CHAPTER 7

ENVIRONMENTAL MONITORING FOR RADIONUCLIDES

ABSTRACT

This chapter summarizes the history of the environmental monitoring program at the Savannah River site (SRS). The SRS program provides the largest source of environmental monitoring data for radionuclides originating from the SRS. This chapter describes the sources and types of documents reporting environmental monitoring data, and provides an overview of the methods used to compile and cross-check the data. Chapters 8, 9, 10, 11, 12.1, 12.2, 13, and 14 describe the environmental monitoring data for radionuclides identified as potentially useful for the dose reconstruction in detail by media. The environmental monitoring data for chemicals are discussed separately in Chapters 19 and 20. Quality assurance and quality control issues related to environmental monitoring for radionuclides are also discussed in this chapter.

Chapters 8, 9, 10, 11, 12.1, 12.2, 13, and 14 focus on the radionuclides that were determined to be most important by screening calculations (Chapter 3), and those radionuclides that were monitored on a regular basis, especially during the early years and that can be used to confirm the magnitude of releases and/or the fate and transport in the environment. These chapters evaluate the available environmental monitoring data by media from the beginning of SRS operations through approximately 1991. This does not mean that environmental monitoring data do not exist after 1991, but the focus of this dose reconstruction project is on historical exposures so the earlier data are generally most useful.

This chapter stresses the importance of environmental monitoring data collected by groups and organizations independent of the Site, and summarizes the useful datasets that have been identified and compiled. Specific details concerning these independent data are provided in Chapters 8, 9, 10, 11, 12.1, 12.2, 13, and 14.

INTRODUCTION

Environmental monitoring data are a valuable resource for dose reconstruction because they provide direct information about the concentrations of contaminants in various environmental media (e.g., air, water, vegetation, and biota) at particular points in space and time. Depending on the nature and quality of these data, they may be used in several important areas in the dose reconstruction. For example, the data may be used to independently check source term estimates or environmental transport model calculations, or to derive specific parameters used in the environmental transport models.

The current phase of the SRS Dose Reconstruction Project focuses on reconstructing the releases of radionuclides and chemicals and, therefore, does not yet use environmental transport models. Each chapter discusses the media-specific potential usefulness as well as limitations of each compiled data set. These discussions include the impact of such things as original data availability, measurement uncertainties, spatial and temporal resolution, the ability to establish appropriate background concentrations, and other media-specific factors. However, making definitive statements about precisely how the data will be used is beyond the scope of this phase of the project.

REGIONAL MONITORING PROGRAM

The SRS has carried out environmental monitoring activities since before operations at the Site commenced. A preoperational background survey designed to establish background levels of naturally occurring radionuclides before plant startup was carried out from June 1951 to January 1953 (Reinig et al. 1953). Indigenous terrestrial and aquatic animals, vegetation, and food crops were collected and analyzed for total alpha and beta content. Once operations commenced in 1953, this program was adopted for routine monitoring (Harvey 1964). The following excerpt from Harvey (1964) describes the development of the program through the early 1960s.

> Emphasis was placed on the collection and radioanalysis of terrestrial plants and animals through 1955 due to the dominance of fallout radioactivity. Radioiodine (^{131}I), radiostrontium ($^{89,90}Sr$), and radiocesium ($^{134,137}Cs$) analyses were begun for certain samples. In 1956, 1957, and 1958, a series of fuel element failures released low concentrations of radioactive material to the Plant streams, so sampling emphasis was shifted to the aquatic environment. In 1956, gamma spectrometry was first used to identify gamma-emitting radionuclides in environmental samples.
> Data collected through 1959 indicated that the program could be improved by selective sampling. For example, routine collection of seven species of fish not normally eaten by man was discontinued because they contained essentially the same or lower concentrations of radionuclides than the three most common species of edible fish. The analyses of flesh and bone only were continued because the other tissues are not normally eaten. The use of gamma spectrometry to identify gamma-emitting radionuclides was a major factor in developing a selective sampling program for aquatic and terrestrial specimens. The value of spectrographic analyses was subsequently enhanced by the development of computer programs for routine determinations of radionuclide concentrations.
> In the current program, radionuclide uptake and retention patterns of biota are determined from specific analyses of selected indicator organisms, including algae, bluegill sunfish, ring-necked ducks, and cottontail rabbits.

The routine environmental monitoring program was designed to ensure that the amounts of radioactivity released to the environs of the Site did not exceed the maximum permissible concentrations (MPC) that had been established by the National Committee on Radiation Protection (Horton 1957). MPCs were established for various radioactive isotopes in water and air from which the Site calculated MPCs for foods (Horton 1957).

