CHAPTER 15

FACILITIES AND OPERATIONS RELEVANT TO THE USE AND RELEASE OF CHEMICALS

ABSTRACT

This chapter provides information about the major facilities and operations responsible for releases of chemicals to the air and surface water at the Savannah River Site (SRS). The most important facilities and operations were the powerhouses, the separations processes, and raw materials operations. This chapter also describes key sources of information about releases of chemicals, site operations, waste disposal, water treatment, explosions, fires, and spills.

RELEASE POINTS AND PROCESSES

The SRS has several thousand process exhaust points and "literally tens of thousands of administrative events" according to the Part 70 Operating Permit Application submitted to the South Carolina Department of Health and Environmental Control (SCDHEC). Inquiries made to the Air Emissions Inventory database in October 1997 indicate that there were 527 emission points in D-Area; 3023 emission points in A-Area, which includes the powerplant, Savannah River Laboratory (SRL), and Savannah River Ecology Laboratory; 540 emission points in M-Area; 2347 emission points in F-Area, including the Naval Fuels Facility; 2123 emission points in H-Area, including the tritium facilities; 396 in T-Area or TNX; 535 in G-Area or CMX; and from 600 to 650 in each reactor area (Faugl 1996).

Six onsite process stacks emitted most of the nonradioactive materials released: three 313-M stacks and one 321-M stack in M-Area and two, 200-ft-high stacks (291/292-H and 291/292-F) in the separations areas. Because of the sensitive nature of some of the information about process equipment, design, and location, exhaust points were combined into one location for each area. Combining the exhaust points is justified because most of the toxic emissions came from the large stacks, and for air transport modeling that might be an option in later phases of the study, one exhaust point for each area would be adequate because of the size of the SRS.

This assessment focuses on major releases from processes. Activities not covered in this assessment include the operation of cars and trucks, painting, landscaping, and other maintenance work. Reinig et al. (1973) estimated that the Site had 675 vehicles that operated about 6,800,000 mi y^{-1} and consumed about 624,800 gal of gasoline per year. There are few records available to estimate releases from maintenance, construction projects, and central shop activities, which were not monitored before the late 1980s. Operations such as welding, painting, sawing, and cutting would have released nitrogen dioxides, sulfur dioxide, metals, and other pollutants. Operation of diesel generators, landscaping maintenance equipment, painting equipment, and other nonprocess-related equipment also released pollutants. Many of these sources have been included in the Air Information Reporting System (AIRS) database since about 1990.

KEY SOURCES OF INFORMATION

The monthly reports, area histories, annual reports, waste site characterization reports, environmental information documents, systems and safety analysis reports, technical progress reports, letters, memos, logbooks, and many other records were reviewed for information on chemical use and release data and how processes and pollution control measures may have changed over time. Examples of some of the process changes that would have affected releases are (a) conversion from the PUREX to the HM process in H-Area in May 1959, (b) initiation of recovery of ^{237}Np in 1963, and (c) installation of an electrolytic dissolver in H-Canyon, which could dissolve stainless and zirconium-alloy fuels, in 1969 (Westinghouse 1990).

Source term estimates were determined using inventory or usage estimates, knowledge of processes, information about release estimates as currently required by regulatory agencies, and monitoring data. There is very little monitoring data for chemical releases from the SRS. A limited amount of data are available from ambient air monitoring, water quality monitoring, and special studies, which are described in Chapter 19. Available monitoring data from the 1980s and 1990s were reviewed and compiled for selected chemicals. Chemicals detected at significant levels in the environment were added to the list of chemicals subjected to the ranking discussed in Chapter 16. For some chemicals, extrapolating back in time from 1980s monitoring data was the best way to estimate a source term, assuming the amounts and types of materials used and the processes did not change very much over the years.

The Emergency Planning and Community Right-to-Know Act of 1986 required the tracking of chemicals. Before this regulation, little or no information was available to describe or quantify the amounts of chemicals used, except in the raw materials area and tritium and separations facilities which kept inventories of process chemicals (Kvartek et al. 1994). Because chemical releases were not monitored and chemical use and disposal were not recorded before the late 1970s, much of the information on chemical use and release in the earlier years was learned from former and current Site employees. The following former and current Site personnel were interviewed about records of the amounts and uses for chemicals, including purchasing records and essential materials ledgers:

Retired	Bob Rodman, Purchasing
	Herman Drummond, Essential Materials Clerk in 300-Area
	Jim King, Essential Materials for the Power Department
	Paul Katonak, Computer Services
	Hap Holbrook , Essential Materials Clerk
	W.E. (Bill) Borders, Essential Materials Clerk in Separations
Onsite	Jim Morgan, Chemical Commodities Management Center
	Bob Harris, Procurement
	DuPree Simmons, Procurement
	Sally Strain, Industrial Hygiene
	Greg Still, Industrial Hygiene

In general, procurement records were kept for about 3 years, longer if they involved equipment for nuclear safety. Some summary information was retained for some vendors, but

most of the records on commodities and purchasing that might still be available pertain to transactions that occurred after 1990 (Morgan 1996).

Chemical storage, distribution, and record keeping practices have changed often over the years. Since 1994, all chemical purchases have gone through the Chemical Commodities Management Center, facilitating entry in the Worker Right-to-Know database and compliance with U.S. Environmental Protection Agency (EPA) regulations, according to Jim Morgan of the Chemical Commodities Management Center. Previously, many chemical purchases, primarily those with low exposure limits, were routed through the Industrial Hygiene Department. John Harris, was interviewed extensively in Phase I and provided the CIIS database information used for ranking the chemicals of concern. The Industrial Hygiene Department also maintains a comprehensive set of Material Safety Data Sheets. Chemical coordinators are designated in each major process area to function as a central point of contact for all chemical use in that area.

During interviews, essential materials clerks mentioned the existence of Cost Accounting Books, called Orange Books, which were kept in the years before the Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III inventory records were required. These books were not located in the Phase I document search, and retired individuals who had kept these books and current staff in the Cost Accounting Department could not locate any of the Orange Books.

Essential materials ledgers were kept in H-Area, F-Area, and M-Area and probably in other areas as well. They typically listed the date, essential material code and/or the name of the material, the purchase order number, the receipt number, the vendor, and the quantity received. Essential materials ledgers for the separations areas and M-Area were found in Phase I and in the early part of Phase II. After the mid-1970s, receiving, inspecting, and sample logs were also used in M-Area (DPSOL-315-1060) to log materials received and to note whether they met specifications (Westinghouse 1987). Another record, called a consumption log, was kept after 1987 in M-Area. This generally contained the same information as the essential materials ledgers (Gary 1996). In addition, monthly essential materials transaction reports, also called chemical accountability reports, for M-Area were available from 1969. The information contained in the chemical accountability reports is difficult to compile into annual use amounts and is hard to interpret because many of the materials were procured by a bulk purchase order. Very large amounts of materials may have been listed when only small amounts were received and used. Total balances were sometimes reported rather than the monthly usage amounts. It became clear to both *Radiological Assessment Corporation* (*RAC*) and the Centers for Disease Control and Prevention (CDC) researchers reviewing the purchase orders in Phase I that these records would not be very relevant. In early years bulk chemicals were generally obtained through a standing order or by contract rather than through routine procurement. Many of the ledgers seem to reflect cost accounting rather than actual consumption or use by the facilities.

Preparing quantitative source term estimates for chemicals involved acquiring an understanding of their historic use in the SRS processes. A review of specific facilities and processes was presented in the Phase I Task 3 Report (Meyer et al. 1995). The processes of most concern for chemical dose reconstruction were the raw materials manufacturing processes in M-Area; the canyon processes in F-Area and H-Area; and the powerhouses in A-Area, F-Area, H-Area, and especially D-Area.

The operations of heavy water production facilities in D-Area, CNX and TNX, tritium production facilities, reactor areas, separations areas, waste disposal areas, and other facilities as

they pertain to chemical releases are also addressed further in the sections on individual chemicals in Chapters 17 and 18.

Safety analysis and systems analysis reports and standard operating procedures provided some of the best process descriptions. The 1996 operating permit application included useful descriptions of some of the most important processes and the air exhaust and liquid effluent discharges associated with them (Westinghouse 1996).

Site Studies of Nonradioactive Releases

Some research on chemical releases to the environment has been done previously at the SRS. In 1970, Monier and Bebbington compiled information on quantities and manner of disposal for nonradiological wastes in a memo. Monier and Bebbington (1970) states that "by far the largest quantities of such [nonradioactive] wastes come from the treatment of process and boiler feed water and these are almost entirely common inorganic compounds. I found no evidence of discharge of highly toxic and persistent chemicals directly to the environment." The memo acknowledged that wastes were discharged into streams that flow into the Savannah River, but it said that chemical analyses of river water above and below the Plant showed no consistent differences that could be attributed to these wastes. Most of the solvents used at the Site were thought to have been discharged to trenches and burned or buried, and a larger amount was discharged to sewers (most of which discharges to seepage basins) than directly to streams. M-Area was cited as the only area that does not have a "proper" facility for disposal of process wastes. At that time, acids, bases, salts, and chlorinated solvents were being discharged to a sewer that flows directly to Tim's Branch. The quantity of coal ash was said to be about 100 times that of the next largest waste discharge, which was caustic (sodium hydroxide). The memo recognized that significant quantities of inorganic materials might leach from the coal ash.

A summary of the estimates of the amounts of waste reported to have been "discharged" (Monier and Bebbington (1970)) is listed below. Most of the discharges were to waste sites, basins, and other contained areas rather than to areas from which the chemicals may have been transported offsite. Materials discharged to streams are listed separately below.

