United States General Accounting Office

GAO

Report to the Honorable Ernest F. Hollings
United States Senate

July 1986

NUCLEAR WASTE

Impact of Savannah River Plant's Radioactive Waste Management Practices

GAO/RCED-86-143

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-202377

July 29, 1986

The Honorable Ernest F. Hollings
United States Senate

Dear Senator Hollings:

In response to your July 5, 1984, letter and our subsequent agreements with your office, we reviewed the radioactive waste[1] management practices at the Department of Energy's (DOE) Savannah River Plant (SRP) to determine if these practices have adverse environmental impacts.

SRP primarily produces plutonium, tritium, and other special nuclear materials for national defense, and it occupies an area of about 300 square miles along the Savannah River in South Carolina. The E. I. du Pont de Nemours and Company (DuPont) constructed the plant in the 1950's and has since operated it for DOE under a cost reimbursement, no-fee type contract. DuPont's operational responsibilities include carrying out the various radioactive waste disposal and storage activities.

SRP generates radioactive airborne, liquid, and solid waste during its operations. Some of this waste is disposed of by shallow land burial or by controlled releases into the atmosphere and surface streams on the plant site. A large part of SRP's radioactive waste, however, is in interim storage awaiting the completion of permanent offsite disposal facilities. DuPont continuously monitors the radioactive waste disposal and storage operations to ensure that radioactivity released into the environment does not exceed DOE and Environmental Protection Agency (EPA) radiological protection standards The states of South Carolina and Georgia also monitor concentrations of radioactivity in the vicinity of the plant.

Our analysis of DuPont and state monitoring reports showed that radioactivity contained in the environment outside the plant boundary was well within applicable standards. Within the plant boundary, however, some of the surface streams contained elevated levels of radioactivity, and the soil and groundwater at several waste storage and disposal sites were highly contaminated with radioactivity. While SRP officials stated that a remote possibility exists that some contamination could reach the

[1]Materials from nuclear operations that are radioactive and for which there is no practical use or for which recovery is impractical Because of the technical nature of this subject, a glossary is provided at the end of this report

deep Tuscaloosa aquifer, they believe that the concentration of radioactivity would be very low by the time it discharged into the Savannah River.

SRP has taken several actions and has other actions underway to reduce radioactive releases into the environment. However, the waste storage and disposal sites may require long-term institutional control. In addition to these actions, SRP is preparing an environmental impact statement (EIS) to evaluate the impact of its waste management practices on groundwater quality and to assess remedial actions that may be needed.

Our review objective, scope, and methodology is discussed in appendix I. Our overall review results are summarized in this letter, and detailed information about SRP's radioactive waste management practices is included in appendices II through V.

Impact of Radioactive Releases

The offsite and onsite impacts of SRP's radioactive releases are summarized below; specific details are discussed in appendices III through V.

Offsite Impact

Except for a small swamp area near the plant site, our analysis of DuPont's records showed that radioactive releases from SRP's operations have had very little impact outside the plant boundary. Except for tritium, DuPont's reports show that there is no distinguishable difference between airborne radioactivity at the plant boundary and that observed at air-monitoring stations located 25 and 100 miles from the plant. Although tritium can be detected outside the plant, the highest airborne concentration measured during 1984 at the plant boundary was less than 1 percent of DOE's offsite concentration guide. The 1984 measurements are consistent with measurements made during 1982 and 1983.

DuPont's monitoring report for 1984 also showed that tritium and occasional traces of strontium-90 were the only two radionuclides that could be detected in the Savannah River using routine analytical methods. By using special low-level analysis techniques, DuPont was also able to detect very low levels of cesium-137. The monitoring report showed, however, that the concentrations of these three radionuclides were less than 1 percent of DOE's offsite concentration guides. Although DuPont has detected tritium and very low concentrations of cesium-137 at the two downriver public drinking water treatment plants, the average tritium

concentrations measured during 1984 were only 8.5 and 12.5 percent, respectively, of EPA's public drinking water standard. The average cesium-137 concentrations measured were considerably less than 1 percent of the drinking water standard.

DuPont reports also show that concentrations of radioactivity in other elements of the environment in the vicinity of the plant were very small. Dupont's reports for 1984, for example, show that concentrations of radioactivity found in such items as rainwater, milk, food, vegetation, soil, and fish were similar to levels found in these items in other parts of the country. Georgia and South Carolina measurements of radioactive concentrations in the environment in the vicinity of the plant generally agreed with the results being reported by DuPont. Officials from both of these states told us that they considered DuPont's monitoring data to be reliable and that tritium is the only radionuclide in the offsite environment that they can attribute to SRP's current operations. EPA's Eastern Environmental Radiation Facility also made limited measurements in December 1982 of radioactive concentrations in the environment around the plant and reported that its results generally agreed with those obtained by DuPont.

Most of the radioactivity released from SRP's operations are of such low concentrations that, when dispersed in the environment, they are not measurable by conventional monitoring procedures; therefore, DuPont has to use mathematical models to calculate offsite concentration levels and radiation doses to the public Dupont uses models that the Nuclear Regulatory Commission (NRC) prescribes for the commercial nuclear industry in calculating doses from air and water DuPont modified these models in order to input physical and biological data specifically applicable to SRP and to expand the amount of output data.

DuPont's computations for 1984, as in previous years, showed that SRP's operations had very little impact on the public. Its computations showed, for example, that a hypothetical individual living on the plant boundary would have received a maximum annual whole body dose of less than 1 percent of DOE's standard. DuPont's calculated doses were also well within EPA's airborne emission and public drinking water standards. We noted that EPA in December 1982 made a limited verification of DuPont's dose computations during its work leading to the establishment of the airborne emission standard. Using release data provided by DOE, EPA calculated offsite doses using its own models and found a very close correlation with DuPont's calculations.

While radioactive concentration levels in the environment around SRP are very low, there is a swamp adjacent to the southern boundary of the plant site that was contaminated during the 1960's because of leaks from defective fuel elements in a storage basin at one of the nuclear production reactors. Neither SRP nor South Carolina officials, however, consider it necessary to restrict usage of the swamp or to take remedial actions because no one is living in the area. DuPont's evaluations show that it is possible for an individual to receive a dose ranging from a few millirem to a few tens of millirem if a person used the swamp for fishing, hunting, or launching boats; however, these doses would be well within DOE's standards

Onsite Impact

SRP's radioactive waste management operations have resulted in elevated levels of radioactivity in surface streams on the plant site, and the soil and groundwater at several waste disposal and storage sites are highly contaminated with radioactivity. Also, SRP officials told us that there is a remote possibility that some of this contamination could reach the deep Tuscaloosa aquifer. In addition, DOE may have to maintain long-term institutional control of these contaminated waste sites. Specifics of these problems are discussed below.

Extent of Contamination

DOE did not have standards governing concentrations of radioactivity that could be contained in surface and groundwater within the boundaries of its facilities.[2] We therefore compared the tritium, gross alpha, and gross beta contamination levels measured by DuPont during the period 1980 through 1984 with DOE's offsite concentration guides and EPA's public drinking water standard to illustrate the extent and levels of contamination within the plant boundary. The extent and levels of contamination in surface streams, groundwater, and soil are discussed below.

Surface streams—Our analysis of DuPont's monitoring reports showed that onsite surface streams during the period 1980 through 1984 contained elevated levels of radioactivity resulting primarily from the low-level radioactive liquid waste that SRP released into these streams and the contaminated groundwater which discharged into them from beneath the waste burial ground and seepage basins. Most of the streams, for example, contained tritium concentrations which ranged

[2]DOE is in the process of developing onsite concentration guides to govern the amount of radioactivity that can be contained in surface and groundwater As part of this effort DOE established an interim guide for onsite surface waters on April 24, 1986

from slightly above to 750 times greater than EPA's public drinking water standard, and tritium concentrations in one of the streams were also greater than DOE's offsite concentration guide. In addition, three streams contained maximum gross alpha and beta radioactivity exceeding EPA's drinking water standard; and, at times, gross beta levels were greater than DOE's offsite concentration guide. The radioactivity, however, was diluted to levels well within both of these standards by the time it reached DuPont's river monitoring stations along the southwestern boundary of the plant

Groundwater—We determined that groundwater was highly contaminated with radioactivity at the low-level waste burial ground, some of the seepage basins, and the high-level waste tank farms. The contamination occurred primarily as a result of radioactivity migrating from buried waste, discharges of contaminated liquid waste into the seepage basins, and unintentional spills and leaks of high-level liquid waste. Most of the groundwater at the low-level waste burial ground, for example, contained maximum tritium concentrations ranging from slightly above to about 116,000 times greater than EPA's public drinking water standard, and some concentrations ranged up to about 770 times greater than DOE's offsite concentration guide. Some of the groundwater at the high-level waste storage tanks, for example, contained maximum gross beta concentrations ranging from slightly above to 500 times greater than EPA's drinking water standard, and the highest concentration was also about 83 times greater than DOE's offsite concentration guide.

Soil—Large amounts of soil have also been contaminated at these waste sites; however, DuPont's evaluations show that, except for tritium, there has been very little movement of the radionuclides because of the retention capability of the soil around the sites. The evaluations further show that it will take many years for most of the radioactivity to reach groundwater and that even longer periods will be required for the contaminated groundwater to discharge into a surface stream. About 30,000 square feet of soil was unintentionally contaminated, for example, as a result of leaks in one of the high-level waste storage tanks. DuPont estimates, however, that it will take thousands of years for most of the radioactivity to reach the groundwater and over a million years for the contaminated groundwater to discharge into a surface stream. DuPont's evaluations show that most of the radioactivity will decay to very low levels during this period.

Potential Contamination of Tuscaloosa Aquifer

Under a large area of the plant, groundwater moves primarily in a horizontal direction because underlying hydrological conditions prevent its downward migration. These conditions, however, do not exist under seepage basins at two of the production reactors, and DuPont has determined that there is a possibility for some of the contaminated groundwater under these basins to migrate downward and reach the Tuscaloosa aquifer. SRP environmental and waste management officials told us that the possibility of radioactive contamination reaching the aquifer is very low but that a remote possibility does exist. Even if this happens, SRP officials said that it would take about 200 years for the radionuclides to discharge into the Savannah River. Because of the retention capabilities of the soil and the decay that would occur during this period, these officials also said that the contamination level would be very low by the time it reached the river. The low level of contamination would be further diluted by river water before reaching the public drinking water treatment plants located 60 to 70 miles downriver

Institutional Control

DOE may have to maintain long-term institutional control over the low-level burial ground, several of the seepage basins, and the high-level waste tank farms because of radioactive contamination at these sites. We noted, for example, that an EIS issued in 1977 showed that these waste sites would remain contaminated with radioactivity for the foreseeable future even after production operations ceased and that their restoration might not be technically or economically practical.

Actions Intended to Reduce Future Impacts

SRP has taken several actions and has others underway that are intended to reduce the amount of radioactivity reaching the environment from both normal and unintentional releases. These actions include transferring the extremely hazardous high-level liquid waste to safer storage tanks, preparing to permanently dispose of high-level and transuranic waste in offsite repositories, changing certain low-level waste disposal practices, evaluating new low-level disposal methods, and modifying the tritium production facilities.

In addition to these actions, SRP is evaluating the extent of radioactive contamination at the waste sites to determine whether any remedial actions are warranted, including removal of the contamination, as part of an EIS being prepared to assess the impact of its radioactive waste management practices on groundwater quality The EIS will also contain additional information on the need to maintain long-term institutional

control over the waste storage and disposal sites and the potential contamination of the Tuscaloosa aquifer. The EIS is scheduled to be completed in the spring of 1987.

DOE Comments

In commenting on a draft of this report, DOE stated that the report accurately characterized the existing situation at SRP and suggested only minor revisions to update and clarify several statements contained in the report. (See appendix VI.) We have incorporated DOE's suggestions where appropriate.

As arranged with your office, unless you publicly release its contents earlier, we plan no further distribution of this report until 7 days after the issue date. At that time we will send copies to interested parties and make copies available to others upon request.

Sincerely yours,

J. Dexter Peach
Director

Contents

Abbreviations

DOE	Department of Energy
DuPont	E. I. du Pont de Nemours and Company
EIS	environmental impact statement
EPA	Environmental Protection Agency
GAO	General Accounting Office
GCD	greater confinement disposal
NRC	Nuclear Regulatory Commission
SRP	Savannah River Plant
TRU	transuranic
WIPP	Waste Isolation Pilot Plant

Objective, Scope, and Methodology

In a July 5, 1984, letter, Senator Ernest F. Hollings requested that we examine various aspects of the Savannah River Plant's (SRP) radioactive waste management practices. After performing preliminary review work at SRP, we met with Senator Hollings' office and agreed to review SRP's current and planned practices for handling, storing, and disposing of radioactive waste to determine whether these practices had adverse environmental impacts.

We performed most of our review work at SRP and at the Department of Energy (DOE) headquarters in Washington, D.C., because DOE is responsible for establishing department-wide radiological protection standards, monitoring radioactive releases against these standards, and assessing the impact of the releases. We also performed work at the Environmental Protection Agency (EPA) headquarters in Washington, D. C.; Georgia's Environmental Protection Division, Atlanta, Georgia; EPA's Eastern Environmental Radiation Facility, Montgomery, Alabama; and South Carolina's Department of Health and Environmental Control, Columbia, South Carolina, because these activities have performed limited verifications of the impacts of SRP's radioactive releases.

To accomplish our overall objective, we reviewed SRP's current and planned radioactive waste management practices, examined information relative to the type and concentrations of radioactivity being released into the environment, compared these releases with applicable standards and guides, reviewed assessments and comparisons made by organizations other than SRP, and identified and assessed the existing and potential environmental problems that have resulted from the radioactive releases.

To identify SRP's current and planned radioactive waste management practices, we examined applicable waste management procedures, directives, and regulations; waste management program and project plans; operational descriptions of the waste disposal and storage facilities; and various other documents, reports, and assessments. We also visited the major waste disposal and storage facilities and discussed the operation of these facilities with SRP and E. I. du Pont de Nemours and Company (DuPont) officials.

