
Conductivity	umho/cm	132	131	140	23
TDS	mg/L	45	104	106	58
Temperature	°C	16.6	18.6	19.0	18.5
Turbidity	NTU	0.4	2.6	-	0
Ag	mg/L	<0.001	<0.001	-	-
As	mg/L	<0.002	<0.002	-	-
Ba	mg/L	<0.05	0.24	-	-
Be	mg/L	<0.005	<0.005	-	-
Cd	mg/L	0.006	0.005	-	-
Cr	mg/L	0.009	0.012	0.013	<0.001
Cu	mg/L	0.005	<0.001	-	-
Fe	mg/L	4.97	4.21	-	-
Hg	mg/L	0.0003	<0.0002	-	-
Mn	mg/L	0.02	0.046	-	-
Na	mg/L	15.94	17.70	-	-
Ni	mg/L	0.005	0.025	-	-
Pb	mg/L	0.047	0.024	0.003	0.015
Se	mg/L	<0.002	<0.002	-	-
Zn	mg/L	2.810	0.708	-	-
Cl	mg/L	11.4	8.4	3.6	6.0
Cyanide	mg/L	<0.005	<0.005	-	-
F	mg/L	0.05	<0.01	-	0.01
Surfactants	mg/L	<0.01	<0.01	-	-
H_2S	mg/L	<1.0	<1.0	-	-
NO_2 (as N)	mg/L	<0.01	<0.01	-	<0.5
NO_3 (as N)	mg/L	1.0	0.7	-	<0.5
SO_4	mg/L	<5	<5	-	<5
Gross Alpha	pCi/L	0.2	1.9	1.03	<2.0
Gross Beta	pCi/L	5.0	8.6	6.33	<3.0
Ra	pCi/L	0.59	1.4	-	-
DOC	mg/L	3.0	3.0	-	7
GC Scan	ug/L	<40	<40	-	-
Phenols	mg/L	<0.002	<0.002	-	-
TOC	mg/L	6.0	9.0	-	6
TOH	mg/L	0.210	0.146	0.109	0.160
Endrin	ug/L	<0.04	<0.04	-	-
Lindane	ug/L	<1	<1	-	-
Methoxychlor	ug/L	<20	<20	-	-
Toxaphene	ug/L	<1	<1	-	-
24D	ug/L	<20	<20	-	-
245TP (Silvex)	ug/L	<2	<2	-	-

TABLE C-20

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 5A

				meters	feet
SRP Grid Coordinates	N 105885.5	Screen Zone Elev.		75.6-66.4	248.0-218.0
	E 52865.7	Screen Zone Depth		29.0-38.1	95.0-125.0
		Drill Depth		38.10	125.0
Latitude	33.346207°N	Casing Elevation		105.15	345.0
Longitude	81.733325°W	Casing Material PVC			

