G.5.6 Review of Severe LOCA Scenario

A loss-of-coolant-accident (LOCA) is defined as a leak of heavy-water coolant from the reactor's primary cooling system. No fuel melting is expected in any probable LOCA. The rate of leakage in a LOCA could range from a trickle at a flange to a major discharge if a large pipeline should experience a rupture. An emergency cooling system (ECS) is provided to add water to the reactor to cool the core in case such a leak occurs. For conservatism, the ECS design provides sufficient flow to cool the core completely for the most severe leak that can be hypothesized. No reasonable mechanism has been identified that can cause a leak of this magnitude. For smaller, more probable leaks, the ECS would supply coolant far in excess of that needed to cool the core.

The heavy water in the SRP reactors gradually builds up small amounts of radioactive tritium from neutron activation. If part of the tritium evaporates, some would mix with the reactor building atmosphere and pass to the environment via the 61-meter exhaust stack. Assuming conservatively that there is 3 percent of heavy water evaporated and that it contains a maximum tritium content, the maxium dose from exposure to tritium to a person at the Plant boundary would be 0.007 rem.

If the ECS were activated, it would flood the reactor cooling system at a rate of up to 53,000 liters per minute, causing the heavy-water primary coolant to be displaced into sumps from which the heavy water would be pumped into two holding tanks that are vented to the reactor building. The first holding tank has a capacity of 225,000 liters and would retain initially all of the displaced heavy water from the reactor. The second holding tank has a capacity of 1.9 million liters. Following an accident, the ECS flow could be reduced gradually as the leak is isolated and the residual decay power in the reactor decreases. If the leak is isolated promptly, as expected in most cases studied, the holding tanks would not be completely filled. Otherwise, the holding tanks might be filled in a few hours. In the unlikely event that the ECS flow would have to continue beyond the time the holding tanks are filled (2.1-million-liter capacity), the water from the reactor would be river water with little or no tritiated heavy water expected. This water would then bypass the holding tanks and flow to the 190-million-liter excavated basin. Some additional tritium release to the atmosphere might occur; it would, however, be very small.

Even if only one of three ECS supply lines functions properly (i.e., if the LOCA occurred in one of the lines and if valves in a second line failed to open), no melting would be expected for the more credible leak rates. For the hypothetical maximum leak rate, it has been estimated that as much as 1 percent of the core might become overheated and possibly melt in the first minutes of an accident while the decay power is high. In the event of such melting, some radioactive fission products--particulates, volatile noble gases and radioiodine--would be released from the fuel and swept along with the ECS flow. The particulates and soluble radioiodine would be carried to the holding tanks where they would be confined. Noble gases and volatile radioiodine would tend to enter the building or confinement tank and pass into the confinement filter system. More than 99 percent of the radioiodine would be absorbed on the carbon beds provided for that purpose. However, noble gases would be released to the environment. The estimated radiation exposure to the maximum individual at the plant boundary would be approximately 0.1 rem whole body and 0.5 rem to the thyroid.

As noted above, if ECS flow continues beyond the time at which the 2.1-million-liter tanks are filled, any additional discharge would bypass the holding tanks and enter directly into the 190-million-liter basin. Because possible melting and fission-product release would have occurred early in such a transient, river water entering the earthen basin after the holding tanks were filled would have passed through a well-cooled and well-flushed core. That river water would be expected to carry only a minimal quantity of fission products and other contamination into the earthen basin. No additional risk is attributed to this accident because the metallic fuels used in SRP reactors will resolidify when cooling is restored; there is an extremely low probability of delayed core damage after the ECS flow has been established and the confinement tanks have been filled.

Therefore, no radioactive material, except some tritiated moderator, would be released as a result of any expected LOCA (no melting occurs). For the more severe hypothetical and improbable case of a 1-percent core heatup and melt following a LOCA, most fission products, except noble gases and small amounts of tritium and radioiodine, which could escape from the core, would be contained within the reactor building and the holding tanks.

While there has never been a major accident to challenge the confinement system, the system was developed on the basis of a comprehensive experimental program. Routine performance tests of the confinement system are conducted regularly. Furthermore, when a source rod melt at one of the SRP reactors did challenge the major features of the system in 1969, it responded perfectly. The system is always on line (i.e., ventilation air is continuously drawn through the filters by three fans powered by two independent motors with automatic backup power supplies). Only one operating fan is required.

The confinement system ventilation air first passes through demisters that remove any water droplets, allowing the HEPA and carbon filters to operate at maximum efficiency. The effect of radioiodine overloading causing carbon to overheat has been studied extensively. Even for a maximum loading associated with a theoretical 100-percent core meltdown, the air flow from a single fan is sufficient to keep the carbon from overheating. For the postulated worst hypothetical accident of a 3-percent core melt, the margin on overheating would be much larger.

Because carbon is less effective in absorbing and retaining organic iodide compounds compared to elemental iodine, SRP has developed special impregnants for the carbon used in the confinement system. These impregnants improve the capacity of the system both to absorb and to retain organic iodide. Furthermore, the nuclear power industry is developing a considerable body of evidence that radioiodine released from fuel elements would be largely in nonvolatile forms that would stay dissolved in water or tend to remain inside the reactor vessel and the reactor building. Because of these phenomena, little volatile radioiodine was released to the reactor building during the TMI-2 accident. The Savannah River Laboratory is engaged in a research program to quantify these effects. The conclusion is that no mechanism exists by which a large portion of the iodine would be converted instantaneously to organic compounds in an accident; the effect of organic radioiodine release through the confinement system is not a significant dose factor. |TE

The potential for steam or hydrogen explosions in an accident has been analyzed; the impact of such explosions on the confinement system has been assessed. For more credible accidents, the amount of fuel damage is so small as to preclude the potential for such explosions. For the more severe hypothetical accidents, the confinement system has the capacity to accommodate the hypothetical gas or energy releases. If hydrogen were formed during an accident, it would be swept from the building by the high ventilation flow of the confinement system before explosive hydrogen concentrations could be reached. This sweepout is in contrast to a closed containment where a buildup of hydrogen gas could threaten the containment integrity in certain hypothesized accidents. The nuclear industry is considering how to deal with this threat. One option being considered, and already adopted in Sweden, is a filtered, vented containment incorporating many of the features of the SRP confinement system.

G.5.7 Improbability of fission product release

As discussed in previous sections, release of fission products to the environment would first require an initiating event to challenge the physical barriers and safety systems provided to prevent such a release, and then a breakdown or failure of these barriers and systems. Such a sequence is improbable. Although probability values are not precisely known for the rare events being considered here, estimates can be made for illustration. Several sequences using estimated or bounding probability values are discussed in this section for two of the accidents analyzed in Section G.4.1. A more complete probabilistic risk assessment study of the entire spectrum of accidents is under way.

G.5.7.1 Hypothetical D_2O pipe break

An abrupt double-ended break of a major D_2O pipe is discussed in Section G.4.1.17. It is not considered to be a credible accident because an abrupt catastrophic failure that allows unimpeded leakage from both sections of pipe is believed to be impossible with stainless steel pipe. However, the frequency of some type of large pipe failure has been previously estimated at 1×10^{-4} to 1×10^{-5} per reactor year. The log mean of this range, 3×10^{-5}, is assumed to be the upper bound of probability of the maximum possible pipe break, which is the initiating event of the sequence shown in Figure G-4. This event challenges the shutdown systems, the Emergency Cooling System (ECS), and possibly the Airborne Activity Confinement System (AACS). The shutdown systems have a very high probability of working, and are excluded as a failure mode in the sequence shown in Figure G-4. The ECS has a high probability of working, which leads to the most probable and least harmful outcome of the sequence, namely, a moderator tritium release, but no fission product release. But the ECS can experience partial or total failure; analysis of ECS failure modes lead to the probabilities shown in Figure G-4. These failure modes lead to less probable but larger releases of fission products. For total failure of ECS, the AACS is

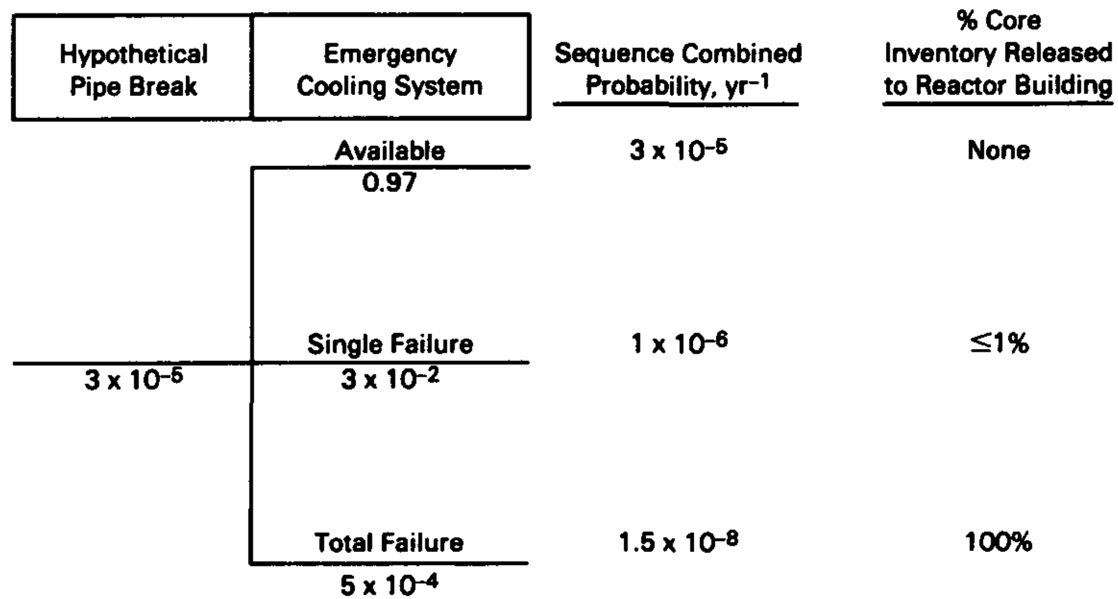

Figure G-4. Illustrative sequence of hypothetical double-ended D_2O pipe break.

protected by the Confinement Heat Removal System (CHRS). A probability of failure of 0.5 is assumed for this illustration. The probability of outcomes that lead to larger releases of fission products is extremely small, as shown in Figure G-4.

G.5.7.2 Control rod withdrawal accident

The control rod withdrawal accidents are discussed in Section G.4.1.3. These accidents challenge the shutdown systems and possibly the AACS. The gang rod withdrawal is more challenging but less probable, and the sequence is illustrated in Figure G-5. No such event has occurred in over 115 reactor-years of operation, and this establishes an upper bound of an occurrence, with 95-percent confidence, of 3×10^{-2} per reactor year. The safety rod scram system and the automatic backup shutdown system (ABS-S/C) have a high probability of working, and success of either one leads to an outcome with negligible fission product release. Failure of both systems would lead to an undefined amount of core melting, damage to the reactor structure, and ejection of steam into the process room. Even so, there is a good, but undefined, probability that the AACS would contain most of the iodine (but release noble gases and tritium). The probability of significant or large fission product release is very small, as shown in Figure G-5.

G.5.7.3 Total risk from all postulated reactor accidents

To provide a perspective on the overall accident risk of L-Reactor operation, Figure G-6 is a preliminary total probability curve that presents the annual probability of a resident living at the SRP site boundary receiving more than a certain dose from postulated accidents. These results are based on accident analyses presented in the Safety Analysis Report (Du Pont, 1983a), including less severe accidents at the high end of the probability spectrum and an assumed hypothetical 100-percent core melt at the upper bound of the consequences spectrum. Six different accident initiators were considered. For all the accidents, the most probable outcome is no reactor damage. For the six accidents, only 11 postulated, but highly improbable, sequences resulted in significant amounts of reactor core damage (ranging from 1 percent to 100 percent). These accident sequences were as follows: EN-27

1. A loss-of-coolant accident with only one operable ECS.

2. A loss-of-coolant accident with a total failure of the ECS.

3. The withdrawal of a single control rod or a gang of control rods with a failure of both the safety-rod scram and the ABS-SC.

4. Loss of coolant to a single target assembly with a failure of both the safety-rod scram and the ABS-SC.

5. A loss-of-pumping accident with only one operable ECS.

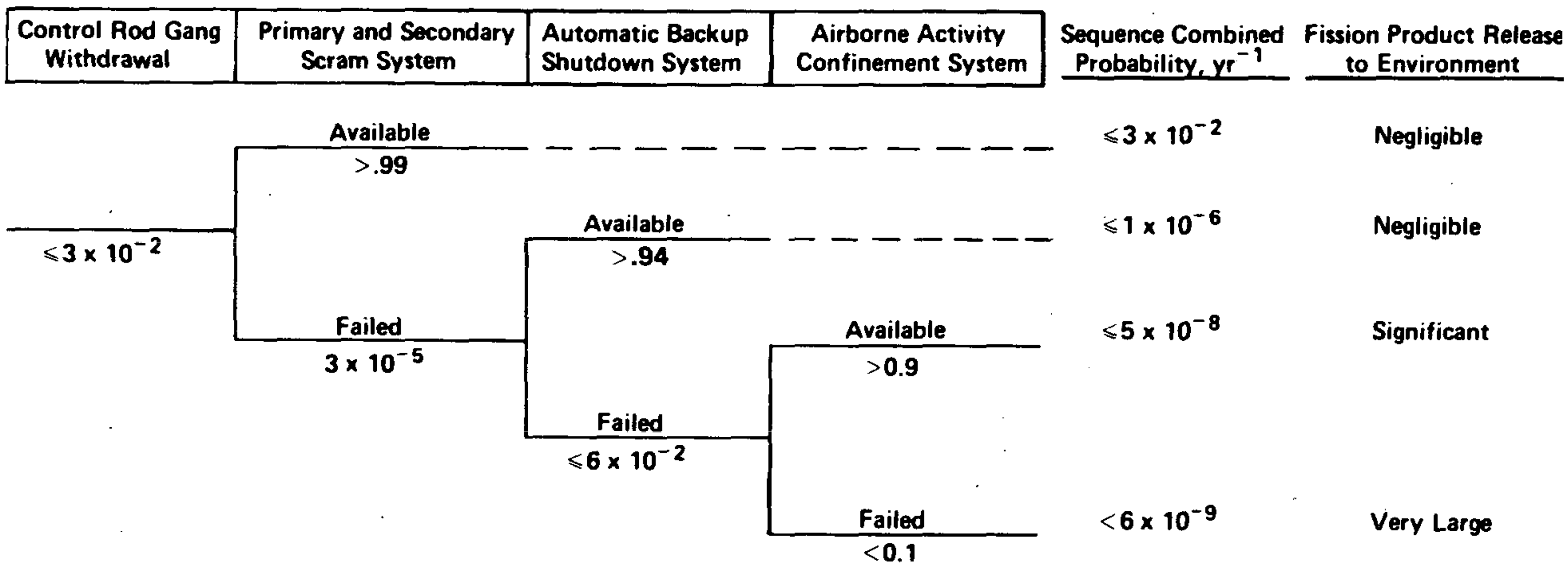

Figure G-5. Illustrative sequence of control rod withdrawal accidents

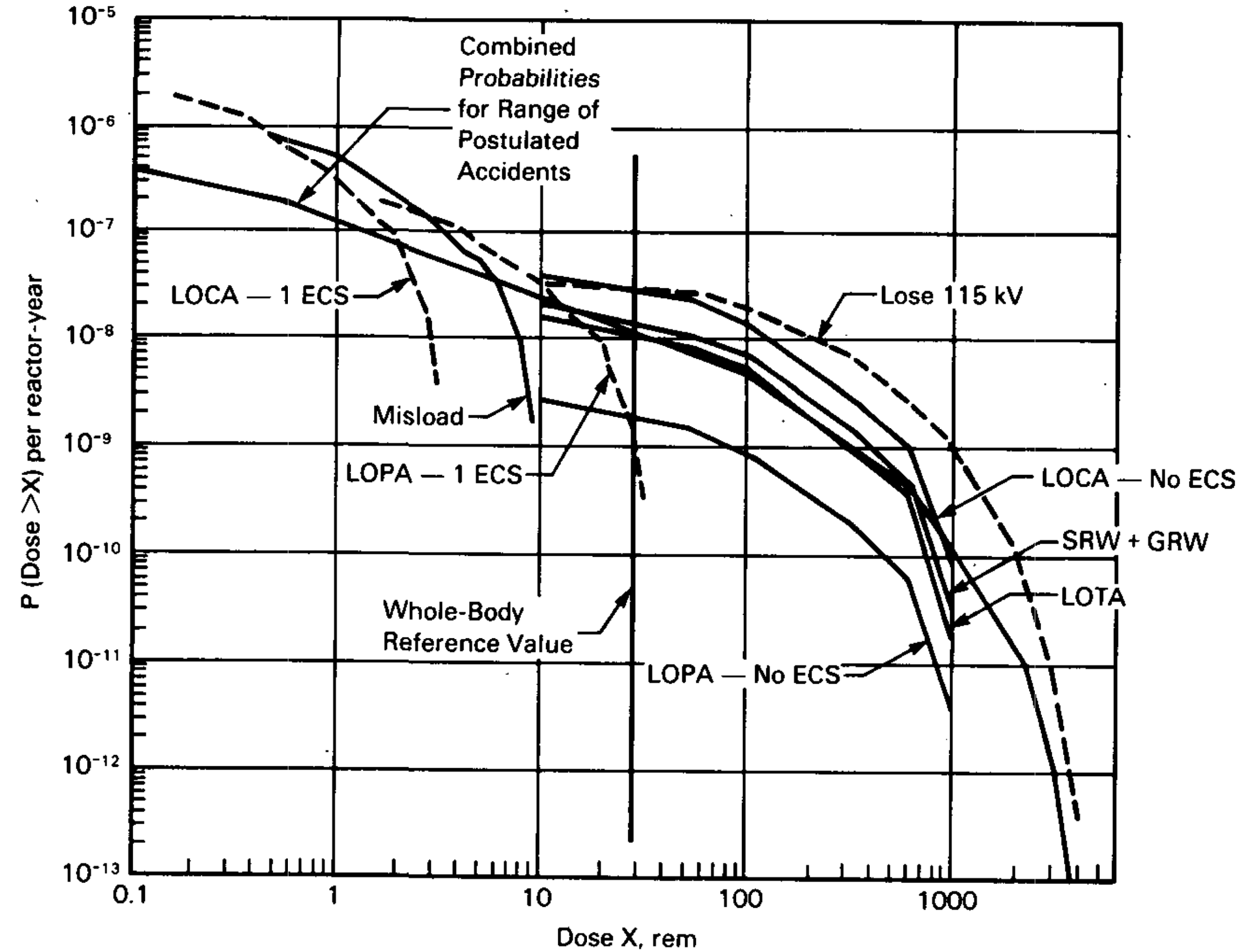

Figure G-6. Total probability (P) per reactor year that the whole body dose to a person on the plant boundary will exceed a specified value, X rem.

6. A loss-of-pumping accident with a total failure of the ECS.

7. A reloading error during charge/discharge operations making the reactor supercritical.

8-11. Extended total loss of offsite (commercial) power together with extended loss of onsite generating capability. This sequence affects all reactors and is postulated to result in core damage to 1, 2, 3, or 4 reactors.

The computed offsite doses for the loss-of-coolant accident with 1 percent core damage and the reloading error with 3-percent core damage are listed in Table G-8 for median meteorology (conditions for which the more severe meteorological conditions are not exceeded 50 percent of the time). The relative doses for other meteorological frequencies are shown in Figure G-7. Doses for postulated core damage of 10 and 100 percent are, respectively, 10 and 100 times the dose for 1-percent damage.

N-27 The probability of occurrence of an accident sequence was combined with the data for meteorological probability versus offsite dose for each of the above 11 sequences. Then, for a given dose rate, the occurrence probabilities were combined to obtain an overall probability per reactor-year of exceeding a given dose. This overall dose probability curve is shown in Figure G-6. The results are consistent with (1) the decreasing frequency of meteorological conditions that give higher doses for any accident (Figure G-7), and (2) the extremely low probability of accidents occurring with core damage exceeding 3 percent.

The implementation of reactor safety programs has reduced the probability of occurrence of accidents to extremely low levels. Figure G-6 indicates that the probability of exceeding the Nuclear Regulatory Commission site whole body dose criteria for commercial power reactors (10 CFR 100) of 25 rem at the site boundary in accident situations is extremely low (less than 10^{-7} per year), even in the most severe hypothetical accidents.

The traditional approach to SRP reactor safety analysis addressed the consequences for "worst case credible" (and even some "noncredible") accidents based on the single failure criterion. This criterion assumes that the initial accident is compounded by the failure of the single most important active component designed to mitigate the accident. (An active component is one that must change its state to perform its duty; e.g., a valve must be realigned, etc.) The initiation of the accident and the failure of the component were considered without regard to the actual probability of their occurrence.

Results from the preliminary risk evaluation of the eleven accident sequences discussed above support earlier evaluations, made for worst-case scenarios using single failure criteria, which concluded there is negligible risk to public health and safety.