To determine the type and extent of radioactivity released into the environment, we examined various radioactive release reports and documents prepared by SRP, DuPont, Georgia and South Carolina; identified the source data and methods used for compiling some of these reports and

documents; and examined various other documents, reports, and assessments relative to the radioactive releases. We did not evaluate the adequacy of the methods DuPont and the states used to determine the types of radioactivity released or the concentration levels of the releases; however, we did discuss these matters with SRP, DuPont, EPA, and state officials.

To compare the radioactive releases with applicable DOE and other radiological protection standards, we identified standards applicable to SRP's radioactive waste management operations, determined the basis used to establish the standards, and compared the radioactive releases with these standards. We also reviewed comparisons made by DuPont as well as independent assessments by South Carolina, Georgia, and EPA's Eastern Environmental Radiation Facility. Since DOE did not have standards governing the concentrations of radioactivity that could be contained in surface and groundwaters within the boundaries of its facilities, we compared the contamination levels in these waters with DOE's offsite concentration guides and EPA's public drinking water standard to illustrate the extent and levels of radioactive contamination within the SRP plant boundary. We also discussed various aspects of the radioactive release standards and assessments of the releases against the standards with DOE, SRP, DuPont, EPA, and state officials.

To identify and assess the environmental impacts that have resulted from SRP's radioactive waste management practices, we examined the results of the above discussed comparisons, reviewed various environmental assessments and evaluations prepared by SRP, DuPont, and the states of Georgia and South Carolina; and examined other documents, reports, and evaluations related to environmental conditions both within and outside the plant boundaries. We also discussed the environmental impacts with SRP, DuPont, and state officials.

As discussed above, our review was limited to examining the environmental impacts resulting from SRP's radioactive waste management operations. We did not address the health or safety aspects of SRP's waste management operations or assess the programmatic aspects of these activities, such as program cost or the need for additional storage tanks. In addition, we did not address SRP's hazardous waste management operations; however, we did provide Senator Hollings with information about these activities in a 1984 report.[1]

[1]Department of Energy Acting To Control Hazardous Wastes at Its Savannah River Nuclear Facilities, (GAO/RCED-85-23, Nov 21, 1984)

Our review work was done between October 1984 and January 1986 in accordance with generally accepted government auditing standards.

Waste Management Operations

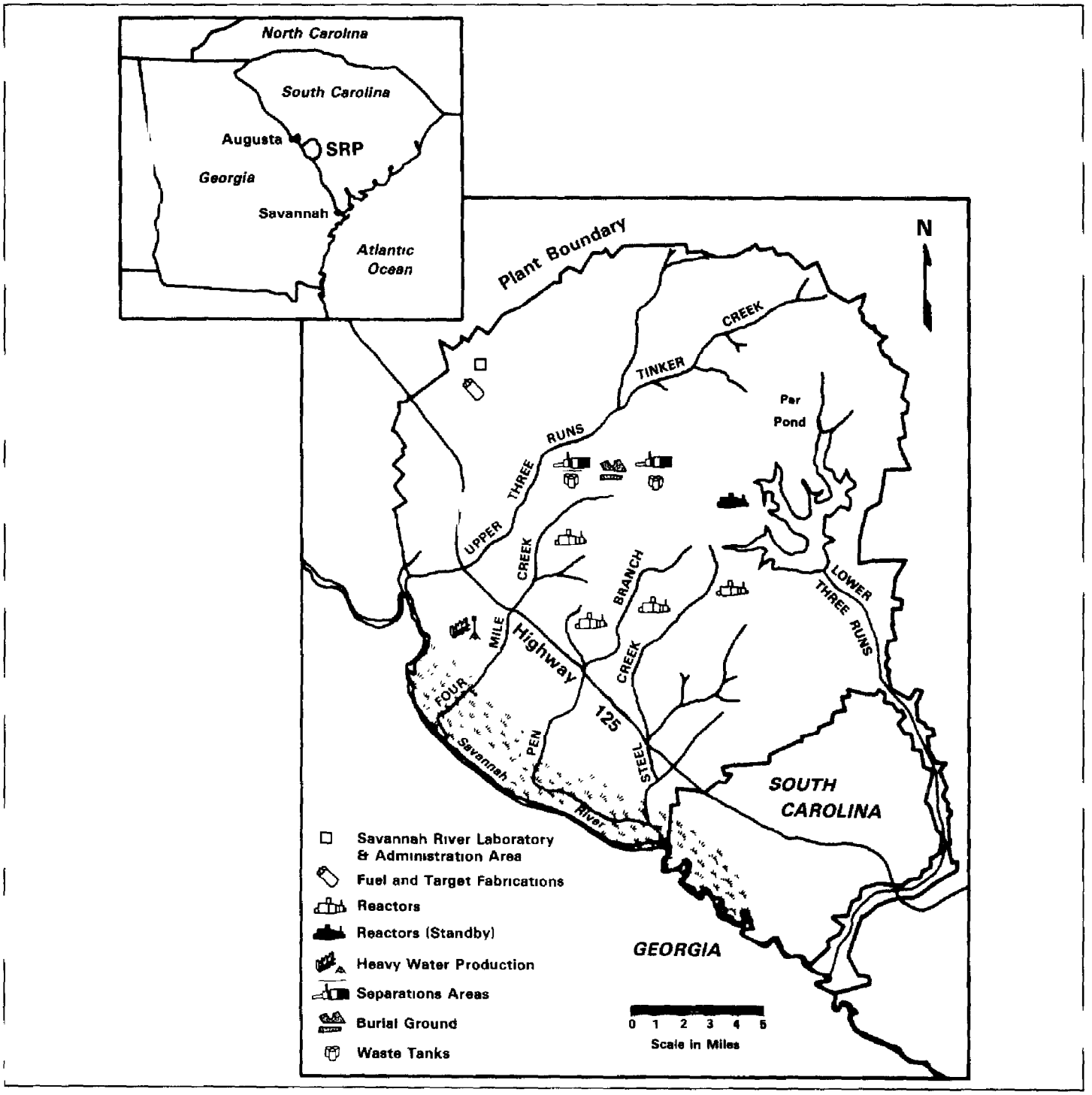
The Savannah River Plant primarily produces plutonium, tritium, and other special nuclear materials for national defense. While most of SRP's activities are defense oriented, some projects involve peaceful uses of atomic energy. Plutonium-238 produced by SRP, for example, has been used in nuclear-powered cardiac pacemakers; and this product also plays a prominent role in our space program by generating electric power and providing a source of heat to warm scientific instruments. DuPont constructed the plant in the early 1950's and has since operated it for DOE under a cost reimbursement, no-fee type contract. DuPont's operational responsibilities include carrying out the various radioactive waste disposal and storage activities and conducting an extensive environmental monitoring program to assess the impact of radioactive releases.

Major Operating Facilities

SRP's major operating facilities include four nuclear production reactors,[1] a plant for fabricating fuel and target elements to be irradiated in the reactors, two chemical separations plants for processing the irradiated elements, a research and development laboratory, and various support facilities. SRP occupies an area of about 300 square miles along the Savannah River in South Carolina. The plant complex is in a rural setting, and public access to the site is restricted. The production reactors, chemical separations plants, and major radioactive waste storage and disposal facilities are located near the center of the site which provides for considerable dispersion and dilution of radioactivity before it reaches the plant boundary as shown by figure II.1.

[1]One additional nuclear production reactor is located at SRP, but it is in a standby status

Figure II.1: Savannah River Plant



Waste Management

Large quantities of radioactive airborne, liquid, and solid waste are generated during SRP's research, development, and production of special nuclear materials. In managing this waste, DuPont uses different disposal and/or storage techniques depending upon the waste form and its associated hazards. DuPont's disposal and/or storage techniques are summarized below; specific details are discussed in appendices III through V.

Airborne Waste

As part of its normal operations, the facility routinely releases various radionuclides into the atmosphere, but there are occasional unintentional releases. During 1984, for example, the plant released about 1.7 million curies of airborne radioactivity which included emissions from normal operations and two unintentional releases containing about 65,000 curies. Most of these releases came from the production reactors and the chemical separations plants. DuPont limits these releases by using various containment processes, but its evaluations show that it is technically and economically impractical to eliminate all airborne releases.

Liquid Waste

SRP also generates large volumes of highly radioactive liquid waste which is isolated from the environment in large underground steel storage tanks. After aging for 1 to 2 years, a layer of highly radioactive sludge settles to the bottom of the tanks, and the remaining solution is evaporated leaving damp salt which is much less mobile and safer to store. As of December 1984, SRP's high-level waste inventory contained about 796 million curies of radioactivity and consisted of 3.5 million gallons of sludge, 9 million gallons of damp salt, and 20.6 million gallons of liquid solution.

Some of SRP's liquid waste contains low concentrations of radioactivity and is disposed of directly into surface streams on the plant site. Some of the low-level liquid waste, however, is discharged into large earthern pits—referred to as seepage basins—to prevent surges of radioactivity in the streams and to allow short-lived radionuclides to decay. The liquid waste seeps downward through the sides and bottoms of the basins and eventually discharges into surface streams which carry the low concentrations of radioactivity to the Savannah River.

Solid Waste

SRP also generates large quantities of radioactively contaminated solid materials which are placed in a centrally located burial ground. Most of this waste is buried in shallow earthen trenches, but some of it is temporarily stored on large, above grade concrete pads where it can be

retrieved for final disposal. This latter waste—referred to as transuranic (TRU) waste—is long-lived and highly radiotoxic. As of December 1984, SRP's solid waste inventory contained about 3.5 million curies of radioactivity and consisted of about 15.3 million cubic feet of low-level and transuranic waste

Radiological Protection Standards

In establishing radiological protection standards to control radioactive releases to the environment, DOE has generally followed the recommendations of the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, and the Federal Radiation Council, which is now a part of EPA. This includes adopting the principle of maintaining radioactive releases at levels as low as reasonably achievable below recommended standards.

DOE Standards

Based on recommendations by the above activities, DOE established a departmentwide standard which limits the annual whole body dose to individual members of the public to no more than 500 millirem from all sources of radioactive releases. To implement this standard, DOE established offsite concentration guides limiting the amounts of radioactivity that can be contained in air and water outside the boundaries of its plant sites. DOE's offsite concentration guides are generally the same as those prescribed by NRC for use by the commercial nuclear industry. Within the boundaries of its plant sites, DOE also has concentration guides limiting the amounts of airborne radioactivity; however, except for onsite drinking water, DOE did not establish concentration guides governing the levels of radioactivity that could be contained in onsite surface water or underlying groundwater because none were considered necessary.

In August 1985, DOE notified its field installations of revised annual whole body standards to implement recommendations made by the National Council on Radiation Protection and Measurements and EPA's radioactive airborne emission standard. DOE's revised standards, in essence, provide that the maximum annual whole body dose from all routine releases to any member of the public shall not exceed 500 millirem for occasional exposures and 100 millirem for prolonged exposures lasting longer than 5 years. SRP will be required to use these new standards in assessing the impact of its radioactive airborne releases for calendar year 1985

In addition to establishing new annual whole body dose standards, DOE is also in the process of preparing onsite concentration guides to govern the amount of radioactivity contained in surface and groundwater within the boundaries of its plant site. The SRP Manager recommended in May 1985 that DOE headquarters initiate a program to establish standards for onsite surface waters and to review the need for establishing radiation protection standards for groundwater. In response to SRP's recommendation, DOE's Office of Assistant Secretary for Environment, Safety, and Health has initiated actions to develop an overall strategy for protection of surface and groundwater at its facilities. As part of this effort, DOE plans to issue onsite concentration guides for surface water and groundwater in 1986. Although not considered necessary in the past, an official of this office told us that onsite guides were now believed to be needed because of recent changes in regulatory requirements and the increasing concern to protect the environment. On April 24, 1986, DOE established an interim guide for radioactivity in onsite surface water and is in the process of finalizing the guide.

EPA Standards

SRP is required to comply with EPA's standards for public drinking water and radioactive airborne emissions. EPA's interim primary drinking water standard limits the annual whole body dose to 4 millirem, and applies at the two public water treatment plants located about 60 and 70 miles, respectively, downriver from the plant site to protect the public from radioactivity released into the river. The EPA airborne emission standard established in February 1985 limits the annual whole body dose to members of the public to no more than 25 millirem and applies at the boundary of the SRP plant site. As indicated, these EPA standards do not apply within the SRP boundary because DOE is responsible for prescribing onsite radiological protection standards for its facilities.

DuPont Administrative Guide

In carrying out plant operations, DuPont uses an administrative control guide which is much more stringent than either the DOE or EPA standards. DuPont's guide limits the annual whole body dose to members of the public to 10 millirem from all sources of radioactivity. To ensure that radioactive releases are controlled to the extent practical, DuPont also establishes annual operating guides limiting emissions from the plant's production and waste management facilities. The guides are reviewed at least annually and are revised based on operating practices, prior experience, and production commitments. In addition, DuPont has a program to implement DOE's policy of maintaining radioactive releases to levels as low as reasonably achievable. In accomplishing this effort,

DuPont evaluates new technology that has the potential for improving the plant's current containment processes.

Radiation Monitoring

DuPont closely monitors radioactive releases from the plant site to ensure that they are within the limits prescribed by DOE's concentration guides. In order to determine radioactive concentrations in the environment and the resulting doses to members of the public, DuPont conducts an intensive environmental surveillance and monitoring program.

DuPont routinely monitors for radioactivity in an area of about 2,000 square miles on and around the plant site and accomplishes limited monitoring in an additional 30,000 square-mile area in Georgia and South Carolina. Since the program was initiated in 1951, DuPont has collected and analyzed thousands of samples to determine concentration levels of radioactivity in the environment on and around the plant. During 1984, for example, DuPont collected more than 25,000 samples and accomplished more than 100,000 radiological analyses. The results of the environmental monitoring program are made available to the public in annual reports.