Discharged to Site streams	lb y^{-1}
Caustic	10^6 to 10^7
Sodium nitrate	10^6 to 10^6
Nickel sulfate	10^3 to 10^4
Aluminum nitrate	10^3 to 10^4
Chromate	10^3 to 10^4
Nickel chloride	10^3 to 10^4
Lead oil lubricant	10^2 to 10^3

Discharged to seepage basins, waste disposal pits, and trenches, etc.	lb y^{-1}
Coal ash	10^8 to 10^9
Nitric acid	10^5 to 10^6
Mercury	traces

Discharged to air	lb y^{-1}
Hydrogen sulfide	10^5 to 10^6
Ammonia	10^5 to 10^6
Hydrocarbon solvents	10^4 to 10^5

Discharged to sewers and pits	lb y^{-1}
Trichloroethylene	10^4 to 10^5
Tetrachloroethylene	10^5 to 10^6

In conclusion, Monier and Bebbington (1970) recommend that the dumping of chemicals from M-Area be reduced, the discharge of chlorinated solvents be stopped, and sediments of Tim's Branch be studied for solvent deposition. They also recommended the continuous samplers used to collect samples for radioactivity also be used to institute a program of chemical analyses in streams and the river.

In 1973, a survey of effluent monitoring at the Site was documented in Reinig et al. (1973). This survey was the report of a task force named to study releases. The task force attempted to identify release points and characterize releases from manufacturing, power generation, construction, and research activities. The report acknowledged that the characterization of nonradioactive releases from Site activities was much less complete than for radioactive releases. For many emissions points, no information was available about the concentrations or quantities of nonradioactive materials discharged in air and water effluents. Where analytical data were lacking on the nonradiological pollutants discharged from specific emission points, the task force relied on consumption of essential materials used in the particular plant operations and knowledge about the formation of substances during processes. Examples include sulfur oxides from burning coal, runoff from construction activities, and pesticide applications. They concluded that the effects of dilution, streambed deposition, chemical or biological reaction during transit, or other phenomenon that would change the concentrations of contaminants between the point of discharge and the point of stream discharge into the river needed to be better understood (Reinig et al. 1973).

For dose reconstruction, we agree that much more information on the dynamics of the system is required than is currently available. This information is needed to determine how much of a chemical released to a seepage basin may have reached groundwater, outcropped, or overflowed to Site streams and been transported to the river. Indeed, many scientists at the Savannah River Ecology Laboratory have dedicated their research careers to better characterizing SRS's streams and swamp systems and mobility and transport of materials to the river. We cannot expect to adequately define this system in a limited-duration dose reconstruction project.

DOE's (1987) *Preliminary Environmental Survey Report of the Defense Production Facilities*, included a section on the SRS. The following were of concern to the survey team because of nonradioactive materials:

- M-Area settling basin
- Sediments in Steel Creek Corridor
- Airborne mercury releases
- 1,1,1- Trichloroethane from M-Area

- Nonradioactive pits and piles in K-Area, L-Area, P-Area, R-Area, CFH-Area, CS-Area, A-Area, M-Area, and D-Area and TNX.

The M-Area unit ranked high because of the high mobility of tetrachloroethylene. Much of the concern came from scenarios involving onsite exposure to groundwater used as drinking water. This is not an applicable scenario for historical offsite exposure. See Appendix J for further details.

DOE (1987) mentioned that 1,1,1-trichloroethane releases from M-Area were derived from measured release data. However, no such records, or personnel who recollect monitoring of solvents in M-Area, have been found in the course of our study. The emission rate for trichloroethane was said to be about 200 ton y^{-1}.

The report also recognized that mercury was released to the air from the H-Area separations and tritium facilities. The survey team thought that there was a potential for stack emissions of mercury to be inhaled by the surrounding population. Again, DOE (1987) states that "the source term was derived from measured release data… Since a moderate number of assumptions were made in deriving the release rate . . . ," but the sources of the monitoring data and source terms were not given. Mercury monitoring was done in 1985 and these might be the data to which the survey referred. The potential consumption of mercury in crops and livestock drove the hazard ranking determined by DOE. They noted that the air emissions of mercury from the Site had been within the Clean Air Act standard of 200 lb y^{-1} and that mercury concentrations were also within the limit (0.25 μg m^3 at the plant boundary) of the SCDHEC Air Toxic Policy.

The nonradioactive pits and piles evaluated and ranked in the DOE Survey included: the K, L, R, C, F, D and A burning/rubble pits, Road A chemical basin, CMP pits, L-Area oil and chemical basin, the L-Area acid and caustic basin, Ford Building seepage basin, old H-Area seepage basin, hydrofluoric acid spill area, Radioactive Waste Burial Ground 643-G, Silverton Road waste site, TNX burying ground, metallurgy laboratory basin, metals burning pit/miscellaneous chemicals basin, and the SRL seepage basin. The potential for groundwater contamination from these sites was of concern. Source term data were taken from Site Environmental Information Documents. Tetrachloroethylene and trichloroethylene consumption in fish and potential ingestion of surface water while swimming drove the ranking. These hypothetical, worst-case scenarios are not applicable to dose reconstruction.

For all of the units ranked, the report says that, "This ranking… would place this …. unit with those environmental problems that are characterized as generally reaching receptors at levels below those used in regulatory decisions." The TNX Burying ground and D-Area Burning/Rubble Pit would be placed with those environmental problems "that are not projected to reach receptors"(DOE 1987).

FACILITIES OF MOST INTEREST FOR CHEMICAL RELEASES

M-Area

M-Area (also referred to as the 300-Area, the Reactor Materials Area, the Raw Materials Area, and Nuclear Fuel Fabrication Area) manufactured fuel and targets to be irradiated in the reactors (DOE 1987). M-Area is relatively close to the Site boundary, about 0.3 mi. M-Area contained five process buildings where reactor fuel elements were fabricated, extruded, cleaned,

and tested; it also included the 305-M Test reactor. Processes included uranium metal element fabrication (in Building 313-M), alloy extrusion (in Building 321-M), target extrusion (in Building 320-M), and the Chemical and Metallurgical Laboratories (in Buildings 321-M and 322-M) (Colven et al. 1985). M-Area processes were described in the Phase I Task 3 report (Meyer et al. 1995). A detailed description can be found in the technical manual written by Pelfrey (1987). The main process buildings described in the Operating Permit Application were (1) the slug production facility, which used a press, welding machines, cleaning and plating baths, autoclaves and other inspection, testing and cleaning operations, (2) the target and fuel fabrication facility, which included an extrusion press, degassing ovens, magneforming machines, radiography equipment, and other equipment used to produce aluminum clad fuel elements, (3) a target fabrication facility, which used similar equipment but primarily made lithium-aluminum tubes and control rods and tubes. M-Area operations involved chemical cleaning, etching, stripping, and plating (DOE 1987). Maximum production for M-Area occurred from about 1978–1986 (Gary 1996).

The M-Area facilities processed uranium, lithium, and aluminum into fuel and target components for the nuclear reactors. Processing included aluminum alloy formation, degreasing, etching, metal extrusion, hot-die size bonding, and nickel plating (Specht et al. 1987). Many memoranda and standard operating procedures describe the use of acids, caustics, and chlorinated solvents to etch and clean products, equipment, and tools. For example, the process for target slug fabrication used in 1985 involved degreasing in a hot nitric acid solution, dipping in Aquadag or Hydrograf solution to check cleanliness (if all lubricants had been removed these solutions would then uniformly coat the caps), dipped in nitric acid again if necessary, then cold water washing before etching. The cans were degreased in 1,1,1-trichloroethane, dipped three times in boiling 1,1,1-trichloroethane, then held in vapors above the 1,1,1-trichloroethane for about 3 minutes. The cans were etched in nitric and phosphoric acid and aluminux caustic (Pelfrey 1987).

Emission sources included solvent degreasing operations, metal cleaning and etching tanks, fixed roof storage tanks, metal extrusion, metal machining, metal casting, welding, groundwater treatment and wastewater treatment.

Much of the information used to determine emissions estimates was derived from the air emissions inventory estimates. These estimates were determined by the SRS using information obtained from interviews with operating personnel, standard operating procedures, stack testing results, and engineering judgment. Measurements of emissions were available or made for the acid etch tank and at least one degreaser. Mass balance approaches were used for the air stripper and other degreasers. Engineering calculations were used to estimate releases from the fixed roof storage tanks and open top process tanks and for releases from machining, casting, and extrusion. Four stacks were described by Hardt (1970) for M-Area:

1. The 313-M North plating line stack, 100 ft high, which vents the anodic etch, post-anodic nitric acid etch, dummy nitric acid etch, and the rinse and plating tanks
2. The 313-M South cleaning line stack, 100 ft high, which vents the pre-anodic nitric acid etch and the obsolete slug cleaning using nitric acid
3. The 313-M Final etch recovery stack, 100 ft high, which is equipped with a fume scrubber and vents the recovery and final etch nitric acid tanks
4. The 321-M Stack, also 100 ft high, which vents the tubs nickel nitric acid tank, tetrachloroethylene degreaser, and the etch caustic tanks (Hardt 1970).

The emissions sources for M-Area listed in 1992 by Radian Corporation, the contractor who estimated emissions for Westinghouse Savannah River Company, included fixed roof storage tanks; metal casting operations; metal extrusion operations; metal machining (grinding, polishing, and cutting); solvent degreasing; metal cleaning and acid etching tanks; welding; wastewater treatment; and groundwater treatment (Radian 1992b). Information sources listed include air permits, process and equipment diagrams, interviews with operating personnel, material safety data sheets, standard operating procedures, industrial hygiene data, stack testing results, and experience and engineering judgment. The approaches to estimate emissions were material balance, emission factors, stack measurements, and engineering calculations and assumptions. It appears that the methods required more detailed information than we have been able to locate for the dose reconstruction. The methods also seem to be conservative. These estimates are probably less uncertain than those we could calculate based on less information.