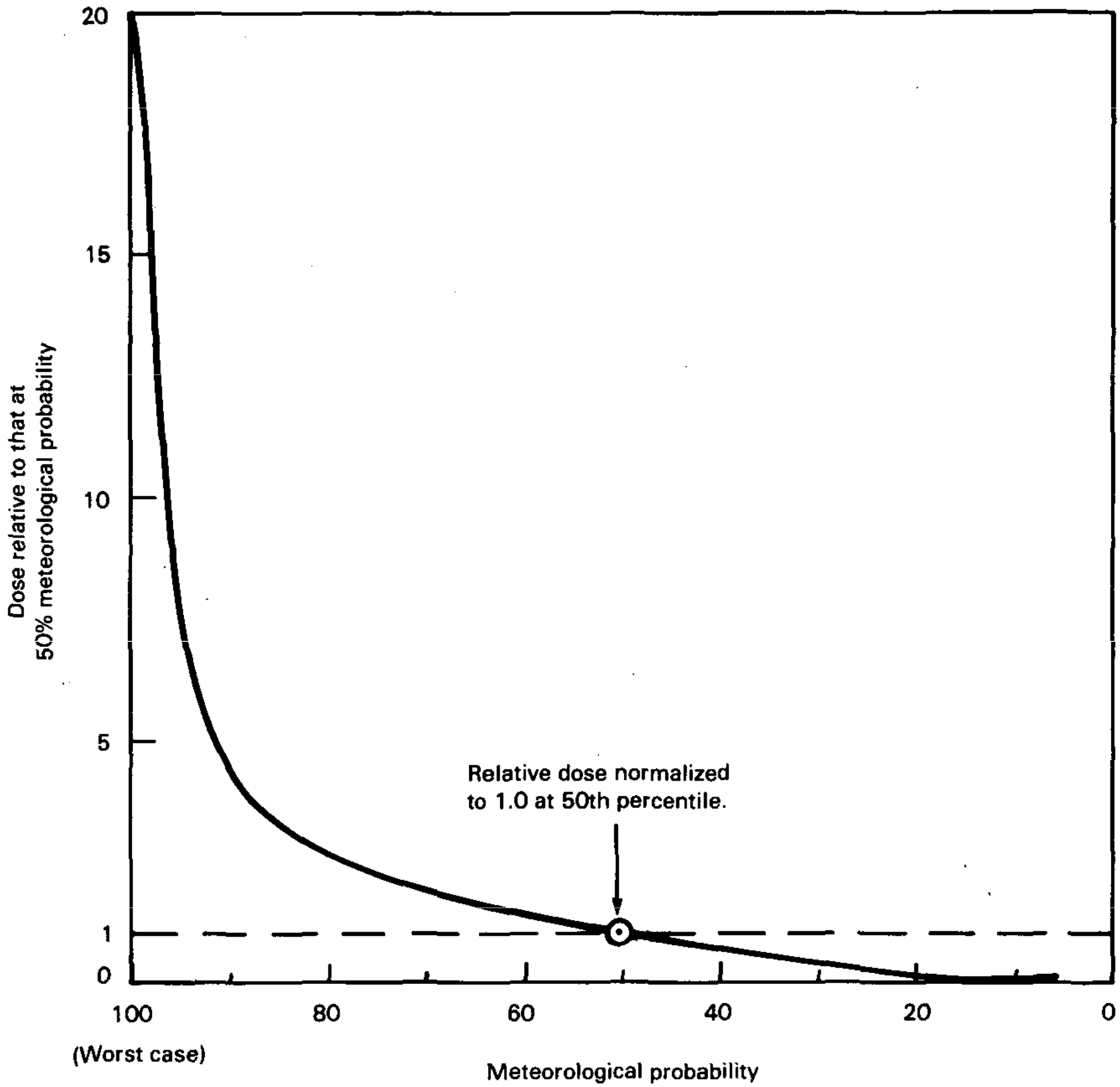

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Figure G-7. Approximate effect of meteorology on boundary dose.

G.6 CONSEQUENCE ANALYSIS FOR A 10-PERCENT CORE MELT

Any accident resulting in damage greater than the maximum calculated for the previously discussed accidents (3-percent core melt) is highly improbable. However, in order to assess the consequences of core-melting for which no reasonable mechanistic scenario can be conceived, a 10-percent melt accident (more than three times as severe as the worst accident previously considered) is postulated. Based on the discussion for the lesser consequence accidents, the probability of a 10-percent core melt would be considerably lower than 10^{-6} per reactor year.

The consequence analysis for a 10-percent core-melt accident has been carried out with the CRAC2 code (Ritchie et al., 1981). This is a revised version of the code CRAC (Calculation of Reactor Accident Consequences) which was developed for use in the Reactor Safety Study (NRC, 1975). The organization of CRAC2 is given in Figure G-8.

This section of the appendix summarizes the input data used for CRAC2 analysis. The results of this analysis are presented in Section 4.2.1.5 and summarized in Table 4-24.

Curies of fission products and actinides released to the atmosphere

The amount (curies) of each radionuclide released to the atmosphere for each accident sequence is obtained by multiplying the release fractions by the amounts that would be present in the core at the time of the hypothetical accident.

For a 10-percent core-melt accident, the release fractions are 0.1 for the noble gases, 5×10^{-6} for the particulates and 1.66×10^{-3} for the iodines. Included in the iodine release fraction is the 120-hour desorption from a 30-month service aged carbon filter bed.

The fission product inventory in any SRP reactor charge varies with the reactor charge, the irradiation history, and the operating power level. For purposes of consistency and conservatism, a 3000-megawatt operating power level and saturation inventory of the important fission gases was used. The inventory values were calculated using the Du Pont SHIELD code (Finch, Chandler, and Church, 1979) for single assemblies of both Mark 16 and Mark 31A in the highest power zone of the reactor at the end of the first subcycle. The specific power was 6 megawatts per assembly for the fuel and 2.88 megawatts per assembly for the target. Three hundred assemblies of each type were assumed to obtain a total power of 2664 megawatts. Individual assembly inventory values were then corrected by the factor (300)(3000)/(2664) to obtain full core inventory values for each assembly type. For all short-lived (half-life less than 45 days) isotopes the values thus obtained are saturation inventory values. For long lived isotopes (half-life greater than 225 days), the SHIELD code values for the fuel tubes were multiplied by 5 to obtain the approximate inventory at the end of 5 subcycles. For isotopes with half lives of between 45 and 225 days, the standard buildup decay equations were used to obtain an equilibrium inventory at the end of 5 subcycles. Since targets are not recycled, no correction is necessary for Mark 31A assemblies.

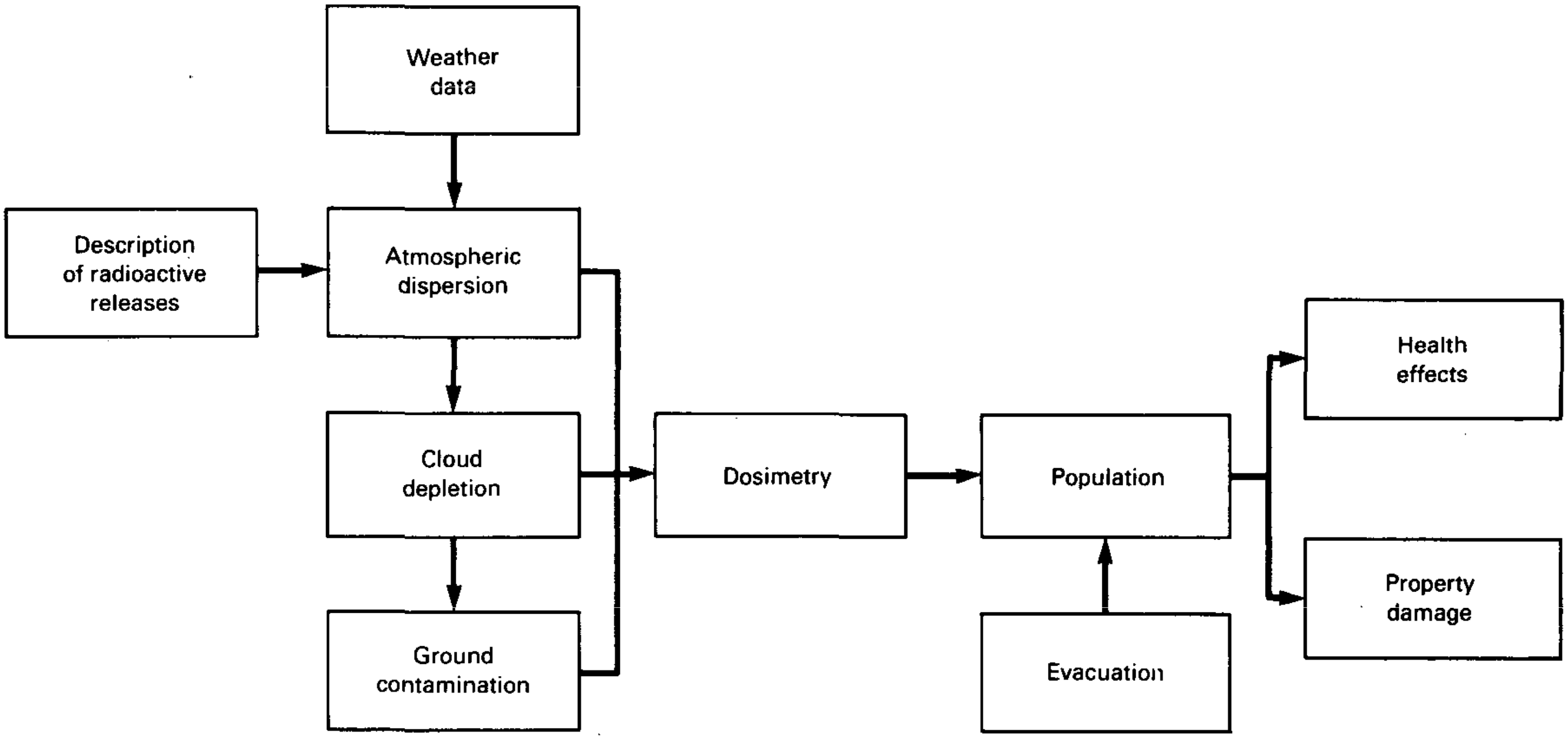

Figure G-8. Schematic outline of consequence model, CRAC2.

The equilibrium isotopic inventory for important radionuclides is tabulated in Table G-10. The radionuclides in this table are the same as those used in the Reactor Safety Study (NRC, 1975). The elimination of radionuclides from consideration in radiation dose calculations was based on a number of parameters, such as quantity (curies), release fractions, radioactive half-life, emitted radiation type and energy, and chemical characteristics.

Meteorological data

The CRAC2 input data file contains a full year of consecutive hourly values of windspeed, wind direction, stability class and precipitation. These were processed from measurements taken at the K-Area meteorological tower during the year 1978. Hourly precipitation data for Augusta, Georgia, was obtained from the National Weather Service. The stability category was determined by using the sigma-theta's from the K-Area meteorological data file.

Prior to sequence selection, the entire year of weather data was sorted into 29 weather categories (termed "bins"), as defined in Table G-11. Each of the 8760 potential sequences was first examined to determine if rain occurs anywhere within 50 kilometers of the accident site. If not, a similar examination was made for wind speed slowdowns. If neither of these conditions occurred, the sequence was categorized by the stability and wind speed at the start of the accident. A probability for each weather bin was estimated from the number of sequences placed in the bin. Sequences were then sampled from each of the bins (with appropriate probabilities) for use in risk calculations, assuring that low probability adverse weather conditions were adequately included (four sequences were selected from each bin in this current analysis). The proposed technique also allowed the use of wind direction statistics for specific weather conditions.

Population distributions

The population distribution around the site has been assigned to a grid consisting of 16 sectors, the first of which is centered on due north, the second on 22-1/2 degrees east of north, and so on. There are also 28 radial intervals as shown in Table G-12, which contains the predicted permanent resident population for the year 2000.

Evacuation modeling and other protective measures

In this assessment, no evacuation and special sheltering measures were assumed.

Other countermeasures

The other protective actions include (1) either complete denial of use (interdiction) or permitting use only at a later time after appropriate decontamination of crops and milk; (2) decontamination of severely contaminated land and property when it is considered to be economically feasible to lower the levels of contamination to protective action guide levels; (3) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels are reduced by radioactive decay and weathering to such a level that decontamination is economically possible as in (2) above.

Table G-10. Equilibrium activity in the reactor core

Group/radionuclide	Radioactive inventory (millions of curies)	Half-life (days)
A. Noble Gases		
Krypton-85	0.23	3,919
Krypton-85m	4.8	0.187
Krypton-87	35	0.0528
Krypton-88	73	0.117
Xenon-133	167	5.29
Xenon-135	20	0.382
B. Iodines		
Iodine-131	74	8.04
Iodine-132	114	0.0952
Iodine-133	174	0.867
Iodine-134	181	0.0365
Iodine-135	164	0.274
C. Alkali metals		
Rubidium-86	0.012	18.7
Cesium-134	0.28	752
Cesium-136	0.44	13.0
Cesium-137	1.9	11,000
D. Tellurium-antimony		
Tellurium-127	3.6	0.390
Tellurium-127m	0.31	109
Tellurium-129	5.3	0.049
Tellurium-129m	4.3	33.4
Tellurium-131m	10.3	1.25
Tellurium-132	113	3.25
Antimony-127	4.1	3.80
Antimony-129	18.8	0.181
E. Akaline earths		
Strontium-89	100	52.0
Strontium-90	0.59	10,260
Strontium-91	136	0.395
Barium-140	145	12.8
F. Cobalt and noble metals		
Cobalt-58	0.0	71.3
Cobalt-60	230	1,921
Molybdenum-99	156	2.75
Technetium-99m	134	0.251
Ruthenium-103	80	39.6
Ruthenium-105	7.8	0.185
Ruthenium-106	4.5	369
Rhodium-105	38	1.48

Table G-10. Equilibrium activity in the reactor core (continued)

Group/radionuclide	Radioactive inventory (millions of curies)	Half-life (days)
G. Rare earths, refractory oxides and transuranics		
Yttrium-90	0.12	2.67
Yttrium-91	118	58.8
Zirconium-95	132	65.5
Zirconium-97	145	0.70
Niobium-95	39	35.1
Lanthanum-140	144	1.68
Cerium-141	135	32.5
Cerium-143	147	1.38
Cerium-144	62	284
Praseodymium-143	132	13.6
Neodymium-147	54	11.0
Neptunium-239	45	2.35
Plutonium-238	0.45	32,510
Plutonium-239	0.022	8.9×10^6
Plutonium-240	0.020	2.5×10^6
Plutonium-241	4.9	5.333
Americium-241	Trace	1.6×10^5
Curium-242	Trace	163
Curium-244	0.25	6,611

Table G-11. One year of SRP meteorological data summarized using CRAC2 weather bin categories

Weather bin[a]	Number of sequences	Percent
1 R (0)	397	4.53
2 R (0-5)	27	.31
3 R (5-10)	86	.98
4 R (10-15)	76	.87
5 R (15-20)	68	.78
6 R (20-25)	58	.66
7 R (25-30)	56	.64
8 S (0-10)	65	.74
9 S (10-15)	46	.53
10 S (15-20)	57	.65
11 S (20-25)	47	.54
12 S (25-30)	50	.57
13 A-C 1,2,3	1609	18.37
14 A-C 4,5	1985	22.66
15 D 1	19	.22
16 D 2	116	1.32
17 D 3	303	3.46
18 D 4	1239	14.14
19 D 5	1016	11.60
20 E 1	8	.09
21 E 2	33	.38
22 E 3	109	1.24
23 E 4	654	7.47
24 E 5	456	5.21
25 F 1	1	.01
26 F 2	0	.00
27 F 3	7	.08
28 F 4	99	1.13
29 F 5	73	.83
30 All	8760	100.0

[a]Weather bin definitions: R = rain starting within indicated interval (miles); S = Slowdown occurring within indicated interval (miles); A-C, D, E, F = stability categories; 1(0-1), 2(1-2), 3(2-3), 4(3-5), 5(GT 5) = wind speed intervals (m/s).

Table G-12. 500 mile population around the Savannah River Plant (year 2000)

Sector (miles)	Direction N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5-6	343	0	0	0	0	0	0	0	0	0	0	0	0	594	166	582
6-7	406	0	0	0	0	0	0	0	0	0	0	0	0	702	196	688
7-8.5	725	0	0	0	0	0	0	0	0	0	0	0	0	1,256	350	1,231
8.5-10	866	0	0	0	0	0	0	0	0	0	0	0	0	1,498	418	1,469
10-12.5	744	248	244	1,296	668	1,339	0	136	191	54	195	0	441	681	681	681
12.5-15	910	303	298	1,584	816	1,636	0	166	234	65	238	0	539	832	832	832
15-17.5	1,075	357	352	1,871	964	1,934	0	196	276	78	282	0	636	983	983	983
17.5-20	1,240	412	406	2,159	1,112	2,231	0	226	319	90	325	0	734	1,134	1,134	1,134
20-25	1,534	1,710	2,606	1,058	6,435	1,750	3,213	344	1,354	1,098	1,328	3,514	4,370	85,500	22,545	5,625
25-30	1,876	2,090	3,184	1,292	7,865	2,140	3,927	421	1,656	1,342	1,622	4,296	5,340	104,500	27,555	6,875
30-35	4,829	2,303	4,425	4,332	3,329	1,490	2,776	263	3,622	3,264	961	984	1,416	53,859	3,608	6,175
35-40	5,571	2,657	5,105	4,998	3,841	1,720	3,204	303	4,178	3,766	1,109	1,136	1,634	62,141	4,162	7,125
40-45	15,960	11,569	9,491	24,696	4,207	2,370	5,241	3,329	2,323	1,454	1,180	35,934	6,186	12,183	746	2,153
45-50	17,840	12,931	10,609	27,604	4,703	2,650	5,859	3,721	2,597	1,626	1,320	40,166	6,914	13,617	834	2,407
50-55	6,597	20,006	7,913	3,363	10,196	13,538	950	4,769	2,663	12,436	1,945	6,746	4,359	4,207	0	3,973
55-60	4,049	83,355	1,801	5,692	7,064	7,942	3,877	5,331	2,012	16,314	2,774	6,732	2,259	15,373	1,843	8,114
60-65	4,469	238,810	12,399	7,452	6,781	3,414	1,963	1,774	7,440	8,319	12,828	1,406	2,161	3,883	4,117	3,513
65-70	7,469	71,605	8,754	2,744	9,262	1,175	14,588	9,772	2,419	2,807	2,032	4,121	808	5,073	7,112	2,160
70-85	28,254	32,443	83,105	26,074	46,641	29,868	49,554	149,261	15,174	18,912	14,431	20,134	8,345	13,548	13,176	63,868
85-100	17,848	15,101	50,275	24,691	73,165	307,548	0	81,166	43,624	18,753	28,273	33,616	30,326	18,03[illegible]	30,880	64,774
100-150	535,167	739,871	242,749	220,574	65,823	17,049	0	0	110,916	130,924	85,650	322,803	155,158	321,599	303,938	627,901
150-200	520,257	569,736	471,232	226,947	0	0	0	0	481,647	94,143	296,543	129,361	661,698	1,997,307	252,347	423,326
200-350	1,544,634	2,353,312	1,898,145	677,017	0	0	0	0	2,992,666	359,816	700,371	1,123,321	1,870,505	1,970,892	1,570,018	1,578,207
350-500	3,981,245	5,776,096	3,376,463	23,776	0	0	0	11,165	5,583,113	461,840	1,343	1,773,316	1,149,501	2,392,794	3,266,522	4,759,461

These actions would reduce the radiological exposure to the people from immediate and/or subsequent use of or living in the contaminated environment. In CRAC2, these protective actions are modeled in the same way as in WASH-1400 (NRC, 1975).

-xposure pathways

The exposure pathways modeled by CRAC2 are the following. First, there is inhalation of radioactive material from the passing cloud. The inhalation dose conversion factors, which relate the curies inhaled to the subsequent radiation dose to various body organs, remain the same as those used in the Reactor Safety Study and are contained in the standard CRAC2 data file. Second, there are cloudshine and groundshine, the irradiation of body organs by gamma rays emitted by the passing cloud or by fission products deposited on the ground. The cloudshine and groundshine dose conversion factors also remain the same as in the Reactor Safety Study and are contained in the CRAC2 data file. Third, there are chronic exposure pathways, which include (1) resuspension of deposited radioactive material by the wind; (2) long-term exposure to gamma rays from deposited fission products, especially cesium, including the effects of weathering; (3) consumption of milk; (4) consumption of milk products; (5) consumption of contaminated vegetation; and (6) consumption of crops contaminated by root uptake. The treatment of these chronic exposure pathways remains precisely the same as in the Reactor Safety Study.

Health effects

In CRAC2, the calculation of the health effects caused by radiation doses delivered to various organs is still handled in virtually the same way as was done in the RSS. The health effects model in CRAC2 is based on the BEIR (1972) report of the National Academy of Sciences.