DuPont routinely monitors the concentrations of radioactivity in air and water because these are the two principal pathways to the environment and public. DuPont also periodically collects and analyzes samples from various other environmental media to determine radioactive concentrations that may be present. Samples of such items as rainwater, vegetation, soil, milk, food, and animals are routinely collected and analyzed because they could be contaminated by radioactivity in air and water releases and become additional exposure pathways to people. When there are unintentional releases of radioactivity from plant operations, DuPont conducts special radiological surveys which are in addition to its routine environmental monitoring activities. During these special surveys, DuPont collects and analyzes additional samples of such items as air, water, vegetation, and milk to determine the effect of the unintentional releases.

The states of South Carolina and Georgia also maintain routine surveillance programs to determine the concentrations of radioactivity in the environment around the plant site. Combined, these two states monitor over 50 locations around the plant for radioactivity and periodically collect and analyze samples of air, water, soil, vegetation, and milk to determine the concentrations of radioactivity that may be present. Both states also monitor the unintentional airborne releases.

Airborne Waste

As part of its various operations, SRP routinely releases radioactivity into the atmosphere; there are also occasional unintentional releases of airborne radioactivity While DuPont uses various containment systems to reduce atmospheric releases of radioactivity, evaluations show that it is technically and economically impractical to completely eliminate all of the releases. DuPont continuously monitors airborne radioactive releases in order to determine the types and concentration levels of the emissions and to ensure that the releases do not exceed DOE and other applicable radiological protection standards. Our analysis of DuPont monitoring reports showed that SRP's airborne releases are well within prescribed standards and that the releases have had very little impact. Specifics of these matters are discussed below.

Radioactive Airborne Releases

SRP's various operations and activities result in the release of over 30 different radionuclides to the atmosphere. While the releases of these 30 radionuclides vary, 4 of them generally account for most of the airborne radioactivity released from plant operations. During 1984, for example, krypton accounted for about 50 percent, tritium for about 47 percent, argon for about 2 percent, and xenon for less than 1 percent.

Although a number of SRP's operations and facilities contribute to airborne releases, most of the routine and unintentional releases come from SRP's chemical separations plants and nuclear production reactors. During 1984, for example, SRP released about 1.7 million curies of radioactivity into the atmosphere; and, of this amount, about 83 percent came from the chemical separations plants and about 16 percent came from the nuclear production reactors. Table II.1 shows the total amount of radioactivity released during 1984 from routine and unintentional releases.

Table III.1: Total Airborne Radioactive Releases During 1984

(in curies)

Radionuclide	Production reactors	Separations plants	Other	Total
Krypton	2,702	840,000	0	842,702
Tritium	231,000	554,000	1,980	786,980
Argon	35,900	0	0	35,900
Xenon	6,170	18	0	6,188
Carbon	49	34	0	83
Other	0	1	0	1
Total	**275,821**	**1,394,053**	**1,980**	**1,671,854**

The unintentional airborne releases of radioactivity result primarily from equipment failures, operator errors, and maintenance operations. Over the past 10 years, there have been six major unintentional releases of radioactivity. All of these releases came from the tritium production facilities located in one of the chemical separations areas and consisted of tritium concentrations ranging from about 8,000 to 480,000 curies. The two most recent major unintentional releases occurred in March and September 1984 and contained about 65,000 curies of tritium. One of these releases occurred, for example, because of a leak in a process line in the tritium production facility.

There are various processes installed in the SRP facilities to reduce the amount of radioactivity contained in the air being released from these facilities. After the air is passed through these various processes, it is released into the atmosphere through stacks ranging up to 200 feet in height in order to disperse and dilute the remaining radioactivity in the surrounding atmosphere. Although the containment processes reduce the amount of radioactivity released, SRP evaluations show that it is not practical from either a technical or economical standpoint to contain all of the radioactivity before the air from these facilities is released into the atmosphere

Radiation Monitoring Program

DuPont conducts an extensive surveillance and monitoring program for the purpose of determining the types and concentration levels of radioactivity in SRP airborne releases and assessing the impact of these releases. To accomplish this effort, DuPont uses a system of air-monitoring stations, a large network of thermoluminescent dosimeters, and field teams to collect samples of air and other environmental media that could be impacted by airborne releases coming from plant operations.

Monitoring Stations

To measure the concentrations of radionuclides in the atmosphere, DuPont periodically analyzes filter papers, charcoal filters, and tritium desiccants collected from 38 air-monitoring stations located on the plant site, around the plant perimeter, and outside the plant boundary. These air-monitoring stations provide comprehensive surveillance of radioactivity in the atmosphere and make it possible for DuPont to distinguish between radioactivity from natural background radiation and worldwide fallout and that from plant operations.

Nine of the 38 air-monitoring stations are located on the plant site near major production and radioactive waste disposal and storage facilities.

Thirteen air-monitoring stations are located around the plant perimeter, and 12 more stations are located about 25 miles from the center of the plant site. The specific locations of these stations permit continuous sampling for airborne radioactivity within every 30-degree sector around the plant perimeter and at 25-mile distances from the plant site. The spacing arrangement of these stations also enhances the probability of DuPont detecting a significant radioactive airborne release regardless of the prevailing wind direction.

The four remaining air-monitoring stations are located about 100 miles from the plant site at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina. At this distance, the effect of airborne releases from plant operations is negligible; however, these stations are useful in measuring background radiation from natural sources and fallout from nuclear weapons tests during prior years. In its environmental reports, DuPont therefore compares the measurements taken at these distant air-monitoring stations with measurements taken on and nearer the plant site.

In 1982, DuPont installed gamma radiation monitors at the 12 air-monitoring stations located around the plant perimeter to improve the plant's emergency response capabilities. These monitors continuously measure gamma radiation levels at the plant perimeter to detect any significant airborne release of radioactivity and to provide near realtime information for any emergency response actions that are warranted. DuPont is also installing (1) tritium monitors to provide near realtime data on unintentional tritium releases and (2) satellite telemetry equipment to improve the transmission of data between the air-monitoring stations and a central control facility. This effort was scheduled for completion in June 1986.

Thermoluminescent Dosimeters

In addition to the air-monitoring stations, DuPont has an extensive system of thermoluminescent dosimeters which are used to continuously measure airborne gamma radiation in an 8,000-square-mile area around the plant site. The dosimeters measure gamma radiation from all sources but do not distinguish between radiation being emitted from natural background sources, worldwide fallout, or releases from plant operations. The dosimeters are located on the plant site, around the plant perimeter, and at various locations outside the boundary of the plant. Thirty-seven dosimeters are located at air-monitoring stations, 79 are spaced at 1-mile intervals around the plant perimeter, 63 are located in towns and cities within 50 miles of the plant, and 20 are located at

nuclear facilities near the plant. DuPont also uses dosimeters to measure gamma radiation levels in a swamp located adjacent to the southern boundary of the plant

Field Sampling

In addition to the systems used for monitoring airborne radioactivity, DuPont also routinely monitors other environmental media that could be contaminated by airborne releases and thus provide an exposure pathway to people residing in the vicinity of the plant. DuPont's field teams collect samples of such items as rainwater, vegetation, soil, milk, and food which are then analyzed to determine the concentrations of radioactivity that are present.

Concentrations of radioactivity deposited in rainwater, for example, are determined from samples routinely collected on a quarterly or more frequent basis at each of the air-monitoring stations. DuPont also routinely collects and analyzes on a quarterly basis samples of grass at air-monitoring stations on and outside the plant perimeter because of its year-round availability and importance as food for dairy herds. This type vegetation provides an early indication of radioactive fallout because of its large exposed surface area. In 1973, Dupont also started collecting and analyzing annual soil samples to assess the amount of radioactivity deposited from the atmosphere. DuPont obtains and analyzes soil samples from eight locations near the two chemical separations plants, four locations along the plant perimeter representing each quadrant of the plant, and two control sites located about 100 miles from the plant.

Special Surveys

In addition to its routine monitoring activities, DuPont also conducts special radiological surveys when there are unintentional airborne releases from plant operations During these special surveys, DuPont's field teams collect additional samples of such environmental media as air, water, vegetation, and milk. These additional samples are then analyzed to determine the effect, if any, of the unintentional releases.

State Monitoring

The states of South Carolina and Georgia also maintain routine environmental surveillance for radioactivity around the plant site. Combined, these two states monitor over 50 locations around SRP for airborne radioactivity, and they routinely collect and analyze samples of such environmental media as air, rainwater, surface water, drinking water, soil, vegetation, and milk to determine the concentrations of radioactivity. These two states also monitor concentrations of radioactivity resulting

from large unintentional releases from plant operations. Both of these states issue periodic reports documenting the results of their respective radiological environmental monitoring programs.

Impacts of Airborne Releases

To assess the environmental impact of airborne radioactive releases from plant operations, DuPont compares the measured and/or calculated concentrations of radioactivity in the air on and in the vicinity of the plant site to DOE's concentration guides to determine whether the releases are within prescribed limits. DuPont also measures radioactive concentrations contained in various other environmental media to identify any increases that could result from plant operations. As discussed earlier, Georgia and South Carolina also assess the concentrations of radioactivity in various environmental media around the plant site. In addition to the measurements of radioactive contamination in the environment, DuPont also calculates annual doses to individual members of the public and compares the results of its calculations to DOE and other standards.

DuPont's environmental monitoring reports show that concentrations of airborne radioactivity measured both on and outside the plant site have been well within DOE's concentration guides over the past several years and that the releases have had very little impact either within or outside the boundary of the plant. Although the onsite concentration levels of tritium are higher than offsite levels, the maximum airborne tritium concentration measured onsite during 1984 was less than 1 percent of DOE's onsite concentration guide for this radionuclide. We also noted that the maximum tritium concentration measured in rainwater on the plant site during 1984 was only 13 percent of DOE's concentration guide for onsite drinking water.

During 1984, measured concentrations of tritium contained in air samples collected at the monitoring stations located on the plant perimeter were also less than 1 percent of DOE's offsite concentration guide which is consistent with measurements in 1982 and 1983. Concentration levels at stations located 25 and 100 miles away from the plant site were considerably less than the level detected at the plant perimeter. With the exception of tritium, concentrations of airborne radioactivity outside the plant boundaries are generally too low to distinguish from natural background sources and worldwide fallout from nuclear weapons tests during prior years. Also, concentrations of radioactivity found in such items as rainwater, milk, food, vegetation, soil, and fish were similar to levels found in these items in other parts of the country.

Our assessment showed that monitoring reports prepared by the states of Georgia and South Carolina generally confirmed the low concentration levels being measured and reported by DuPont. Officials from these two states told us, for example, that tritium was the only radionuclide that they could attribute to SRP's airborne releases. In addition to the confirmation of DuPont's measurements by Georgia and South Carolina, we also noted that EPA's Eastern Environmental Radiation Facility in 1982 made limited measurements of concentrations of radioactivity contained in samples collected on and off the plant site and that EPA's measurements generally agreed with the measurements made by DuPont's laboratory.

SRP's airborne releases are generally of such low concentrations that, after being dispersed in the atmosphere, DuPont has to use a mathematical model to calculate the concentration levels of radioactivity contained in the air in order to compare these levels with DOE's concentration guides In making these calculations, we noted that DuPont used the same model that NRC prescribes for commercial nuclear power plant operators to use in assessing airborne releases.

We reviewed the results of DuPont's calculations during the period 1982 through 1984 and noted that the highest calculated concentrations at the plant boundary were significantly less than 1 percent of DOE's offsite concentration guides. During this 3-year period, for example, tritium had the highest calculated concentration levels; but the calculated concentrations for this radionuclide were less than one-fourth of 1 percent of the DOE concentration guide. To verify the accuracy of its model calculations, DuPont compares the measured concentrations of tritium at the plant boundary with its calculated concentration levels. These comparisons indicate that the model calculations tend to be conservative and overstate radioactivity concentrations at the plant boundary. During the 3-year period 1982 through 1984, for example, measured concentrations of tritium at the plant perimeter were about one-half the calculated concentrations.

Because of the low concentrations of radionuclides contained in airborne releases, DuPont uses the previously discussed concentration model along with another NRC model to calculate doses to individuals and the general public in the vicinity of the plant. DuPont expanded NRC's commercial nuclear power plant models in order to input physical and biological data specifically applicable to the plant site and to expand the amount of output data. Using these two models, DuPont calculates the average and maximum annual doses to the whole body and specific organs at

various distances from the plant site for infants, children, teenagers, adults, and the general population. The maximum dose calculations are based on hypothetical individuals residing at the perimeter of the plant. Of these calculations, the whole body dose is the most important because SRP's airborne releases primarily affect the whole body rather than individual organs.

When we completed our review in January 1986, DuPont had not completed its report on the annual whole body doses for calendar year 1985. Table III.2, however, shows the calculated average and maximum whole body doses for individuals at the plant boundary by various age groups resulting from SRP's airborne releases during calendar year 1984.

Table III.2: Calculated Impact of 1984 Airborne Releases

In millirem

	Annual whole body dose[a]	
Age Group	**Average**	**Maximum**
Infant	0 47	1 11
Child	0 87	2 37
Teenager	0 73	1 78
Adult	0 67	1 64

[a]As shown in table III 1, krypton releases during 1984 were greater than tritium releases, however, about 95 percent of the annual whole body doses resulted from tritium releases whereas less than 1 percent of the doses resulted from krypton releases

The above calculated doses are less than 1 percent of DOE's annual 500 millirem standard and would have been less than 3 percent of DOE's new annual whole body standard of 100 millirem for prolonged exposures. These doses are also less than 10 percent of EPA's new airborne annual whole body dose standard of 25 millirem and are well within DuPont's administrative control guide of 10 millirem a year. DuPont records show that individuals residing in the vicinity of the plant receive an average annual whole body dose of about 93 millirem from natural background radiation sources and that measured variations in natural background radiation in 1984 ranged from about 47 to 153 millirem in the vicinity of the plant. The doses from SRP's airborne releases were only a small percentage of these background radiation levels.