In reviewing the Regional Monitoring Program in 1960, Horton (1960) states that the program was established to accumulate information necessary for determining the effectiveness of Plant controls for radioactive wastes and for an authoritative record of environmental conditions in the event of litigation. The environmental monitoring staff also considered that the purpose of the program should be extended to include collecting scientific information concerning the fate of radionuclides in the environment and to determine better methods of waste management (Horton 1960; Marter and Boulogne 1961).

Horton (1960) also stated that the program needed to emphasize isotopic analysis of samples and, more scientifically, defined MPCs in foods before the best interpretation of the data could be

made. The automation of gamma spectrometry analyses in the early 1960s permitted routine analysis of effluent streams, river water, reactor area effluents, biological specimens, and many other samples not previously analyzed isotopically (Marter and Boulogne 1961). As a result, gross analyses of many samples were supplemented with quantitative data on specific isotopes.

In 1965, the number of samples obtained for the routine environmental monitoring program was reduced by 1500 to approximately 14,000 samples (Marter and Johnson 1966). The reduction in sampling load permitted more duplicate analyses of certain "critical" samples and made the program more cost effective (Marter and Johnson 1966). The memo also indicated that a further reduction of 5000 samples a year could be made without compromising the effectiveness of the environmental monitoring program.

Although the Health Physics Environmental Monitoring Program at SRS was initiated primarily to measure radioactivity, the schedule was expanded in 1973 to include nonradioactive measurements (Johnson and Zeigler 1972). Environmental monitoring for chemicals is discussed further in Chapters 19 and 20.

DATA SOURCES

The environmental monitoring data relevant to SRS are obtained from a number of different sources. The largest source is the various series of environmental monitoring reports that SRS produced throughout its operation. These are summarized in Table 7-1 and include weekly, monthly, quarterly, semiannual, and annual report series; however, none has been produced throughout the entire time period. Probably the earliest study is Reinig et al. (1953), which describes a preoperational background survey that established background levels of naturally occurring radionuclides before plant startup. That survey was carried out from June 1951 to January 1953, during which time approximately 6600 samples from the environs of the SRS were collected and analyzed. Water, mud, air, and biological specimens were sampled. The biological specimens included aquatic and terrestrial animals and a wide range of vegetation.

The first reports concerned with environmental monitoring activities were a series of monthly reports (Table 7-1). These were first produced in August 1951 (Reinig 1951a) by the Health Instrument Group, which was renamed the Health Physics Group by November 1951 (Reinig 1951b). The early reports document the progress of the Site survey. Environmental monitoring monthly reports continued to be produced through 1979. During this time, the name of the group producing them changed periodically. For example, from Health Physics to Control in July 1956 (Du Pont 1956) to Control and Methods in November 1959 (Du Pont 1959) and to Environmental and Allied Studies by March 1961 (Du Pont 1961b). Starting in July 1965, three separate monthly reports were produced by what had become the Radiological and Environmental Sciences Division: (1) Environmental Monitoring (Du Pont 1965a), (2) Earth Sciences (Du Pont 1965b), and (3) Radiological Sciences (Du Pont 1965c). We reviewed all of these reports for relevant environmental monitoring data.

Weekly environmental monitoring reports cover the time period from the end of May 1954 (Du Pont 1954) through October 1962 (Du Pont 1962). However, from around mid-August 1961, the reports covered 2-week periods (Du Pont 1961c), and reports from May through October 1962 appear to have been produced monthly. These reports were separate from the monthly reports described above (Table 7-1). Quarterly environmental monitoring reports were produced briefly for a 2-year period that covered the first quarter of 1960 (Du Pont 1960) through the last

quarter of 1961 (Du Pont 1961a). Semiannual reports were produced over a significantly longer time period than the quarterly reports (Table 7-1). The first semiannual report covers the first 6 months of 1953 (Albenesius 1954). No semiannual report was produced for the last 6 months of 1953, and the next report covered January to July 1954 (Horton 1954). The final environmental monitoring semiannual report covered the first 6 months of 1971 (Du Pont 1971).