Parameter	Units	02/25/85	04/23/85	08/26/85	10/29/85
Sampling Method		Pump	Pump	Pump	Pump
Water Table	meters	74.3	74.3	73.8	73.9
Elevation	feet	243.9	243.8	242.1	242.6
Coliform B	#/100 ml	<2	-	-	-
Color	CU	-	-	-	-
Corrosivity		-	-	-	-
Odor		-	-	-	-
pH	pH	4.4	4.7	4.4	4.3
Conductivity	umho/cm	87	61	52	38
TDS	mg/L	-	-	-	-
Temperature	°C	18.0	18.9	19.3	19.0
Turbidity	NTU	2.2	-	-	-
Ag	mg/L	<0.0020	-	-	-
As	mg/L	<0.001	-	-	-
Ba	mg/L	0.010	-	-	-
Be	mg/L	-	-	-	-
Cd	mg/L	<0.002	-	-	-
Cr	mg/L	<0.004	<0.004	<0.004	<0.004
Cu	mg/L	-	-	-	-
Fe	mg/L	<0.004	-	-	-
Hg	mg/L	0.0004	<0.0002	0.0002	<0.0002
Mn	mg/L	0.004	-	-	-
Na	mg/L	7.41	6.72	7.38	6.21
Ni	mg/L	-	-	-	-
Pb	mg/L	<0.004	0.008	<0.010	0.005
Se	mg/L	<0.001	-	-	-
Zn	mg/L	-	-	-	-
Cl	mg/L	11.7	-	-	-
Cyanide	mg/L	-	-	-	-
F	mg/L	<0.10	-	-	-
Surfactants	mg/L	-	-	-	-
H_2S	mg/L	-	-	-	-
NO_2 (as N)	mg/L	-	-	-	-
NO_3 (as N)	mg/L	1.15	-	-	-
SO_4	mg/L	<5.0	-	-	-
Gross Alpha	pCi/L	5.0	-	-	-
Gross Beta	pCi/L	3.0	-	-	-
Ra	pCi/L	2.0	-	-	-
DOC	mg/L	-	-	-	-
GC Scan	ug/L	-	-	-	-
Phenols	mg/L	<0.002	-	-	-
TOC	mg/L	0.334	0.669	0.450	0.490
TOH	mg/L	0.356	0.295	0.128	0.047
Endrin	ug/L	<0.04	-	-	-
Lindane	ug/L	<1.00	-	-	-
Methoxychlor	ug/L	<20.0	-	-	-
Toxaphene	ug/L	<1.0	-	-	-
24D	ug/L	<20	-	-	-
245TP (Silvex)	ug/L	<2.0	-	-	-

TABLE C-22

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 6

				meters	feet
SRP Grid Coordinates	N 105721.1 E 52683.1	Screen Zone Elev.		74.6-68.5-	244.8-224.8
		Screen Zone Depth		31.6-37.7	103.6-123.6
		Drill Depth		37.67	123.6
Latitude	33.345546°N	Casing Elevation		106.80	350.4
Longitude	81.733486°W	Casing Material Steel			

Parameter	Units	1/25/83	4/20/83	8/31/83	11/24/83
Sampling Method		Bail	Bail	Bail	Pump
Water Table	meters	73.5	73.6	-	73.9
Elevation	feet	241.0	241.4	-	242.3
Coliform B	#/100 ml	7	0	-	<2
Color	CU	2	3	-	40
Corrosivity		No	No	No	-
Odor		0	0	-	-
pH	pH	4.2	4.1	5.0	4.4
Conductivity	umho/cm	41	42	64	42
TDS	mg/L	56	62	58	42
Temperature	°C	16.9	18.1	21.1	19.1
Turbidity	NTU	0.2	1.6	-	0
Ag	mg/L	<0.001	<0.001	-	-
As	mg/L	<0.002	<0.002	-	-
Ba	mg/L	<0.05	<0.05	-	-
Be	mg/L	<0.005	<0.005	-	-
Cd	mg/L	0.009	0.003	-	-
Cr	mg/L	0.030	0.009	0.005	0.002
Cu	mg/L	0.006	0.004	-	-
Fe	mg/L	4.44	2.33	-	-
Hg	mg/L	0.0006	0.0003	-	-
Mn	mg/L	0.07	0.068	-	-
Na	mg/L	5.0	4.89	-	-
Ni	mg/L	0.016	0.010	-	-
Pb	mg/L	0.431	0.068	0.038	0.010
Se	mg/L	<0.002	<0.002	-	-
Zn	mg/L	27.84	1.596	-	-
Cl	mg/L	5.5	7.7	6.2	8.6
Cyanide	mg/L	<0.005	<0.005	-	-
F	mg/L	0.05	<0.01	-	0.02
Surfactants	mg/L	<0.01	<0.01	-	-
H_2S	mg/L	<1.0	<1.0	-	-
NO_2 (as N)	mg/L	<0.01	<0.01	-	<0.5
NO_3 (as N)	mg/L	1.4	1.4	-	1.3
SO_4	mg/L	203	<5		<5
Gross Alpha	pCi/L	0.5	2.9	1.06	5.0
Gross Beta	pCi/L	0.9	4.0	4.19	4.0
Ra	pCi/L	2.89	3.1	-	-
DOC	mg/L	4.0	4.0	-	<5
GC Scan	ug/L	<40	<40	-	-
Phenols	mg/L	<0.002	<0.002	-	-
TOC	mg/L	5.0	16.0	-	8
TOH	mg/L	0.240	0.137	0.354	0.013
Endrin	ug/L	<0.04	<0.04	-	-
Lindane	ug/L	<1	<1	-	-
Methoxychlor	ug/L	<20	<20	-	-
Toxaphene	ug/L	<1	<1	-	-
24D	ug/L	<20	<20	-	-
245TP (Silvex)	ug/L	<2	<2	-	-