M-Area emissions to air included nitrogen oxides and nitric acid fumes from acid etching, cleaning, and plating processes and metal fumes from extrusion operations (Du Pont 1973; DOE 1987). Chlorinated solvents also evaporated from degreasers and from liquid effluents discharged to Tim's Branch and to the seepage basins.

The buildings are relatively close together so the emissions from the building's vents and three stacks were combined, and the four buildings were considered one release point. This is an adequate assumption for modeling transport of contaminants offsite.

Large quantities of chemicals were stored and handled in M-Area. Chemicals used in the M-Area processes included aluminum fluoride, boric acid, hydrochloric acid, lead powder, lithium fluoride, nitric acid, nickel carbonate, nickel sulfate, nickel chloride, organic phthlate compounds, phosphoric acid, sodium nitrate, sulfuric acid, tetrachloroethylene, trichloroethylene and 1,1,1-trichloroethane (DOE 1987; Colven et al. 1985). Use of these chemicals resulted in wastewater that resembled electroplating waste from metal forming and finishing processes. The waste effluent contained hydroxide precipitates of uranium, nickel, lead, chromium, zinc, and other metals as well as nitric acid and nitrates (Specht et al. 1987; Colven et al. 1985; Bradley 1981). The effluents discharged from M-Area have also included millions of pounds of chlorinated organic solvents used for cleaning and metal degreasing. Moderate quantities of acids, bases, salts, other cleaning solutions, and lubricants were also discharged to the sewer (Monier and Bebbington 1970). The sewer flowed directly to Tim's Branch, which flowed through a swampy area into Upper Three Runs Creek or to a settling basin after 1958. Not until 1979 were waste solvents barreled and not released to the sewer (Christensen and Brendell 1981). Groundwater analysis has indicated that trichloroethylene, tetrachloroethylene, 1,1-dichloroethylene, lead, and nitrates have contaminated the groundwater beneath M-Area. The groundwater has not migrated offsite (DOE 1988).

The releases to air are described in Chapter 17 for each individual chemical. Surface water and air releases of solvents from M-Area were related by the fact that the process sewer and surface water releases evaporated to the air and seeped into the ground to contaminate groundwater, which has been treated using an air stripper, resulting in additional releases to the atmosphere. Because of these relationships, Chapter 17 addresses the releases of the chlorinated solvents from M-Area liquid effluents, air strippers, and processes to the air and to surface water. Chapter 17 presents an assessment of the use and release of trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane to the air, primarily from evaporation of solvents as they were used and discharged to streams and the settling basin.

The influent to and effluent from the M-Area settling basin was sampled and analyzed weekly for 10 weeks from March through May 1985. Based on these sampling data, a removal efficiency was calculated for the basin ([the influent concentration minus the effluent concentration] divided by the influent concentration). The results indicate that the retention of metals in the basin averaged about 80%. Although trichloroethylene and tetrachloroethylene were not being used at the time of this analysis, they were detected in the influent and effluent, presumably from the process sewer line and sludge and soils of the basin. 1,1,1-Trichloroethane was found at about 150 ppb in both the influent and effluent (Colven et al. 1985; Pickett et al. 1987). Table 15-1 summarizes this basin retention data for chemicals of concern.

Table 15-1. Average Influent and Effluent Concentrations from Nine Weekly Composite Sample and Calculated Removal Efficiency for the M-Area Seepage Basin in 1985 (Colven et al. 1985)

Chemical	Average influent concentration (mg L^{-1})	Standard deviation	Average effluent concentration (mg L^{-1})	Standard deviation	Average removal efficiency (%) for settling basin
Nitrate	361	180	156	70	57
Lead	0.407	0.50	0.110	0.31	71
Nickel	5.95	5.0	0.573	0.98	90.4
Cadmium	0.004	0.002	0.003	0.001	25
Chromium	0.037	0.037	0.006	0.006	84
Mercury	0.276	0.14	0.215	0.024	22
Zinc	0.141	0.065	0.024	0.03	83
Manganese	0.034	0.20	0.008	0.009	76
Magnesium	0.210	0.25	0.0513	0.042	75
Trichloroethane	144	79	151	67	<1
Trichloroethylene	<11	15	<18	9.5	<1
Tetrachloroethylene	<10	12	<10	6.5	<1
Uranium	50.9	70	66.7	51	<1

Uranium levels (ranging from 3.5 to 185 mg L^{-1}) were considered low, but the removal of uranium by the seepage basin was very poor. In fact, the average effluent concentration was greater than the average influent concentration, although both were extremely variable (Colven et al. 1985). The authors thought this may have been due to the high pH (averaging 11) of the water, which would tend to dissolve uranium (Pickett et al. 1987).

The release of metals from M-Area to surface water was researched. Metals were not measured in Tim's Branch discharges when process wastes were being discharged directly to the stream. In 1966, the spillway of Steed's pond gave way and allowed the pond to drain, exposing the sediments. The Site Health Protection Department conducted a study of Steed's Pond sediments in 1967. They sampled for cadmium, chromium, lead, nickel, uranium and zinc and decided that uranium was the contaminant of most concern. The study's authors concluded that the amount of sediment transported to Upper Three Runs Creek was not affected by the spillway collapse (Pickett 1990).

Merz (1982) summarized two years of effluent sampling data and reported that M-Area effluent concentrations of chemicals were less than the newly proposed EPA liquid effluent regulations for the metal finishing industry. The exceptions were the concentrations of total toxic organics, which were 1.66 mg L^{-1} in sewer effluent going to the settling basin and 0.70 mg L^{-1} in sewer effluent going to Tim's Branch, and the total suspended solids, which were 34 mg L^{-1} in sewer effluent going to the settling basin and 20 mg L^{-1} in sewer effluent going to Tim's Branch. Merz (1982) estimated that sludge in the settling basin contained about 32,000 lb of heavy metals. Groundwater samples at that time did not detect elevated concentrations of metals in the groundwater beneath the basin.

In 1984, sediment samples were collected at 31 locations along Tim's Branch and at Steeds Pond. In 1985 and 1986, monthly analysis was done for metals at four locations along Tim's Branch. Based on analyses of these samples, the effluent was thought to have contained tons of chromium, nickel, aluminum, and iron and thousands of pounds of cadmium, copper, lead, and zinc (Specht 1991). Chapter 18 describes concentrations of metals in Tim's Branch sediments found in these studies. A memo from Pickett (Pickett 1990) reports that sampling data indicate that metals are substantially elevated in the sediments of Tim's Branch, downstream of the confluence with the influent discharge ditches from the 300/700 Areas (NPDES outfalls A-014, A-011, and A-008). The contamination was attributed to historical discharges from 313-M, which were not diverted to the seepage basin until 1973 (Pickett 1990). Chapter 18 individually addresses the uses and surface water releases of nitrates, nitric acid, and the metals arsenic, cadmium, chromium, lead, nickel, uranium, and zinc.

A-Area

Many of the administrative buildings are located in A-Area. The Savannah River Technology Center (SRTC) in A-Area has done research and development and analytical support for Site operations. SRTC operations involve laboratory hoods, shielded cells, small pilot-scale facilities, waste handling facilities, glass shop, and laboratory chemicals. The radioactive hoods and cells are vented through a sand filter and one main stack. The SRTC metallurgy laboratory has been used to test corrosion and cleaning of metallurgic samples. The relatively small emissions of nitric acid and other pollutants have been exhausted through two 35-ft-tall stacks. The Savannah River Ecology Laboratory facilities include laboratory hoods, environmental sample analysis, and diesel generators.

Separations Areas

Two chemical separations plants were located near the center of the site between Upper Three Runs Creek to the north and Four Mile Creek to the south, in areas designated as 200-F and 200-H. The principal facility in each area was called the 221 Building or Canyon. Each separations plant contained remotely serviced and operated canyon facilities and directly serviced and operated finishing facilities for processing irradiated materials from the production reactors. The process dissolved the irradiated fuel and target materials and produced solutions containing various products that were separated from fission products by solvent extraction and ion exchange (Fisk and Durant 1987). Special reports, monthly progress reports, and other records provide information on how much and how many of the process chemicals were used in the

process each month and how much went to the high level and low-level waste for several years in the 1980s. However, we do not know how much went out the stacks or into Site streams because this was not measured.

Emissions examined in Chapters 17 and 18 included ammonium nitrate, cadmium, chromium, hydrazine, mercury, manganese, nitric acid, and nitrogen dioxide. Emissions of volatile organic compounds from F-Area and H-Area have not been measured, but they would be expected to be minimal based on process knowledge. The extractants, kerosene and tributyl phosphate, have relatively low vapor pressures and the amounts volatilized and exiting the process vessel vents would be expected to be small (DOE 1987).

A history for the separations areas (Du Pont 1988) contains useful information on typical operating times and process rates. The report summarizes the specific leaks, spills, and other incidents that occurred in the canyon buildings. All of the spills, leaks, and overflows described in the history and in the monthly reports seem to have occurred inside the canyons and did not involve releases to the environment (Du Pont 1988). In the late 1980s, an effort was made to reduce the volume of waste discharged from the separations areas (Pickett 1996). Several processes changes have been noted, such as the mercury reduction and deletion of the manganese oxide strike in the 1980s. The years 1987–1988 were the last two of maximum throughput through H-Canyon (Pickett 1996). F-Area processes were at peak operations in 1984 and 1986 (Villa 1996).