Economic costs

CRAC2 requires various elements of economic cost. These are generally in the form of a cost per person or a cost per acre, e.g., the cost of evacuating a person or of decontaminating an acre of land. The calculation of many of these costs is described in the Reactor Safety Study, Chapter 12, Appendix VI, where they are presented in 1974 dollars. Some allowance has, therefore, to be made for inflation and the CRAC2 manual contains 1980 values. Table G-13 contains a summary of important parameters. In general, it is three of these that dominate the out-of-plant property damage--the value of residential, business, and public areas; the relocation cost; and the decontamination costs. All other costs, including those for agriculture, are relatively unimportant.

Difference between CRAC and SAR analyses

As mentioned in Section 4.2.1.5, there are several differences between the CRAC2 methodology and those that were used to calculate the doses in Section 4.2.1.4. The most important difference is that CRAC2 considers more radiation dose pathways (e.g., doses from groundshine (from radioactivity deposited on the ground), inhalation of resuspended materials, ingestion of milk, milk products,

Table G-13. Economic input data

Parameter	Value (1980 dollars)	Comment
Decontamination cost for farm areas (for DF of 20)	$499 per acre	From CRAC2 Manual
Decontamination cost for residential, business and public area (for DF of 20)	$3349 per person	From CRAC2 Manual
Compensation rate per year for residential, business and public area	$6305 per person	WASH-1400, Appendix VI, para. 12.4.2.1
Value of residential, business and public areas	$31,527 per person	From CRAC2 Manual
Relocation cost	$4,344 per person	From CRAC2 Manual
Annual cost of milk consumption	$135 per person	From CRAC2 Manual
Annual cost of consumption of non-dairy products	$685 per person	From CRAC2 Manual
Evacuation cost	$165 per person	From CRAC2 Manual

and contaminated vegetation). Sensitivity studies show that these additional pathways could contribute an additional 50 percent of the total dose.

Other differences include the following:

- Meteorological data utilization.
- One-year (CRAC2) versus 5-year (SAR) meteorological data period
- Site boundary distances. In the CRAC2 analysis, the site boundary is defined as a radius of 13.7 kilometers. In Section 4.2.1.4, the actual site boundary is used.
- Iodine desorption rates. In the CRAC2 analysis, a 30-month aged iodine filter was assumed (with a 3.3-percent cumulative desorption; in Section 4.2.1.4, a 19-month aged iodine filter was assumed (with a 1.3-percent cumulative desorption).
- Population distribution. The CRAC2 analysis uses a population distribution for the year 2000; Section 4.2.1.4 uses the population distribution for 1980. Furthermore, the population distribution in the CRAC2 analysis extends to 800 kilometers rather than the 80-kilometer distribution used in Section 4.2.1.4.

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APPENDIX H

OFFSITE EMERGENCY PLANNING

H.1 INTRODUCTION

The comprehensive emergency preparedness planning effort for the Savannah River Plant (SRP) and its environs includes the development and maintenance of programs and plans at four levels of responsibility: (1) U.S. Department of Energy - Savannah River Operations Office (DOE-SR) Emergency Management Plans (DOE, 1983a-k); (2) Site-specific Contractor Response Plans (Du Pont, 1981); (3) State Emergency Plans (EPD, 1978; EPD draft; GDOD, 1978); and (4) County Emergency Plans (AEPA, 1982; ACCD, 1982). The basis for the SRP Emergency Response Program is the:

- Development of responsible organizations
- Delineation of procedures
- Identification of facilities
- Development of communications systems
- Commitment of resources
- Training of personnel
- Coordination with other agencies

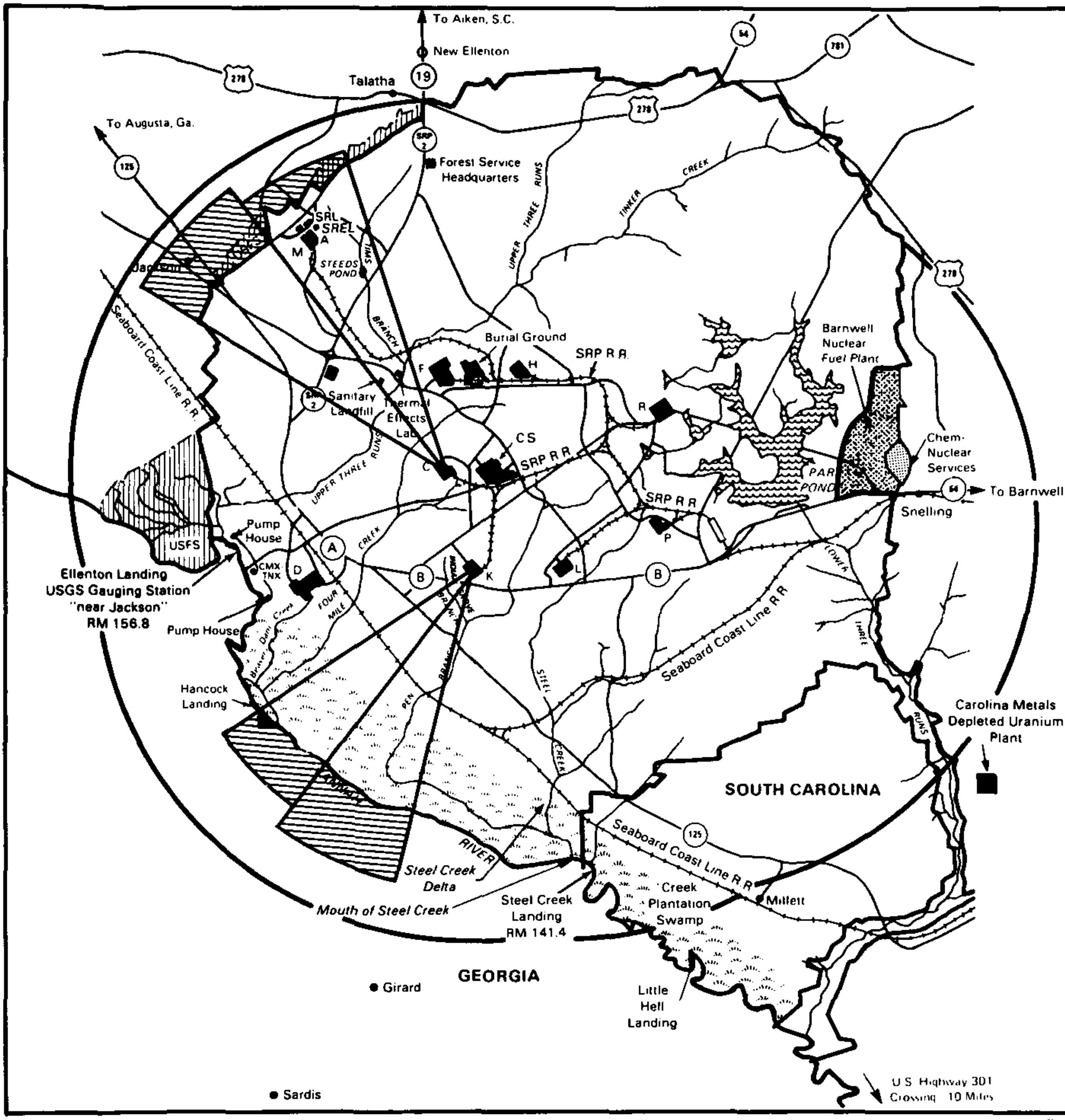
DOE-SR Emergency Management Plans provide the basis for responses by Department of Energy management to incidents on the Savannah River Plant site, and when necessary, for interfaces with offsite organizations. Site-specific Contractor Response Plans are developed by E. I. du Pont de Nemours and Company, Inc. (Du Pont), the Department of Energy's operating contractor, in accordance with the Emergency Management Plans to implement responses to unusual incidents at the SRP. State Emergency Plans are used by South Carolina and Georgia state governments to respond to all types of emergencies within the states. They include specialized radiological emergency response plans. County plans further implement site-specific response actions defined in state plans.

The definition of a SRP Emergency Planning Zone (EPZ) is required by DOE Order 5500.3 (DOE, 1981e) relative to the evaluation of a worst credible accident. DOE-SR has bounded this accident as having a probability of occurrence equal to or greater than 10^{-6} per year for the site (Du Pont, 1983). Use of the probability of 10^{-6} per reactor-year as a threshold for reactor accidents has no absolute statistical basis, but it is consistent with normal practice in the nuclear power industry. The concept, used in this way, states that beyond this threshold, judgmentally, it is reasonable to regard the probability of an accident to be effectively zero, even though it might be unprovable, in a strictly physical sense, that the accident cannot occur. For example, this value can be derived from both an American National Standards Institute (ANSI) standard and the U.S. Nuclear Regulatory Commission Standard Review Plan. ANSI/ANS-212-1978, Appendix B, uses the value of 10^{-6} per site per year as a cutoff probability, below which combinations of events leading to accidents need not be considered for design purposes. The cutoff value does not include the probability of the consequences exceeding 10 CFR 100 dose guidelines, which is included in the NRC Standard Review Plan (NUREG-0800) acceptance criteria of 10^{-7} per year. The use of the 10^{-6} per site per year value in the ANSI standard for accident probability is consistent with the NRC Standard Review Plan's value TC

of 10^{-7} per site per year for accident plus consequence probability because the probability of the consequences exceeding 10 CFR 100 dose guidelines following an accident are conservatively estimated to be less than 10^{-1}. The SRP use of the 10^{-6} threshold is not for a so-called "uncontrolled" release, but
TC for separating "treated-as-credible" from "treated-as-noncredible" accidents. Even with estimates of accident probabilities beyond the 10^{-6} per reactor-year threshold, radioactive releases are limited by performance of the reactor confinement system; they are not uncontrolled releases to the environment. The zone boundary is defined by calculated doses that exceed potential dose levels above 5 rem total body or 25 rem to an individual organ (EPA, 1975). A review of the fuels separation facilities Safety Analysis Reports (SAR) revealed that site boundary doses for the spectrum of postulated process accidents were all far below the 5 rem whole-body and 25 rem individual-organ criteria. A spectrum of events including fire, criticality, equipment failures, and natural disasters was considered. The maximum dose calculated at the SRP boundary from any of these incidents was about 0.12 rem to the whole body and about 8.5 rem to the lung from uranium.

For the reactors, the worst accident for which it has been possible to assign a credible mechanism is a reloading accident, in which a series of faults and errors lead to a double target vacancy at the periphery of the reactor, causing a criticality. The probability of this accident ranges from 1.6 x 10^{-5} to about 1.6 x 10^{-6} per site-year, depending on whether credit is taken for
TC protection provided by the recently installed charge/discharge computer system (discussed in Section 4.2.1.4); the consequence is that about 3 percent of the reactor core would melt. The release from the melted fuel assemblies is conservatively estimated to be equivalent to about 3 percent of the equilibrium fission product inventory of an operating reactor. This accident, evaluated for each reactor, is the bounding case for establishing the EPZ. The doses from this accident were calculated for each 22.5° sector around each reactor, and isodose boundaries were drawn. The calculations were performed in a manner consistent with the revised Safety Analysis Report; that is, for "worst case" meteorology that is exceeded only 0.5 percent of the time in each wind direction sector. This zone is defined by calculation of the gaseous plume (airborne release) exposure pathway doses wherein the principal exposure sources are: (1) total-body external exposure to gamma radiation from the plume and radioactive materials deposited on the ground, and (2) inhalation exposures from the passing radioactive plume. For this accident, the isodose line for the 25-rem thyroid dose remains within the Plant boundary. However, the 5-rem total-body isodose line extends as far as 2.9 kilometers beyond the Plant boundary in the northwest and southwest directions, as shown in Table H-1 and Figure H-1. The calculations were done individually for P-, K-, L-, and C-Reactors. The table shows the sectors in which the 5-rem boundary extends off the site and the contributing reactor. L-Reactor does not contribute to the offsite EPZ.

The EPZ defines the area where provisions for immediate response actions are required. It also defines the area for detailed pathway analysis, predictions, monitoring, and radiological assessments. A larger planning zone has been defined for evaluation of potential exposures from the ingestion pathway (food and water), and is shown in Figure H-2. The zone covers an area with an
AY-8, 80-kilometer radius about the center of the SRP, a corridor 2 kilometers wide
BG-7 centered on the Savannah River from the SRP to the Atlantic Ocean and an area encompassing Savannah, Georgia, Beaufort, South Carolina, and the Savannah River Delta. Planning for this zone includes consideration of potential radioactive



Legend:

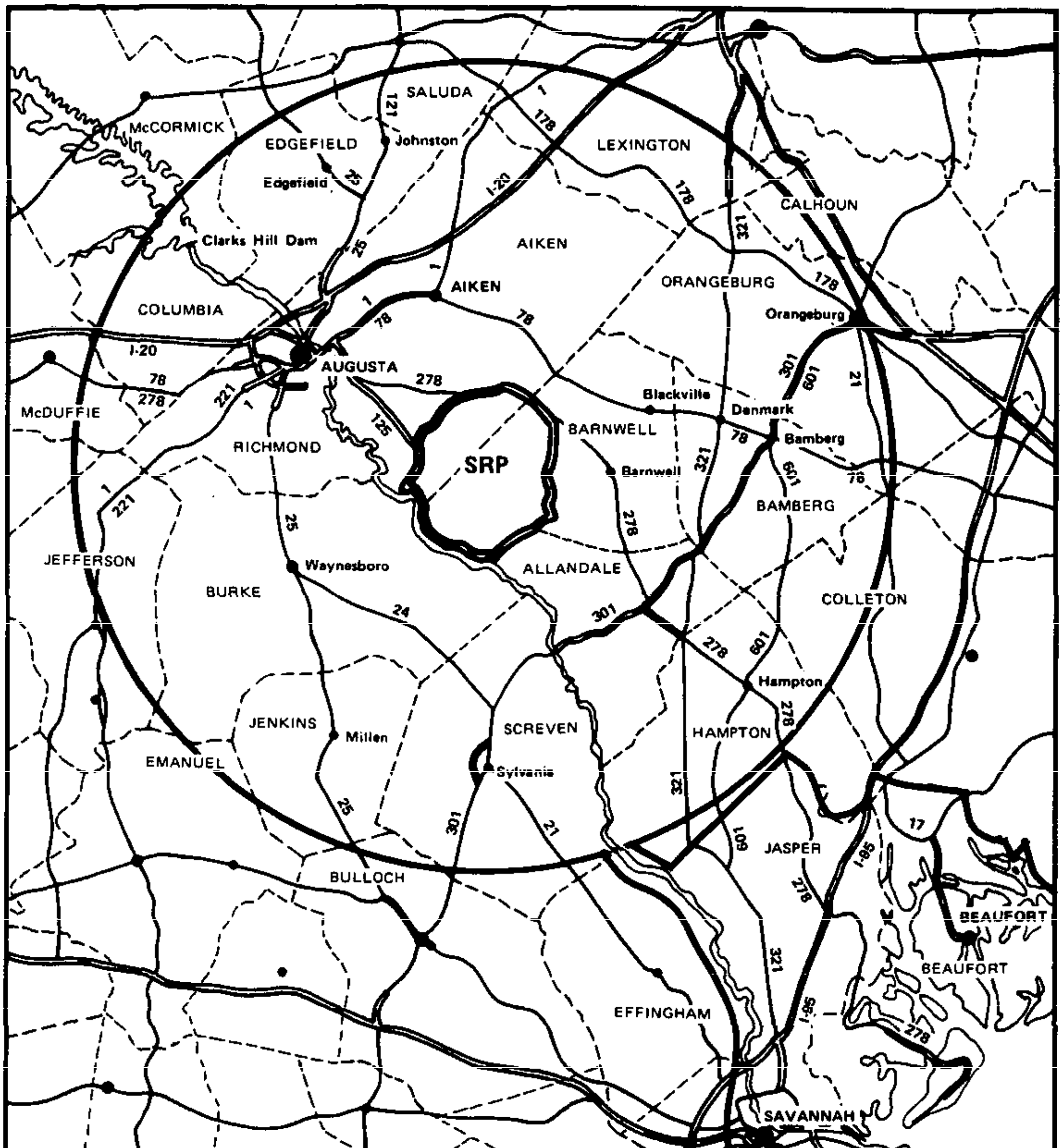
- Preliminary Emergency Planning Zone (from maximum credible accident analysis)
- Preliminary Contingency Planning Zone (16-kilometer radius about each operating reactor)

TC

Source: DuPont, 1983.

Figure H-1. Emergency Planning Zone for the Savannah River Plant.

-8,
-7



Legend:

Major roads

County lines

• Cities/towns

0 10 20 30 40 Kilometers

Figure H-2. Ingestion Emergency Planning Zone for Savannah River Plant

Table H-1. Dose calculation results for reactor reload accident[a,b,c]

Reactor	Sector	Distance to 5 rem boundary, miles	Distance to plant boundary, miles	Whole-body dose at plant boundary, rem
C	NW	9.0	7.6	6.0
	NNW	8.3	8.2	5.2
K	SSW	8.5	6.7	7.0
	SW	7.8	6.6	5.4

[a]Source: Du Pont, 1983.
[b]3% inventory release.
[c]99.5% meteorology, worst sector.

materials deposited on ground and water surfaces that might be incorporated into food and water sources. No immediate responses are necessary in this zone, but monitoring and assessments are prudent to control or avoid internal doses from ingestion of contaminated foods (both terrestrial and aquatic) or water.

Beyond the EPZ, DOE has established a Contingency Planning Zone (CPZ) with a 10-mile radius around each reactor. In the CPZ, DOE will provide information and education about SRP operations and notification of incidents. In this area, calculated doses are less than those required by DOE for the EPZ; therefore, immediate warnings and population protective actions are not required. Within this zone, Georgia and South Carolina State guidelines indicate that an additional level of planning is appropriate to provide mechanisms for population sheltering and possible evacuation. In addition, estimates of reactor accident probabilities and consequences change with time as new operating data are added, understanding of processes improves, and process and equipment changes are made. For example, the probabilistic risk assessment (PRA) that has been initiated for SRP reactors might provide more accurate estimates of reactor accident risks, and the DOE establishment of EPZs in cooperation with South Carolina and Georgia officials should make allowances for variations in calculational analyses. The establishment of a Contingency Planning Zone accounts for these variations. Though potential doses in this area are expected to be less than those that require evacuation, and no other immediate protective actions are anticipated, this zone defines an area where DOE-SR and state and local authorities will agree on exactly what kinds of notification and responses are appropriate for SRP incidents.

AY-8, BG-7

The Department of Energy informs the States of South Carolina and Georgia promptly of all incidents that have potential offsite consequences in excess of those stipulated in 10 CFR 20 (NRC, 1964) (the limits in 10 CFR 20 are not requirements but are used by DOE-SR for comparability). However, offsite emergency responses are not implemented unless an unplanned event could have radiological consequences above preset limits and for which protective actions might have to be implemented. These preset limits and their corresponding incident classification are as follows (DOE, 1983ℓ):

1. Unusual event. An event in progress or having occurred which normally would not constitute an emergency but which indicates a potential exists for possible significant offsite release of radioactive material. Activation of offsite response organizations is not expected. Emergency response actions are limited to onsite areas.

   NOTIFICATION LEVEL*

Release or release potential with projected offsite whole-body doses	≥2 mrem in any one hour or;
	≥0.1 rem in any 7 consecutive days or;
	≥0.5 rem in any period of one calendar year.
or	
Airborne or waterborne radioactivity concentrations released offsite	≥10 CFR 20, Appendix B Table 2 > 24 hr.

   NOTIFICATION TIME

States will be notified as soon as practicable on discovery of an event but no later than 1 hour after discovery.	≤1 hr.

2. Alert. An event in progress or having occurred which involves an actual or potential substantial reduction of the level of nuclear safety of the facility. Limited offsite releases of radioactive material may occur. The purpose of an alert level is to assure that onsite and offsite emergency response personnel are properly advised and available for activation if the situation becomes more serious, to initiate and perform confirmatory radiation monitoring as required, and to assure appropriate notification of emergency conditions to the responsible organizations within DOE.

   NOTIFICATION LEVEL

Release or release potential	≤10 Ci I-131 equivalent or; ≤10^4 Ci Xe-133 equivalent.
or	

*10 CFR 20.105 and .106 (10 FR 14434, October 20, 1964)

Releases with projected offsite dose	$\geq .5$ rem $<$ 1 rem whole-body, or; ≥ 1.5 rem $<$ 5 rem thyroid.

NOTIFICATION TIME

States will be notified as soon as practicable on discovery of an event but no later than 30 minutes after discovery.	≤ 30 min.

3. Site emergency. An event in progress or having occurred which involves actual or likely major failures of facility functions which are needed for the protection of onsite personnel, the public health and safety, and the environment. Releases offsite of radioactive material, as identified below, are likely or are occurring. The purpose of the site emergency designation is to assure that appropriate monitoring teams are dispatched, personnel required for determining onsite protective measures are at duty stations, predetermined protective measures for onsite personnel are identified and to provide current information to DOE and consultation with offsite officials and organizations.