We noted that EPA's Eastern Environmental Radiation Facility in December 1982 made a limited verification of DuPont's calculations as a part of EPA's effort to establish a nationwide radioactive airborne emission standard Using airborne release data for 1981 provided by DOE, EPA independently calculated offsite doses with its own models, and the

results of these calculations generally confirmed DuPont's dose calculations. As a result of the new EPA airborne standard, we also noted that DuPont will be required to either use EPA models or have its own models approved by EPA in computing future doses.

According to one of the DuPont officials responsible for these calculations, DuPont's dose models are very conservative because they contain a higher factor for tritium than recommended by either the International Commission on Radiological Protection or the National Council on Radiation Protection and Measurements. We noted that use of the lower factor would result in a significant reduction in DuPont's offsite whole body dose calculations because tritium releases are responsible for most of the dosage. During 1984, for example, tritium accounted for about 95 percent of the calculated 2.37 millirem maximum whole body dose. Had DuPont used the lower tritium factor in its calculations, the maximum offsite dose would have been less than 1.5 millirem. SRP officials told us that DuPont would use the lower factor in calculating doses from 1985 airborne releases.

In addition to calculating annual offsite doses, DuPont makes real-time calculations of doses resulting from unintentional releases of radioactivity to assist in determining whether any emergency actions are warranted. To assess the impact of these releases, DuPont uses a system, referred to as the Weather Information and Display System, which consists of meterological towers, several computers, and a network of terminals. The system combines radioactive airborne release data with existing meterological data and calculates dispersion factors and resulting doses from airborne releases at various locations both on and off the plant site. To verify these calculations, DuPont uses a mobile laboratory with a near realtime monitoring capability and dispatches field teams to collect samples from various segments of the environment. In addition, Georgia and South Carolina are collecting and analyzing samples from various offsite environmental media which verify DuPont's measurements.

We examined the impact of the unintentional release which occurred in September 1984 and noted that DuPont calculated a maximum whole body dose of 1.6 millirem to a hypothetical individual at the plant boundary. We also noted that DuPont made an extensive verification of the calculated maximum whole body dose, and its assessments showed that the actual dosage was probably much smaller than 1.6 millirem. Immediately following the release, DuPont dispatched field teams which

collected and analyzed about 300 samples of air, various types of vegetation, and surface waters in order to confirm the path of the release and to measure the levels of radioactivity in these items. Over the next several days, these teams also collected 25 samples of milk which were analyzed for radioactivity in assessing the offsite dose. To further verify its calculated doses, DuPont collected and analyzed urine samples from 73 people who were located in or near the path of the release. The maximum dose observed in any of these individuals was less than one-quarter of 1 millirem. South Carolina also made an extensive assessment of the tritium concentration in the unintentional release, and its measurements compared favorably with those made by DuPont.

Actions to Reduce Future Impacts

DuPont is making several modifications to the tritium facilities primarily for the purpose of improving production capabilities; however, DuPont projects that these modifications will also result in a significant decrease in the maximum whole body dose to the public in the vicinity of the plant. As previously discussed, tritium releases accounted for about 95 percent of the calculated maximum offsite dose during calendar year 1984. Had the above improvements been in place during this year, we determined that DuPont's calculated maximum dose of 2.37 millirem to the whole body would have been reduced to about 1.24 millirem. In addition to these changes, DuPont is evaluating changes in the containment processes and technologies that have the potential for further reducing the concentrations of radionuclides in plant airborne releases.

Liquid Waste

Large volumes of radioactive liquid waste are generated as a result of SRP's various research, development, and production operations. A large part of the liquid waste—referred to as low-level waste—contains small concentrations of radioactivity and is released directly into surface streams on the plant site. Some of the low-level liquid waste, however, is discharged into large, excavated earthen pits, referred to as seepage basins, to prevent surges of radioactivity in surface streams and to provide time for short-lived radionuclides to decay. Part of the liquid waste—referred to as high-level waste—is highly radioactive and has to be isolated from the environment so that present and future generations will be protected from potential radiation hazards.

Our analysis showed that SRP's radioactive waterborne releases have had very little impact outside the plant boundary. Within the plant boundary, however, we determined that surface streams as well as soil and groundwater at some of the waste storage and disposal sites were contaminated with radioactivity. SRP officials told us that there is a remote possibility that some of this contamination could reach the deep Tuscaloosa aquifer. Further, DOE may have to maintain long-term institutional control over these waste sites because of the radioactive contamination. Specifics of these matters are discussed below.

Low-Level Liquid Waste

As a part of its various research and production operations, SRP generates large volumes of liquid waste contaminated with low-levels of radioactivity. Most of the low-level liquid waste is generated at the nuclear production reactors and various facilities in the chemical separations areas. Depending upon the concentrations of radioactivity contained in the waste effluents, they are either released directly into onsite surface streams or discharged into seepage basins. Since initiating plant operations in the early 1950's, DuPont has routinely released millions of gallons of low-level liquid waste into surface streams and seepage basins.

DuPont releases low-level liquid waste directly into surface streams from several facilities, but most of these releases are from contaminated water used to cool the nuclear production reactor heat exchangers. DuPont also releases process cooling water and storm water runoff from the chemical separations areas directly into surface streams; however, when these effluents are known or suspected to contain radioactivity, they are diverted to large retention basins. The retention basins initially used at SRP for this purpose were shallow, earthen pits; however, in 1972, DuPont replaced these with new basins lined with plastic to prevent potentially higher concentrations of radioactivity from seeping into the

soil and underlying groundwater. After the levels of radioactivity in the retention basins are determined, the liquid waste is either retained for further decontamination or discharged into nearby seepage basins or surface streams.

DuPont discharges millions of gallons of low-level liquid waste each year into large, earthen seepage basins located near the research and production facilities. As a part of the high-level waste evaporation process discussed later in this appendix, for example, DuPont discharges an average of about 6 million gallons of low-level radioactive liquid waste annually into seepage basins located in the chemical separations areas. The purpose of using seepage basins is to prevent surges of radioactivity in the streams and to allow short-lived radionuclides such as tritium to decay. These basins are purposely designed to allow the liquid effluents to seep through their sides and bottoms to the underlying groundwater. During this process, much of the radioactivity is retained in the soil around and under the seepage basins, and the time required for the radioactivity to reach groundwater allows some of the short-lived radionuclides to decay. The remaining radioactivity is further diluted upon reaching the groundwater and its slow movement provides additional time for short-lived radionuclides to decay before eventually discharging into a surface stream.

Since initiation of operations, DuPont has constructed 35 seepage basins for disposal of low-level radioactive liquid waste, but waste is no longer being discharged to 15 of these basins because of various reasons. Six of these basins, for example, are no longer used because SRP placed one of its nuclear production reactors in a standby status. Of the 20 active basins, 11 are being used for only radioactive waste, and the other 9 are being used for mixed waste containing both radioactive and hazardous chemicals. Eleven of the active seepage basins are located at the operating nuclear production reactors, 7 at the chemical separations areas, and 2 at other facilities.

Although seepage basins have been used since initiating operations in the early 1950's to dispose of low-level liquid waste, SRP plans to close the 9 basins currently being used for mixed waste. As part of its ongoing EIS to assess the effect of its waste management practices on groundwater quality, SRP also plans to evaluate the continued use of the 9 seepage basins located at three of its four operational production reactors. SRP has already determined that it will continue to use the 2 basins located at the other reactor.

Radiation Monitoring Program

DuPont conducts a monitoring program for the purpose of determining the types and concentration levels of radioactivity in waterborne releases and assessing the impact of the releases. To accomplish this effort, DuPont obtains and analyzes samples from various sources, including onsite surface streams, groundwater monitoring wells, the Savannah River, public drinking water systems, and two large public drinking water treatment facilities located downriver from the plant site.

DuPont collects and analyzes water samples from onsite sources before the waterborne releases ever reach the plant boundary. DuPont collects and analyzes weekly water samples, for example, from 38 locations along onsite streams which drain the plant site to determine the concentration levels of radioactivity being carried to the Savannah River. These samples are analyzed for gross alpha, gross beta, tritium, and individual radionuclides such as strontium-90 and cesium-137.

DuPont also collects and analyzes monthly, quarterly, and/or semiannually samples from 92 routine groundwater monitoring wells located near the seepage basins for gross alpha, gross beta, and tritium radioactivity. Of these 92 monitoring wells at seepage basins, 26 are located in the chemical separations areas and the remaining 66 are located at the five production reactors. DuPont also analyzes drinking water from 26 onsite facilities for radioactivity on a semiannual basis. South Carolina also periodically monitors drinking water from onsite facilities for radioactivity.

In addition to the onsite monitoring activities, DuPont collects weekly water samples from the Savannah River at five locations above, adjacent to, and below the plant site. The samples are analyzed for gross alpha, gross beta, tritium, and other radionuclides. Since 1975, DuPont has collected annual sediment samples in river floodplain areas at six locations above, adjacent to, and below the plant site to obtain estimates of the maximum accumulation of various radionuclides in the river bed. In 1977 DuPont also began to collect and analyze annual sediment samples from the floodplains of onsite streams in order to determine the amount of radioactivity coming from SRP operations, global fallout, and other sources. On a weekly basis, DuPont also traps fish in the river upstream, adjacent to, and below the plant to determine and assess the levels of radioactivity in the fish.

As part of its routine monitoring, DuPont also collects and analyzes samples of community drinking water supplies coming from deep wells or surface streams in the vicinity of the plant site. DuPont tests samples of

drinking water from 14 of these communities for gross alpha, gross beta, and tritium radioactivity on a semiannual basis. In addition to these samples, DuPont obtains daily samples of both raw and finished water at the two public drinking water facilities located about 60 and 70 miles, respectively, downriver from the plant site. These samples are combined and analyzed monthly for gross alpha, gross beta, tritium, and cesium-137 concentrations.

In addition to the routine monitoring accomplished by DuPont, South Carolina and Georgia conduct environmental monitoring programs to determine concentrations of waterborne radioactivity from SRP operations. South Carolina, for example, monitors for concentrations of gross alpha, gross beta, and tritium in groundwater wells located in six communities located near the plant site. Georgia also monitors for these radioactive elements in groundwater wells at 10 locations near the plant site. In addition, both states collect and analyze samples of water from the Savannah River for gross alpha, gross beta, and tritium as well as samples of other environmental media that could be affected by waterborne releases.

Impacts of Radioactive Releases

Except for a small swamp area located near the boundary of the plant, our analysis showed that SRP's practice of releasing low-level radioactive liquid waste directly to surface streams or to earthen seepage basins has had very little impact outside the plant boundary. We determined, however, that some onsite surface streams contained elevated levels of radioactivity and that the soil and groundwater at some of the seepage basins have been contaminated with radioactivity. While some of this contamination could potentially reach the Tuscaloosa aquifer, SRP officials believe that the concentration level would be very low by the time it reached the Savannah River. Further, DOE may have to maintain long-term institutional control over some of the contaminated sites to protect people who may have access to these areas after the plant is closed.

Offsite Impacts

According to DuPont's reports, tritium accounts for about 99 percent of the radioactivity reaching the Savannah River. Of the tritium reaching the river during 1984, DuPont assessments showed that about 67 percent came from the seepage basins and that 32 percent came from direct releases into onsite surface streams. In examining the results of DuPont's environmental monitoring activities for the period 1980 through 1984, we found that tritium and trace amounts of strontium-90 and cesium-137 were the only specific radionuclides that DuPont measured in river

water by using routine analytical techniques. At times during this period, DuPont had to use special low-level analysis techniques to detect the very small concentrations of cesium-137. DuPont's environmental monitoring reports during this period also showed that the average concentrations of gross alpha, gross beta, and tritium radioactivity in the river were less than 1 percent of DOE's offsite concentration guides.

Although EPA's public drinking water standard does not apply to river water along the boundary of the plant site, we determined that the gross concentrations of radioactivity being measured were well below this standard. Measured alpha concentrations were generally less than 5 percent of EPA's standard, gross beta concentrations were generally less than 20 percent of the standard, and tritium concentrations were generally less than 50 percent of the standard. We also determined that monitoring reports prepared by both South Carolina and Georgia generally confirmed the low concentrations of radioactivity in the Savannah River. Officials from both of these states told us that they considered DuPont's monitoring data reliable and that their monitoring results generally agreed with those being obtained and reported by DuPont.

At the two downstream public water treatment plants, DuPont's monitoring reports showed that tritium and trace amounts of cesium-137 were the only two radionuclides that have been detected in the water. During 1984, the average concentrations of these two radionuclides, however, were considerably less than 1 percent of DOE's offsite concentration guides. Furthermore, the tritium concentrations at the plants were only 8.5 and 12.5 percent, respectively, of EPA's public drinking water standard. The cesium-137 concentrations at the two plants were considerably less than 1 percent of the EPA standard.

After dilution in the onsite streams and river water, the concentrations of most radionuclides released from SRP's operations are too small to be measured. DuPont therefore uses an NRC model to calculate the concentrations and the resulting annual whole body doses to hypothetical individuals downstream from the plant site who might drink river water, eat large amounts of fish, and spend many hours on the river boating and swimming. Table IV.1 shows DuPont's calculated maximum annual whole body doses to hypothetical individuals of various age groups resulting from SRP waterborne releases during 1984.

Table IV.1: Maximum Annual Whole Body Doses From 1984 Waterborne Releases

Age group	Millirem
Infant	0 26
Child	0 27
Teenager	0 31
Adult	0 52

The maximum annual whole body dose to any of these individuals was less than 1 percent of DOE's 500 millirem whole body dose standard which was in effect during 1984 and would have been less than 1 percent of DOE's new whole body dose standard of 100 millirem for prolonged exposures. DuPont's calculated doses for individuals consuming water at a maximum consumption rate from the two downstream public water treatment plants during 1984 were also very small percentages of DOE's standards as well as EPA's more restrictive public drinking water standard of 4 millirem a year. During 1984, for example, DuPont's calculations showed that a child would have received a maximum whole body dose of about 0.18 millirem and that an adult would have received a maximum dose of 0.20 millirem. These doses are small when considering that DuPont records show that persons living near the plant receive an annual whole body dose of about 93 millirem from natural background radiation.