TABLE C-24

Results of Monitoring Well Analysis for SRL Seepage Basins

Well: ASB 6A

				meters	feet
SRP Grid Coordinates	N 105716.0	E 52675.9	Screen Zone Elev.	75.6-66.5	248.2-218.2
			Screen Zone Depth	30.5-39.6	100.0-130.0
			Drill Depth	39.62	130.0
Latitude	33.345523°N		Casing Elevation	106.67	350.0
Longitude	81.733495°W		Casing Material PVC		

Parameter	Units	02/25/85	04/23/85	08/26/85	10/29/85
Sampling Method		Pump	Pump	Pump	Pump
Water Table	meters	74.2	74.2	73.7	73.8
Elevation	feet	243.3	243.6	241.7	242.2
Coliform B	#/100 ml	<2	-	-	-
Color	CU	-	-	-	-
Corrosivity		-	-	-	-
Odor		-	-	-	-
pH	pH	4.1	4.6	3.9	4.2
Conductivity	umho/cm	57	40	41	37
TDS	mg/L	-	-	-	-
Temperature	°C	19.8	19.8	19.9	19.7
Turbidity	NTU	5.2	-	-	-
Ag	mg/L	<0.0020	-	-	-
As	mg/L	<0.001	-	-	-
Ba	mg/L	0.007	-	-	-
Be	mg/L	-	-	-	-
Cd	mg/L	<0.002	-	-	-
Cr	mg/L	<0.004	<0.004	<0.004	<0.004
Cu	mg/L	-	-	-	-
Fe	mg/L	<0.004	-	-	-
Hg	mg/L	<0.0002	<0.0002	<0.0002	<0.0002
Mn	mg/L	0.009	-	-	-
Na	mg/L	4.21	3.68	4.27	4.99
Ni	mg/L	-	-	-	-
Pb	mg/L	<0.004	0.007	<0.010	0.013
Se	mg/L	<0.001	-	-	-
Zn	mg/L	-	-	-	-
Cl	mg/L	6.8	-	-	-
Cyanide	mg/L	-	-	-	-
F	mg/L	<0.10	-	-	-
Surfactants	mg/L	-	-	-	-
H_2S	mg/L	-	-	-	-
NO_2 (as N)	mg/L	-	-	-	-
NO_3 (as N)	mg/L	1.00	-	-	-
SO_4	mg/L	<5.0	-	-	-
Gross Alpha	pCi/L	9.0	-	-	-
Gross Beta	pCi/L	7.0	-	-	-
Ra	pCi/L	4.0	-	-	-
DOC	mg/L	-	-	-	-
GC Scan	ug/L	-	-	-	-
Phenols	mg/L	<0.002	-	-	-
TOC	mg/L	1.265	0.481	0.610	0.600
TOH	mg/L	0.044	0.013	0.009	0.013
Endrin	ug/L	<0.04	-	-	-
Lindane	ug/L	<1.00	-	-	-
Methoxychlor	ug/L	<20.0	-	-	-
Toxaphene	ug/L	<1.0	-	-	-
24D	ug/L	<20	-	-	-
245TP (Silvex)	ug/L	<2.0	-	-	-