An annual environmental monitoring report titled Health Physics Regional Monitoring Annual Report was first produced for the year 1963 (Du Pont 1964). The title was changed the following year (Ashley 1964) to Environmental Monitoring at the Savannah River Plant Annual Report and remained the same for the annual reports produced through 1984. Beginning in 1971, a second annual report series titled Environmental Monitoring in the Vicinity of the Savannah River Plant was produced (Du Pont 1972). This series was replaced in 1984 by a series titled Savannah River Plant Environmental Report that is produced to the current day. In 1988 the title was revised to Savannah River Site Environmental Report (Table 7-1).

Table 7-1. Summary of Savannah River Site Environmental Monitoring Reports

Report title	Period of publication	Frequency of publication	SRS Doc. Series #
Health Physics Regional Monitoring Annual Report	1963	Annual	DPSPU 64-11-12
Environmental Monitoring at the Savannah River Plant	1964–1984	Annual	DPST 65-302 through DPST 85-302
Environmental Monitoring in the Vicinity of the Savannah River Plant	1971–1983	Annual	DPSPU 72-30-1 through DPSPU 84-30-1
Savannah River Plant Environmental Report	1984–1987	Annual	DPSPU 85-30-1 through DPSPU 88-30-1
Savannah River Site Environmental Report	1988–present	Annual	WSRC-RP-89-59-1
Health Physics Site Survey Data	1953 (Jan-Jul)	Semiannual	DPSPU 54-11-12
Radioactivity in the Environs of the Savannah River Plant	1954 (Jan-Jul)	Semiannual	DP-92
Semi-Annual Progress Report	1954 (Jul–Dec)	Semiannual	DPSP 55-25-34
	1955 (Jan-Jun)		DPSP 56-25-13
Health Physics Regional Monitoring Semiannual Report	1955 (Jul–Dec)	Semiannual	DPSP 56-25-54
	1956 (Jan-Jun)		DPSP 56-25-4
	1956 (Jul–Dec)		DPSP 57-25-15
	1957 (Jan-Jun)		DPSP 57-25-43
	1957 (Jul–Dec)		DPSP 58-25-17
	1958 (Jan-Jun)		DPSP 58-25-38
	1958 (Jul–Dec)		DPSPU 59-11-23
	1959 (Jan-Jun)		DPSPU 59-11-30
	1959 (Jul–Dec)		DPSPU 60-11-9
	1960 (Jan-Jun)		DPSP 60-25-26

Report title	Period of publication	Frequency of publication	SRS Doc. Series #
	1960 (Jul–Dec)		DPSP 61-25-4
	1961 (Jan-Jun)		DPSP 62-25-2
	1961 (Jul–Dec)		DPSP 62-25-9
Health Physics Environmental Monitoring Semiannual Report	1962 (Jan-Jun)	Semiannual	DPSP 63-25-3
	1962 (Jul–Dec)	Semiannual	DPSP 63-25-10
Effect of the Savannah River Plant on Environmental Radioactivity Semiannual Report.	1962 (Jan-Jun)	Semiannual	DPSPU 62-30-24
	1962 (Jul–Dec)		DPSPU 63-30-12
	1963 (Jan-Jun)		DPSPU 63-30-1
	1963 (Jul-Dec)		DPSPU 64-30-1
	1964 (Jan-Jun)		DPSPU 64-30-2
	1964 (Jul-Dec)		DPSPU 65-30-1
Effect of the Savannah River Plant on Environmental Radioactivity Semiannual Report.	1965 (Jan-Jun)	Semiannual	DPSPU 65-30-2
	1965 (Jul–Dec)		DPSPU 66-30-1
	1966 (Jan-Jun)		DPSPU 66-30-2
	1966 (Jul–Dec)		DPSPU 67-30-1
	1967 (Jan-Jun)		DPSPU 67-30-2
	1967 (Jul–Dec)		DPSPU 68-30-1
	1968 (Jan-Jun)		DPSPU 68-30-2
	1968 (Jul–Dec)		DPSPU 69-30-1
	1969 (Jan-Jun)		DPSPU 69-30-2
	1969 (Jul–Dec)		DPSPU 70-30-1
	1970 (Jan-Jun)		DPSPU 70-30-2
	1970 (Jul–Dec)		DPSPU 71-30-1
	1971 (Jan-Jun)		DPSPU 71-30-16
The Effect of the Savannah River Plant on Environmental Radioactivity Quarterly Report	1960 (Jan-Mar)	Quarterly	no number
	1960 (Apr-Jun)		no number
	1960 (Jul-Sep)		no number
	1960 (Oct-Dec)		no number
	1961 (Jan-Mar)		no number
	1961 (Apr-Jun)		no number
Effect of the Savannah River Plant on Environmental Radioactivity Quarterly Report	1961 (Jul-Sep)	Quarterly	no number
	1961 (Oct-Dec)		DPSPU 62-30-11
Health Instrument Group Site Survey Monthly Progress Report	1951 (Aug – Oct)	Monthly	no number
Health Physics Group Monthly Report	1951 (Nov) – 1956 (Jun)	Monthly	no number
Control Monthly Report	1956 (Jul) – 1959 (Oct)	Monthly	no number
Control and Methods Monthly Report	1959 (Nov) – 1961 (Feb)	Monthly	no number