While the radioactive concentrations in waterborne releases are very low, we noted that a swamp located adjacent to the southern boundary of the plant site had become contaminated primarily with cesium during the 1960's as a result of leaks from defective fuel elements stored in a basin at one of the production reactors. According to DuPont assessments, a few areas of the swamp contain cesium-137 levels high enough to result in an individual receiving a radiation dose in excess of DOE's whole body dose standard if the individual resided in the swamp. Since the swamp is uninhabited, DuPont studies show that it is highly unlikely that anyone would receive a dose of this magnitude.

For individuals using the swamp for such purposes as hunting, fishing, and launching boats into the river, DuPont assessments show that it is conceivable that an individual could receive an annual whole body dose ranging from a few millirem to a few tens of millirem. Neither SRP nor South Carolina officials, however, consider it necessary to place any restrictions on use of the swamp for these purposes or to take any remedial actions to remove the radioactivity. DuPont continuously monitors

the area and includes the results of its surveillance in annual environmental monitoring reports which are available to the public.

Onsite Impacts

We determined that some of the onsite surface streams contained elevated levels of radioactivity and that the groundwater beneath seepage basins at the chemical separations areas and nuclear production reactors was contaminated with radioactivity. SRP officials told us that there is a remote possibility that some of the contamination at two of the production reactors could reach the Tuscaloosa aquifer. In addition, DOE may have to maintain long-term institutional control over some of the seepage basins at these facilities because of radioactive contamination. Specifics of these matters are discussed below.

Contamination of surface streams and groundwater—DOE did not have standards governing the amounts of radioactivity that could be contained in either onsite surface water or groundwater within the plant boundary. Therefore, we compared the concentrations of gross alpha, gross beta, and tritium contained in the streams and groundwater at the chemical separations areas and production reactors during the period 1980 through 1984 with DOE's offsite concentration guides and EPA's public drinking water standard to illustrate the degree of contamination. In assessing gross alpha and beta concentrations, we used plutonium and strontium-90— principal alpha and beta emitters, respectively, in SRP's waste. The DuPont official responsible for environmental analysis and reporting told us that these emitters would be the most appropriate radionuclides for use in our assessment.

We determined that most of the onsite surface streams contained tritium concentrations which consistently exceeded EPA's drinking water standard during the period 1980 through 1984. Tritium concentrations ranged from slightly above to 750 times greater than the EPA standard. Tritium concentrations in one of the streams also consistently exceeded DOE's offsite guide, with maximum levels ranging from about 2 to 5 times greater than the guide. In addition to tritium contamination, three of the streams contained maximum gross alpha concentrations which exceeded EPA's drinking water standard during most of the 5-year period. These streams also contained maximum gross beta concentrations ranging from slightly above to over 17 times greater than DOE's offsite guide. As previously discussed, however, the gross alpha, gross beta, and tritium concentrations are diluted to levels well within both of these standards by the time the radioactivity reaches DuPont's monitoring

stations on the Savannah River which flows along the southwestern boundary of the plant site.

As for groundwater contamination at seepage basins, the highest levels of contamination were at those basins located at the chemical separations areas and nuclear production reactors. Tritium concentrations measured in all 26 routine groundwater monitoring wells around the seepage basins in the chemical separations areas consistently exceeded EPA's drinking water standard during the period 1980 through 1984. Maximum tritium concentrations during this period ranged from slightly above to 5,550 times greater than the EPA standard. Thirteen of these wells also contained maximum tritium concentrations which exceeded DOE's offsite guide at least once during this period, and 6 of these wells consistently exceeded DOE's guide, with maximum measurements ranging from slightly above to 37 times greater than the guide.

Six of the 26 wells also contained gross alpha concentrations exceeding EPA's drinking water standard at least once during the period 1980 through 1984. Two of these 6 wells consistently exceeded the EPA standard, with maximum measurements ranging from about two to over four times greater than the standard. Fourteen of the 26 wells also contained gross beta concentrations exceeding EPA's drinking water standard at least once during the period, and 7 of these 14 wells consistently exceeded the EPA standard, with maximum readings ranging from about 2 to 200 times greater than the standard. The maximum gross beta concentrations in 8 of the 14 wells ranged from slightly over to 33 times greater than DOE's offsite guide during the 5-year period.

In addition to the 26 routine groundwater monitoring wells, there are 3 other wells located near the seepage basins in the separations areas which DuPont no longer routinely monitors because it does not believe the concentrations of radioactivity contained in the wells are representative of the extent of groundwater contamination under the seepage basins. These wells only extend into very shallow groundwater which ranges from 10 to 25 feet deep; however, we noted that they contained high concentrations of gross beta and tritium radioactivity. DuPont's 1980 monitoring report, the most recent report containing the results from all 3 wells, showed that maximum gross beta concentrations ranged from 25 to 1,200 times greater than DOE's offsite guide and that maximum tritium concentrations ranged from about 8 to 18 times greater than the guide.

As for groundwater contamination under seepage basins at the three nuclear production reactors in operation during the period 1980 through 1984, we determined that tritium concentrations in the 18 groundwater monitoring wells around these basins consistently exceeded EPA's drinking water standard. Maximum tritium concentrations in these wells ranged from about 2 to 42,000 times greater than EPA's standard. The maximum concentrations of tritium in 10 of these wells also consistently exceeded DOE's offsite guide, with measurements ranging from slightly above to 280 times greater than the guide. None of the 18 wells contained gross alpha or beta concentrations exceeding DOE's offsite guides, but 1 of them contained gross beta concentrations which were about twice as high as EPA's drinking water standard during 2 of the 5 years.

As for seepage basins at the other two reactors, DuPont did not monitor for groundwater contamination at one of the reactors during the period 1980 through 1984; however, this reactor has been recently refurbished, and DuPont plans to begin monitoring groundwater at the seepage basins. DuPont continued to monitor groundwater under the seepage basins at the other inactive reactor, however, because large amounts of strontium-90 and cesium-137 were released to these basins in 1957 as a result of a fuel element failure. Monitoring reports for these basins show that the groundwater still contains elevated levels of gross beta radioactivity.

Twenty-two of the 48 wells around these basins, for example, contained gross beta radiation exceeding EPA's drinking water standard at least once during the period 1980 through 1984. Maximum measurements from these wells ranged from slightly above to 620 times greater than EPA's drinking water standard. Thirteen of the wells also contained gross beta contamination levels which ranged from slightly above to 103 times greater than DOE's offsite guide. According to DuPont evaluations, radioactivity in the soil at these basins has not migrated any significant distance since the 1957 incident. DuPont's assessments show that almost half of the strontium-90 and cesium-137 has decayed since the release and that the remaining radioactivity has been essentially immobilized in the soil. Based on the slow rate of migration to date, DuPont concluded that the radioactivity at these basins will decay to nondetectable levels before reaching the nearest surface stream.

Potential contamination of Tuscaloosa aquifer—DuPont's evaluations show that the most detrimental impact of using seepage basins has been the contamination of soil resulting from the slow buildup of radioactivity over the years of operations. We noted, however, that DuPont's assessments also show that there is a possibility of radioactivity at two

production reactor's seepage basins reaching the Tuscaloosa aquifer. The hydrological conditions existing under these areas of the plant site do not create an upward pressure against the shallower groundwater as is the case under other areas of the plant site. For this reason, the radioactivity at these seepage basins could migrate downward rather than primarily in a lateral direction and contaminate the aquifer.

We discussed the possible radioactive contamination of the aquifer with SRP environmental and waste management officials, and they said that the likelihood of this happening was very low but that a remote possibility does exist. Additional information should be available on the potential aquifer contamination when SRP completes in the spring of 1987 its ongoing EIS on the impact of its radioactive waste management practices on groundwater quality.

Even if some of the radioactivity did reach the aquifer, SRP officials said that it would take about 200 years for the radionuclides to discharge into the Savannah River just west of the plant site. Because of the retention capabilities of the soil and the decay that would occur during this period, however, these officials said that the concentrations of radionuclides would be very low by the time they discharged into the river. The river water would provide even further dilution before the contamination reached the public drinking water facilities located 60 to 70 miles downstream from the plant site.

Institutional control—DOE may have to maintain long-term institutional control over the areas of the plant site in which seepage basins are located because of the radioactive contamination that has occurred over the past years. An EIS prepared in 1977, for example, pointed out that these areas would remain contaminated for the foreseeable future even after the plant was closed. More definitive information should be available on the required institutional control period when SRP completes the EIS on the impact of its radioactive waste management practices on groundwater quality. As part of this effort, SRP is also evaluating the extent of radioactive contamination at all of the seepage basins to determine whether any remedial actions are warranted, including the removal of radioactive contamination at these sites.

High-Level Liquid Waste

High-level liquid waste at SRP is generated during the chemical reprocessing of fuel and target assemblies which have been irradiated in the nuclear production reactors. After the fuel and target assemblies are removed from the reactors, they are temporarily stored in water-filled

basins where they remain for several months. The assemblies are then transported to the chemical separations plants where they are dissolved in acid and the desired special nuclear products are removed.

The acidity of the remaining solution, which contains high-level liquid waste and a small amount of unrecovered products, is neutralized to prevent corrosion of the storage tanks. The waste solution then flows by gravity to storage tanks through pipes enclosed in concrete to provide double containment of the waste. The waste is allowed to age in a receiving tank for 1 to 2 years where short-lived radionuclides decay and a layer of sludge settles to the bottom of the tank where it remains. The sludge represents only about 5 percent of the waste volume but contains most of the radioactivity.

The remaining waste liquid—referred to as supernate—is successively passed through evaporators to reduce its volume and form crystallized salt which settles on the sides and bottoms of the storage tanks. These successive evaporation cycles not only reduce the waste volume by a factor of four, but also result in the formation of a much less mobile waste form which is safer to store than liquid waste. The radioactive concentration in the crystallized salt is about three times the concentration levels contained in the liquid supernate. The evaporation process also results in a large amount of low-level liquid waste which is discharged into seepage basins.

As of December 1984, SRP's high-level waste inventory contained about 796 million curies of radioactivity and consisted of 3.5 million gallons of sludge, 9 million gallons of crystallized salt, and 20.6 million gallons of supernate solution. Over the next several years, SRP estimates that it will generate an annual average of about 3.7 million gallons of high-level liquid waste.

Waste Storage Tanks

During the period 1951 through 1982, DuPont constructed 51 large, underground tanks to store its high-level radioactive waste. The tanks are located in two areas referred to as farms—one with 29 tanks and the other with 22 tanks—adjacent to the chemical separations plants and range in capacity from 750,000 to 1,300,000 gallons. The individual tanks and the two farms are interconnected so that waste can be transferred between tanks within a farm or tanks located in the other farm. All of the tanks were constructed of carbon steel and reinforced concrete, but there are four different designs or types of tanks.

Forty-three of the tanks have primary and secondary walls with a space, referred to as an annulus, between the sides and bottoms; and the outer or secondary walls are encased in reinforced concrete. The secondary walls serve as saucer-type devices to catch waste leakage. The secondary walls for 16 of these tanks extend 5 feet up the sides of the primary walls, but the other 27 tanks are of a newer design and have secondary walls completely encasing the primary walls. These 43 tanks also have cooling coils to reduce the high heat content of some of the waste received from the separations plants. The other eight tanks were designed to store waste that does not require auxiliary cooling and only have single carbon steel walls encased in reinforced concrete. All of the tanks are equipped with various automatic controls and alarms to monitor for potential leakage of high-level waste.

Nine of the older double-walled tanks have developed leaks in their primary walls, but the secondary walls of eight of these tanks contained the leakage Leakage from the other tank, however, rose above the secondary wall and seeped through the concrete encasement into the soil and groundwater. In addition, DuPont discovered in December 1983 that cracks had developed in one of the single-walled tanks. Because of the leaks and unacceptable risk associated with the single-walled tanks, DuPont is transferring the waste into newer tanks.

Leak Detection and Radiation Monitoring Program

Because of potential environmental hazards of high-level waste, DuPont conducts a waste tank inspection and radiation monitoring program aimed at ensuring that the waste is being safely stored. DuPont's leak detection system is primarily based on two basic principles—disappearance of waste from its proper location and appearance in an improper location. The latter principle is the most reliable because the volume of waste inventories is too large for precise measurements. A small difference in inventory levels, for example, could result in the release of a very large amount of radioactivity. Although inventory surveillance is used as a backup, primary leak detection methods rely on automatic surveillance of those areas into which leakage is most likely to migrate.

Various controls and alarms are installed on the waste tanks to detect leakage and to automatically transmit this information to control rooms located in each tank farm. The annuli of the 43 double-walled tanks, for example, are equipped with at least two probes which constantly monitor for the presence of liquid under their primary containers. When liquids are detected, these probes automatically activate audiovisual alarms located in the control rooms. Once each month, DuPont visually

inspects the annulus of each tank and tests the probes. Since the eight single-walled tanks do not have an annulus space, probes cannot be used on these tanks for leak-detection purposes. These tanks, however, were constructed on concrete slabs with a network of leak collection channels which drain into sumps located under the tanks. Liquid levels in the sumps are continuously monitored and recorded; and, if liquid in one of the sumps reaches a preset level, an alarm is automatically activated.

The storage tanks are also equipped with radiation monitors for detecting surface spills and leaks and airborne releases. In addition, DuPont makes routine visual observations in and around the waste tank farms and uses portable radiation monitoring instruments to detect radioactive leaks and spills. DuPont also periodically obtains and analyzes samples of the high-level waste and constantly monitors its temperature using automatic instrumentation to ensure that it is not damaging the tanks' primary walls.

For inventory control and as a backup to the automatic leak-detection equipment, liquid levels inside the tanks are automatically measured with a reel tape and recorded hourly in the control rooms. At least once each day, DuPont compares the readings with those recorded during the previous day. The reel tapes are also equipped with automatic alarms that sound if liquid levels are either above or below preset alarm levels. DuPont waste management personnel also measure the liquid levels in the tanks at least once each month using a hand-held tape. DuPont also uses the hand-held tape along with other instruments to determine the amounts of submerged salt and sludge contained in the tanks.