NOTIFICATION LEVEL

Release or release potential	$\geq 10 < 10^3$Ci I-131 equivalent or $\geq 10^4 < 10^6$Ci Xe-133 equivalent.
or	
Release with projected offsite dose	≥ 1 rem $<$ 5 rem whole body, or; ≥ 5 rem $<$ 25 rem thyroid.

NOTIFICATION TIME

States will be notified as soon as practicable on discovery of an event but no later than 30 minutes after discovery.	≤ 30 min.

4. General emergency. An event in progress or having occurred which involves actual or imminent substantial reduction of facility safety. Releases offsite are occurring or are expected to occur and exceed the levels identified below. The purpose of the general emergency level is to initiate predetermined protective actions for onsite personnel, the public health and safety, and the environment, provide continuous assessment of emergency conditions and exchange of information both onsite and offsite. Declaration of a general emergency will initiate major activation of DOE-wide resources required to effectively mitigate the consequences of emergency conditions and assure the protection of onsite personnel, the public health and safety, and the environment to the extent possible.

NOTIFICATION LEVEL

Release or release potential	≥10^3 Ci I-131 equivalent or; ≥10^6 Ci Xe-133 equivalent.
or	
Releases with projected offsite dose	≥5 rem whole body, or; ≥25 rem thyroid.

NOTIFICATION TIME

States will be notified as soon as practicable on discovery of an event but no later than 30 minutes after discovery.	≤30 min.

Should the initial assessment indicate that the incident falls below classification guidelines outlined above (e.g., of minor consequence to the public health and safety), DOE will make additional evaluations to further determine the need for notification of offsite authorities. Considerations in this determination will include an assessment of the potential/actual level of news media and/or public interest resulting from the incident. Prompt notifications will be made, to the extent practical, prior to issuance of a formal "News Release" or if a significant number of inquiries concerning the incident are received from the media or general public.

The development of emergency response plans for SRP is based on (1) the quantity of radioactive material released, or (2) the projected offsite doses from operational releases, as shown in the classifications above. However, the mechanism causing the release does not govern the protective actions implemented. Therefore, emergency response plans are valid for all releases caused by (1) natural phenomena (e.g., earthquakes or tornados), (2) equipment failures (e.g., power outages or broken pipes), (3) procedural errors (e.g., misloading or valve closings), or (4) deliberate actions (e.g., sabotage or terrorist attacks). The offsite response to the released radioactivity is the same. The onsite safeguards and security responses would be different if the cause is identified as a deliberate action. Emergency responses to acts of war also would mobilize the same resources used for general emergencies, with the addition of higher level coordination and the involvement of regional military units. However, specific planning for acts of war on the SRP are not included in these plans.

TC

Emergency plans for the EPZ and CPZ require cooperation, coordination, and integration of resources and responses of the state agencies of South Carolina and Georgia and the county agencies of Aiken, Allendale, and Barnwell in South Carolina, and Burke in Georgia. State and county agencies are responsible for developing and implementing emergency plans for their respective jurisdictions. The Department of Energy is responsible for developing and implementing plans for the plant site. They are also responsible for interfacing with other Federal agencies, local industries, and state and county agencies to define potential incidents, potential consequences of releases, and required resources, and to ensure that response plans and actions are fully integrated to meet potential needs.

Memoranda of Understanding (MOU) between the States of South Carolina and Georgia and the DOE relative to general responsibilities for notification and emergency response to incidents or potential incidents at SRP were established in August 1974 under the DOE predecessor, the Atomic Energy Commission. These memoranda were renegotiated between the States and DOE-SR, December 1978, and November 1979, respectively (DOE, 1978; DOE, 1979). The current list of agencies and organizations to be notified is:

Always required	Only when necessary	Only for general emergency
DOE-HQ	South Carolina Governor's Office	Aiken County, SC
South Carolina Department of Health and Environmental Control	Georgia Governor's Office	Barnwell County, SC
South Carolina Emergency Preparedness Division	U.S. Army Corps of Engineers	Allendale County, SC
Georgia Department of Natural Resources	Federal Aviation Administration	Burke County, GA
Georgia Emergency Management Agency	Fort Gordon	Richmond County, GA
	Federal Emergency Management Agency	
	Fort Jackson	
	Chem-Nuclear Services, Inc.	
	Seaboard Coast Line Railroad	
	Vogtle Power Plant	
	Allied General Nuclear Services	

The plans outlined in this appendix meet requirements set forth by Department of Energy Orders (DOE, 1981a-f; 1983o) and reflect Department of Energy guidance for offsite planning.

H.2 EXISTING EMERGENCY PLAN

The Department of Energy, the States of South Carolina and Georgia, and the Counties of Aiken, Allendale, Barnwell, and Burke have designated persons responsible for emergency preparedness and have developed various forms of emergency plans. Since portions of the EPZ and CPZ lie outside of the SRP boundary, and within these jurisdictions, response plans are being developed with full cooperation of DOE and state and county agencies. Integration of technical expertise and other resources of responsible agencies is necessary in the development of effective response action plans. General program requirements also include drills and exercises to address various potential emergencies including the Savannah River Plant. The present status of plans is detailed in the following sections.

H.2.1 DOE-SR emergency management plans

The DOE-SR is developing a set of 11 Emergency Management Plans for managing emergencies on and off the SRP (DOE, 1983a-k). These plans are listed in Table H-2, along with their general content and status. Each plan addresses the:

- Purpose
- Jurisdiction and authority
- Policy
- Scope
- Organization
- Responsibilities
- Operations

for the activities and responses defined by the plan as well as appendices and annexes to delineate details, definitions, logic, procedures, and checklists for responsible agencies and individuals. These plans include actions to be taken by the Department of Energy and appropriate coordination by designated state and county officials. They are expected to provide information and guidance concerning incidents at the Plant and the use of resources to disseminate and/or take action. Details of organization, responsibilities, and operations are given in each plan. DOE-SR Emergency Management Plans will be submitted to DOE-HQ for review and concurrence before their formal adoption. The DOE-SR Office of External Affairs (OEA) is responsible for developing and implementing all emergency plans for the SRP.

To provide examples of the general content of these plans, the following discussions are provided from the Emergency Public Information Plan (EPIP), TC SR306 (DOE, 1983e) and the Onsite Radiological Emergency Response Plan, SR402 (DOE, 1983f). Figure H-3 shows the lines of communication and coordination for the plan. Figure H-4 shows the steps to be followed to make decisions and take actions relative to preparing statements, issuing news releases and operating information centers. In addition to the overview logic, the plan provides sublogic networks for each activity step (circles) so that directions at the most detailed level are available.

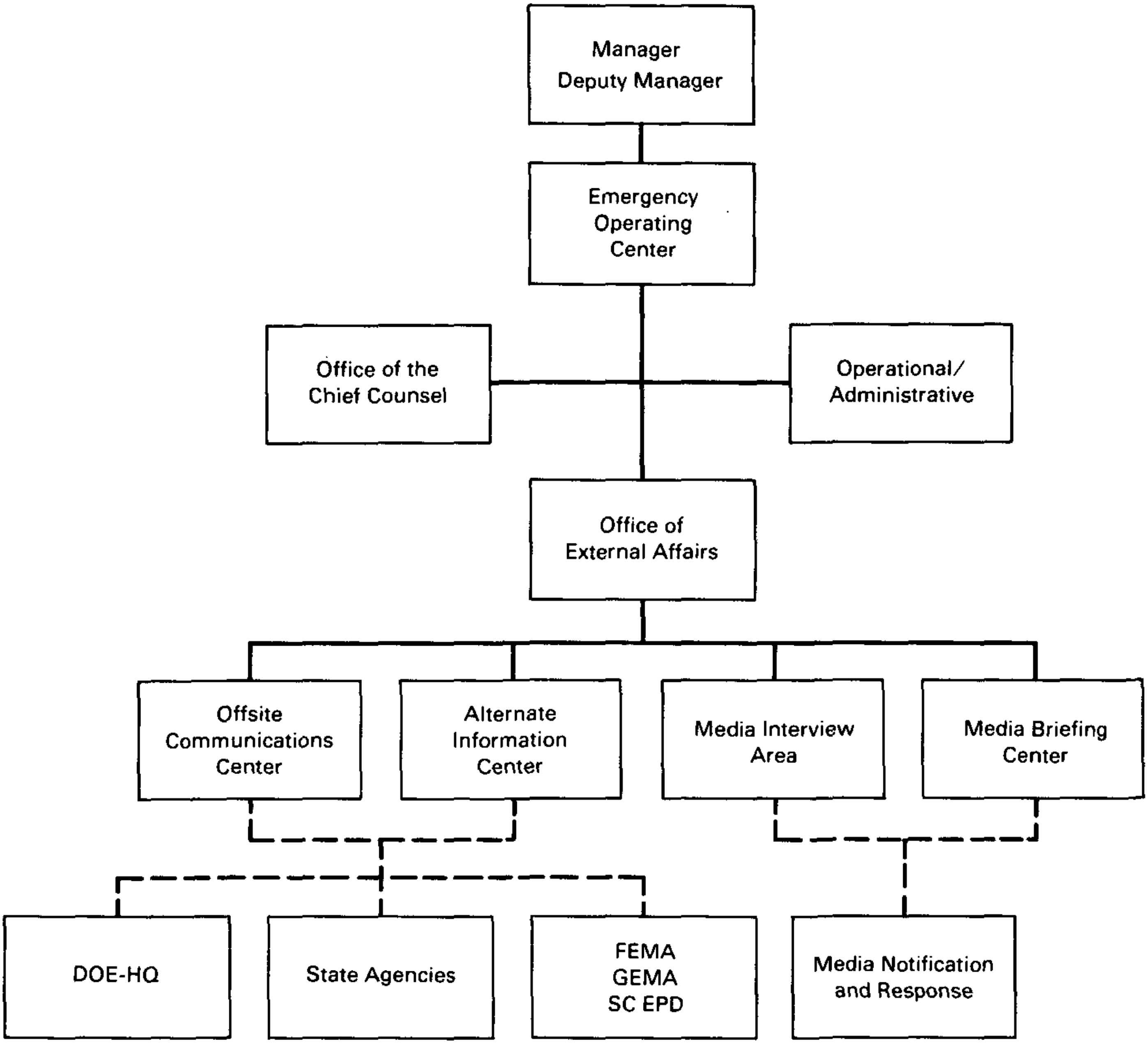
Figure H-4 provides a summary of the sequence of events, decisions and the consequent flow of information that results from an SRP incident. Beginning with (1) a declared emergency, (2) the activation of the Emergency Operations Center (EOC), and (3) a need to implement EPIP, the overview logic diagram outlines the activities that follow:

- OEA initial response OEA determines whether or not an initial response is required, and if so, provides the necessary response. After analyzing data provided upon arrival at the EOC, OEA advises the DOE-HQ Press Secretary and assesses the public information impacts of the incident.

- Assessment preparatory to a statement or news release OEA prepares a statement for the media and determines the associated onsite and offsite impacts. Based upon the determined response level, OEA assesses the impacts of the incident on the Congress, DOE-HQ, other Federal agencies, state and local governments, industry, and the media, as well as other organizations.

Table H-2. Emergency Management Plans for the Savannah River Plant (DOE, 1983a-k)

SR 101	Comprehensive Emergency Preparedness and Response Plan - provides the overall, integrated organization and operations of the DOE-SR Emergency Management Program.
SR 201	Duty Officer Procedures - delineates the responsibilities and actions of the DOE-SR Operations Duty Officer relative to plant emergencies.
SR 202	Emergency Management Team Plan - provides for a comprehensive response to any accident that is not a health and safety problem but is or may be of high interest, to governmental authorities or the general public.
SR 302	Offsite Notification Plan - provides a classification and procedure for defining onsite incidents and notifying designated offsite agencies of the potential consequences.
SR 306	Emergency Public Information Plan - provides for a comprehensive response and sustained information dissemination capability for a wide range of incidents to satisfy offsite interests and inquiries.
SR 402	Onsite Radiological Emergency Response Plan - provides procedures and resource responsibilities for onsite responses to potential radiological consequences.
SR 403	Nonradiological Hazardous Substances Spill or Release Response Plan - provides for an effective level of response to a broad scope of unplanned spills or releases of nonradiological substances. It also addresses communication and coordination with state response agencies.
SR 405	Bomb Threat Response Plan - provides for an effective level of response to bomb threats and discovery of suspicious devices.
SR 501	Weapons Incident/Accident Response Group Support Plan - provides the procedures for interim response to an incident or accident involving a nuclear weapon, until the DOE Region 3 Accident Support Group assumes their responsibilities. It also provides necessary interface with state and local agencies.
SR 502	Radiological Assistance Program Plan - provides the response for requests to assist with respect to radiological incidents outside of SRP but within DOE-Region 3. The Radiological Assistance Team advises the onscene authorities on measures to contain and eliminate radiological emergency situations.
SR 602	Emergency Preparedness Appraisal Program - provides the necessary coordination and direction to ensure adequate response capabilities. It provides for evaluation of the level of emergency preparedness.



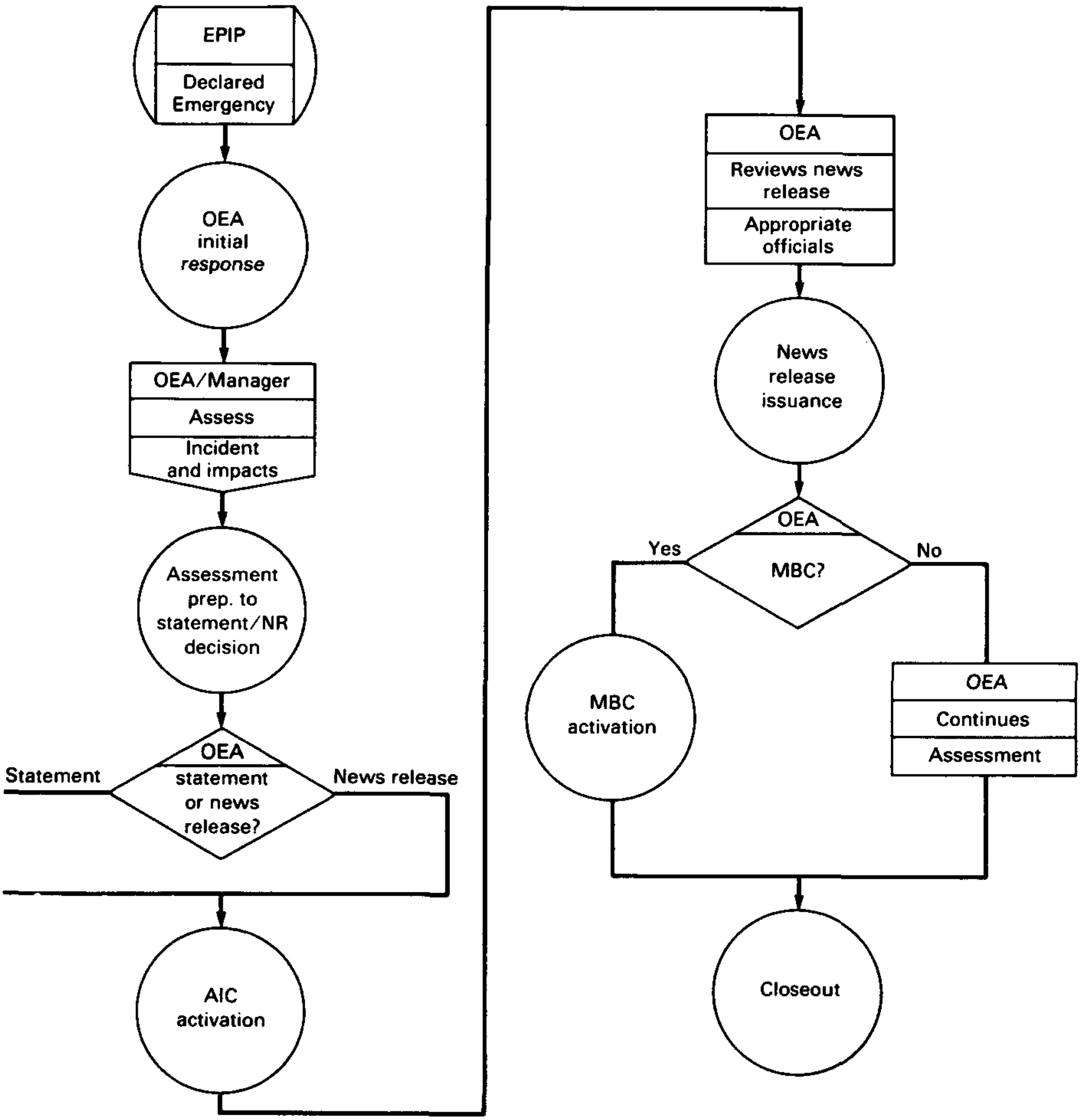
Legend:

——— Internal SRP information flow
– – – – External SRP information flow

FEMA — Federal Emergency Management Agency
GEMA — Georgia Emergency Management Agency
SC-EPD — South Carolina Emergency Preparedness Division
DOE-HQ — Department of Energy Headquarters

Source: DOE, (1983e).

Figure H-3. Lines of communication and coordination for the Emergency Public Information Plan.



Source: DOE (1983e).

Legend:
EPIP — Emergency Public Information Plan
OEA — DOE-SR Office of External Affairs
NR — News Release
AIC — Alternate Information Center
MBC — Media Briefing Center

Figure H-4. Overview logic of the Emergency Public Information Plan.

- Alternate Information Center (AIC) activation Based upon the offsite notifications to be prepared (see notification classification in Section H.1 Introduction), the scope of the response, and current incident status information, OEA prepares the appropriate news release or statement and submits it to the Manager for his approval. The AIC is activated as needed. If additional public affairs support is required, OEA notifies DOE-HQ.

- News release issuance Whether or not the AIC is activated, OEA reviews the news release with the Governor's office and obtains approval of the release from the Manager. OEA provides early notification to state agencies, issues the news release, and provides appropriate offsite notification.

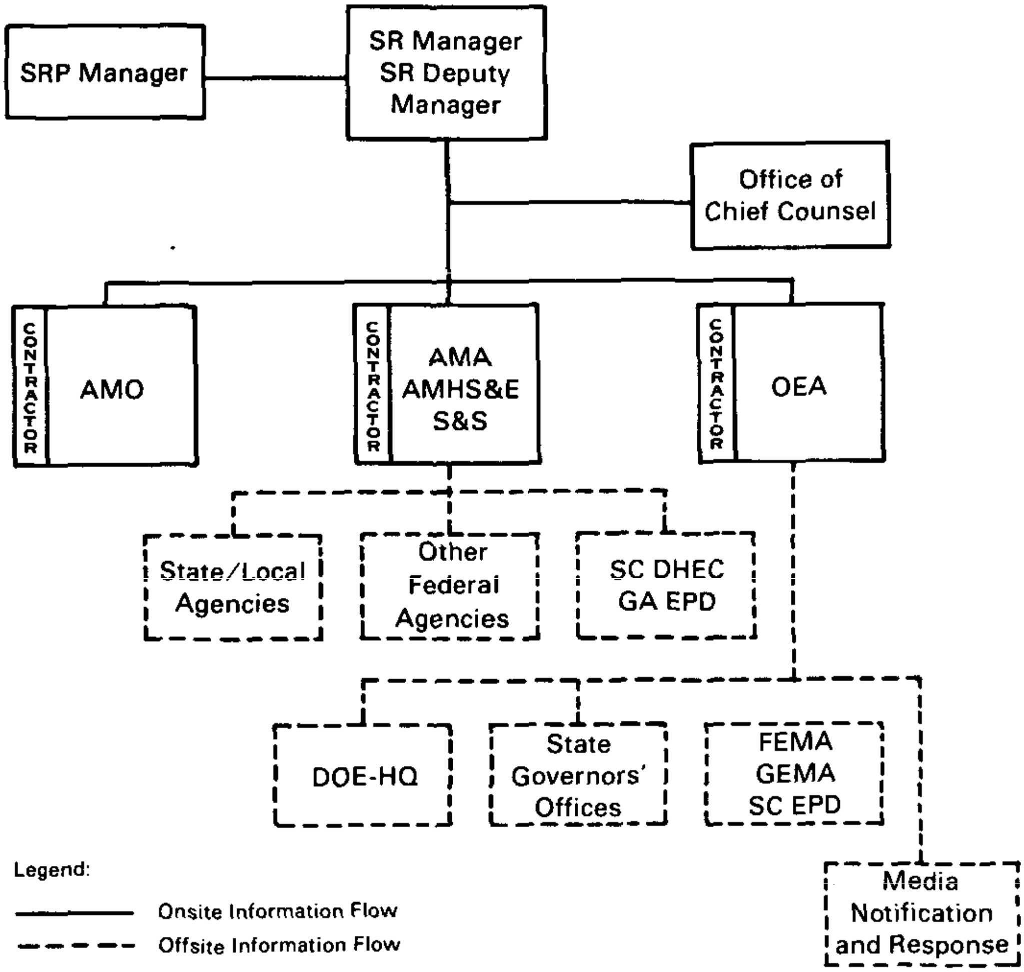
- MBC activation After a further assessment of media response, OEA evaluates the need for a Media Briefing Center (MBC). If an MBC is to be established, OEA determines the MBC location and directs the necessary Contractor technical and administrative support. OEA identifies the technical interviews required.