The 211 Buildings in the separations areas, also called the Outside Facilities, included bulk chemical storage and water handling, acid recovery, evaporation, segregated solvent facilities, water treatment, and electricity and steam generation (Fisk and Durant 1987). Spill containment dikes were installed around the 211 storage areas in 1988. Before that, any potential release would have traveled to outfall ditches and surface water. Liquid chemicals used in the separations areas were received by rail or truck by the chemical storage facilities. Tributyl phosphate, n-parriffin, aluminum nitrate, and sodium hydroxide were received in tank cars, and nitric acid was delivered by tank trailers. Bulk liquids were pumped into large tanks that were mounted in concrete saddles. The nitric acid and aluminum nitrate tanks were stainless steel and most of the other tanks were carbon steel.

Chemicals were pumped through pipelines to points of use in 221-H and F, and 211-H and F. Storage tanks and makeup tanks were on concrete pads with curbs and sumps or concrete basins surrounding them. In later years, additional confinement barriers were built and used. Most of the tanks had agitators, overflows, floor drains, drain sumps, and decant sumps, each with a pump. The tank areas had a sump collection tank and a recycle sump. A recycle vent system provided a way to filter contaminated air in tanks or vessels and vent tanks while they were being filled.

Canyon production rates were compiled and are presented in Chapter 2 of this report. Data on F-Area and H-Area production were correlated to known periods of waste generation, descriptions of volumes of chemicals used per batch or per mass of material process, and compiled as a part of waste reduction or cost accountability studies. For some of the chemicals, we used the production rates to normalize release rates in order to predict releases for the years we did not have monitoring data.

The major canyon processes were dissolution, head end, first solvent extraction cycle, second uranium solvent extraction cycle, and the second neptunium/plutonium solvent extraction cycle. Waste stream preparation and treatment included the high activity waste, low activity

waste, frames waste recovery and general-purpose evaporator systems. Chemicals used in the processes were cleaned and purified for reuse by the acid recovery, solvent recovery, waste handling, and segregated solvent systems (Westinghouse 1996).

The dissolving process was performed in two steps or batches. The first step involved dissolving aluminum cladding in caustic, which emitted ammonia, and the second step involved dissolving the irradiated uranium in nitric acid, evolving nitrogen oxides. The two dissolution steps were vented separately to separate stacks (DOE 1987). The second stack was added sometime in the 1960s to prevent the ammonia emitted from the first step from reacting with nitric acid to form ammonium nitrate solid material. This material condensed on the inside of the stack (Pickett 1996) and could be dislodged, which resulted in radioactive spalls from the stacks depositing on nearby ground and sidewalks.

The canyon stacks are 200 ft high and 10 ft in diameter. The canyon exhaust system consisted of five separate systems: the dissolver off-gas system, gang valve corridor and central exhaust system, old HB-Line exhaust system, process vessel vent system, and recycle vessel vent system. The sand filters and high-efficiency particulate air (HEPA) filters between these systems and the stack were said to provide confinement for nearly 100% of the radioactive particulates, except for the dissolver off-gas system. The dissolver off-gas was vented through an iodine reactor, followed by a fiberglass filter to remove particulates, then exhausted through the stack. The central exhaust system drew air from the hot and warm canyon cells through HEPA filters using exhaust fans. The process vessels for the head end process, the first solvent extraction cycle, the second uranium cycle, the second neptunium/plutonium solvent extraction cycle, solvent recovery system for each extraction cycle, the frames waste recovery system, low activity and high activity waste process vessels, and rerun system were all vented through the process vessel vent system fiberglass filters followed by sand filters then out the stack. The acid recovery system, general purpose evaporator, segregated solvent system, third-level cold feed process, sump exhaust, waste handling facility, and uranyl nitrate storage tanks were vented to the recycle vessel vent system fiberglass filters followed by sand filters then out the stack. Chapter 17 describes mercury and nitrogen dioxide emissions from the canyon stacks.

Tritium Facilities

The 1996 operating permit application, an unclassified document submitted to the SCDHEC, described the tritium facilities operating in 1994. In 1994, Lines I and II of the 232-H tritium operations included separations, cryogenic distillation, gas stripping, Z-Bed recovery, degreasing, metallography, and cutting. The process gases from 232-H were passed through a uranium and zeolite bed to remove water vapor from the hydrogen isotopes. They were then passed through a palladium-silver diffuser to separate the isotopes from argon, helium, and nitrogen. The purified isotopes were then fed into a cryodistillation process. If the off-gas met the stripper feed limits, it was discharged through the stack stripper to the stack. If it did not meet limits, it was recycled back to the diffuser for the removal of more tritium. Tritium was separated from protium and deuterium by cryogenic distillation using a batch still. The product stream was loaded into gas containers in 232-H or sent to 233-H or 234-H for loading into reservoirs. The off-gas from 232-H and purged nitrogen collected in the nitrogen collection tank was collected in a stack tank and passed through a stripper system involving zeolite beds to remove tritium, and then was discharged to the stack. Regeneration of the zeolite beds involved the use of magnesium. The

process also involved moderate quantities of freon and degreasing solvents, such as 1,1,1-trichlorethane. Exhaust air from these processes, including the laboratory, degreasing, metallography, and cutting hoods, as well as the processes just described, was released from the 200-ft-tall, 10-ft-diameter, 295-H stack with an exhaust velocity of about 13 ft s^{-1}. Most of the processes have been in place in some form since 1954. The metallography processes were installed in 1986. The release of chlorinated solvents out the stack were said to have been negligible. Relatively small nitrogen oxide emissions were a result of nitric acid etching, performed on a small laboratory scale. The degreasing hood emissions were primarily freons (Freon TF or 1,1,2-trichloro-1,2,2-trifluoroethane) (Westinghouse 1996).

Line III of 232-H involved the extraction of tritium from target assemblies. These were loaded into crucibles and melted in a vacuum extraction furnace. The product gases were purified in Lines I and II as described above. Most of the off-gas treatment was concerned with reducing the amount of tritium released. The line III off-gas was released through a 200-ft exhaust stack, 297-H, and subject to pre-filter and HEPA filters. The extraction furnace described in 1994 has been in place since 1961 (Westinghouse 1996).

The tritium loading facilities, 234-H, include the finishing operations for reservoirs loaded in 233-H, receiving and unloading reservoirs, packaging and shipping reservoirs, inspecting and storing reservoirs, providing tritium assay of filled reservoirs, providing stripper for the off-gas treatment from 236-H and 232-H operations, proof testing new reservoirs, and sealing reservoirs for disposal. Before 1994, reservoirs received were unloaded, the gas was transferred to 232-H Lines I and II, and the reservoirs were sent to 238-H for reclamation. Emissions were released from a 200-ft-tall stack, 296-H. Emissions of nickel from the reservoir finishing operations were classified, but they would be expected to resemble other fabrication processes.

Emissions from the reservoir reclamation facility in 238-H were released from a 75-ft stack. Processes include milling and machining, lathe, and decontamination of reservoirs. The reservoir loading facility, 233-H, receives filled reservoirs, unloads them, transfers gas to Lines I and II, compresses the gas, and loads it into new or reclaimed reservoirs. Emissions were released from a 50-ft-tall stack. No chemical emissions were listed in the operating permit application, which focused on releases of tritium and control equipment to reduce these emissions (Westinghouse 1996).

The Systems Analysis for the Tritium Processing Facilities in 234-H states that chemical toxicity hazards in the building are small and that the only hazard identified by the industrial hygienists was associated with careless handling of cleaning solvent [freon] and exposure to mercury only specific chemical toxicity hazard is associated with the careless handling of cleaning solvent, [and] mercury (Haynes and Stoddard 1984).

Naval Fuel Manufacturing Facility

The Naval Fuel Manufacturing Facility (FMF) Project began in 1981. Pilot plants for the processes were operated at the SRTC in 1983. From 1986 to 1989, the facility manufactured highly enriched uranium fuel to be used by the nuclear Navy, from uranium shipped in cylinders from the gaseous diffusion plant at Portsmouth, Ohio. The FMF, housed in a single building in F-Area, 247-F, operated independently from other facilities in F-Area and maintained its own analytical laboratory (Zeigler et al. 1987; Evans 1998).

The Naval Fuels processes resulted in the release of relatively small amounts of nitric, sulfuric, and hydrochloric acids; nitrogen oxides; sulfur compounds; and other chemicals from stacks and vents (Du Pont 1994). Some of the process exhaust was released through roof top vents (DOE 1982). The facility was designed with a 7-ft diameter, 108-ft-tall stack with a predicted flow rate of 54 ft s^{-1} (Du Pont 1994). The facility's off-gas treatment system was constructed with filters, vapor coolers, a cyclone separator, a venturi scrubber, and caustic scrubbers to remove aerosols, vapors and hydrogen fluoride, sulfates, sulfuric acid, ammonia, and hydrochloric acid (DOE 1987; Du Pont 1994). Predicted emissions were described in detail in the construction permit filed with the state and in subsequent operating permit applications. Air exhausted from the facility was first treated using HEPA filters. Liquid effluent was subject to evaporation then was either put into saltstone and buried or discharged to a treatment plant and then to Upper Three Runs Creek, as a permitted discharge. The liquid wastes likely contained nitrates, chlorides, fluorides, and trace quantities of process solvents. The process wastes were neutralized and evaporated, and the evaporator condensate was mixed with concrete and encapsulated as a block in steel containers and buried in the burial ground. Organic wastes were placed in solvent storage tanks in the burial ground (DOE 1982). Although the information about the processes, capacities, and end products are not presented here because some of this information is sensitive, *RAC* researchers holding the appropriate clearances have reviewed and assessed this information. Releases were included in the source term estimates for the separations areas.