DuPont makes periodic evaluations of the condition of the storage tanks using visual and photographic inspections, steel thickness measurements, and metallurgical evaluations. By inserting special equipment through openings in the tops of the tanks, for example, DuPont is able to visually inspect and photograph the interior of all of the primary walls. DuPont is also able to inspect the exterior of the primary walls for the 43 double-walled tanks that have an annulus space. Although these inspections are not primarily designed for detecting leaks, most of the leaks in the older waste tanks were found during visual inspections.

While DuPont primarily relies on the previously discussed automatic surveillance and backup systems for leak detection purposes, DuPont has drilled wells both within and outside the two tank farms to monitor for waste that may have escaped without being detected and to assess the environmental impact of the waste spills and leaks that have occurred

during past years. A number of these wells were drilled, used for a period of time, and then closed. At the time of our review, however, DuPont had 142 monitoring wells—71 groundwater wells and 71 dry wells—located within and outside the 2 tank farms. DuPont uses the 71 groundwater wells to monitor the concentration levels of gross alpha, gross beta, and tritium in the groundwater beneath and around the perimeter of the farms. Forty-nine of these wells are located inside the farms, and the other 22 are located around the perimeter of the farms. DuPont uses the 71 dry wells, located within the two tank farms, to measure gamma radioactivity contained in the soil.

Impacts of Radioactive Releases

Our analysis showed that SRP's high-level waste operations have had very little impact outside the boundary of the plant; however, the groundwater and soil around and beneath several of the storage tanks have been contaminated with radioactivity which will require many years to decay. Although SRP has not prepared a decommissioning and decontamination plan for its high-level waste storage tanks, this area of the plant site may have to remain under long-term institutional control to protect individuals who have access to the site after the plant is closed.

Offsite Impacts

SRP's high-level waste storage operations result in small routine releases of airborne radioactivity and large volumes of low-level liquid waste to the environment. To prevent a potential explosion, the waste storage tanks are equipped with ventilation systems to remove hydrogen, and this process results in the release of radioactive tritium to the atmosphere. According to DuPont estimates, about 650 curies of radioactive tritium are released annually from each tank containing newly generated and unevaporated waste. The annual offsite whole body dose from these airborne releases, however, is estimated to be less than one one-thousandths of a millirem which is very small when compared to EPA's new airborne emission standard of 25 millirem to the whole body. DuPont also discharges large volumes of low-level liquid waste into seepage basins located near the two tank farms. Over the past several years, an annual average of about 6 million gallons of low-level liquid waste has been discharged into these basins. As discussed in the previous section of this appendix, however, these releases have had very little impact outside the boundary of the plant.

Onsite Impacts

There have been a number of unintentional releases of high-level waste at the waste tank farms. Some of these releases contained large amounts of radioactivity and contaminated the soil as well as the groundwater beneath the tank farms. As a result, DOE may have to maintain long-term institutional control over the tank farms. Specifics of these matters are discussed below.

Soil and groundwater contamination—DuPont cleaned up many of the high-level waste surface spills and leaks by removing the contaminated soil and disposing of it in the low-level burial ground or by taking other measures. Some of the unintentional releases, however, contaminated subsurface soil. One large unintentional release which occurred in September 1960, for example, resulted because of leaks in the primary wall of one of the older storage tanks. Although this tank had a 5-foot secondary wall, DuPont assessments showed that an estimated 700 gallons of high-level waste exceeded the top of its secondary wall for a 6-hour period. DuPont estimated that a few tens of gallons of high-level waste seeped through the concrete encasement and reached the soil and groundwater beneath the tank. According to DuPont's assessments, much of the radioactivity was retained in about 30,000-square-feet of soil around and under the tank

For the radioactivity reaching the groundwater, DuPont evaluations show that the leading edge of the contamination will take from about 100,000 to 800,000 years to discharge into a surface stream which will allow sufficient time for most of the radionuclides to decay to low levels. These evaluations further show that most of the radioactivity will require from about 200,000 to 1.2 million years to reach a surface stream which will allow considerably more time for the radionuclides to decay. A DuPont assessment in October 1984 shows that DuPont plans to continue monitoring the migration of the radioactivity and that the site will be investigated to determine if any other actions are required

In addition to this example, another large unintentional release of high-level waste occurred in April 1961 when one of the tanks was overfilled because measuring devices were not properly calibrated. DuPont initially concluded that the waste overflow had drained into a catch tank, but they determined in 1974, after installing 8 new monitoring wells, that about 1,500 gallons of the waste escaped to the soil and groundwater around and beneath the tank. According to a February 1985 DuPont assessment, the radioactive waste overflow contaminated about 1,000 to 1,500 cubic feet of soil located from 12 to 26 feet below grade. As for the

radioactivity that reached the groundwater beneath the tank, DuPont estimates that it will take several hundred thousand years for the radionuclides to discharge into a surface stream which will allow time for most of them to decay to very low levels. DuPont has determined that there has been very little migration of the radioactivity in the soil and that the contaminated areas will not be excavated at this time because of radiation exposure to personnel.

To determine the extent of groundwater contamination beneath the two tank farms and the rate of migration, we examined DuPont's monitoring reports showing the concentrations of gross alpha, gross beta, and tritium radiation contained in the 49 interior and 22 perimeter groundwater wells. Because DOE did not have standards governing the amounts of radioactivity that could be contained in either onsite surface water or groundwater, we compared the concentrations of gross alpha, gross beta, and tritium contained in these wells during the period 1980 through 1984 with DOE's offsite concentration guides for uncontrolled areas and EPA's public drinking water standard to illustrate the levels of groundwater contamination beneath the tank farms and the rate of migration.

None of the 49 groundwater wells located inside the tank farms contained gross alpha contamination exceeding DOE's offsite concentration guide during the period 1980 through 1984; however, 3 of these wells exceeded EPA's drinking water standard during this period, with the highest measurement being about 11 times greater than the standard. As for gross beta contamination, 10 of the wells contained concentrations exceeding DOE's offsite concentration guide at least once during the 5-year period The highest concentration measured during this period was about 83 times greater than DOE's offsite guide. We also determined that 21 of the wells contained concentrations exceeding EPA's drinking water standard at least once during this period and that 6 of these wells consistently exceeded the standard. Maximum beta concentrations in these 6 wells ranged from slightly above to 500 times greater than the EPA drinking water standard.

We determined that 36 of the 39 interior wells monitored contained tritium concentrations exceeding EPA's drinking water standard at least once during this period, and 22 of these wells were consistently above the EPA standard Maximum tritium concentrations in these 22 wells ranged from slightly above to 31 times greater than EPA's standard. None of these concentration levels, however, exceeded DOE's offsite guide.

Our examination of the radioactive concentrations contained in the 22 perimeter wells, however, showed that very little radioactivity has migrated out of the tank farm area. Of the 10 perimeter wells monitored for gross alpha and beta radiation, none of the concentrations exceeded EPA's drinking water standard. Fifteen of the perimeter wells contained tritium concentrations which exceeded EPA's drinking water standard at least once during the 5-year period, and 7 consistently exceeded the standard, with maximum concentrations ranging from slightly above to 65 times greater than the standard. None of the 15 wells, however, exceeded DOE's offsite guide

While not a part of the high-level waste facilities, DuPont has determined that there is radioactive contamination above background levels in the groundwater under one of the chemical separations plants. To assess the extent and cause of contamination, DuPont is measuring radioactive concentrations contained in 14 groundwater monitoring wells around the facility. An assessment made by DuPont in June 1985 shows that it would take about 200 years for the existing contamination to discharge into the nearest stream. The assessment further pointed out that dilution and decay during this period would likely reduce the concentrations to levels that could not be detected. At the time we completed our review, however, DuPont was still in the process of assessing the extent and cause of groundwater contamination under this facility.

Tuscaloosa aquifer—DuPont analyses show that most of the radioactivity in the high-level waste spills and leaks has been retained by the soil around and under the tanks and that the radionuclides in the groundwater will decay to very low levels before discharging into one of the onsite surface streams DuPont evaluations also show that the radioactivity is not expected to migrate downward into the large Tuscaloosa aquifer. DuPont has determined that groundwater beneath the two tank farms moves primarily in a lateral or horizontal direction and eventually discharges into surface streams The groundwater movement is lateral rather than downward because of hydrological conditions under this area of the plant site which, in essence, create an upward pressure against the shallow groundwater.

DuPont plans show that it will continue monitoring the movement of groundwater beneath the two tank farms and assessing potential changes that could occur in the existing hydrological conditions. We also noted that SRP plans to assess the impact that the unintentional releases of high-level waste has had on groundwater beneath the two tank farms

as part of the EIS currently being prepared to assess the effect of its waste management practices on groundwater quality.

Institutional control—In addition to the groundwater and soil contamination, we noted that long-term institutional control may have to be maintained over the tank farms. We noted, for example, that an EIS prepared in September 1977 on SRP's radioactive waste management activities showed that institutional control of the area occupied by the two tank farms would have to be maintained for the foreseeable future. The EIS pointed out, for example, that areas contaminated with cesium and strontium would have to be controlled for at least 300 years, and a much longer control period would be required for those areas contaminated with longer lived radionuclides unless major recovery and cleanup programs were initiated A more current assessment of the institutional control period, however, will be available when SRP completes its ongoing EIS and prepares its decommissioning and decontamination plan for the older high-level waste tanks that are currently being emptied as a part of the waste transfer program.

Actions Intended to Reduce Future Impacts

Although SRP has taken a number of actions over the years to improve its management of high-level waste and upgrade the waste storage tanks with more current automatic control and alarm devices, two of the more significant actions involve the waste transfer program and preparations to permanently dispose of this waste offsite in a deep underground repository. Both of these actions should significantly reduce the potential for future unintentional releases of high-level waste to the environment

DuPont is in the process of transferring high-level waste from 23 of the 24 storage tanks which were constructed prior to 1964 to newer tanks because of the leaks and uncertainties associated with estimating the remaining useful life of the older tanks. One of the older single-wall tanks, however, is being retained to receive and store low-level liquid waste. DuPont expedited the waste transfer process when it discovered in December 1983 that cracks had developed in one of the eight tanks that had been constructed without a secondary wall. Because of the unacceptable risk associated with the single-walled tanks, DuPont plans to complete transferring the high-level waste from these tanks during fiscal year 1986. At the time of our review, DuPont had transferred about 40 percent of the waste contained in the 23 old tanks and was projecting that all of the waste would be transferred by the end of 1994. Completion of the waste transfer program should significantly reduce the

potential for additional contamination of soil and groundwater beneath the two tank farms.

In addition to the waste transfer program, SRP plans to prepare its high-level waste for permanent disposal in a deep offsite underground repository. The waste solidification process is to be accomplished in a Defense Waste Processing Facility which is scheduled to become operational in fiscal year 1990. The highly radioactive waste sludge will be transferred to this facility where it will be mixed with fine particles of borosilicate glass and melted. The molten glass will then be poured into stainless steel canisters where it will solidify. The waste canisters are to be stored onsite in air-cooled vaults until an offsite repository is available for their final disposal. The liquid and salt portions of the high-level waste will be decontaminated in the tank farms to remove cesium and traces of other radioactive elements. The decontaminated salt will then be mixed with cement and other additives and treated as low-level waste for onsite disposal.

Solid Waste

SRP generates large quantities of solid radioactive waste during its research, development, and production of special nuclear materials Since initiating operations in the early 1950's, solid radioactive waste generated at SRP as well as waste materials received from other facilities have been placed in a large, centrally located burial ground. Most of this waste has been permanently disposed of by burial in shallow earthen trenches, but some of it is stored temporarily on large, above grade concrete pads awaiting shipment to a permanent disposal facility being constructed in New Mexico.

Our analysis showed that SRP's solid radioactive waste operations have had very little impact outside the plant boundary, but the groundwater beneath the burial ground has been highly contaminated with radioactivity This contamination coupled with the large amount of radioactive waste which has been buried may require DOE to maintain long-term institutional control over this waste site. Specifics of these matters are discussed below.

Solid Radioactive Waste Operations

Solid radioactive waste consists of such materials as equipment, plastic gloves, protective clothing, and waste paper that are contaminated with varying levels of alpha, beta, and gamma radiation. DuPont classifies these waste materials as either low-level waste or TRU waste. Low-level waste is generated in a number of research, development, and production operations, but TRU waste is primarily generated at the chemical separations plants during cleaning operations, maintenance inspections, equipment replacements, and other activities. In addition to the solid materials generated by its own operations, SRP also receives shipments of both low-level and TRU waste from other federal installations.

Most of the low-level waste contains very little radioactivity; however, some of it contains contamination levels high enough to require shielding to protect personnel during waste handling and disposal operations Over 90 percent of the radionuclides in low-level waste decays to acceptably safe levels within about 100 years, but a few of them will require as long as 500 years to decay to safe levels. On the other hand, TRU waste contains very long-lived, radiotoxic radionuclides such as plutonium which will remain dangerous to humans for thousands of years.

Burial Ground

DuPont stores and/or disposes of solid waste in a fenced 195-acre burial ground located at the approximate center of the plant which is about 6

miles from the nearest plant boundary. The original burial plot, consisting of 76 acres, was placed in operation in the early 1950's; and, after it was filled with waste in 1972, the site was expanded to an adjacent 119 acres. Although the primary purpose of this facility is to handle solid waste materials, DuPont also uses it as an interim repository to store organic solvents and lubricating oils contaminated with low levels of radioactivity. DuPont is currently demonstrating the incineration of these contaminated liquids as a final disposal measure.

The fenced burial ground is relatively level and contains a number of drainage ditches to control rainwater runoff. The area is planted with specially selected grass to control surface erosion and to prevent possible uptake of radionuclides by deep-rooted vegetation. Also, the soils underlying the burial ground have a high capacity for retaining most radionuclides which reduces their migration into groundwater. The mean water table beneath the burial ground is about 45 feet, and it takes from about 20 to 100 years for the underlying groundwater to discharge into one of the onsite surface streams.