- Closeout OEA continues to analyze the volume of inquiries, to direct media response, and to obtain incident status information. When the incident is concluded, OEA prepares and delivers a closeout statement.

The first step in implementation of an effective Emergency Planning and Response Program is the development of SRP site-specific emergency response plans in cooperation with affected state and county officials and agencies. DOE-SR has recently entered into agreements with lead agencies of South Carolina (DOE, 1983m) and Georgia (DOE, 1983n) to prepare such plans. The Department is providing staff assistance to develop these plans and will conduct exercises to assure that they provide appropriate responses. These agreements delineate the purpose, authorities, stipulations, responsibilities, and implementation procedures for developing the required plans.

For the Onsite Radiological Emergency Response Plan, SR402, Figure H-5 shows the lines of communication and coordination to be followed during a response. Figure H-6 shows the steps to be followed to make decisions and take actions related to reporting, activating the Emergency Operations Center, activating emergency management teams, making offsite modifications, and activating
TC the Offsite Technical Coordination Center (OTCC). The plan includes sublogic networks for each activity step (circles), so directions and procedures at the most detailed level are available. The logic in Figure H-6 begins with the discovery of a radiological incident by a reporting source and includes the activities that follow:

- Incident Discovery Response. On discovery of an incident, the reporting source must determine if it is an emergency. If the incident is an emergency, the reporting source notifies the Emergency Operation Center (EOC) Patrol, which activates the EOC. If the reporting source does not classify the incident as an emergency, he or she notifies the EOC Patrol and the contractor management. Contractor management assesses the incident and either activates the EOC or notifies SR management to make that decision. In the latter case, SR management assesses the incident and



Legend:

——— Onsite Information Flow

– – – – Offsite Information Flow

FEMA — Federal Emergency Management Agency

GA EPD — Georgia Environmental Protection Division

GEMA — Georgia Emergency Management Agency

SC DHEC — South Carolina Department of Health and Environmental Control

SC EPD — South Carolina Emergency Preparedness Division

AMO — Assistant Manager for Operations

AMA — Assistant Manager for Administration

AMHS&E — Assistant Manager for Health, Safety and Environment

OEA — Office of External Affairs

SRP — Savannah River Plant

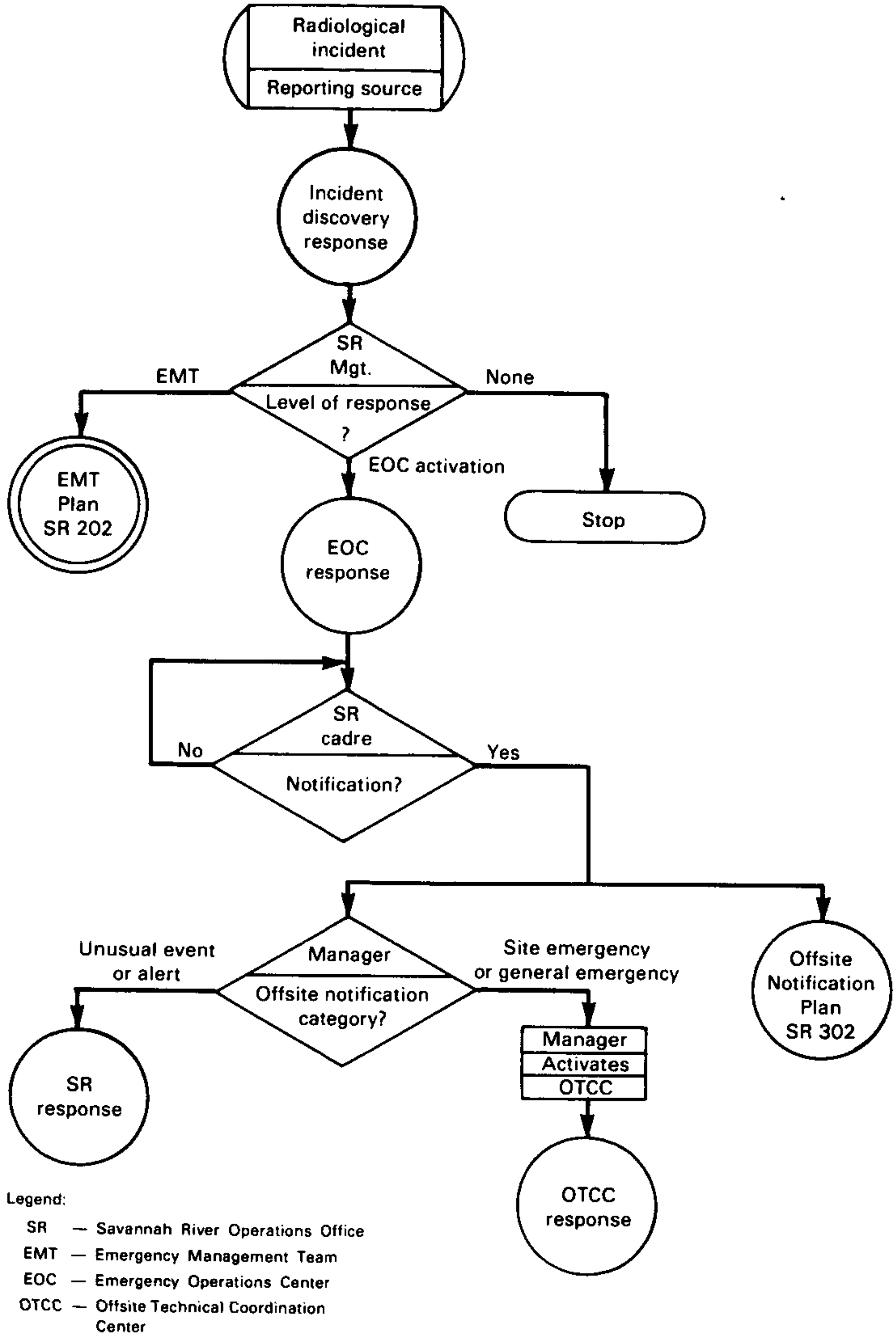
SR — DOE Savannah River Operations Office

Source: DOE, 1983f

Figure H-5. Lines of communication and coordination for an onsite radiological emergency response.

TC

TC



Source: DOE, 1983f

Figure H-6. Overview logic of the onsite radiological emergency response plan.

determines whether the incident requires EOC or Emergency Management Team (EMT) activation or no further action.

- EOC Response. After the decision has been made to activate the EOC, the EOC patrol notifies the EOC Cadre. The cadre reports to the EOC and obtains the emergency Incident Summary to identify characteristics that will enable it to make an assessment. EOC Cadre recommendations are forwarded to the Manager concerning incident mitigation procedures, SRP impacts, required logistical support, security requirements, worker and safety impacts, medical requirements, classification requirements, public impacts, and the need for media and other offsite notifications.

- SR Response. The Manager determines the SR response to offsite radiological incidents. He is assisted by senior SR management staff who are part of the EOC Cadre. SR maintains technical coordination with both the South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Environmental Protection Division (GA EPD); controls access to the SRP plant site; maintains coordination with the Georgia Emergency Management Agency (GEMA) and the South Carolina Emergency Preparedness Division (SCEPD); and monitors control and mitigation actions.

  The level of SR response is determined by the selection of an offsite notification category. If the incident is classified as an unusual event or alert, the EOC Cadre advises the states on offsite consequences and advises the Manager on whether to activate the OTCC.

  If the EOC Cadre does not recommend activation of the OTCC, it maintains coordination and communication with state authorities until the incident is terminated. Periodically the cadre reevaluates the need to activate the OTCC. TC

  In addition, the Manager directs the deployment of the offsite liaison and ensures that technical briefings are provided and response actions outside procedures are assessed. Offsite liaison is provided to state authorities (Georgia and South Carolina Forward Emergency Operating Center (FEOC)) and commercial operators (Barnwell and Vogtle). The offsite liaison advises these authorities on the status of the incident. The offsite liaison in turn advises the EOC Cadre of the response actions of the state and commercial authorities. Briefings provided by the offsite liaison, in addition to technical briefings, allow the EOC Cadre to brief the Headquarters EOC on the incident status; it does this periodically throughout the incident.

  The EOC staff also assesses response actions outside of established procedures. Based on recommendations, the Manager decides to initiate response action outside of procedures.

- OTCC. After the decision has been made to activate the OTCC, the EOC Cadre determines its staffing requirements. The cadre notifies OTCC participants. The OTCC staff (onsite and offsite participants) has three primary functions: to coordinate radiological monitoring, to advise the EOC on the state assessment of offsite consequences, and to conduct periodic briefings on the onsite situation. When the OTCC staff

TC has completed these activities and the incident has terminated, the OTCC is deactivated. The EOC Cadre then advises offsite authorities and DOE-HQ of the termination of the incident and the Manager submits a formal report to the Secretary.

H.2.2 Savannah River Plant site-specific contractor response plans

DOE-SR's operating contractor for the Savannah River Plant is E. I. du Pont de Nemours and Company (Du Pont). Du Pont has been responsible for preparing all the onsite emergency response plans and for carrying out their responsibilities under these plans. All onsite plans developed by Du Pont are submitted to DOE-SR for approval before they are implemented. The Emergency and Disaster Plans for the Savannah River Plant (Du Pont, 1981) implement the onsite portions of the DOE-SR's Comprehensive Emergency Preparedness and Response Plan (DOE, 1983a). These two plans are the foundation of the DOE-SR Emergency Management Program. There are many subtier plans of both documents that implement the specific facility, process, or event aspects of the general plans. All necessary plans have been prepared and exercised in simulated operating conditions and/or utilized in actual emergency incidents. Table H-3 lists the key subtier plans. These plans will be integrated with state and local offsite plans, so the total response to SRP incidents will be coordinated adequately and appropriately. DOE-SR has entered into an MOU with The Dwight David Eisenhower Army Medical Center at Fort Gordon, Georgia, in which the parties have agreed to assist in SRP emergencies and accept radiation-exposed or contaminated emergency
TC patients (DOE, 1982). See Appendix G for additional details of onsite planning.

H.2.3 South Carolina and Georgia state plans

As described in Section 1.0, general radiological emergency response plans exist for both states. Additionally, both states have site-specific radiological emergency response plans for nuclear power plant incidents which establish emergency organizations, and assign responsibilities and resources. These general plans with overall direction have been determined adequate by responsible state agencies and respective radiological response plans for nuclear power plant facilities have been approved by the Federal Emergency Management Administration (FEMA), the Nuclear Regulatory Commission (NRC), and other appropriate agencies. These plans provide an effective basis for the development of site specific response plans for the SRP.

H.2.4 County plans

South Carolina Counties of Aiken, Allendale, and Barnwell, and the Georgia County of Burke have existing emergency plans (e.g., ACCD, 1982; AEPA, 1982) in varying stages of formalization. These plans assign responsibilities for responding to general emergency situations. The general portions of the Aiken and Allendale County plans have been approved by the State. Aiken County has a full-time emergency preparedness director and Allendale County has a part-time emergency preparedness director. The general portion of the Barnwell County

Table H-3. Subtier Emergency Plans to Support "Emergency and Disaster Plans for Savannah River Plant" (Du Pont, 1981)

DPSOP Numbers[a]	Title
67	Emergency and Disaster Plans - Reactor Department
67-1	Fire Control Plan: 100 Areas
115-FH	200 Areas Emergency and Disaster Plans
115-2FH	Fire Protection Plan for 200 Areas
119	Emergency and Disaster Plans, 300/700 Area
119-1	Fire Control Plan, 300/700 Area
130-2	Separations Process, Building 221-F
135	400 Area Emergency and Disaster Plan
135-1	Fire Control Plan: 400 Area
147-3	HM[b] Process: 221-H Industrial Hazards
178	Fire Control Plan for SRP
179	Emergency and Disaster Plans for Health Physics Section
181	Emergency Actions: Medical Department and Security Division
307	Consolidated Communication Center Equipment
47	CMX-TNX[c] Emergency and Disaster Plans

[a]Document identification numbers
[b]Enriched uranium process
[c]Experimental and testing area

plan is complete and the county has a full-time emergency preparedness director. The general portion of the Burke County plan is not formalized but the county has a part-time emergency preparedness director. Richmond County is not included in the EPZ or the CPZ. However, because the county has a relatively large population, planning for notification and public education will be conducted. Specific plans for responses to SRP incidents are being developed with staff assistance from DOE-SR. AY-8

H.3 OFFSITE PLANNING

Because portions of the EPZ and CPZ fall outside SRP boundaries, within state and county jurisdictions, a higher degree of planning has been considered by these governments. The specific nature of capabilities to meet these requirements has been determined in cooperation with responsible state and county agencies. General program requirements also include drills and exercises to evaluate plans and responses for incidents at the Savannah River Plant.

H.3.1 Department of Energy plans

All DOE-SR Emergency Management Plans are complete. The Department of Energy has consulted with appropriate state and county officials and agencies AY-8, EM-40 and has provided staff assistance in the development of detailed offsite plans for the EPZ and CPZ to respond to incidents at the SRP. The site-specific aspects of these plans include actions to be taken by the Department of Energy and provide for coordination with state and county officials. Additionally, these plans provide information and guidance on responses to incidents at the Plant and the use of resources to disseminate and/or take action on the guidance. Formal agreements have been reached between the states and DOE-SR to conduct appropriate exercises to assure the necessary coordination, integration, and implementation (DOE, 1983m,n).

H.3.2 South Carolina and Georgia plans

Site-specific SRP emergency response plans for South Carolina and Georgia provide prompt notification of SRP incidents to responsible officials in the EPZ and CPZ. The States' general radiological response plans are presently based on TC a full NRC-type Emergency Planning Zone response. Plans for the SRP EPZ address comparable considerations. These requirements include the following:

- Organization and Assignment of Responsibilities - to assure that emergency organizations are established and responsibilities assigned and included in written emergency plans.
- Emergency Response Support and Resources - to ensure that arrangements are made for requesting and effectively using outside assistance resources.
- Emergency Response Level Plans - to assure that a standard emergency response level plan is adopted and the associated response actions for each emergency response level are established.
- Notification Methods and Procedures - to assure that notification procedures and message content are developed and means of notification are established.
- Emergency Communications - to assure that provisions exist for prompt communications among principal response organizations, emergency response personnel, and appropriate Federal, State, and local officials.
- Public Education and Information - to ensure that public education is provided and that plans are in place for a coordinated media program.
- Emergency Facilities and Equipment - to ensure adequate facilities and equipment are provided and maintained to support emergency response.
- Accident Assessment - to ensure that adequate methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences of a radiological emergency condition are in use.

- Protective Response - to assure guidelines are developed and are in place for protective actions for emergency workers and the general public.

- Radiological Exposure Control - to ensure guidelines and means for controlling radiological exposures are established for emergency workers.

- Medical and Health Support - to ensure that arrangements are made for medical services for contaminated injured individuals.

- Recovery and Re-entry Planning and Post Accident Operations - to assure general plans for recovery and re-entry are developed.

- Exercises - to ensure that DOE, state and local organizations conduct periodic exercises to develop and maintain key skills.

- Radiological Emergency Response Training - to ensure that training programs are provided for management officials, specialized emergency duty personnel, and all other personnel having emergency responsibilities.

- Memoranda of Understanding and Letters of Agreement - to ensure that appropriate instruments of agreement/understanding have been entered into with onsite and offsite support organizations.

To ensure the adequacy of plans, the Department of Energy will conduct an annual exercise and provide the opportunity for state and county government participation. The basic responsibility of state and county government emergency preparedness organizations is to provide appropriate capabilities for responding to potential emergencies that may occur in their jurisdiction.

Plans for the CPZ will focus more on:

- Incident notification
- Emergency public information and education
- DOE/state communication and coordination
- State/county communication and coordination.

State emergency response plans for SRP were completed in March 1984. AY-8, EM-40

H.3.3 County plans

County emergency response plans for the SRP supplement the general county emergency plans and provide for the implementation of appropriate actions related to an SRP incident. Site-specific plans identify the organizations, responsibilities, resources, and coordination to be undertaken by the county in such cases. Interfaces with the Savannah River Plant and with state emergency preparedness organizations have been established. Areas considered during this planning include notification, communication and coordination, public information, public warning, law enforcement, and protective response (sheltering, evacuation, or other protective action), depending on whether portions of the county are in the EPZ, the CPZ, or both.

County Emergency Response Plans include site-specific radiological plans relating to incidents at the Savannah River Plant and follow a standardized format approved by the states that support the state plans on a site-specific basis.

No requirement exists for public warning outside the Emergency Planning Zone. However, specific plans for public notification within the CPZ and general plans for notification in outlying areas have been implemented at an appropriate level, having been determined through the ongoing planning process between DOE and officials of state and county governments.

H.4 SUMMARY

The Department of Energy has emergency plans to respond to onsite incidents at the SRP. The South Carolina Operational Radiological Emergency Response Plan is completed; it includes a site-specific Radiological Emergency Response Plan for the Savannah River Plant. The State of Georgia Radiological Emergency Plan also includes a site-specific Radiological Emergency Response Plan for the SRP. County plans are complete for the site-specific radiological plans for the EPZ or CPZ.

Department of Energy personnel, working with state and county emergency preparedness officials, have identified the organizations, responsibilities, coordinations, and resource aspects of participating agencies. State and county jurisdictions/issues were resolved before the completion of state plans. County plans support the state plans on a site-specific basis. All plans were completed by March 31, 1984.

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APPENDIX I

FLOODPLAINS/WETLANDS ASSESSMENT*

Executive Orders 11988 (Floodplains Management) and 11990 (Protection of Wetlands) and U.S. Department of Energy (DOE) regulation "Compliance with Floodplain/Wetlands Environmental Review Requirements (10 CFR 1022)" specify the requirements for a floodplain/wetlands assessment.

DOE issued a floodplain/wetlands notice regarding the proposed reactivation of L-Reactor on July 14, 1982 (47 FR 30563). A floodplain/wetlands determination regarding no practical alternative was published in the Federal Register on August 23, 1982 (47 FR 36691-2). The updated and/or modified floodplain/wetlands determination will follow the completion of this EIS.

This appendix describes the effects on floodplains and wetlands that would result from the direct discharge of L-Reactor cooling water to Steel Creek, or from the implementation of alternative cooling systems, as discussed in Section 4.4.2. Some estimates of wetlands losses have been revised since the DEIS due to the availability of new data. These alternatives include the following:

Once-through alternatives

- Direct discharge to Steel Creek (reference case)
- Spray canal
- Small lakes
- Small lakes with spray cooling (1-2 sets)
- 500-acre lake
- 500-acre lake with spray cooling (1-2 sets)
- 1000-acre lake
- Diversions to Pen Branch

Mechanical-draft cooling tower alternatives

- Once-through with discharge to Steel Creek
- Once-through - canal to swamp
- Once-through - spray canal and canal to swamp
- Once-through - canal to swamp; pipe to river
- Total recirculation - blowdown to Steel Creek
- Total recirculation - blowdown treatment
- Partial recirculation - with discharge to Steel Creek
- Partial recirculation - with refrigeration

Other recirculation alternatives

- Recirculation through creation of L-Pond
- Recirculation through creation of Kal Pond
- Recirculation through creation of High-Level Pond
- Recirculation through Par Pond

*Vertical change bars have not been used in this appendix because of the extensive revisions that have been made.

Other alternatives

- Thermal cogeneration
- Low-head hydropower
- Modified reactor operation
- Fisheries management programs
- Protect similar wetlands

I.1 WETLANDS

I.1.1 Direct discharge to Steel Creek (reference case)

Direct discharge would release about 11 cubic meters of thermal effluent per second from L-Reactor directly to Steel Creek, as was done during the pre-1968 operation of L-Reactor. Modeling of L-Reactor liquid discharges indicates that the thermal effluent will be discharged to Steel Creek at a maximum temperature of 73°C. Cooling will occur as the effluent flows to the Savannah River. The thermal effluent will enter the swamp at temperatures between 41°C (spring) and 46°C (summer). When L-Reactor is operating, the segment of Steel Creek above the swamp will be subjected to temperatures 19° to 38°C above ambient in summer, spring, and winter.

The species found in Steel Creek today are typical of those in similar nonthermal streams at the Savannah River Plant. The presence of stoneflies, mayflies, caddisflies, and dragonflies indicates that Steel Creek is recovering from prior cooling-water discharge impacts. Collections of species of crustaceans (crayfish) have been similar in both Steel Creek and the nonthermal Upper Three Runs Creek. About 50 species of fish have been collected from 1981 to 1983 from Steel Creek (Smith, Sharitz, and Gladden, 1981, 1982, 1983). The present diversity of organisms in Steel Creek indicates that post-thermal recovery of the macroinvertebrate communities has progressed during the past 15 years.