The Reactor Areas

The reactor areas and special reactor projects, such as HWCTR, which operated from March 1962 to December 1964, did not use large quantities of hazardous chemicals. The reactor building stacks were 200 ft high with a normal flow of 120,000 cfm. Building roof vent releases of trichloroethylene used for fuel element cleaning were reported (Reinig et al. 1973).

Each reactor area had a solvent degreaser, but the details of solvent use and waste solvent discharge are unknown. The solvent used in the reactor areas was procured through M-Area, so the M-Area inventories and materials ledgers include reactor area solvent use. The releases to the air are included in the release estimates calculated for M-Area (in Chapter 17), which were based on total inventory amounts.

After 1989, each reactor area submitted an inventory to be included with the Section 313 Hazardous Chemical Inventory Report as required by EPA's SARA Title III Regulations. A memo, Mundy (1989), submitted for the SARA regulations, listed moderate quantities of nitric acid, freon 113, sodium hydroxide, phosphoric acid, and trichloroethane for the reactor areas. The reactor areas released sulfur dioxide and nitrogen dioxide from coal burning and the use of diesel fuel burning generators. Small emissions from the reactor areas may have resulted from the use of solvents for degreasing and cleaning, the use of other cleaners and disinfectants, and the use of paint, solder, and halon fire protection systems (Radian 1992a).

G-Area

The G-Area or general area includes areas and facilities outside of other designated areas. G-Area operations include the Forest Station, the Railroad Classification Yard, the Central Sanitary

Waste Water Treatment Facility, and the Par Pond Radioecology Laboratory. Emissions from the G-Area facilities include criteria pollutants from the railroad locomotives and generators as well as water treatment chemicals and small amounts of laboratory chemicals.

CMX

CMX performed research and development and testing for the reactor areas. This included water treatment and testing of fuel assemblies, temperature, and other sensors (Crawford 1995).

TNX

TNX facilities, also called the 600 Area, handled support services and conducted research and development for the 200 Areas. Many chemicals were used in bulk quantities at TNX. Canyon processes were tested with pilot-scale plants. Research and development for the Defense Waste Processing Facility (DWPF) was conducted at TNX through the 1980s. The DWPF involved waste processing into immobile forms. The TNX facility had pilot equipment, models, and mockups of DWPF equipment. The facility vented air exhaust to a 50-ft stack. DOE (1987) stated that stack exhaust was tested in 1984 and average emissions were found to be 0.037 lb h^{-1} nitric acid, 0.00074 lb h^{-1} depleted uranium, and 0.022 lb h^{-1} benzene. We could not find a copy of the report about this testing referenced in the DOE Survey. We did not locate another mention of TNX nonradiological monitoring and data are not available on emissions from this facility to the air until the air emissions inventory was begun in 1989.

Powerhouses

As many as seven coal-fired powerhouses operated onsite and released sulfur dioxide, ash particulates, oxides of nitrogen, and other pollutants to the air. Chapter 17 addresses the powerhouse operations, off-gas systems, pollution control, and releases in the “Coal” section.

Defense Waste Processing Facility

The DWPF is a glassification plant for high activity waste, located in S-Area. Constructed in 1985, cold (nonradioactive) runs began in 1990 (Cummins et al. 1991).

Saltstone Facility

The Saltstone Facility or Saltcrete Facility in Z-Area was designed to stabilize a salt solution containing waste in concrete. Many of the chemicals currently listed in inventories onsite are used at the Saltstone Facility. The facility began test runs in 1989. The DWPF and the Saltstone Facility are not included in the historical dose reconstruction study because they began operating after 1989 and releases from these facilities are subject to more stringent, current air quality and air toxics regulations. These plants also have a Chemical and Industrial Waste Treatment Facility to treat liquid waste effluent.

Waste Handling Facilities and Disposal Sites

RAC reviewed documentation on chemical and solvent burning and disposal pits and other waste areas. Only those waste disposal sites with a potential for offsite releases of chemicals are discussed in the sections on source term determination for chemicals released to the air and water in Chapters 17 and 18.

The waste storage and disposal areas reviewed include:

- Bingham pump outage pits
- C-Area burning/rubble pit
- Central Shops burning/rubble pits
- CMP pits
- D-Area burning/rubble pits
- F-Area burning/rubble pit
- K-Area burning/rubble pit
- L-Area burning/rubble pits
- Miscellaneous chemicals basin/metal burning pit
- Metals burning pit
- P-Area burning/rubble pit
- R-Area burning/rubble pits
- 488-D ash basins
- 716-A Motor Shop seepage basin
- A-Area coal pile runoff basin
- D-Area oil seepage basin
- F-Area and H-Area seepage basins
- G-Area oil seepage basin
- K-Area reactor seepage basin
- L-Area oil and chemical basin
- M-Area process sewers
- M-Area seepage basin
- Old F-Area seepage basin
- Road A chemical basin
- Tank farm
- Hydrofluoric acid spill area.

Chemicals of concern from the waste areas include chemicals that might have volatilized into the air, or leaked into the soil and then become suspended in air, or migrated from soil into groundwater (which could have outcropped into surface water that flowed to the Savannah River). Chemicals of concern released from the F-Area, H-Area, and M-Area seepage basins; the ash disposal and coal runoff basins; the M-Area process sewers; and open burning pits and pans are discussed further in the chapters on the releases of chemicals to the air and water. The remaining waste disposal sites listed above and those described below do not appear to have caused releases of chemicals offsite, and release of chemicals from these sites do not comprise a complete exposure pathway for people offsite.

The seepage basins and disposal sites that released materials into the air are addressed in Chapter 17. Releases from the basins and sites that contaminated groundwater that outcropped to

surface water or that overflowed to surface water are discussed in Chapter 18. Although many of the basins or waste areas characterized below caused groundwater and soil contamination onsite and have required remediation, their contribution to releases to the Savannah River and air is considered negligible.

Seepage, Settling, and Retention Basins

Seepage basins are shallow earthen excavations used for disposal of wastewater containing chemicals and radionuclides. Some of the wastewater discharged to the basins evaporated while some seeped through the bottom of the basin into shallow groundwater, which in some cases traveled horizontally and discharged to surface streams. Before reaching the streams or the groundwater, contaminant levels were reduced by processes like radioactive decay, filtration, absorption on the soil, and ion exchange. Determining what fractions of contaminants that were discharged to the Site seepage basins, eventually reached surface streams, and were subsequently released to the Savannah River is a part of Phase II of the dose reconstruction study and is addressed in Chapters 5 and 18.

The history of the seepage basin operations was obtained from monthly progress reports and separations histories. For example, the Monthly Progress Report for 1964 reported that failed tubes in the reboiler at 211-F acid recovery unit necessitated the transfer of about 1.1 million gallons of 5–9% nitric acid, containing 85,000 lb of 100% nitric acid and 13 Ci of gamma activity to the F-Area seepage basins. Enough caustic to neutralize this amount of acid was sent to the seepage basins from March 8–11 (Du Pont 1964). Environmental Information Documents contain estimates of the amounts of liquid effluent and contaminants that may have been discharged to the basins. Site characterizations and remedial investigations, required by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), have also been helpful for characterizing releases to the basins.

The basins received waste oils, solvents, and chemicals resulting in groundwater contamination by metals and solvents. F-Area, H-Area, and M-Area seepage basins received the most chemicals. Before the Resource Conservation and Recovery Act (RCRA), most of the seepage basin monitoring effort was devoted to radioactivity. Under RCRA, basins had to be evaluated for hazardous waste criteria by sampling the basin influent and liquid. Three basins onsite have contained waste considered hazardous: 200-F for pH; 200-H for pH, mercury, and chromium; and 300-M for pH and organics. Some of the radioactive seepage basins also received chemical wastes, but most of the decontamination solutions and oily wastes were discharged to the reactor area's oil and chemical pits (Peralta and Lewis 1982).

Of interest for dose reconstruction are those seepage basins and waste disposal areas that had the potential to contribute to offsite releases. Seepage basins that contaminated groundwater, outcropped into surface streams, and eventually empty into the Savannah River are of most concern. The four seepage basins for which this applies are the F-Area and H-Area seepage basins that outcrop to Four Mile Creek; K-Area retention basin, which outcrops to Pen Branch and Indian Grave Branch; and the P-Area seepage basin, which outcrops to Steel Creek.

The Old TNX basin was evaluated because it has overflowed into a swamp. In addition, the settling basin at M-Area is of interest because large amounts of chemicals were released to this basin, including volatile organics that evaporated into the air. Coal and ash pile runoff basins

were also considered and are described in Chapter 18 with the discussion of releases of chemicals to surface water.

This chapter provides a brief characterization of the seepage basins in F-Area, H-Area, P-Area, and K-Area that have contaminated groundwater that outcrops to surface water. Chapter 18 provides a further analysis of F-Area, H-Area, and M-Area basins in the sections on releases of mercury, nitrates, chromium, and the chlorinated solvents.

Separations Area Basins. Four seepage basins and one lined retention basin are located in both F-Area and H-Area, for a total of 10 basins. In contrast to seepage basins that are unlined, retention basins are lined pits that allow radioactive decay, evaporation, and storage. Historically, the safety analysis reports for these areas have characterized the flow of cooling water, contaminated storm water, and process fluids through the separations processes and described the potential of radioactive contamination of wastewaters; however, they have not addressed nonradioactive constituents (Holcomb and Emslie 1984). The seepage basins were operated in a cascade arrangement, overflowing from one basin to the next. Liquid waste going to the basin system was proportionally sampled by a trebler sampler, and chemical analysis of some of the samples for nonradioactive metals began in 1982 (Holcomb and Emslie 1984). A special study on influent composition was done in 1975. This and other studies to characterize the release of metals and nitrates to the basins and their transport to groundwater or surface streams are compiled with the releases of chemicals to surface water in Chapter 18.