Although the present burial site has sufficient space to continue storing TRU waste for many years, disposal space for the large volume of low-level waste is becoming limited. DuPont has taken several measures such as a new trench design to conserve remaining burial space and is evaluating others; however, it projects that additional burial space will be needed within 3 to 4 years. DuPont is evaluating several potential new sites, including a 200-acre area directly north and adjacent to the existing burial ground

DuPont is in the preliminary stages of developing a closure plan for the initial 76 acres of the burial ground which has been filled with waste materials. As part of this effort, DuPont has contracted for studies to identify state-of-the-art closure concepts and assess such factors as the impact and cost of placing impermeable materials over the site to reduce the infiltration of rainwater and to retard the discharge of contaminated groundwater into surface streams. The studies are to also identify the best type of vegetation to plant in order to minimize soil erosion and prevent the possible uptake of radionuclides.

Low-Level Waste

DuPont segregates low-level waste for disposal in the burial ground into three categories depending upon the types and levels of radioactivity. These categories are low-level alpha, low-level beta-gamma, and intermediate-level beta-gamma The low-level alpha and beta-gamma waste

contains very low concentrations of radioactivity but represents about 95 percent of the low-level waste volume generated. On the other hand, the intermediate-level beta-gamma waste represents only about 5 percent of the low-level waste volume generated but contains about 95 percent of the radioactivity

DuPont packages most of the low-level waste in rigid metal containers which are then stacked in a shallow earthen trench. Large, bulky items that will not fit into metal containers are buried in the trenches without any additional containment. In September 1983, DuPont started using metal containers for packaging most of the low-level waste in order to provide for greater confinement of radionuclides from the environment and to make better utilization of burial space. Prior to this time, DuPont packaged low-level waste in cardboard boxes and then dumped the boxes into the burial trenches. In April 1985, DuPont also changed the design of the burial trenches. The floor of the new trench is sloped so that rainwater will flow away from the waste during disposal operations. The rainwater is collected in sumps and tested for radioactivity before being pumped out of the trench.

DuPont currently disposes of low-level alpha and beta-gamma waste in the same trench but uses separate trenches for the intermediate beta-gamma waste. DuPont also uses separate trenches for most low-level waste received from other installations. Low-level alpha and beta-gamma waste is periodically covered with soil to minimize the potential for releases of radioactivity to the environment. Intermediate-level beta-gamma waste, however, is covered with soil immediately after emplacement because of its higher levels of radioactivity. DuPont maintains records of the contents, radiation levels, and storage locations of waste placed in the trenches

DuPont is disposing of about 1 million cubic feet of low-level waste a year in the burial ground. About 10 percent of this waste, or 100,000 cubic feet, is generated by other installations and shipped to SRP for disposal. As of December 1984, SRP's low-level waste inventory consisted of about 15 million cubic feet containing about 2 8 million curies of radioactivity.

TRU Waste

DuPont initially disposed of TRU waste by burying it in plastic bags and cardboard boxes in earthen trenches specifically designated for this waste Because of its potential environmental hazards, however, SRP decided in 1965 that TRU waste should be separated into retrievable and

nonretrievable categories based on radiation levels. Waste packages containing less than 0.1 curies of radioactivity were designated as nonretrievable and disposed of in earthen trenches. Waste packages with more than 0.1 curies, however, were designated as retrievable and placed into prefabricated concrete containers before being buried. Large, bulky items of equipment and other waste items that would not fit into the prefabricated containers were first encapsulated in concrete before being buried.

SRP changed these practices in 1974 to comply with revised DOE criteria and procedures for handling TRU waste. The revised procedures stipulated that all TRU contaminated waste containing more than 10 nanocuries of radioactivity per gram had to be stored in a retrievable mode. The procedures also stipulated that the waste had to be placed in containers that would be contamination free and readily retrievable for a period of at least 20 years after being placed in storage. DuPont, therefore, began placing retrievable TRU waste in 55-gallon polyethylene-lined drums or carbon steel containers and storing them on large concrete pads above grade.

Containers with less than 0 5 curies of radioactivity are placed directly on the concrete pads, but packages with higher levels of radioactivity are first placed into large concrete culverts for additional containment. Very large items of process equipment which may be contaminated with greater than 10 nanocuries per gram but that are also highly contaminated with beta-gamma radiation are disposed of in earthen trenches without being placed in a container. Before putting the waste in the trench, however, DuPont backfills it with at least 6 feet of gravel, sand, or other material to protect the waste from contact with infiltrating water.

In February 1984, DOE advised its field installations that any waste materials contaminated with less than 100 nanocuries per gram of TRU radionuclides could be disposed of in earthen trenches as low-level waste. However, at the time we completed our review, DuPont was continuing to store waste contaminated with more than 10 nanocuries on concrete pads while evaluating a new disposal facility that would provide greater containment than earthen trenches. DOE also advised its field installations that waste with contamination levels of 100 nanocuries or more per gram should continue to be stored in a retrievable mode for future shipment to a deep geological repository referred to as the Waste Isolation Pilot Plant (WIPP)

WIPP is a research and development facility being constructed in New Mexico to demonstrate the safe and permanent disposal of TRU waste. If the planned 5-year demonstration program is successful, DOE plans to designate WIPP as a permanent disposal facility for TRU waste. SRP's program plans show that it will begin in 1986 to certify some of its newly generated TRU waste for shipment to WIPP. SRP's first shipment of this type waste is tentatively scheduled to be made in the early 1990's. DuPont will then begin retrieving, processing, and certifying the retrievably stored TRU waste. As of December 1984, SRP had about 138,000 cubic feet of retrievably stored TRU waste containing about 597,000 curies. SRP's operations result in the generation of about 21,000 cubic feet of TRU waste a year, with contamination levels of 100 nanocuries or more per gram.

DOE has no plans to require its field installations to retrieve buried TRU waste because of potential radiation hazards to operating personnel. DOE's program plan shows, however, that its field installations will be required to monitor buried TRU waste and to make periodic evaluations of its safety for the purpose of determining whether remedial actions are warranted During early years of plant operations, DuPont buried about 160,000 cubic feet of TRU waste containing about 54,000 curies of radioactivity in earthen trenches. SRP officials told us, however, that DuPont plans to evaluate the feasibility of retrieving TRU waste that was buried in prefabricated concrete containers DuPont buried about 12,000 cubic feet of TRU waste containing about 18,000 curies of radioactivity in prefabricated containers during the period 1965 through 1974.

Radiation Monitoring Program

DuPont conducts radiation monitoring and research programs for the purpose of detecting migration of radionuclides from the burial ground and evaluating potential environmental impacts of the burial ground practices. The programs provide for measuring radionuclide concentrations in groundwater beneath the burial ground, analyzing gross movements or changes in radiation levels, and assessing potential future radionuclide migration DuPont also maintains surveillance of the retrievably stored TRU waste to ensure that no radionuclides are being released into the environment To accomplish this effort, DuPont has over 300 monitoring wells at various locations within, on the perimeter, and outside the burial ground The five basic types of wells used for the monitoring and research programs are referred to as perimeter, grid, cluster, trench, and dry wells

DuPont has 35 wells located around the perimeter of the burial ground which it uses in its routine monitoring program to detect radionuclide migration from the buried waste. DuPont also has 89 grid wells located inside the burial ground to support both routine monitoring and radionuclide migration research. Of the 89 grid wells, DuPont currently uses 73 for research purposes and the other 16 for routine monitoring. The perimeter and grid wells are sampled and analyzed on a quarterly basis, and the results of the analyses are included in DuPont's routine monitoring reports which are made available to the public.

DuPont has 23 wells, referred to as cluster wells, along the southern boundary of the burial ground for measuring the vertical distribution of radionuclides in groundwater flowing out of the burial site. DuPont samples and analyzes water from the cluster wells each month for concentrations of tritium and twice a year for the presence of other radionuclides. DuPont also has 24 wells penetrating through filled waste trenches for the purpose of periodically sampling rainwater that might collect in the trenches In addition, DuPont has 11 dry wells penetrating through waste trenches to detect yearly vertical movements of radioactivity. DuPont uses the monitoring results from these three types of wells in its research program

In addition to these wells, DuPont has 120 other wells located both in and outside the burial ground which it uses for detecting radionuclide movement in groundwater flowing out and away from the burial ground and for measuring the levels of groundwater near the burial site. Of these 120 wells, 97 are used in DuPont's research program and the other 23 are used for routine monitoring purposes. DuPont uses 20 of these wells, for example, to monitor migration from an offsite waste shipment containing a large amount of tritium which was placed in the burial ground in 1972 DuPont also uses 37 grid wells located south of the old burial ground to measure groundwater levels near the burial site.

In addition to monitoring for possible radionuclide migration from the waste that has been buried over the past years, DuPont maintains a continuous surveillance program to detect potential radionuclide migration from the retrievably stored TRU waste DuPont has sumps located at the corners of the concrete storage pads to catch any water that may run off the pads. DuPont periodically analyzes water that collects in these sumps for the presence of radioactivity DuPont also visually inspects the pads as they are being filled for the purpose of detecting containers that may be leaking and the growth of any deep-rooted plants or trees which could uptake radiation through their root systems.

Impacts of Radioactive Releases

We determined that SRP's practice of disposing of solid radioactive waste in shallow earthen trenches has had very little impact outside the boundary of the plant; however, groundwater beneath the burial ground has become contaminated with radioactivity which will require many years to decay. This practice has also resulted in the disposal of a large amount of radioactive waste which may require long-term institutional control to protect individuals who may have access to the site after plant operations cease

Offsite Impacts

DuPont's monitoring and research activities show that tritium, technetium-99, and iodine-129 are the only radionuclides that have migrated outside the burial ground boundary Although high concentrations of tritium have been measured in several of the monitoring wells located on and outside the perimeter of the burial ground, DuPont has found only trace quantities of technetium-99 and iodine-129 outside the burial site. Because of the small concentrations of these two radionuclides, however, DuPont does not believe that remedial actions are warranted. DuPont does plan, however, to change its future disposal practices for iodine-129 to prevent its release to the environment because it is very mobile in water and will remain radioactive for millions of years.

DuPont evaluations show that much larger amounts of tritium are migrating out of the burial ground and discharging into a stream which empties into the Savannah River. According to these evaluations, tritium is discharging into the stream at a rate of about 450 curies a year; however, it is considerably diluted by the time it reaches the Savannah River which is about 14 miles downstream. After the dilution process, DuPont estimates that the maximum annual whole body dose that an individual could receive at the plant boundary from tritium migration would be about .0018 millirem This dosage is a small fraction of DOE's annual whole body dose standard of 500 millirem for occasional exposure and 100 millirem for continuous exposure.

The discharge of tritium from the burial ground occurred much sooner than DuPont had originally projected. DuPont estimated in 1977 that it would be several years before tritium would discharge into the nearest surface stream. DuPont discovered in the next year, however, that tritium was discharging into a drainage ditch which emptied into a surface stream located near the burial ground. Over the years, the ditch had eroded to a depth lower than the water table which permitted the discharge to occur. To reduce the quantity of tritium that was discharging, DuPont initiated action in 1979 to fill the ditch with clay, cover it with

topsoil, and plant grass to control future erosion. DuPont also constructed a new drainage canal and added graded rock to prevent future erosion. According to DuPont evaluations, a major part of the discharge was caused by tritium leaching from the open ends of buried crucibles which had been used in the production of tritium. To reduce future leaching, DuPont started in 1982 capping the open ends of crucibles before burying them in the earthen trenches.

Onsite Impacts

We determined that much of the groundwater under the burial ground contains extensive levels of tritium and that some groundwater is contaminated with elevated levels of gross alpha and gross beta radiation. Because of this contamination, coupled with the large amount of buried waste, DOE may have to maintain long-term institutional control over the low-level burial ground.

Groundwater contamination—In examining the extent of groundwater contamination, we reviewed DuPont's monitoring reports showing the concentrations of gross alpha, gross beta, and tritium radiation in the grid wells during the period 1980 through 1984. Since DOE did not have standards governing the amounts of radioactivity that could be contained in onsite groundwater, we compared the concentration levels with DOE's concentration guides for uncontrolled areas off the plant site and EPA's public drinking water standard to illustrate the degree to which the groundwater beneath the burial ground has been contaminated. In assessing gross alpha and beta concentrations, we used plutonium and strontium-90—principal alpha and beta emitters, respectively, in SRP's waste The DuPont official responsible for environmental analysis and reporting told us that these would be the most appropriate radionuclides to use for our assessment.

We determined that 10 of the 89 grid wells contained gross alpha contamination exceeding EPA's drinking water standard at least once during the period 1980 through 1984, and 1 of the wells contained levels consistently exceeding the standard The highest reading from this well was about 49 times greater than EPA's drinking water standard. None of the grid wells, however, contained alpha levels exceeding DOE's offsite concentration guide.

As for gross beta concentrations, we determined that 57 of the grid wells contained concentrations which exceeded EPA's drinking water standard at least once during the 5-year period. Maximum readings from these 57 wells ranged from slightly above to over 400 times greater than EPA's

drinking water standard Six of these wells also contained gross beta levels exceeding DOE's offsite concentration guide at least once during the 5-year period. Maximum concentration levels in only 1 of these wells, however, consistently exceeded DOE's offsite concentration guide. Maximum annual readings from this well ranged from about 2 to 68 times greater than the DOE offsite guide.

Most of the grid wells contained tritium concentrations which exceeded EPA's drinking water standard during the 5-year period, and some of these wells contained extensive amounts of tritium. Readings taken from 85 of these wells during 1984, for example, showed that maximum tritium concentrations ranged from slightly above to as much as about 80,000 times greater than EPA's drinking water standard. One other well, however, contained a maximum tritium concentration measuring about 116,000 times greater than the EPA standard. We also noted that maximum tritium concentrations in 43 of the wells ranged from slightly above to about 770 times greater than DOE's offsite guide.