L-Reactor discharge is expected to have effects similar to those that occurred during previous operations; this is described in Section 4.1. Flooding and siltation associated with the thermal discharge are expected to adversely affect aquatic habitat in the Steel Creek floodplain and delta area. An estimated 730 to 1000 acres of wetlands will receive adverse impacts from the direct discharge of thermal effluent to Steel Creek. These wetlands, which have become established during the past 15 years through the process of natural succession, are structurally different from the closed canopy of mature cypress and tupelo gum that existed before the SRP began operation. These wetlands include approximately 420 to 580 acres of the Steel Creek corridor and between 310 to 420 acres of swamp (approximately 250 acres of swamp are expected to receive adverse impacts almost immediately; the remainder would be affected at a rate of about 7 to 10 acres per year). The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). The delta is expected to expand into the swamp at a rate of about 3 acres per year. Aquatic macrophytes and woody plants will be eliminated in the Steel Creek corridor. Species that inhabit cooler backwater pools or other suitable substrates might experience a reduction in productivity.

After the resumption of operations, emergent wetland flora and submergent hydrophytes will be eliminated and their substrates will revert to mudflats. Some herbaceous flora will become established on exposed floodplain sediments and elevated stumps, and logs of fallen trees. Most shrubland communities also will probably be eliminated. Riverine vegetation in the vicinity of the mouth of Steel Creek consists primarily of bottomland hardwood forests; emergent and submergent macrophytes are sparse or absent. It is improbable that the thermal effluent would impact these riverine flora.

During thermal discharge, Steel Creek above the delta will be inhabitable for most aquatic life. In addition, the water temperature of Steel Creek might isolate the floodplain swamp from river fish. Most, if not all, spawning activity will probably be eliminated. The most common fish remaining in the Steel Creek area probably will be the mosquitofish, although a few centrarchids might occur in backwater areas and tributary streams such as Meyers Branch (Cherry et al., 1976; Falke and Smith, 1974; Ferens and Murphy, 1974; McFarlane, 1976; McFarlane et al., 1978).

Although 2280 acres of the wetlands along Steel Creek above L-Area and along Meyers Branch above its confluence with Steel Creek will not receive direct thermal discharges, access to these areas by fish from the Savannah River will be restricted. The entrance to Boggy Gut Creek, an offsite tributary immediately downriver of Steel Creek, could be blocked at times by the thermal plume; fish access would be limited. Wetland areas of Boggy Gut Creek total about 230 acres.

Except for backwater pools or other cool-water refuges, the high water temperatures from the outfall to the delta will make this section of Steel Creek uninhabitable for amphibian eggs and larvae. Adult life forms might survive along the stream margins or relocate to adjacent habitats.

Reptiles depend more on aquatic habitat for food (i.e., insects, fish, amphibians) and shelter than for reproduction. The elevated water temperature and the elimination of prey organisms will eliminate the habitats of semiaquatic snakes and turtles upstream from the delta, and will cause a marked decrease in species richness. Portions of the delta might provide marginal habitat for water snakes and turtles following L-Reactor restart.

The endangered American alligator inhabits all parts of Steel Creek from the L-Reactor outfall to the cypress-tupelo forest adjacent to the Steel Creek delta; it also uses areas lateral to Steel Creek, including Carolina bays, backwater lagoons, and beaver ponds. The number of alligators inhabiting the Steel Creek area has ranged from 23 to 35 individuals. Telemetry studies showed that adult males had larger home ranges than juveniles and females. Males sometimes moved from the delta into the Savannah River swamp (Smith, Sharitz, and Gladden, 1982).

Direct discharge will eliminate alligator habitat in Steel Creek from the reactor outfall to the Savannah River, except for backwater pools or other cool-water refuges, by increasing the water temperature above limits that are physiologically tolerable, eliminating its principal food sources, and possibly inundating its nests and shallow-water wintering habitats (Smith, Sharitz, and Gladden, 1981, 1982). Adult alligators can avoid thermal waters and migrate considerable distances overland. Overwintering alligators could be killed by thermal effluent if they were in a torpid condition. Juveniles could also avoid thermal effluents, but smaller alligators might experience difficulty in migrating to suitable habitats and could be more subject to predation. Nesting sites and eggs could be inundated and destroyed. Red sore, a bacterium-caused disease that affects fish and reptiles, could become more prevalent with thermal loading and could affect the American alligator. Conditions conducive to the reproduction of this bacterium, however, are very specific (i.e., water temperature, pH, etc.), and are associated more with lentic (nonflowing) ecosystems such as Par Pond. This bacterium currently appears isolated in Par Pond, and its presence has not been confirmed in SRP stream ecosystems.

Formal consultation on the American alligator was held under the Endangered Species Act in September 1982 with representatives of DOE-SR, Du Pont, NUS Corporation, the Savannah River Ecology Laboratory (SREL), and the U.S. Fish and Wildlife Service (FWS). A Biological Opinion was received from the FWS in which FWS judged that protection of the lagoons at SRP Road A should provide sufficient mitigation for the American alligator potentially impacted by L-Reactor restart. Protection of these lagoons has been completed. DOE has reinitiated consultations with FWS (Sires, 1983).

The Savannah River swamp and Steel Creek delta provide an important regional sanctuary and refuge for waterfowl. More than 400 wood ducks and nearly 1200 mallards have been observed roosting and feeding in the Steel Creek delta. Seven other species of waterfowl also use this area. These habitats will be eliminated by direct discharge.

The Steel Creek delta also provides important foraging habitat for the wood stork, a large wading bird that is listed as an endangered species (USDOI, 1984). A total of 478 observations of foraging wood storks was made in the Savannah River swamp in 1983, of which 102 were in the Steel Creek delta. Thermal discharge will eliminate these feeding habitats. DOE has initiated a consultation process with the U.S. Fish and Wildlife Service on the wood stork.

Semiaquatic mammals that will be affected by the thermal effluent include the beaver, river otter, mink, and muskrat. Except for the muskrat, these species are common throughout the Savannah River Plant. Adults should not experience mortality due to increased flow and temperature.

I.1.2 Once-through alternatives

I.1.2.1 Once-through spray canal system

This alternative would provide a spray canal to reduce L-Reactor effluent temperatures before the effluent is discharged to Steel Creek. During the summer, effluent entering this spray canal at a rate of about 11 cubic meters per second would be cooled by about 5°C and discharged to Steel Creek at about 73°C. Based on thermal modeling, extreme summer effluent temperatures at Road A and Steel Creek delta would be 53°C and 45°C, respectively. These temperatures are slightly cooler than those of the direct-discharge effluent at the same locations. Given this slight reduction in effluent temperature and identical flow rates, the impact of a spray canal on wetlands would not differ significantly from that of direct discharge. Delta growth would be about 3 acres per year, and as many as 785 to 1005 acres of wetlands would be impacted. Additionally, approximately 110 acres, half of which are wetlands, would have to be cleared in the vicinity of the spray system in order to enhance cooling performance. If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be essentially the same. Any mitigative effects resulting from the small lakes alternative would not begin until the end of the 18- to 24-month construction period. Furthermore, this system offers no mitigation to the habitat of the endangered American alligator, the endangered wood stork, migratory waterfowl, or other aquatic species.

Wetland impacts expected from implementation of the spray canal system would not differ appreciably if this system was implemented either before or after L-Reactor restart (a maximum of 1060 acres compared to 1005 acres).

I.1.2.2 Small lakes on Steel Creek

A series of rubble dams on Steel Creek could provide several small lakes with a combined area of about 120 acres. The thermal effluent discharged through these lakes at 11 cubic meters per second and under maximum summer conditions would be cooled to about 45°C on discharge from the last lake and 40°C where Steel Creek enters the swamp. This cooling system would provide limited use of Steel Creek below Road A by some thermally tolerant aquatic organisms. However, this system would not maintain alligator habitat below Road A, because of the general loss of prey organisms. Although this alternative provides some mitigation below Road A, thermal impacts will occur. Delta growth would be about 2 acres per year, and as many as 1000 acres of wetlands would be adversely affected by flooding, siltation, and thermal impacts. Flooding, controlled by the reactor operation schedule, would be intermittent and would cause fluctuating water levels. The cooler temperatures near the delta would result in a decreased rate of vegetative mortality. However, flooding, siltation, and fluctuating water levels, when coupled with the thermal effects, would have adverse impacts on wetlands that are classified as Resource Category 2 by the U.S. Fish and Wildlife Service (USDOI, 1981). This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value." In addition, about 2500 acres of wetlands could be physically isolated by the dams and thermal temperatures.

I.1.2.3 Small lakes with spray cooling (1-2 sets)

The combination of small rubble dams to create approximately 120 acres of shallow lakes combined with a spray cooling system (1-2 sets) would mitigate some of the environmental effects of a direct discharge system. The gravity spray canal system would be installed to obtain about 5°C cooling before the water enters the first lake. The small dams would create pools that would slow the movement of the water and enhance cooling. Maximum exit temperatures in the summer would be 44°C with one spray system or 39°C with two spray systems. In the swamp the effluent would be cooled to 34°C and 37°C, respectively.

The use of small lakes without sprays would impact between 420 and 580 acres of wetlands in the Steel Creek corridor and between 310 and 420 acres of wetlands in the delta and swamp. The use of sprays (1 or 2 sets) would impact an additional 55 acres of wetlands in the vicinity of the spray canal. However, the cooling achieved by sprays would reduce the impacts to the delta and swamp to between 215 and 335 acres of wetlands. Thus, the total wetlands impacted by small lakes without sprays would range between 730 and 1000 acres. Small lakes with sprays (1 or 2 sets) would impact between 690 and 970 acres of wetlands. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce its becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

Erosion and transport of sediment will increase because the flow rate will be about 11 cubic meters per second. A delta growth rate of about 2 acres per year is anticipated. In addition to sedimentation and erosion from flow, some sedimentation will be associated with construction of the embankment; however, it will be covered by an erosion/sedimentation plan. Spoil removed from the embankment site will contain small amounts of radioactivity. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the jurisdictional wetlands upstream of the embankment, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

If the small lakes alternative (1-2 sets) is implemented before direct discharge occurs, the environmental effects would be as described above. If it is implemented after direct discharge starts, the environmental effects would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from small lakes with sprays (1-2 sets) would not begin until the end of the 18- to 24-month construction period.

I.1.2.4 500-acre lake

The impacts on wetlands from a 500-acre lake on Steel Creek would generally be similar to those for the spray canal and small lakes systems. Although lower maximum summer effluent temperatures are projected at Road A (37°C) and the delta (36°C), the high rate of flow and fluctuating water levels would adversely affect the wetland vegetation. Macrophytes would be uprooted by strong currents, and woody flora would be eliminated due to prolonged inundation. Reproduction of wetlands vegetation in most areas would be uncommon because of the flooding and fluctuating water levels associated with reactor operation. Roosting and feeding habitat for waterfowl will be lost. In addition, the fluctuating water levels are expected to discourage spawning and inhibit the successful reproduction of fish. Even with lower effluent water temperatures below Road A, vegetation will be lost in the Steel Creek corridor and on the delta. Habitat quality for the American alligator will be reduced in Steel Creek below Road A because of the loss of prey organisms.

Delta growth is projected to be 2 acres per year. Between 650 and 930 acres of wetlands would be impacted by this action. This includes between 435 and 595 acres in the Steel Creek corridor and between 215 and 335 acres in the delta and swamp. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). Approximately 2280 acres of riparian wetlands associated with Meyers Branch and the upper headwaters of Steel Creek could be isolated. As many as 360 acres of upland vegetation would be inundated by the impoundment. The principal difference between this option and direct discharge or spray canal options is not the magnitude, but the rate and location of impacts. Cooler temperatures in peripheral areas of the delta should enable limited vegetative establishment. Flooding, siltation, and fluctuating water levels, when coupled with thermal effects, would halt the vegetative succession that has been progressing in the swamp since 1968.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts to wetlands would be as described above. If it is implemented after direct discharge occurs, there would be some limited mitigation, but this would not begin until the end of the 18- to 31-month construction period. The construction of this alternative could be expedited to about 6 months.

I.1.2.5 500-acre lake with spray cooling (1-2 sets)

Combinations of several once-through cooling-water systems could have fewer thermal effects than a single system. The combined system discussed in Section 4.4.2 consists of a 500-acre lake with a spray cooling system (1-2 sets). The gravity spray canal system would obtain about 5°C cooling before the water enters the lake. This water (at 73°C) would be cooled to about 38°C during its travel through the lake (under extreme meteorological conditions). A system with two sprays would cool the water to less than 32°C before discharging it to Steel Creek. With a single spray system located above the 500-acre lake, the maximum summer discharge temperature from the lake would be 37°C.

Approximately 705 to 985 acres of wetlands habitat would be lost with one or two sets of sprays. This would consist of 490 to 650 acres in Steel Creek corridor and 215 to 335 acres in the delta and swamp. This system would not mitigate flooding and fluctuating water levels in the Steel Creek system. Therefore, the principal differences between the combined system and other once-through systems would be a decreased rate of vegetative mortality in the Steel Creek corridor and delta below the final spray lake; it is possible that fish and other organisms would be able to use the creek below the dam.

If the 500-acre lake with spray cooling system (1-2 sets) is implemented before direct discharge occurs, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.2.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from this alternative would not begin until the end of the 31- to 36-month construction period.

I.1.2.6 1000-acre lake

This alternative consists of the construction of a 1000-acre once-through cooling lake on Steel Creek. The normal water surface elevation would be 61 meters above mean sea level. The embankment for this cooling lake would be at the same location as the embankment for the 500-acre lake described in Section 4.4.2. The impacts from the 1000-acre lake were bracketed by those from the 500-acre lake and the 1300-acre lake described in the Draft EIS.

Projected water temperatures in the summer (5-day, worst-case) at the Steel Creek delta, mid-swamp, and the mouth of Steel Creek would be within about 1°C of ambient. In the spring, water temperatures at the delta would be 3°C above ambient. Water temperatures would be near ambient at the mouth of Steel Creek. These conditions do not pose any adverse impacts to aquatic and semiaquatic biota. In the winter, however, projected temperatures at Road A and points downstream would be 7°C to 9°C above ambient. These warmer conditions could concentrate fish at the mouth of Steel Creek. Reactor shutdowns during the winter would result in a gradual heat loss in this area, which would minimize any cold shock effects. This alternative would not adversely affect access to, and the spawning of riverine and anadromous fishes in, the Savannah River swamp below the Steel Creek delta.

The habitat impacted by the 1000-acre lake would include between 520 and 680 acres of wetlands in the Steel Creek corridor. The flow of discharge water would have adverse impacts on between 215 and 335 acres of wetlands in the Steel Creek delta and swamp. This area, which is dominated by forested (45 percent) and scrub-shrub (36 percent) wetlands, provides foraging habitat for the endangered wood stork and American alligator. These wetlands also represent important feeding and roosting habitat for as many as 1200 mallard and 400 wood duck. A delta growth rate of about 1 to 2 acres per year is anticipated. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from the 1000-acre lake alternative would not begin until the end of the 35-month construction period. Construction of this alternative could be expedited to about 6 months.

I.1.2.7 Once-through cooling by diversions to Pen Branch

This alternative includes two options: (1) a diversion to Pen Branch by penstock and canal, and (2) a diversion to Pen Branch by lake and canal.

The lower segment of Pen Branch presently receives thermal effluent from K-Reactor. Depending on the diversion option, approximately 2 to 5 kilometers of Pen Branch above Indian Grave Branch that have never received thermal discharge would receive heated effluent from L-Reactor. Flows in this reach would be about 10 times the natural rate at the point of L-Reactor discharge, resulting in appreciable stream erosion. Portions of Pen Branch are expected to be severely eroded by the downcutting, widening, and straightening of its channel. A mixture of sand and mud would be deposited in its delta region, resulting in the growth of the delta by 18 acres or more per year during the first 7 to 10 years of combined K- and L-Area discharges to Pen Branch and eventually modifying the heat dissipation characteristics of the swamp. Below the confluence of Pen Branch and Indian Grave Branch, the combined K- and L-Reactor discharges would double the flow of Pen Branch. The effluent temperature is estimated to be 58°C when it enters the swamp. Approximately 1280 acres of wetlands are expected to be adversely impacted: this would consist of (1) a small portion of Steel Creek (60 acres), (2) a previously unimpacted part of Pen Branch (50 acres), (3) the Pen Branch delta (210 acres), and (4) 960 acres of the Savannah River floodplain. No mitigation of swamp habitat for the endangered American alligator or wood stork would be achieved by this alternative.

The diversion of L-Reactor cooling water by a penstock canal to Pen Branch would eliminate thermal discharges to Steel Creek. Therefore, between 730 and 1000 acres of wetlands in Steel Creek, delta, and Savannah River floodplain would receive no impact. However, about 1220 acres of previously undisturbed wetlands in the Pen Branch (55 acres), its delta (210), and the Savannah River swamp (960 acres) would be affected by the diversion. Implementation after restart would impact between 730 and 1000 acres of wetlands and wetland habitat in the Steel Creek, Steel Creek delta, and Savannah River floodplain. After the completion of the diversion, the wetlands in the Steel Creek and portions of the Savannah River swamp system could reinitiate a successional recovery.

The implementation of the lake-diversion system before or after L-Reactor restart would be similar to that for the penstock canal diversion except for (1) the 60-acre lake caused by damming Steel Creek and (2) the smaller reach of Pen Branch that has not previously received thermal discharges.

I.1.3 Mechanical-draft cooling towers

Mechanical-draft cooling towers added to the L-Reactor site could utilize three principal modes of operation: (1) once-through with direct discharge to Steel Creek, the swamp via a canal, or the Savannah River via a canal and pipeline, (2) total recirculation via the 186-Basin, or (3) partial recirculation with and without refrigeration. A summary of the impacts to floodplains and wetlands from the various alternative cooling systems is given below.

I.1.3.1 Cooling towers with once-through and direct discharge

I.1.3.1.1 Once-through and direct discharge to Steel Creek

This alternative would discharge cooling effluent into Steel Creek at a somewhat lower rate of flow (10.2 cubic meters per second) due to evaporation losses. The temperature of the effluent would be lowered by the towers, and would vary according to the approach to the design wet bulb temperature (i.e., 2.8° or 5.6°C). Temperature of Steel Creek in summer and spring would be at or near ambient above Steel Creek delta (2.8°C approach); in winter temperatures would be 7°C above ambient at the delta. The 5.6°C approach could have adverse effects on Steel Creek because the discharge temperatures would be about 31°C during a 5-day period that is expected to occur once about every 5 years. Otherwise the 5.6°C approach tower will meet the 32°C water-quality standard about 99 percent of the time.

The towers would substantially mitigate the effects associated with direct discharge temperatures; the environmental impacts of this alternative would be less than those for direct discharge; they are summarized as follows:

- High flow rate would eliminate between 420 and 580 acres of wetlands within the Steel Creek corridor. Because the effluent would not have markedly elevated temperatures, high flow rate would impact between 70-80 percent of the delta and swamp area predicted for direct discharge. Thus, between 215 and 335 acres of delta or swamp wetlands would be eliminated (or a total of 635 to 915 acres) due to high flow rate from this alternative cooling system. This would include foraging habitat of the endangered wood stork and the endangered American alligator.

- The spring temperatures should not affect approximately 2500 acres of wetlands and aquatic habitat for spawning riverine and anadromous fishes and other semiaquatic biota because spring temperatures in the swamp and delta would be within 4°C of ambient.

- No impacts to substrate, water quality, or water levels due to dredging and filling.

If this alternative is implemented before restart occurs, environmental impacts would be as described above (i.e., loss of about 635 to 915 acres of wetland due to high flow). If it is implemented after restart occurs, the environmental impacts would be the same as those described in Section 4.4.2 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.1.2 Once-through - canal to swamp

This alternative would directly discharge cooling-water effluent into a canal at a rate of 10.2 cubic meters per second. This canal would bypass the Steel Creek corridor and discharge through a diffuser in the vicinity of Steel Creek delta.

This alternative (all approaches) would avoid Steel Creek down to the swamp, allowing approximately 420 to 580 acres of wetland to continue successional recovery in the Steel Creek corridor, including habitat for the endangered American alligator. The effluent would reach the swamp via the canal near Steel Creek and enter the swamp through a diffuser at temperatures between 23°C and 28°C during the spring, which would allow riverine and anadromous fish and other biota to have access to the swamp during the spawning season. Temperatures at the delta during the summer would be 28°C and 31°C for the 2.8°C and 5.6°C approaches, respectively. However, the impacts on the swamp from the 10.2-cubic-meter-per-second flow would be almost the same as those described for direct discharge.

The canal would be routed adjacent to Steel Creek above the floodplain and extend for approximately 10.4 kilometers before discharging at the delta. The canal would impact about 120 acres of upland pine forest and open fields, and require the disposal of approximately 850,000 cubic meters of spoil.

This alternative cooling system would have no impact on endangered and threatened species that inhabit Steel Creek above its delta because the creek corridor would not receive thermal effluent. The discharge of 10.2 cubic meters per second through a diffuser located at the Steel Creek delta might channelize portions of the existing wetlands. Between 215 and 335 acres of wetlands in the delta and swamp would be impacted. However, the discharge temperatures (28°C and 34°C for 2.8°C and 5.6°C approaches in summer, respectively) would not adversely impact the American alligator. The greatest potential impact would result from elevated water levels, which could eliminate foraging habitat for the endangered wood stork. The shortnose sturgeon would be unaffected by this alternative.