Overheads condensed from various evaporators (such as the nitric acid recovery unit and general-purpose evaporators) were the major contributors to the volume of water going to the separations areas seepage basins. Nitrates and mercury appear to be the chemical contaminants of most concern for surface water releases from the 200 Areas. The primary sources of effluent sent to the seepage basins were the nitric acid recovery unit overheads, the general-purpose evaporator overheads, waste tank farm evaporator overheads, and other evaporator overheads. The wastewater flowed to the basin through an underground pipeline into basin 1, which overflowed into basin 2, then 3 through underground pipelines. Wastewater was sampled and flow measurements were taken at trebler monitors upstream of basin 1 (Killian et al. 1987).

Groundwater beneath the F and H seepage basins areas flows toward Four Mile Creek, which is 2200 ft from the nearest basin in F-Area and 500 ft from the nearest basin in H-Area. The seep from the basins that eventually outcrops into Four Mile Creek is being evaluated as a part of the dose reconstruction because Four Mile Creek eventually empties in the Savannah River.

The F-Area and H-Area seepage basins were characterized by Christensen and Gordon (1983). The groundwater flow rate was reported to have been 0.5 ft d^{-1} in F-Area and 1.0 ft d^{-1} in H-Area. The travel time calculated from the basin to the creek was 9 years for F-Area and 4 years for H-Area. Low pH, increased conductivity, and tritium were noted along the seep line in the 1960s and were attributed to the F-Area and H-Area seepage basins (Du Pont 1967; Arnett 1993). An extensive study was conducted by SRTC to characterize the shallow groundwater that was seeping into Four Mile Creek and its associated seep line in 1988 and 1990 (Haselow et al. 1990; Arnett 1993). Further evaluation of the outcropping and chemical releases to Four Mile Creek is presented in the sections on nitrates, mercury, and chromium in Chapters 18 and 20. The F-Area and H-Area seepage basins were not used after 1988 when the Effluent Treatment Facility for the separations areas began operation (Arnett et al. 1992).

Old F-Area Seepage Basin. The first seepage basin (Building 904-49G) was built north of F-Area and received effluent from 221-F from November 1954 until May 1955. Three additional basins were constructed south of F-Area in 1955, and the 49-G basin was abandoned. It is often referred to as the Old F-Area Seepage Basin or the abandoned seepage basin (Odum et al. 1987). Chemical discharges to the basin were not recorded. Sediment core samples have shown that mercury and uranium concentrations were greater than background levels. Manganese, nitrates, lead, chromium, cadmium, and chlorinated solvents have been identified in groundwater under the basin (DOE 1987).

F-Area Seepage Basins. The PUREX process, which has always been in operation in F-Area, involved the dissolution of uranium fuel in nitric acid followed by solvent extraction. The process used three cycles of solvent extraction to separate actinides (uranium and plutonium) from each other and from fission products. The actinides were extracted from an aqueous stream to a solvent stream, scrubbed, then stripped back into a dilute nitric acid stream. High activity waste from the solvent extraction process was sent to waste tanks. Beginning in 1955, the F-Area seepage basins received wastewater from F-Area containing low level radioactivity and chemicals including chromium, mercury, nitric acid, and sodium hydroxide. The basins were taken out of service in 1988 and clay capped in 1991 (DOE 1987).

In F-Area, waste streams discharged to the basins included 1CI and 1EU evaporator overheads, hydrate evaporator overheads, general purpose evaporator overheads, laboratory waste evaporator overheads, acid recovery unit overheads, laundry wastewater, 211-F chemical drain systems, 211-F and A-Line Sumps, and A-Line pad drainage. Some of the overheads were run through a skimmer to remove organic solvents. The acid recovery unit was a fractional distillation unit used to recover nitric acid from acidic overheads generated from evaporation of wastes. The acid recovery unit bottoms, which were about 50% nitric acid, were recycled back through the canyon processes, and the overheads were discharged to the seepage basins. The overheads were typically 0.001 to 0.1 molar nitric acid with an average pH of 2.0. The general-purpose evaporators were used to concentrate a variety of waste solutions, including those from sumps, pads, catch tanks, and vessels that collect rainwater and process leaks and spills. The bottoms from these were sent to the waste tanks, and the overheads were sent to the seepage basins. The 221-F chemical drains included those in the cold-feed preparation area and all of the process and nonprocess sumps. Wastewater could be fed to the general-purpose evaporator if contaminated with radioactivity. Decontamination solutions were also probably fed into this system. Before 1983, the acid recovery overheads were sent to the seepage basins. In 1983, an attempt was made to recycle most of the overheads back into the canyon processes, which reduced the nitric acid and nitrate releases (Holcomb and Emslie 1984). During the early years, waste was sampled for radioactivity before being discharged to the seepage basin or evaporated depending on the activity. The concentrations of chemicals in many of the waste streams related to the PUREX process were nearly linearly related to the production rate. Evaporators, for example, should be directly related and the gallons of wastewater discharged were related to the amount of uranium processed. About 80 million gallons of waste liquid was discharged to the F-Area seepage basin each year (Killian et al. 1987).

The plant laundry, Building 723-F, served the entire Site. It contained five washers with capacities of 300 lb of dry clothes each, five water extractors, four dryers, two wastewater tanks in a concrete box underground, and a lint and dust collector. The wastewater tanks were discharged to the seepage basins. The laundry wastes could also be sent to the general-purpose

evaporator. The Environmental Information Document for the Old-F-Area Seepage Basin reported that laundry employees said that only water soluble detergents were used by the laundry and no other chemicals were present in the building.

H-Area Basins. H-Area basin operations began in July 1955. The HM process was similar to the PUREX process; however, much larger quantities of mercury were used in H-Area to dissolve aluminum. The evaporators and acid recovery operations were similar to F-Area, but quantities of mercury discharged in evaporator overheads were much larger than the quantities discharged to F-Area seepage basins.

From July 1955 to December 1982, the discharge to the H-Area seepage basins was estimated to have totaled 1.24 billion gallons. The trebler sampler was used to sample liquid effluent discharged to the seepage basins. Weekly composites from the trebler samplers were analyzed for mercury and chromium concentrations routinely after 1982 (Holcomb and Emslie 1984). In 1987, levels of nitrate and mercury were greater than the drinking water standards in groundwater below H-Area seepage basins. Nitrate levels were as high as 118 mg L^{-1} and mercury concentrations up to 0.0082 mg L^{-1} were measured (Mikol et al. 1988). Special studies have been done by the Site to characterize potential transport of mercury from the H-Area seepage basins. Most of the mercury was said to be accounted for in the basin soil. Chapter 20 discusses mercury monitoring and Chapter 18 presents estimates of the rate of mercury outcropping into Four Mile Creek.

K-Area Basins. Pen Branch received heat exchanger cooling water from K-Area and flow from Indian Grave Branch. Tritium migration from the K Reactor retention basin outcropped into Indian Grave Branch, which flowed into Pen Branch (Cummins et al. 1991). Tritium migration from the K-Area containment basin has been measured by weekly flow measurements and a continuous sampler in Indian Grave Branch (Gladden et al. 1985; Arnett et al. 1992). However, no mention has been found of chemicals in the water that might have migrated from the basin. In Looney et al. (1987), a chemical constituent selection study, no nonradiological constituents from K-Area basins were selected for consideration.

P-Area Basins. Liquid wastes from P-Area have been released to the seepage basins since 1978. Monitoring in Steel Creek above L-Lake indicated tritium migrated from the P-Area seepage basin to Steel Creek (Arnett 1993). Concentrations of radionuclides in Steel Creek decreased after the construction of L-Lake in 1985. After 1985, the releases first entered L-Lake, then Steel Creek (Cummins et al. 1991). Nitrate, lead, and trichloroethylene have been detected in groundwater below the P-Area basin, but significant amounts of these contaminants have not been reported in Steel Creek.

M-Area Settling Basin. The M-Area settling basin was used from about 1958 to 1982. In 1981, the Site estimated that M-Area processes had used an estimated 6500 tons of chlorinated degreasing solvents. From this quantity it was estimated that about 1000 tons may have been discharged to the sewer leading to the M-Area settling basin and about 750 tons to Tim's Branch through the A14 outfall (Christensen and Brendell 1981). After 1982, all waste went to the settling basin. In 1985, the settling basin was removed from service and wastes were sent through a treatment facility. Lead, manganese nitrates, and solvents reached the groundwater below the settling basin. Concentrations of organics in groundwater have exceeded 250 mg L^{-1} tetrachloroethylene and 150 mg L^{-1} trichloroethylene (DOE 1987).

Old TNX Seepage Basin. The old TNX seepage basin was operated from 1958 to 1980. The basin received process water from tests conducted at TNX in support of the separations areas and

the defense waste processing facility, including discharges of uranyl nitrate and mercury nitrate (Simmons et al. 1985). In 1981, the basin was closed, backfilled, and capped with clay (Simmons et al. 1985). Basin sediments contained chromium, uranium, nickel, mercury, and a number of radionuclides (DOE 1987). Chromium, mercury, nickel, and nitrates have been detected in groundwater below the basin. Inventory calculations estimate about 318 kg of mercury may have entered the basin (Simmons et al. 1985; DOE 1987). Another estimate for mercury discharged to the old TNX seepage basin was 292 kg (Zeigler and Lawrimore 1987).