Report title	Period of publication	Frequency of publication	SRS Doc. Series #
Environmental Monitoring and Allied Studies Monthly Report	1961 (Mar) – 1965 (Jun)	Monthly	no number
Environmental Monitoring Monthly Report	1965 (Jul) – 1979 (Jan)	Monthly	no number
Works Technical Department Monthly Report	1979 (Feb – Dec)	Monthly	no number
Earth Sciences Monthly Report	1965 (Jul) – 1972 (Oct)	Monthly	no number
Radiological Sciences Monthly Report	1965 (Jul) – 1972 (Nov)	Monthly	no number
Radiological Chemistry Monthly Report	1971 (Dec) – 1972 (Aug)	Monthly	no number
Weekly Report – Control	1954 (May) – 1959 (Nov)	Weekly	no number
Weekly Report – Control and Methods	1959 (Nov) – 1961 (Feb)	Weekly	no number
Weekly Report – Environmental Monitoring and Allied Studies	1961 (Feb – Aug)	Weekly	no number
Weekly Report – Environmental Monitoring and Allied Studies	1961 (Aug) – 1962 (~May)	Biweekly	no number
Weekly Report – Environmental Monitoring and Allied Studies	1962 (~May) – 1962 (Oct)	Monthly	no number

A primary source of environmental monitoring data is handwritten compilations of effluent and environmental monitoring results on ledger sheets. At some point in time, each sheet was photographed by the Site in a format similar to microfiche and mounted on a computer card with a hole cut in the center. These cards are called aperture cards. The time period covered by the aperture cards varies depending on the media (Table 7-2) and the type of measurements. Not all of the data on the aperture cards are useful for dose reconstruction; therefore, we reviewed the aperture cards to determine if the data should be compiled in an electronic format. Data that were not relevant included measurements of feral coliform bacteria, river algae, area film badge thermoluminescent dosimeter measurements, and fly paper autoradiographs. Other data were determined not to be useful because individual sample locations could not be identified. Table 7-2 summarizes the environmental monitoring data for radionuclides available from the aperture cards for the media of interest.

The data on the aperture cards have been cross-checked with the data presented in the various weekly, monthly, quarterly, semiannual and annual environmental monitoring reports. In general, good agreement is observed between the two sources of data. Further details about the specific media are provided in Chapters 8, 9, 10, 11, 12.1, 12.2, 13, and 14.

Table 7-2. Summary of Useful Aperture Card Data for Radionuclides

Environmental media	Time period of data	Measurements[a]
Air	1957–1973	Gross alpha and beta, fission products
Rainwater	1959–1973	^{131}I, ^{90}Sr, ^{137}Cs, tritium
Surface water	1962–1973	Gross alpha and beta, tritium
Fish	1970–1981	^{137}Cs, ^{90}Sr
Vegetation	1957; 1959–1973	Gross alpha and beta, fission products, tritium
Milk	1959–1973	^{131}I, ^{90}Sr, ^{137}Cs, tritium
Agricultural products	1966–1973; 1982–1983	Gross alpha and beta, fission products
Wild game	1965–1966; 1970–1982; 1984–1985	Nonvolatile beta, ^{137}Cs, radioiodine

[a] Available measurements may vary by year.

Independent (non-SRS) Data Sources

In a public study such as this dose reconstruction, independent monitoring by groups can be important for developing trust in the Site's monitoring results. These monitoring data are valuable because they have been generated by organizations or groups independent of the day-to-day running of the Site and can be used to determine the quality and reliability of the SRS data. An understanding of background levels can be particularly important to the dose reconstruction process at U.S. Department of Energy sites, because often the time periods of highest releases from the sites overlap with the time of highest depositions of fallout from weapons testing. These independent monitoring programs are rarely as comprehensive, in terms of localized monitoring, as the Site's program, but they can provide a cross-check of results generated by the site at a similar location and time.