Dredge material from the canal and the area in the swamp around the diffuser would be monitored and handled to meet applicable regulatory requirements. Thus, no significant changes in water quality, suspended particulates, or turbidity are expected to occur in the swamp or Savannah River due to dredge and fill activities.

If this alternative is implemented before restart occurs, the environmental impacts would be as described above (successional recovery of 420 to 580 acres of wetland in Steel Creek corridor and losses of 215-335 acres in the swamp). If it is implemented after restart occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.1.3 Once-through - spray canal and canal to swamp

This alternative would discharge cooling-water effluent into the swamp via a canal at a somewhat lower rate of flow (10.2 cubic meters per second) than direct discharge due to evaporation losses. The temperature of the effluent under this alternative would be identical in summer and spring to that of the alternative described in Section 4.4.2.3.1.2, minus the spray system. It would be lower in winter due to cooling by the spray system.

This alternative would include complete avoidance of Steel Creek down to the swamp, allowing approximately 420 to 580 acres of wetland to continue successional recovery in the Steel Creek corridor, including habitat for the endangered American alligator. The effluent would reach the swamp via a canal near Steel Creek and enter the swamp through a diffuser at temperatures between 28°C and 30°C (essentially 2°C below summer ambient temperatures; 2.8°C approach). This would allow access in the spring to the entire swamp and Steel Creek by spawning riverine and anadromous fish and other aquatic biota. However, the impacts on the swamp from the 10.2-cubic-meter-per-second flow would be the same or slightly less than those described for direct discharge.

Except for water temperatures slightly cooler (2°C) than ambient in the swamp and mouth of Steel Creek (with a 2.8°C approach tower), the environmental impacts of this alternative would be the same as those for cooling towers having once-through discharge via a canal to the swamp. These impacts are summarized as follows:

- No impact to the Steel Creek corridor, but increased flow rate would eliminate 215 and 335 acres or wetlands in the swamp.
- Approximately 120 acres of upland pine forest and open fields would be disturbed for construction of the canal; 850,000 cubic meters of spoil would have to be removed and stored or utilized. About 30 acres of upland pine forest would be removed for the construction of the towers. In order to achieve optimal cooling performance with one set of sprays, vegetation within 300 meters of the sprays must be cleared to enhance evaporative rates. This would eliminate approximately 55 acres of wetlands and 55 acres of upland habitat.
- No impact to the American alligator and shortnose sturgeon; foraging habitat of the endangered wood stork would be adversely impacted due to increased water levels.
- Modification of the bottom contour of the swamp in the vicinity of the diffuser.
- No impact to water quality or increased suspended particulates and turbidity would result from the dredging of the canal. Short-term impacts might be associated with the installation of the diffuser.

If this alternative is implemented before restart occurs, the environmental impacts would be as described above (successional recovery of 420 to 580 acres of wetlands in Steel Creek and loss of about 215 to 335 acres in the swamp due to high flow rate). If it is implemented after restart occurs, the environmental impacts would be the same as those described in Section 4.4.2.3.1.2 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.1.4 Once-through - canal to swamp - pipe to river

This alternative would completely avoid Steel Creek and the swamp, allowing approximately 730 to 1000 acres of wetland to continue to undergo successional recovery and fish would have full access to Steel Creek and Swamp. However, access of fish to Boggy Gut Branch would be limited, especially during the spring and summer.

The diffuser would be constructed to mix the effluent rapidly with the river. Based on seasonal outfall temperatures, a zone of passage would be maintained to allow movement of anadromous fish past SRP; the mouth of Steel Creek would not be blocked by temperatures high enough to exclude riverine and anadromous fish from entering and spawning in the Steel Creek swamp system (for both 5.6°C and 8.2°C approach temperatures). Discharge temperatures might attract some fish species into the thermal plume during the winter; however, insignificant impacts are expected on riverine species due to overwintering stress.

The greatest impact to wetlands from this alternative would result from the construction of the pipeline. This raised structure would extend from a point near the Steel Creek delta to the Savannah River, a distance of 2500 meters. Pipeline construction could have adverse impacts on the Savannah River swamp because of: (1) piles driven into the substrate to support the pipeline, (2) the use of heavy equipment affecting wetlands through the compaction of substrate, and (3) increased erosion and sedimentation due to disturbances of the substrate.

The pipeline would be constructed above the high-flood mark (about 7 to 9 meters), so it could not act as a dam and impede water flow during flooding.

Proper buffers would be installed during construction to prevent movement of suspended particulates, which might cause turbidity impacts. Discharge water quality would be the same as that described for direct discharge. No significant changes in water quality, suspended particulates, or turbidity are expected to occur in the swamp or the Savannah River.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetland). If it is implemented after direct discharge, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.2 Cooling towers - recirculation

I.1.3.2.1 Total recirculation - blowdown to Steel Creek

The 2.8°C and 5.6°C approaches recirculation alternatives would greatly reduce temperatures discharging to Steel Creek, and would result in a minimal impacts to the biota of the creek, its delta, the floodplain, and the Savannah River in comparison to the effects caused by direct discharge (see Section

I.1.3.1.1). The 2.8°C approach tower would continually meet the 32°C thermal standard except during extreme summer meteorological conditions; during these conditions it would exceed the limit by less than 1°C. The 8.3°C approach tower would not meet the 32°C thermal standard from late spring to early fall. All three approaches have low discharge rates (about 0.6 cubic meters per second), thus, impacts due to flow would be minimum.

The blowdown-to-Steel Creek ion-concentration ratio is expected to be about 3. Thus, the chemical constituents in the creek water near the L-Reactor outfall would be about 1.7 times their normal concentration without the blowdown. At Road A, the increases in concentration would be only about 1.4 times normal. The blowdown is not expected to have an appreciable impact on the water quality of Steel Creek, the swamp, or the Savannah River.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetland). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.2.2 Total recirculation - blowdown treatment

This cooling-system alternative (2.8°C approach) would discharge 0.6 cubic meter per second of blowdown effluent at essentially the same temperatures in summer and spring as those achieved by cooling towers having total recirculation. However, in winter and at other times as required, the blowdown would be treated to reduce its temperature and to assure compliance with the 2.8°C delta-T thermal standard. In summer and spring, near ambient temperatures would be achieved from the outfall to the Savannah River. Near-ambient winter temperatures would be reached along the creek, delta, swamp, and at the mouth of Steel Creek.

This alternative would have essentially the same environmental impacts as those resulting from the implementation of cooling towers having total recirculation (2.8°C approach) without blowdown cooling; these impacts are summarized as follows:

- Construction of the towers would affect approximately 30 acres of upland pine forest. There would be no impact to wetlands or the biota that inhabit the Steel Creek ecosystem and swamp.

- There would be no impact to endangered and threatened species, nor would any critical habitat, as designated by the U.S. Fish and Wildlife Service, be affected.

- Because of low discharge rate little or no change in present erosion or sedimentation patterns is expected. There would be no impacts to aquatic substrate or water quality from dredging and filling activities, because they are not required.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetlands). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.3 Cooling towers - partial recirculation

Cooling towers (2.8°C or 8.3°C approach temperature) that only recirculate a portion of the cooling water could be added to the L-Reactor site. From April through October the towers would cool water on a once-through basis and discharge all the effluent directly to Steel Creek. Based on equilibrium temperature calculations for these months, the discharge to Steel Creek under normal weather conditions would continuously meet the 32°C/+2.8°C temperature standard if a 2.8°C approach cooling tower is used. Equilibrium temperature calculations indicate that, from November through March, a portion of the cooling water must be recirculated to the 186-Basin, the remainder of the water discharged to the creek at 10.9 cubic meters per second would be obtained by blending ambient river water with cooling-tower blowdown.

I.1.3.3.1 Partial recirculation - discharge to Steel Creek

Except for the mitigating effects associated with lower discharge temperatures (maximum summer discharge temperatures of 27°C to 28°C, depending on approach), the environmental impacts caused by this alternative (2.8 and 8.3°C approach) would be similar to those for direct discharge; they are summarized as follows:

- High flow rate would eliminate between 420 and 580 acres of wetlands within the Steel Creek corridor. Because the effluent will not have markedly elevated temperatures, high flow rate would impact between 70 to 80 percent of the delta and swamp area predicted for direct discharge. Thus between 215 and 335 acres would be eliminated (or a total of 635 to 915 acres) due to high flow rate from this alternative cooling system. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

- Foraging sites for the endangered wood stork would be eliminated due to increased water levels.

- No impacts to substrate, water quality, or water levels due to dredging or filling.

- Increased sedimentation and erosion due to effluent discharge; delta growth is anticipated to be 3 surface acres per year.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (i.e., loss of 635 to 915 acres of wetlands). If it is implemented after direct discharge occurs, environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.3.2 Partial recirculation - with refrigeration

This alternative is the same as the partial recirculation case described above except that a refrigeration unit would be used primarily at night during the winter, to meet state thermal discharge standards. The refrigeration system would operate about 2 to 5 hours per night from January through March. During those hours, about 1 cubic meter per second would be diverted through the refrigeration unit to give a maximum mixed Steel Creek temperature difference of about 2.8°C. The maximum summer discharge temperatures to Steel Creek would not exceed 30°C for either approach.

High flow rate would eliminate between 420 and 580 acres of wetlands within the Steel Creek corridor. Because the effluent would not have markedly elevated temperatures, high flow rate would impact between 70 to 80 percent of that predicted for direct discharge. Thus between 215 and 335 acres would be eliminated (or a total of 635 to 915 acres) due to high flow rate from this alternative cooling system. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

- Foraging sites for the endangered wood stork would be eliminated due to increased water levels.

- No impacts to substrate, water quality, or water levels due to dredging or filling.

- Increased sedimentation and erosion due to effluent discharge; delta growth is anticipated to be 3 surface acres per year.

If this alternative is implemented before restart occurs, the environmental impacts would be as described above (i.e., loss of 635 to 915 acres of wetlands). If it is implemented after restart occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.4 Recirculation alternatives

I.1.4.1 Recirculation through creation of L-Pond

Under this alternative, a recirculating lake would be constructed in the Steel Creek floodplain below L-Reactor; this lake would inundate approximately 1300 acres of floodplains, bottomland hardwood forest, and stands of upland pine. Under extreme meteorological conditions, discharges from this lake are expected to be about 33°C in the summer; the average discharge temperature would be about 31°C. Near ambient temperatures would be reached in Steel Creek near the delta. L-Pond would support minimal aquatic life because of a continually high water temperature. Isolated cool-water refuges might be utilized minimally by aquatic (fish) and semiaquatic biota (herpetofauna, wading birds, beaver). Approximately 7.6 kilometers of Steel Creek would be eliminated, including existing habitats of the American alligator. Approximately 240 acres of wetlands would be adversely impacted by the impoundment. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

The creation of L-Pond before restart occurs would eliminate thermal discharges to Steel Creek. Approximately 605 to 875 acres of wetlands in Steel Creek below the embankment, Steel Creek delta, and Savannah River floodplain would not be impacted and would remain in post-thermal recovery, unaffected by cooling-water effluents from L-Reactor. However, about 240 acres of wetlands would be inundated.

Implementation after restart occurs would impact between 730 and 1000 acres of wetland habitat in Steel Creek, Steel Creek delta, and Savannah River floodplain. After the completion of the L-Pond, between 605 and 875 acres of these wetlands in Steel Creek below the embankment and the Savannah River swamp would reinitiate a successional recovery.

I.1.4.2 Recirculation through creation of Kal Pond

This alternative would create one large recirculating lake to cool both K- and L-Reactors. Constructing dams across both Steel Creek and Pen Branch would inundate approximately 2620 acres of floodplain, bottomland hardwood forest, and upland conifers. This would include 7.2 kilometers along Pen Branch, 7.6 kilometers along Steel Creek, and 4.0 kilometers on Indian Grave Branch. This impoundment would flood forested habitats that once contained the endangered red-cockaded woodpecker, and would eliminate some alligator habitat. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

Maximum summer discharge temperatures would be about 33°C, but typically would be less. At the Steel Creek and Pen Branch deltas, near ambient water temperatures would exist. Little or no change is expected in the erosion or sedimentation patterns in Steel Creek or Pen Branch because the overflow, about 0.5 cubic meter per second to each creek, would not produce large increases to the normal flows of these streams. Both deltas should remain unchanged.

Kal Pond, which is expected to show thermal behavior much like that of Par Pond, is expected to have adverse impacts on approximately 615 acres of wetlands. However, because it would terminate the existing thermal effluent down Pen Branch, approximately 1170 acres of swamp could undergo successional recovery.

The creation of Kal Pond before restart occurs would eliminate thermal discharges to Steel Creek; approximately 650 to 920 acres of wetlands in the Steel Creek, Steel Creek delta, and Savannah River floodplain would not be impacted and would be allowed to remain in post-thermal recovery, unaffected by cooling-water effluents from L-Reactor. However, about 425 acres of wetlands along Indian Grave Branch and Pen Branch and 2005 acres of uplands would be adversely affected. In addition, the lake would allow approximately 1170 acres of previously disturbed wetlands to recover because the thermal effluent down Pen Branch from K-Reactor would be eliminated.

Implementation after restart occurs would impact between 730 and 1000 acres of previously affected wetlands and wetland habitat in the Steel Creek, Steel Creek delta, and Savannah River floodplain. After the completion of Kal Pond, the wetlands below the dam in the Steel Creek and Pen Branch floodplain and the Savannah River swamp would reinitiate a successional recovery.

I.1.4.3 Recirculation through creation of High-Level Pond

Two dam sites on the Pen Branch drainage area north of L-Reactor have been studied for creating a recirculating High-Level Pond. The first and second dam sites would create pond areas of approximately 1225 and 1785 acres, respectively. This area of upland forest habitat, including 9.4 kilometers of Pen Branch which has not previously received thermal effluent, would be inundated. Thermal discharges (about 0.5 cubic meters per second) could reach 36°C under adverse summer conditions, but would average 34°C in the summer. Near-ambient temperatures would occur at the Steel Creek delta.

Approximately 610 acres of wetlands associated with upper tributaries of Pen Branch and 1175 acres of uplands are expected to be adversely impacted. This alternative would not adversely affect endangered species. After construction of the impoundment, a portion of Pen Branch would remain between the High-Level Pond and the thermally-impacted reach below K-Reactor. However, surviving fishes in this segment would become essentially landlocked; their access to upstream portions would be precluded by the dam and their access to downstream portions and the floodplain swamp would be limited to periods when K-Reactor is shut down.

The creation of a High-Level Pond before L-Reactor restart would eliminate thermal discharges to Steel Creek. Therefore, between 730 and 1000 acres of wetlands in the Steel Creek, Steel Creek delta, and Savannah River floodplain would not be impacted and would remain in post-thermal recovery.

If this alternative is implemented before restart occurs, the environmental impacts would be as described above. Implementation after restart occurs would impact between 730 and 1000 acres of previously affected wetlands in Steel Creek, Steel Creek delta, and Savannah River floodplain plus 1175 acres of uplands and 610 acres of wetlands in upper Pen Branch. After the completion of the High-Level Pond, wetlands in the Steel Creek and Savannah River swamp could reinitiate a successional recovery.

I.1.4.4 Recirculation through Par Pond

Under this alternative, Par Pond would be used to cool the effluent from both P- and L-Reactors. A new pipeline would run northeast from L-Area and discharge into an excavated canal that would connect to Pond A near the R-Reactor effluent canal. From this point, the cooling water from L-Reactor would follow the same path through Par Pond that R-Reactor cooling water followed when that reactor was active. A new underground return pipeline would be constructed from near P-Reactor to the L-Reactor reservoir.

Because Par Pond already exists, any modifications of terrestrial habitat would be limited to a temporary disturbance to approximately 50 acres to construct the new discharge canal. This 2700-acre pond, however, contains a diversified and abundant assemblage of aquatic and semiaquatic biota, including more than 100 American alligators (Murphy, 1981). Based on previous thermal conditions when two reactors were operating, this alternative should not greatly increase water temperatures in the pond as a whole. However, a few acres of wetland habitat adjacent to Ponds A and B and the North Arm of Par Pond would be adversely impacted; some revegetation has occurred along the edges of these bodies since R-Reactor was shut down. This alternative would affect the alligator and aquatic biota through reduction in available habitat and avoidance of the heated effluent, primarily in the North Arm of Par Pond. Under adverse summer conditions, the discharge from Par Pond, about 0.5 cubic meters per minute could reach 33°C, but average summer discharges would be 31°C. Near-ambient temperatures would exist at Steel Creek delta.

The implementation of the Par Pond alternative before restart would eliminate thermal discharges to Steel Creek. Therefore, between 730 and 1000 acres of wetlands in the Steel Creek, Steel Creek delta, and Savannah River floodplain would not be impacted and would be allowed to remain in post-thermal recovery, unaffected by cooling-water effluents from L-Reactor.

Implementation after restart occurs would impact between 730 and 1000 acres of previously affected wetlands and wetland habitat in the Steel Creek, Steel Creek delta, and Savannah River floodplain. After the completion of the Par Pond diversion, the wetlands in the Steel Creek and the Savannah River swamp system would reinitiate a successional recovery.

I.1.5 Other alternatives

I.1.5.1 Thermal cogeneration

Although a feasibility study of various cogeneration options has not been completed, it is anticipated that the most effective use of waste heat would involve utilization of the reactor thermal effluent as a heat source. The use of a Rankine cycle would cool the reactor thermal effluent from 71°C to 49°C. However, three to five times the flow of reactor thermal effluent would be required to cool the condenser in the Rankine cycle and would result in a temperature increase to 3° to 6°C to the ambient-temperature water used for cooling. Thus, approximately 58 cubic meters per second of cooling water will be discharged to Steel Creek at a temperature of about 49°C.

The temperature reduction of thermal effluent would probably be offset by the increased flows and water fluctuation levels to Steel Creek from the Rankine cycle coolant. The expected loss of wetlands would be significantly greater than direct discharge due to the major increase in flow, flow fluctuations, and increased sedimentation, rather than temperature effects.

The principal difference in the implementation of a thermal cogeneration system using the Rankine cycle before or after L-Reactor restart would be the rates of vegetative mortality due to thermal effects versus flow effects.

I.1.5.2 Low-head hydropower

The implementation of a low-head hydropower option either at the L-Reactor outfall or below a 500-acre impoundment would not significantly alter wetland effects, as described either for discharge to Steel Creek (Section I.1.1.1) or for direct discharge to a 500-acre lake (Section I.1.3.2).

I.1.5.3 Modified reactor operation

The total heat load discharged into Steel Creek is a direct function of reactor power. Therefore, power could, in theory, be limited to a level below that achieved at normal operating limits to control this heat load. If the power were reduced, cooling-water flow could also be set to reduce either the total flow or the temperature of Steel Creek. This alternative could be used in combination with other alternatives to reduce heat loading.

As power is reduced, the temperature (under extreme summer conditions) is reduced from 80°C at the outfall at 2400 megawatts thermal to 71°C at 2000 megawatts thermal, to 53°C at 1200 megawatts thermal and to 40°C at 600 megawatts thermal. Temperatures within the Steel Creek system are also affected by reactor power levels. The temperature experiences at various locations below the outfall are presented in Table 4-36.

Under generating levels of 600 megawatts thermal, 30°C is reached prior to entry to the Savannah River. Further temperature reduction in the Savannah River would require simultaneous reduction in power and flow (see Figure 4-2).

This simultaneous reduction would increase the outfall temperatures higher than those reported above and, therefore, offer little benefit to the upper portions of Steel Creek. Although some thermal mitigation is achieved in the swamp, flooding, fluctuating water levels and siltation impacts would still result during periods of reduced power. Therefore, about 730 to 1000 acres of previously impacted wetlands that are beginning a successional recovery would again be affected.

While low power operation is not practical for extended periods of time, it can provide a means of meeting thermal limitations for short periods. The potential reduction of reactor power to reduce the cooling-water temperature is directed at ensuring a sufficient zone of passage in the Savannah River. However, at reduced power, production efficiency would be reduced.

Under extreme meteorological conditions, reducing power by a factor of four could reduce the temperature of the effluent entering the swamp by about 10°C and reduce the creek-to-river delta-T by about 3°C.

I.1.5.4 Fisheries management programs

The direct discharge of L-Reactor cooling water to Steel Creek with fish management programs would essentially have the same wetland impacts as those described in Section I.1.1. Between 730 and 1000 acres of previously impacted wetlands that are beginning a successional recovery would again be impacted.

No designs or site selection for an onsite hatchery facility and rearing ponds have been made. If a hatchery and rearing ponds were established onsite, their construction would occur in upland areas or existing facilities would be used. Therefore, the only impact to wetlands in addition to that from a direct discharge would be the possible construction of an outfall from a wastewater treatment lagoon that might be required for rearing-pond effluent.

The implementation of fish management programs would provide a partial replacement for the productivity of wetland habitat and Steel Creek and Savannah River swamp spawning areas that would be lost due to the resumption of direct discharge.