Chemicals and radionuclides from the old TNX seepage basin have been released to a swampy area located adjacent to and below the basin, and the basin itself was referred to as a swamp in some documents. There has been a loss of forest canopy in this swamp area from the discharges. Mercury is well dispersed in the swamp and has been detected in the vegetation. The swamp water was reported to contain 50 times the drinking water standard for mercury (Zeigler and Lawrimore 1987). The swamp sediments were characterized in 1984 and chromium, mercury, and uranium were found in the top 0.6 m of sediment. Chromium and mercury were found in the swamp vegetation at levels greater than 10 ppm and 3000 ppm, respectively (Simmons et al. 1985; DOE 1987). However, the swamp water and sediments have not been transported offsite.

Material in the basins was pumped into Upper Three Runs Creek on two occasions: once in 1955 and once in 1965. In 1969 and 1970, this basin received etching solution wastes (Odum et al. 1987).

Savannah River Laboratory Seepage Basins. The Savannah River Laboratory seepage basins consist of four earthen basins. Two have received waste since July 1954, one was added in 1958, and one was added in 1960. All of the basins were inactive in October 1982. Most of the waste was laboratory waste, which was pH adjusted before release to the basins. The basins received low-level waste generated in laboratories in 735-A and 773-A. Pipes transferred wastes from building drains to underground tanks. The liquid waste was sampled for radioactivity, and if the levels were sufficiently low, it was discharged to the basin (Looney et al. 1987; Fowler et al. 1987).

Soil cores suggest that relatively small, 10–350 kg amounts of chromium, mercury, manganese, uranium, arsenic, and nitrates have been released to the basin. Christensen and Gorden (1983) suggested that chlorinated solvents were disposed of through drains leading to the basins, but later reports with more detailed history of laboratory practices suggest that significant amounts of chlorinated organics were not sent to the basins. Estimates of solvent release also included freons, which Fowler et al. (1987) said were “improperly assumed to be solvents such as trichloroethylene.” Fowler et al. believed former estimates of solvent discharged mistakenly included other materials and were overestimates. Fowler et al. came to this conclusion after investigating historical handling practices, which involved evaluating disposal records, reviewing waste handling procedures for the SRL, interviewing SRL staff, and assessing data in previous documents used in making various estimates. Most of the solvent used was trichloroethylene in the fabrication laboratory. None of the metals would have been expected to have been released to the air from the seepage basin (Fowler et al. 1992; DOE 1992).

Metals Burning Pit and Miscellaneous Chemical Basin. The metals burning pit and miscellaneous chemical basins were located 1.5 mi south of A-Area and M-Area, 3 mi east of the SRS boundary. The basins were used for liquid wastes from 1956–1974. There are no records of the materials disposed of at this site, but volatile organics have been found in the soil (Arnett

1993; DOE 1987). Some information was compiled for reports about the impact and cost of closure (Muska and Pickett 1985). The Metals Burning Pit was in service from 1960–1974. The pit was used to burn waste and scrap from A-Area and M-Area operations. The waste in the pit consisted mainly of solid lithium and aluminum waste materials generated by the metal finishing operations in M-Area (Muska and Pickett 1985). Metals, especially lithium and aluminum, and chlorinated solvents were the contaminants of concern for cleanup of these areas (Westinghouse 1992). It is thought that barrels of waste solvents, primarily tetrachloroethylene, were emptied at the basin then the empty containers were disposed of in the pit (DOE 1987). The metals and other waste deposited in the pit were burned periodically. In addition, miscellaneous chemical wastes were placed in a small 6 × 6-m basin within the metals burning pit area. The pit was backfilled and graded in 1974. No inorganic chemicals or metals have been detected in monitoring wells, but trichloroethylene has been found at relatively low levels in two of the wells (Muska and Pickett 1985). Soil gas analysis indicated that high levels of organic solvents were present and trichloroethylene was detected in the groundwater (Westinghouse 1989). Trichloroethylene and tetrachloroethylene and a breakdown product, 1,2,-dichloroethylene, have been detected in soil (DOE 1987).

716-A Motor Shop Seepage Basin. The 716-A Motor Shop seepage basin was used from 1977 to 1983 for the disposal of oils, degreasers, and miscellaneous waste. Solvents and metals are present in the basin soil (Westinghouse 1992).

D-Area Oil Seepage Basin. The D-Area oil seepage basin operated from 1952 until 1975. In 1973, when the plant stopped open burning in a number of areas around the Site, the waste going to the basin increased. Numerous 55-gal drums were believed to have been disposed of in the basin (Westinghouse 1992).

Huber et al. (1987) stated that the D-Area waste oil seepage basin accepted things that could not be burned by the powerhouse. We can assume this may have included halogenated compounds and polychlorinated biphenyl-contaminated oils during the time period 1952–1975. In 1975, the basin was backfilled (Westinghouse 1992).

F-Area and H-Area Retention Basins. The F-Area and H-Area retention basins were used from 1955 to 1973. These were open, unlined basins for emergency storage of contaminated cooling water. Only trace quantities of chemicals were thought to have been discharged to the basins (Westinghouse 1992).

G-Area Oil Seepage Basin. The G-Area oil seepage basin took liquid wastes from 1951 to sometime in the 1960s. The exact dates of operations and the nature of the liquids disposed of are unknown. Lead, chromium, chlordane, and solvents have been detected in basin soil and sediment (Westinghouse 1992).

L-Area Oil and Chemical Basin. The L-Area oil and chemical basin was used to dispose of oils and small volumes of other, miscellaneous liquid wastes from 1961 to 1979. Metals, trichloroethylene, and tetrachloroethylene have been found in the basin soils (Westinghouse 1992).

Based on groundwater and sludge and soil concentrations, Looney et al. (1987) estimated that 3 kg of cadmium, 500 kg of chromium, 50 kg of lead, 0.3 kg of mercury, 28 kg of nickel, and 1.4 kg of tetrachloroethylene had been discharged to the basin.

Road A Chemical Basin. Road A chemical basin soils contained trichloroethylene and perchloroethylene. The dates of operation and wastes disposed of were not recorded. This basin

was closed and backfilled in 1973 (Westinghouse 1992). Looney et al. (1987) estimated that about 14 kg of lead has been discharged to the basin.

Acid/Caustic Retention Basins. The acid/caustic retention basins were constructed in the early and mid-1950s in F-Area, H-Area, K-Area, L-Area, P-Area, and R-Area. They are unlined earthen pits that received dilute sulfuric acid and sodium hydroxide solutions used to regenerate ion-exchange units used in the water purification processes for the reactors and separations areas. In addition, steam condensate and runoff from spill containment areas were discharged to these basins. The basins in R-Area and L-Area were closed in the 1960s. Basins in the other areas were used into the 1980s. The basins were taken out of service in 1982 and replaced with neutralization systems. Groundwater contamination under these basins suggests that metals and halogens were also discharged to the basins (DOE 1987).

New TNX Seepage Basin. The new TNX seepage basin has been used to dispose of waste solutions containing chromium, lead, and a large amount of nitrate (Looney et al. 1987).
Ford Building Seepage Basin. The Ford Building seepage basin was constructed in 1964. It received wastewater containing surfactants, oils, and grease from many different sources. Levels of chromium, nickel, and solvents below the drinking water standards were found in groundwater near the basin (DOE 1987).

Metallurgical Laboratory Seepage Basin. The Metallurgical Laboratory seepage basin received wastewater effluent from the Metallurgical Laboratory from 1956 to 1985. Small quantities, usually less than 10 gal d^{-1}, and noncontact cooling water, about 900 gal d^{-1}, were also discharged. The basin was closed and filled in 1992 (Arnett 1993). Based on soil core, groundwater, and process data, Looney et al. (1987) estimated that 4 kg of chromium, 4 kg of lead, 0.05 kg of mercury, and 250 kg of trichloroethane may have been disposed of in this basin over the years.

Other Disposal Pits and Waste Sites

Chemical, Metal, and Pesticide Pits. The Chemical, Metal and Pesticide (CMP) pits were seven trenches, 8 to 10 ft deep, used from 1971–1979 or 1980 (Anonymous 1981; Beckwith 1983). The pits were located on a hill near L-Area, about 7 mi from the nearest plant boundary and about 1200 ft from the nearest surface water outcrop into Pen Branch Creek. Four pits were dedicated for disposal of chemicals, (18G, 18.1G, 18.2G, and 18.3G); two for pesticides (17G and 17.1G); and one for metals (19G). Waste disposal records were kept from 1977 to 1979. No record system was used before 1977, and records of what was disposed of after 1977 were said to be very incomplete (Beckwith 1983). Trichloroethylene, tetrachloroethylene, lithium nitrate, and hydrazine were listed in some of the records (Anonymous 1981). Waste was dumped into the pits by truck. Some of the documentation for remediation (Anonymous 1981) said that, “many containers of chemical wastes were shot by patrol after disposition in pits to absorb chemicals into the soil.” Solvent drums were stacked by dropping them in place and some were said to have been leaking. Pickett et al. (1987) found that little qualitative or quantitative data on the waste disposed of were available. Scott et al. (1987) listed 71 contaminants of potential concern in the pits and concluded that Silvex and toxaphene were the contaminants of greatest concern. Waste disposal records indicate that more than 9550 kg of trichloroethylene and more than 24,100 kg of tetrachloroethylene were buried in the CMP pits. Soil cores taken adjacent to the pits contain 30 ppm tetrachloroethylene and 3 ppm trichloroethylene. Shallow groundwater near the pits

indicates that these solvents have migrated through the soil. However, results of groundwater sampling in the early 1980s suggest that contamination of groundwater by pesticides stored in the pits had not occurred (Beckwith 1983). Yet another document reported that diedrin was detected in groundwater near the pits at concentrations as high as 0.22 μg L^{-1} in 1979 and at a concentration of 0.08 μg L^{-1} in 1981. Lindane and chlordane were detected at low levels in 1981. Details of how this sampling was conducted and pesticides that may have been analyzed for but were not detected are not given (Anonymous 1981). The pits were excavated in 1983 and 1984, and about 75,000 ft^3 of soil was removed, put into drums, and was said, at that time, to be awaiting incineration. The pits then were covered and bermed to protect the soil from rainwater runoff (Beckwith 1983).