In Chapters 8, 9, 10, 11, 12.1, 12.2, 13, and 14, environmental monitoring datasets for radionuclides identified as potentially useful for the dose reconstruction are evaluated. Where possible, environmental monitoring data useful for the dose reconstruction that have not been collected by the SRS are also evaluated. In general, the independent data are most useful for those years when atmospheric fallout from nuclear weapons testing was high and when they provide information about background concentrations of radionuclides at locations away from the Site. A summary of the independent data that have been compiled is provided in Table 7-3.

One source of useful independent monitoring data is the U.S. Environmental Protection Agency (EPA), started by the U.S. Public Health Service (PHS) almost 40 years ago. The U.S. EPA has monitored rainwater and has reported tritium concentrations since 1974 for various locations, including Columbia and Barnwell, South Carolina. See Chapter 8 for additional details.

The PHS also had a milk monitoring program that started in 1957. Milk was sampled from locations throughout the United States. The three monitoring locations closest to the SRS were Atlanta, Georgia; Charleston, South Carolina; and Charlotte, North Carolina. The PHS milk monitoring data provide an independent source of information about the concentrations of fallout radionuclides found in milk in the southeastern United States and allow comparison with the

concentrations measured in milk samples from around the SRS. See Chapter 10 for more detailed information.

The South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Department of Natural Resources (GDNR) generated additional information regarding radionuclide concentrations in fish from the Savannah River. These organizations began routine fish collection programs in the early 1970s and 1980s and provide ^{137}Cs, ^{90}Sr, and tritium concentrations for fish collected from various locations along the river. These data provide independent sources of information that can be used verify concentrations reported by the SRS. See Chapter 14 for a more detailed discussion of data provided by these organizations.

Table 7-3. Summary of Compiled Independent Monitoring Data[a]

Environmental Media	Data source	Measurements	Time period of data[b]
Air	U.S. PHS	beta	1959–1964
Rainwater	U.S. EPA	tritium	1982–1990
Milk	U.S. PHS/ U.S. EPA	^{137}Cs, ^{140}Ba, ^{131}I, ^{89}Sr, ^{90}Sr	1960-1993
Offsite surface water:			
Savannah River	U.S. PHS	gross alpha, beta	1956–1960
Savannah River	U.S. PHS	^{90}Sr	1956–1957, 1961—1964
Savannah River	USGS[c]	tritium	1962–1964
Kissimmee River (FL)	USGS	tritium	1962–1964
Neuse River (NC)	USGS	tritium	1962–1964
Stream (Waynesboro, GA)	USGS	tritium	1962–1964
Fish	GDNR	tritium, ^{137}Cs, ^{90}Sr	1982–1997
	SCDHEC	^{137}Cs	1975–1995

[a] See Chapters 8, 9, 10, 11, 12.1, 12.2, 13, and 14 for specific details.
[b] Available measurements may vary by year.
[c] USGS = United States Geological Survey.

Quality Assurance and Quality Control

The early sampling and analytical techniques used by SRS were limited by the quality of the sampling equipment and detectors available at the time. Furthermore, limitations are associated with some of the SRS environmental datasets, such as inadequate control locations, improper calibrations, and nonrepresentative sampling techniques. These limitations, along with the overall quality of the monitoring program at any given time, must be considered as datasets are identified for use in a specific dose assessment.

The semiannual and annual environmental reports before 1975 do not mention quality assurance or quality control. Discussions with personnel involved in the environmental monitoring program indicate that there were no interlaboratory comparisons in the 1950s and 1960s. However, beginning with the 1958 reports, a table of sensitivities and standard deviations of the laboratory analyses is provided in each semiannual or annual report. The standard deviations are based on spike recovery values.

The 1975 annual report (Ashley and Ziegler 1976) includes a "Monitoring Results Treatment and Quality Control" section, which provides a description of the quality control program including participation in the EPA Interlaboratory Comparison Program. No cross-check data are reported.

In 1976, in addition to participation in the EPA Interlaboratory Comparison Program, SRS participated in an Energy Research and Development Administration (ERDA)-wide quality assurance program conducted by the Health and Safety Laboratory of New York City. The results of the cross-check programs are not provided. The 1976 annual report (Ashley and Ziegler 1978) discusses quality control for nonradiological analyses and provides a comparison of SRS and Georgia Department of Natural Resources data for certain water quality parameters.

Results of SRS participation in the interlaboratory cross-check program are provided in annual reports starting in 1977. An appendix detailing the SRS quality control program can be found in the annual reports starting in 1980.

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