Although the groundwater has been contaminated by radionuclides leaching out of the buried waste, DuPont reports show that there have been only three instances where radionuclides have been released from TRU containers stored on concrete pads. In all three instances which occurred in 1976, DuPont removed the waste from the defective containers, repackaged it in new containers, and cleaned up the contaminated area of the pad where the leak occurred. In one instance, DuPont had to remove and replace a portion of the pad in order to decontaminate the area. DuPont reports on these three instances show that all of the radioactivity was contained on the concrete pads and did not reach the environment.

As part of its long-term research program, DuPont has made analyses over the past several years to evaluate the amount and rate of future radioactive migration from the burial ground as well as the associated environmental impacts DuPont's analyses show that the migration of radionuclides in the groundwater will continue to be minimal and that future discharges into onsite streams will be at levels far below environmental concern

Tuscaloosa aquifer—DuPont's analyses also show that none of the radionuclides in the groundwater beneath the burial ground will migrate down to the Tuscaloosa aquifer because of existing hydrological conditions under this area of the plant site. These hydrological conditions, in essence, create an upward pressure causing the shallower groundwater

to flow in a horizontal direction eventually reaching a surface stream. In addition to this effort, SRP is evaluating the extent of radioactive contamination at the burial ground to determine whether any remedial actions are warranted, including removal of the contamination, as part of its ongoing EIS to assess the impact of its radioactive waste management practices on groundwater quality. The EIS is scheduled to be completed in the spring of 1987

Institutional control—While DuPont's analyses show that future migration is expected to be minimal, long-term institutional control may have to be maintained over the burial site to ensure that future generations who may reside on the site after the plant is closed are not exposed to excessive levels of radiation. An EIS prepared in September 1977 contained an in-depth assessment of SRP's radioactive waste management operations and concluded that the burial ground would have to remain under institutional control for the foreseeable future. The EIS pointed out that institutional control would have to be maintained for at least 300 years because of the presence of cesium and strontium, and a much longer period would be required for plutonium and other long-lived TRU radionuclides unless major recovery and cleanup programs were initiated.

As part of its long-term research program, DuPont has made a number of assessments subsequent to the EIS for the purpose of evaluating potential future impacts to individuals and identifying remedial actions that may be required when the plant is closed One of these studies made in 1983 shows that an individual residing on and farming the burial ground site could receive doses of radiation exceeding DOE's radiation protection standards after the burial ground is closed and a 100-year institutional control period elapses. DuPont's evaluations indicated, however, that the radiation dose could be reduced to an acceptable level by adding an additional 10 to 15 feet of soil over the burial site at the time of its closure.

The model used for these assessments, however, evaluated the potential impact from individual radionuclides and did not take into account potential impacts that could result from multiple radionuclides that are contained in the waste materials. A DuPont official responsible for some of these assessments told us that DuPont plans to use a newly developed EPA model which considers the impact of multiple radionuclides. He also told us that the results of these assessments would be considered in the ongoing EIS that is being prepared to assess the impact of SRP waste management practices on groundwater quality.

As part of this EIS, SRP plans to evaluate various alternatives for closure of the 195-acre burial ground as well as remedial actions that may be needed. The EIS will contain an in-depth assessment of the institutional control period that may be required as well as any remedial actions needed to ensure that the environment and public are adequately protected from radiation hazards in future years. The results of this work should better enable SRP to determine whether the burial ground will need to be designated as a permanent waste site or whether the environment and public can be adequately protected through appropriate remedial actions.

Actions Intended to Reduce Future Impacts

SRP has changed some of the solid radioactive waste management practices and is evaluating others which it believes will reduce the amount of radioactivity being released into the environment. As part of this effort, DuPont plans to demonstrate several new disposal techniques which have the potential for practically eliminating the release of radionuclides into the environment. In addition, DuPont is making preparations to permanently dispose of a large part of SRP's TRU waste in WIPP

Use of Metal Containers

In September 1983, DuPont started burying low-level solid waste in metal containers rather than cardboard boxes. While one purpose of using metal containers was to conserve trench space, the containers also provide for better containment of radionuclides from the environment than the cardboard boxes. In addition, use of metal containers for low-level solid waste is comparable to NRC requirements issued in December 1982 that prohibit commercial burial ground operators from using cardboard or fiberboard containers in their waste disposal operations.

Use of Engineered Trench

In April 1985, DuPont started using a newly designed waste disposal trench, referred to as an engineered trench, which will also assist in preventing the release of radionuclides into the environment. Although the primary purpose of the new trench is to obtain better utilization of disposal space, it is designed to also prevent waste material from standing in rainwater while the trench is being filled. The floor of the trench is sloped so that rainwater will flow away from the waste into a sump located at one corner of the trench. This feature reduces the potential for radionuclides to leach out of the waste material into water that enters the trench

Demonstration of New Disposal Techniques

DuPont is also in the process of evaluating the potential use of two new facilities to dispose of solid waste materials. One of these facilities, referred to as greater confinement disposal (GCD), would be used for waste containing most of the beta-gamma radiation as well as waste contaminated with alpha concentrations ranging between 10 and 100 nanocuries per gram The other facility, referred to as above grade operations, would be used for most of the remaining low-level waste. DuPont's evaluations show that these facilities have the potential for reducing the release of radionuclides into the environment to nearly zero.

Greater Confinement Disposal

The GCD concept provides for two types of waste disposal facilities—a borehole and a specially constructed trench. The borehole demonstration program was initiated in November 1983, and the trench demonstration program is scheduled to begin in November 1986.

DuPont has already constructed 20 boreholes for use in demonstrating the technical feasibility of this disposal method. Each borehole is about 30 feet deep and contains a 20-foot long, 7-foot diameter fiberglass liner which is encased in a 1-foot thick concrete annulus. Each borehole has a fiberglass bottom, and a steel collar is used to line the top 10 feet of the borehole to prevent soil from falling into the hole. Before being placed into the boreholes, the waste will be packaged into 55-gallon drums; and, as the boreholes are being filled, concrete grout will be poured around the waste to provide additional stabilization.

When a borehole is filled with up to 42 drums of waste, a concrete cap will be poured in the top of the fiberglass liner. The steel collar will then be removed, and the borehole will be backfilled with soil. After all of the boreholes are filled, DuPont plans to add a low permeable clay cap so that the waste will be at least 16 feet underground to prevent the intrusion of roots and animals and to discourage human intrusion. After being closed, the boreholes will require minimum maintenance and are expected to last at least 500 years which will be sufficient time for many of the radionuclides to decay to innocuous levels. DuPont also plans to place monitoring wells in each borehole as well as around the perimeter of the site to detect radionuclide migration

During fiscal year 1986, DuPont plans to construct a specially designed GCD trench to demonstrate the technical feasibility of disposing of large, bulky items of waste materials. The trench will be about 100 feet long and 50 feet wide with four separate waste disposal cells Concrete will be used for the walls and bottoms of each disposal cell. To minimize

rainwater from falling into the trench, steel covers will be placed over each disposal cell when it is not in use. As with the boreholes, DuPont plans to cover the trench with soil and a clay cap so that the waste will be at least 16 feet underground. DuPont also plans to install drainage facilities to channel rainwater away from the trench.

DuPont studies show that about 5 percent of the waste volume sent to the burial ground during the period 1979 through 1983 contained between 95 and 97 percent of the radioactivity. According to DuPont, this waste would have met the criteria for disposal in either a GCD borehole or trench. According to DuPont, the GCD disposal facilities will fully meet or exceed requirements established by NRC for commercial burial operators to follow in disposing of solid low-level radioactive waste.

Above Grade Operations

In addition to the GCD disposal facilities, DuPont also plans to begin demonstrating the feasibility of an above grade facility by the end of fiscal year 1987 or later to dispose of solid waste materials containing small amounts of radioactivity. The above grade concept, in essence, provides for placing a specially designed pad over existing waste trenches that have already been filled with waste. Contaminated waste materials will be placed in rigid containers, and the containers will then be stacked on the specially constructed pad. Sand will be used to fill void spaces between the containers, and a specially designed covering will be added to drain rainwater to the sides of the pad and prevent seepage into the facility. The pad will also be sloped and any water that enters the facility will be collected and tested for radioactivity. As with the GCD disposal facilities, DuPont evaluations show that the above grade disposal facility would also provide for a near zero release of radionuclides to the environment. The above grade facility would also reduce seepage of rainwater down through waste already disposed of in underlying trenches

If the above grade and GCD demonstration programs are successful, DuPont assessments show that most of SRP's solid low-level waste could be placed in facilities that would practically eliminate the release of radionuclides to the environment, thus avoiding environmental impacts associated with their potential migration. In addition to evaluating the technical feasibility of these new disposal methods during the demonstration programs, SRP plans to identify and evaluate any environmental impacts of these facilities as a part of its current EIS to assess the effect of its waste management practices on groundwater quality.

Offsite Disposal of TRU Waste

In addition to the potential new disposal facilities for solid low-level waste, most of SRP's long-lived, highly radiotoxic TRU waste may be permanently disposed of in WIPP, provided its 5-year demonstration program is successful. Currently, SRP plans show that most of its newly generated TRU waste as well as the TRU waste currently being stored on concrete pads could be permanently disposed of in WIPP. In addition to this waste, DuPont may recommend that TRU waste which was placed in prefabricated concrete containers and buried in trenches during the period 1965 through 1974 be retrieved and processed for shipment to WIPP.

As of December 1984, SRP had about 150,000 cubic feet of TRU waste containing about 615,000 curies of radioactivity retrievably stored on concrete pads or buried in the prefabricated containers. This represents over 90 percent of the radioactivity contained in TRU waste which SRP has either stored or disposed of since initiating operations in the early 1950's. While none of the radioactive releases from the TRU pads has reached the environment and there has been very little migration of TRU radionuclides from buried waste, the removal of this hazardous, long-lived waste from SRP would eliminate any potential future environmental impacts that could result from accidents or other causes

Advance Comments From the Department of Energy

Department of Energy
Washington, DC 20585

JUN 13 1986

Mr. J. Dexter Peach
Director, Resources, Community, and
Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

The Department of Energy (DOE) appreciates the opportunity to review and comment on the General Accounting Office (GAO) draft report titled "Impact of Savannah River Plant's Radioactive Waste Management Practices," RCED-86-143.

We believe that the draft report accurately characterizes the existing situation at the Savannah River Plant. Minor corrections and suggested changes to update and clarify several of the statements made in the report are included as an enclosure to the letter to Mr. Sam Madonia.

DOE hopes that these comments will be helpful to GAO in the preparation of the final report.

Sincerely,

Martha O. Hesse
Assistant Secretary
Management and Administration

Glossary

Aquifer	A water-bearing formation of permeable rock, sand, or gravel capable of yielding water to wells or springs.
Alpha Radiation	Positively charged particles emitted during radioactive decay. Alpha radiation is easily stopped by several sheets of paper.
Argon	An element that is a chemically inert gas. Its isotopes include argon-41, a short-lived isotope with a half-life of 1.83 hours.
Background Radiation	Radiation in the human environment from naturally occurring radioactive elements and cosmic radiation. Background radiation varies considerably with location.
Beta Radiation	Negatively charged particles emitted during radioactive decay. Beta radiation can be stopped by a thin sheet of metal.
Borosilicate Glass	A strong chemically resistant glass made primarily of sand and borax.
Carbon	A nonmetallic element Its isotopes include carbon-14 with a half-life of 5,730 years.
Cesium-137	A radioactive fission product with a half-life of 30 years. Cesium is highly mobile in the biosphere
Curie	The basic unit used to describe the intensity of radioactivity in a sample of material.
Dose	The energy imparted to matter by ionizing radiation per unit mass of irradiated matter at a specific location.

Fallout	The descent to earth and deposition on the ground of radioactive particulate matter from the atmosphere.
Fuel Element	A tube, rod, or other form into which fissionable material is fabricated for use in a reactor
Gamma Radiation	High-energy, short-wave length electromagnetic radiation accompanying fission. Gamma rays are very penetrating and require a dense or thick layer of materials for shielding
Gross Alpha and Beta Radiation	Alpha and beta radiation without regard to the specific radionuclides from which the activity is being emitted.
Half-Life	The time in which half the atoms of a radioactive substance disintegrates to another nuclear form
Iodine-129	A radioactive isotope that has a half-life of 15.9 million years and emits beta and gamma radiation.
Irradiate	Deliberate exposure of a substance to radioactivity.
Krypton	A colorless, inert, gaseous element that is odorless and tasteless. Of the krypton radioactive isotopes, krypton-85 has a half-life of 10.73 years.
Long-Lived Nuclides	Radioactive isotopes with half-lives greater than about 30 years.
Migration	The natural travel of a material through the air, soil, or groundwater.

Millirem	A quantity used in radiation protection to express the effective dose equivalent for all forms of ionizing radiation. A millirem is one thousandths of a rem
Mixed Waste	Materials containing both nonradioactive and radioactive waste.
Nanocurie	One-billionth of a curie.
Plutonium	A highly toxic element with isotopes having a wide range of half-lives. Plutonium-238 has a half-life of 86 years whereas plutonium-239 has a half-life of 24,400 years.
Radiation	The emitted particles and/or photons from the nuclei of radioactive atoms. The three types of common radiation are alpha, beta, and gamma
Radiation Standard	Permissible exposure levels of radiation and governing regulations.
Radioactive Decay	The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in the emission of nuclear radiation.
Radioactive Waste	Materials from nuclear operations that are radioactive and for which there is no practical use or for which recovery is impractical.
Radioactivity	The spontaneous decay or disintegration of unstable atomic nuclei accompanied by the emission of radiation

Requests for copies of GAO reports should be sent to:

U.S. General Accounting Office
Post Office Box 6015
Gaithersburg, Maryland 20877

Telephone 202-275-6241

The first five copies of each report are free. Additional copies are $2.00 each.

There is a 25% discount on orders for 100 or more copies mailed to a single address.

Orders must be prepaid by cash or by check or money order made out to the Superintendent of Documents.