DOE (1987) estimated that about 50,000 kg of solvents (most likely tetrachloroethylene, trichloroethylene, and freon) and 50,000 kg of oils were excavated and 250 to 290 kg remained after the removal. Concentrations of DDT, lindane, chlordane, endrin, toxaphene, and methoxychlor were detected in soils excavated from the CMP pits (DOE 1987). There is not enough information on the quantities or disposal practices to estimate how much of these materials could have been released into the air. There is no indication that burial of chemicals at the CMP pits resulted in releases that may have traveled offsite.

Radioactive Waste Burial Ground. Contaminants in the groundwater at the Radioactive Waste Burial Ground include mercury, lead, cadmium, and chlorinated solvents, but the groundwater has not moved offsite (Looney et al. 1987; DOE 1987). Mercury releases from the burial grounds are addressed further in the section on releases of mercury to the air.

Bingham Pump Outage Pits. The Bingham pump outage pits were unlined earthen pits that received equipment removed during the Bingham pump shutdowns in 1957 and 1958 while modifications were made to the reactor's primary and secondary cooling systems. One pit was located in K-Area, one in P-Area, two in L-Area, and three in R-Area (Westinghouse 1992).

Silverton Road Waste Site. The Silverton Road waste site received drums, tanks, and metal shavings. In 1987, estimates of disposal amounts included 14 kg of lead, 5 kg of tetrachloroethylene, and 42 kg of trichloroethylene (Looney et al. 1987). The site was closed in 1974 (DOE 1987). In 1983, the groundwater at the Silverton Road site was found to contain measurable concentrations of chromium, manganese, lead, zinc, nitrates, and chlorinated organics (Ziegler et al. 1985).

Tank 16. Tank 16 in the H-Area High Level Waste tank farm developed a below ground leak that overflowed subsurface containment structures. Liquid waste containing mercury, chromium, and lead leaked from the tank. The quantities of these metals in the soil were said to be relatively small and radioactivity was the primary concern (Westinghouse 1992).

Hydrofluoric Acid Spill Area. The hydrofluoric acid spill area is located in the southwest part of the Central Shops Area. It is uncertain whether acid was spilled or if acid-contaminated soil or acid-filled containers were buried at the site. The spill or disposal occurred sometime before 1970. Records and interviews with former and current employees regarding the history of this waste unit, conducted for the remedial investigation, were said to have been inconclusive (Westinghouse 1992). Fluoride and lead have been found in the groundwater (Huber and Bledsoe 1987; Looney et al. 1987).

M-Area West. M-Area West consists of two small areas where empty drums were found. Markings on the drums indicated they once contained chlorinated solvents and were about 30 years old (Westinghouse 1992).

TNX Burying Ground. The TNX Burying Ground was used for material contaminated or damaged during the 1953 evaporator explosion. Nitrates and uranyl nitrate were contaminants of concern for this area (Westinghouse 1992).

Burning Rubble Pits. The burning rubble pits are described in more detail in the Chapter 17 section discussing incineration and burning.

SRL Oil Test Site. The SRL oil test site disposed of paint thinner, hydraulic fluid, and waste-cutting contaminated with heavy metals (Looney et al. 1987).

Chemical Treatment of Water

Well water and Savannah River water has been treated before use for cooling water, drinking water, and other uses. The water is subject to sedimentation, filtration, and pH adjustment. In D-Area, precipitates from the sedimentation process and filter backwash was pumped to the D-Area ash basin. In the 1980s, drinking water was treated with polyphosphate and chlorinated. Of more concern for chemical releases was the chromium, biocides, and other chemicals added to very large quantities of cooling and process water. Process and cooling water for the reactor areas was pumped from the river into the 186-Basin reservoirs. Water to be used for processes and cooling was chlorinated, and water used for the boilers in the powerhouses was demineralized. The demineralized regenerants were neutralized and discharged to the ash basin. All domestic well water was chlorinated and in some areas it was also degassed and pH adjusted. M-Area used a granular activated carbon filter to adsorb chlorinated organics from the groundwater before its use (DOE 1987).

Corrosion inhibiting chemicals, water treatment chemicals, and biocides were added to maintain chemistry control of plant water and to prevent corrosion and proliferation of algae and bacteria in cooling systems. Most of the water flowing down the creeks was pumped from the Savannah River and treated with alum and lime as flocculants, chlorine as a biocide, sodium sulfite, and phosphates; used for cooling or process water; and then discharged. An essential materials listing for water treatment chemicals estimated the monthly consumption from 1951 to September 1954, characterized by area. The specifications for purchasing were also given in this document (Du Pont 1954). Alum, hydrate lime, slaked lime, sulfuric acid, 50% caustic, clay, sodium sulfite, trisodium phosphate, chlorine, tannin, and sodium silicate were listed. For example, reported values for chlorine are summarized in Table 15-2. This suggests that a total of about 120 ton mo^{-1} of chlorine was used in 1954, more than 80% of this for water clarification in the reactor areas (Du Pont 1954).

The only water treatment chemical to come out of the ranking described in Chapter 16 was chromium, which is carcinogenic. The air emissions inventory included cooling tower drift emission estimates for chromium for the 185-K towers for 1985–1990. These estimates were made using groundwater quality data and EPA's AP-42 emission factor for drift loss as a function of cooling water circulation rate. Adequate records on cooling water flows were not available, so cooling water requirements of similar systems were reportedly used.

Table 15-2. Chlorine Use for Water Treatment in 1954

Area	ppm in water	Ton mo^{-1} range	Ton mo^{-1}average	Use
A	20,000		2.7	Cooling tower
A	500	0.09–0.18	0.13	Domestic
D	60,000	5.4–10.8	8.1	River water
D	18,500		2.5	Cooling tower
D	500	0.09–0.18	0.13	Domestic
RPLKC	80,000	43–144	100	Clarification
RPLKC	27,500		3.7	Cooling tower
RPLKC	500	0.09–0.18	0.13	Domestic
FH	3,500	0.31–0.63	.47	Clarification
FH	15,000		2.03	Cooling tower
FH	500	0.09–0.18	0.13	Domestic

Accidental Releases of Chemicals

RAC reviewed documentation on spills, explosions, and fires. The accidental releases involving the chemicals of concern are summarized in the section for each chemical in Chapters 17 and 18.

Explosions and Fires

The presence of an organic material with nitric acid at high temperature can result in a rapid exothermic nitration of the organic material, which is a reaction called a red-oil explosion. Two such explosions have occurred at the SRS. In 1975, a chemical explosion and fire occurred in the A-Line of F-Area, a result of the contamination of uranyl nitrate solution with process solvent (tri butylphosphate). Reports indicate that no contamination was spread outside the fenced A-Line facility (Bebbington 1990; McKibben 1976). On January 12, 1953, an explosive chemical reaction occurred in evaporator building 678-G in the CMX Area. Uranium dust was a worker safety concern (Du Pont 1971). These accidents were described in detail in Durant (1983).

The 200-F and H-Area have sustained about 500 fires, many of which are described in safety analysis reports or incident reports. Solvent fires and red-oil explosions caused by the nitration of extraction solvent were two of the industrial hazards addressed in the separations area safety analysis reports (Fisk and Durant 1987).

Chemical Spills

In addition to routine releases during processing, chemicals have been released to the environment because of inadvertent leaks, transfer errors, spills, overflows, and uncontrolled reactions. We reviewed records of spills involving chemicals of concern and the amounts released were included in the source term estimates. Since the mid-1980s, any spills of toxic materials must be reported to the EPA and the State of South Carolina. In the 1970s, many of the spills were reported in the fault tree databanks. A number of minor spills involving relatively small quantities are compiled in annual reports, monthly reports, and fault tree databank records. For

example, there have been 23 transfer errors reported in the H-Area outside facilities since 1962. Most of the spills reported in the 1970s and 1980s involved fuel oil, sodium hydroxide, and acids used in bulk quantities, usually involving loss to seepage basins when valves were accidentally left open. The Fault Tree Data Storage and Retrieval System lists incidents, occurrences, failures, maintenance problems, etc. (McCulloch 1980). It appears that most of the leaks, spills, and accidents reports resulted in contamination in buildings rather than release to Site streams. There was mention of leaks to sidewalks and ground, but they all involved radionuclides. Reporting of chemical spills before 1980 was uncommon. Inadvertent additions of materials to seepage basins were usually reported in monthly reports for the separations areas. When a leak in a solvent tank or a spill during transfer of a chemical occurred, often the name of the chemical was not reported and the amount released was not mentioned. Only the amount of radioactivity released was reported, which is an example of the concern over radionuclides and lack of concern about reporting chemical releases.

In the 1980s and 1990s, spill incidents and their containment and cleanup had to be reported to the EPA and State. We reviewed the documentation for these reports, and Chapter 18 summarizes information on spills of chromium-treated water, mercury, sulfuric acid and hydrogen sulfide, and chlorinated solvents. Most of the spills influenced surface water. Some of the more notable spills and leaks are described in the section on chemical releases to surface water. The end of Chapter 18 summarizes spills to Beaver Dam Creek, Site-wide oil spills, and fish kills.

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