I.1.5.5 Protect similar wetlands

If available, a property comparable in size and wetlands value to the impacted Steel Creek/swamp area could be designated on SRP or purchased and set aside as a fisheries/wildlife preserve. Thermal discharges from L-Reactor could reduce the spawning/rearing habitat currently utilized by fish species in the Steel Creek/swamp system. Other creeks and associated wetlands with similar spawning/rearing habitat exist between the New Savannah Bluff Lock and Dam and the lower tidal reaches of the Savannah River. A large parcel of land (greater than 1000 acres) would cost approximately $500 per acre.

I.2 FLOODPLAINS

Several of the alternative cooling systems require the construction of dams or structures in the floodplains of streams (Steel Creek, Pen Branch, Indian Grave Branch, and Meyers Branch) on the Savannah River Plant. Because these dams or structures must direct or use onsite streams to achieve a reduction in thermal or flow effects, locating them outside the floodplain would not be possible.

The construction and operation of dams or structures on SRP streams would, to the maximum extent possible, avoid adverse impacts associated with the use and modification of the floodplain for the following reasons:

- There would be no appreciable modification of water levels or flow regimes in offsite streams and rivers. Thus, the natural and beneficial values of offsite floodplains would be maintained.

- If the onsite floodplains were flooded, the dams and structures would not create additional consequences to any emergency conditions.

- Access to the Savannah River Plant is strictly controlled; no dwellings, hospitals, schools, nursing homes, or other structures are located within the floodplain. Thus, no individuals or private property would be affected.

- No essential and irreplaceable records, utilities, and/or emergency services would be affected or lost in the event of flooding.

Impacts to water quality and ground water, archeological sites, wildlife habitat, and other resource uses were described in Section I.2 and in Section 4.4.2.

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APPENDIX J

SRP REACTOR SAFETY EVOLUTION*

INTRODUCTION

The Savannah River Plant reactors have operated for over 115 reactor years without an incident of significant consequence to on or off-site personnel. The reactor safety posture incorporates a conservative, failure-tolerant design; extensive administrative controls carried out through detailed operating and emergency written procedures; and multiple engineered safety systems backed by comprehensive safety analyses, adapting through the years as operating experience, changes in reactor operational modes, equipment modernization, and experience in the nuclear power industry suggested. Independent technical reviews and audits as well as a strong organizational structure also contribute to the defense-in-depth safety posture. A complete review of safety history would discuss all of the above contributors and the interplay of roles. This appendix, however, is limited to evolution of the engineered safety features and some of the supporting analyses.

The discussion of safety history is divided into finite periods of operating history for preservation of historical perspective and ease of understanding by the reader. Programs in progress are also included.

The accident at Three Mile Island was assessed for its safety implications to SRP operation. Resulting recommendations and their current status are discussed separately at the end of the appendix.

SUMMARY

Operation of the Savannah River reactors began in 1953 with a conservative design, automatic shutdown systems, and detailed written procedures. As reactor safety technology advanced at Savannah River and in the U.S. nuclear industry, as modernized equipment (e.g., computers) became available, and as operating experience and comparison to industry standards suggested needs for change, projects were undertaken to upgrade and supplement existing safety systems.

Confinement

Original control of airborne radioactive releases was by dispersion via a tall stack. Confinement features were added beginning in 1960 to cope with the very low probability accidents that could release radioactive materials. The features include filtration of all the ventilating air leaving the reactor building using moisture separators, particulate filters and halogen adsorbers (carbon).

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*This appendix, in its entirety, is derived from: Rankin, D.B., 1983. SRP Reactor Safety Evolution, DPST-83-718, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, South Carolina.

Emergency Cooling and Liquid Activity Containment

The original design provided for emergency manual addition of light water to the reactor core with retention of the water in a dedicated tank after it leaves the building. Improved sources of light water and a common pressurized addition header were added in the mid 60s. Automatic emergency cooling was provided beginning in 1973 with many additional system improvements toward increased reliability being made over the years. Larger contaminated water removal pumps and increased storage capacity were added beginning in 1973.

Computer Monitoring and Control

Safety of reactor operation was enhanced beginning in 1964 by computer monitoring of critical process conditions and in 1970 by computer control of reactor operating and shutdown systems. Updated redundant control computers replaced the original ones in 1978 and redundant "safety" computers were installed for assembly temperature and flow scram protection.

Automatic Emergency Shutdown

The original instrumentation provided numerous monitoring circuits which could actuate the safety rods to drop if prescribed limits were exceeded. Safety rod system improvements over the years provided diverse relay logic and paths for scram signals, utilizing both AC and DC power sources. A backup shutdown system, the Supplementary Safety System, was added in 1957 to provide for manual injection of a liquid neutron poison in the event the safety rods failed to drop. The Gang temperature monitor automated this system in 1974 to be actuated upon sensing of very high temperatures. The Safety Computers were programmed beginning in 1979 to back up scrams with SSS actuation, providing protection for all postulated transients.

Seismic Protection

Seismic scram protection was provided in 1955. As a result of earthquake and building structural analyses, seismic bracing was added beginning in 1976 to protect the susceptible building structures and emergency cooling system piping from postulated credible earthquakes.

Fuel Handling

Fuel handling operations improvements in the late 70s and 80s have equipped the charge and discharge machines with computer positioning and misload protection as well as assembly identification capability. Automatic cooling for all irradiated assemblies was provided to the discharge machines.

Programs In Progress

Programs are currently in progress to assess possible improvements to the confinement system, emergency cooling system and fuel handling equipment and to provide additional seismic analyses for critical systems. In addition, Savannah River Laboratory performs continuing research and development in all areas of reactor safety. And their detailed review of plant operations and programs provides a strong independent safety overview as outlined in the Nuclear Safety Control Procedures.

In addition, an extensive program is currently in effect to incorporate lessons learned from the Three Mile Island accident into the SRP reactor safety features. Numerous changes have been incorporated into the SRP operations and others are in progress related to this program. Computerized diagnosis of multiple alarm situations and availability monitoring of critical equipment are two of the programs in progress.

Figure J-1 presents safety milestones from initial startup to present.

DISCUSSION

1953-1960

The original design concept of the SRP reactors envisioned the prevention of accidents by backup equipment, comprehensive instrumentation, detailed written procedures, well-trained personnel and strong technical backup. Additional safeguards were provided by an isolated site to protect neighboring people, by reactor buildings designed to resist pressures from external blasts, and by exhausting the building air through a high stack for increased dispersion of hazardous airborne contamination.

The earliest formal safety analysis report for SRP reactors was issued in April 1953; inherent reactor hazards and postulated accident scenarios were discussed and the initial facility design features protective of such accidents and mitigative of the consequences were presented.

Original design features directly related to reactor safety (and maintained in similar form to present) are listed below. These formed the "building blocks" for later improvements.

- Safety rod system - Sixty-six cadmium safety rods (79 in C-Reactor) are provided in 1-inch positions interstitial to fuel positions throughout the reactor. The rods are suspended just above the reactor core and will reach their full IN position and shut down the chain reaction about 1 second after a scram demand signal. Original circuits capable of initiating safety rod (scram) action are discussed later.

- Control rod system - Sixty-one control rod bundles (73 in C-Reactor), housing seven control rods each, occupy 4-inch lattice positions in the central portions of the reactor. A combination in each bundle of half-length and full-length (effective portions) rods provides for detailed axial and radial flux control, thus minimizing hot spots and the resultant challenge to assembly cladding and providing for overall power optimization. The control rods are capable of shutting down the reactor and maintaining it subcritical, independent of the safety rods.

- Cooling system - 6 D_2O coolant pumps powered by 3000 HP a.c. motors and backed up by 120 HP d.c. motors originally provided the capability of circulating about 78,000 gpm of assembly coolant. The online (via gear reducers) d.c. motors provided 24,000 gpm capability to remove shutdown decay heat. About 67,000 gpm of Savannah River water provided cooling for the primary loop (D_2O) through 6 heat exchangers.

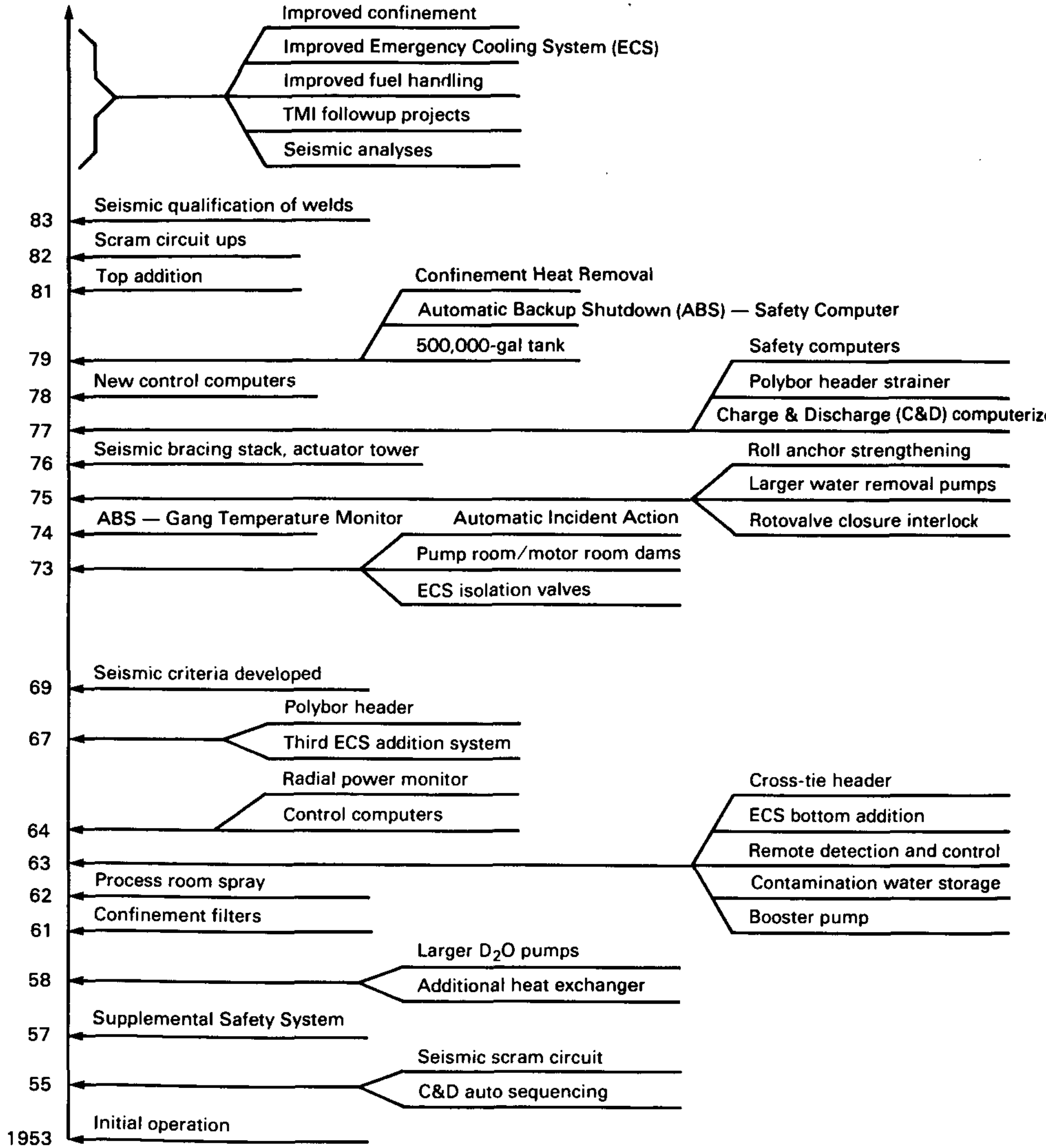

Figure J-1. Reactor safety milestones.

- Shielding - More dedicated to personnel safety than reactor safety, top, bottom and thermal circulating deionized water shields were provided for radiation shielding and removal of heat from neutron and gamma attenuation. Seven feet of concrete immediately surround the thermal shield. The walls, floors, and ceilings of the pump rooms, motor rooms, and heat exchanger rooms are constructed with a minimum of 4 ft of concrete for shielding.

- Instrumentation - Instruments primarily concerned with reactor safety are those that monitor neutron flux in the reactor and cooling system parameters such as activity, temperature and pressure at various points in the system. The original "action-oriented" instrumentation was divided into 4 modes:

  (1) Scram I - energized the safety and control systems, causing reactor shutdown within about 1 second.

  (2) Scram II - energized the scram circuit on the control rod system only, causing reactor shutdown within about 2 minutes. More rapid shutdown was not deemed necessary for these events to justify the thermal transient caused by safety rod action.

  (3) Reversal - caused control rods to be driven into the reactor in the normal sequencing pattern. This slow reduction in power allowed time for correction of less threatening problems with possible return to standard operation without shutdown.

  (4) Annunciators - provided audible and visual indication of abnormal signals. Items causing scram or reversal action as well as numerous process variables were annunciated.

  Original items monitored for scram and/or reversal action included:

    - Neutron flux level
    - Reactor period
    - Temperature of D_2O effluent from assemblies
    - D_2O plenum pressure
    - D_2O pump motor failure
    - Heat exchanger H_2O cooling water flow low
    - Shield flow low

- Fuel Handling

  A charge machine is provided to charge fuel from the assembly area presentation point to the reactor; the discharge machine removes heat-generating irradiated assemblies from the reactor and transports them to the disassembly area canal. All operations are conducted in air. The charge and discharge machines and associated equipment were provided several safety features to prevent erroneous loading and irradiated assembly overheating. Protection included:

  (1) Redundancy of charge and discharge cranes to be able to handle one another's functions.

(2) Ability to discharge housing (with assembly) quickly should sticking of an assembly occur.

(3) D_2O and H_2O coolant supplies to an assembly if discharge required longer than 2 minutes.

(4) Protection against charging to a position already filled.

(5) Anti-collision devices for the machines.

(6) Remote position indicators to operators in the crane control room.

Accidents Considered

The 1953 safety analyses hypothesized two basic accidents: 1) a "boiling accident" caused by complete stoppage of D_2O and H_2O flow by external forces (e.g., earthquake) and 2) a prompt criticality. Offsite doses were calculated to be less than the lethal range for the boiling accident with 10% fission product inventory release. At that time, no credible mechanism for a prompt criticality was determined to exist. Accident scenarios considered for dose calculation were expanded by 1956 to include fuel loading errors, the loss of D_2O circulation accident by system failures, and prompt criticality from startup accidents. Maximum offsite dose from the loss-of-circulation accident were calculated to be in the lethal range.

Administrative Controls

In addition to safety circuits and systems provided in the original facility, a set of detailed written operating instructions governed each step in the process of charging, startup, operation, shutdown and discharge of the reactor. Emergency procedures were provided to respond to conditions necessitating a reactor shutdown. Technical Standards, based on Technical Manual specifications, prescribed limits of operation. Test Authorizations were provided for any changes in operating mode.

Emergency Cooling

In response to postulated loss of D_2O flow incidents, a system was provided for manual addition of H_2O to the reactor. Cooling water lines were provided, with manual activation through remotely operable gate valves.

Seismic

A seismic scram circuit was installed in 1955 to ensure reactor shutdown in the event of an earthquake.

Backup Shutdown Systems

The original safety feature for terminating a power transient if the safety rod system failed was via a moderator dump to dedicated storage tanks. Manual actuation of H_2O addition following the moderator dump would have provided for decay heat removal. The Supplementary Safety System was installed in 1957 to provide for manual reactor shutdown via a liquid neutron poison injection should the safety rods fail to drop during a power rise transient.

The year 1958 was a significant one in both production-oriented facility changes and increased safety effort. New, larger D_2O pumps were installed to increase flow capacity to about 150,000 gpm. An additional heat exchanger was installed in each of the pumping systems in parallel with the existing exchanger. The resultant reactor power increase (to approximately 2000 MW) brought higher individual assembly powers and reactor fission product inventory and thus increased concerns on reactor safety issues. Accidents considered increased to include power surge mechanisms, the "cold-water accident" because of the negative temperature coefficient, loss of coolant, and single assembly melting during operation or discharge. Technical studies produced limits on the heat flux of individual assemblies to prevent cladding "burnout." Tests were proposed to determine the disposition of melted fuel; and reactor containment was first considered.

Fuel Handling

In 1955, primary operations of the charge and discharge machines were provided with the capability to automatically sequence through most steps in the operations without manual input after each step. This "auto cycle" feature significantly reduced the amount of operator input necessary and thus increased system reliability.

External Review

An integral part of the SRP safety philosophy is review by external technical experts. The Atomic Energy Commission Advisory Committee on Reactor Safeguards (ACRS) performed an extensive review in 1958 and concluded:

> "The buildings in which the SR reactors are housed do not possess any significant containment features, such as those now being provided for power reactors located in more populated areas. In the event of a serious accident that would breach the reactor tank and shield, the building shell in itself could not be expected to provide a third line of defense of any consequence on restraining the volatile fission products."

It was recommended "that the Du Pont Company explore alternative paths toward obtaining a higher degree of confinement that is now in effect."

The combination of internal and external review led to a significant increase in safety studies. Primary proposals for partial containment included building sealing and exhaust air filtration.

1960-1965

Confinement System

Containment of fuel melt releases continued to dominate the safety considerations during the early 60s. In 1960-1961, a major improvement project provided moisture separators, particulate filters, and halogen adsorbers (carbon) in the process area ventilation exhaust stream to remove airborne contamination, particularly I^{131}. A backup motor with independent power supply was added to each exhaust fan. Figure J-2 shows the ventilation/confinement system arrangement. The reactor room and process areas were sealed to minimize leakage

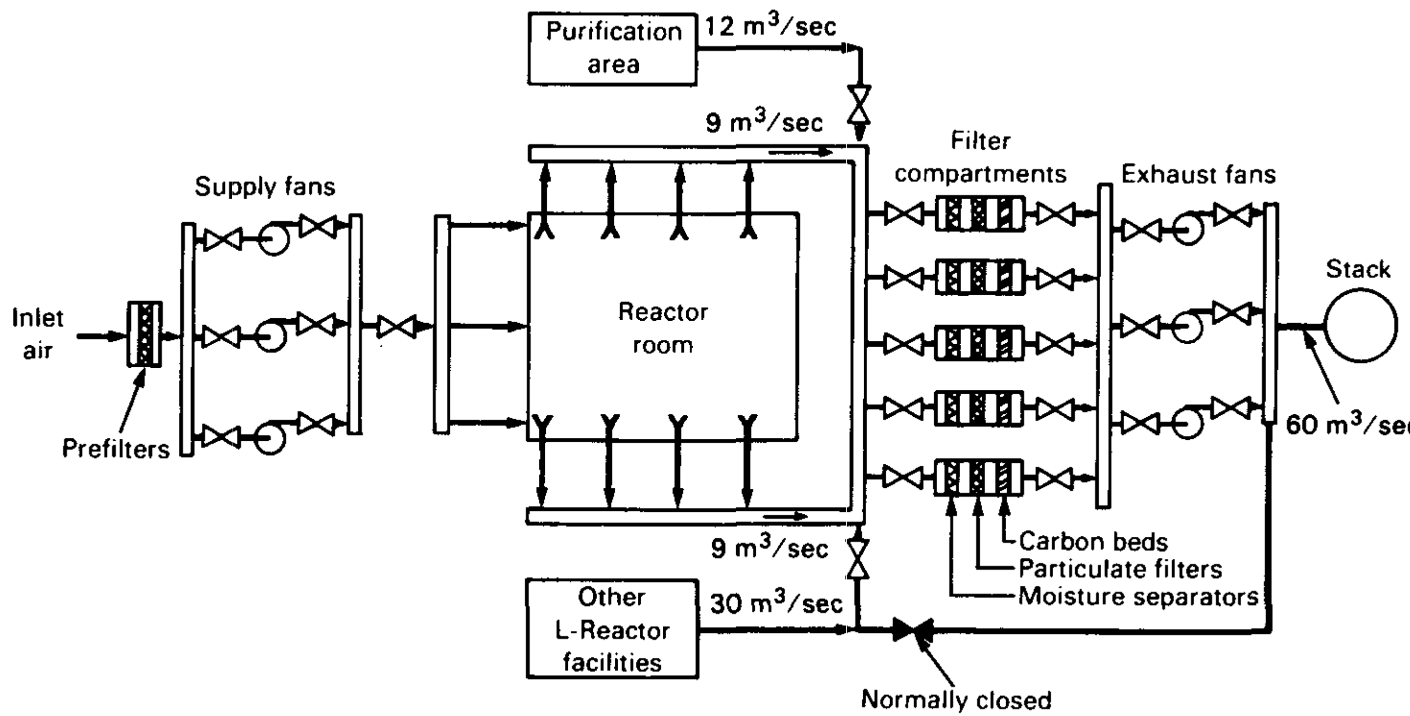

Figure J-2. Flow diagram of reactor ventilation system.

outside the confinement path. The improved system was expected to retain 99% of released particulate activity and 99.9% of the halogens.

ECS

The emergency cooling system received considerable upgrade in 1962-1963. Light water addition lines were tied together by a common "cross-tie header" to facilitate maintaining a pressurized line for monitoring system availability. Piping was redesigned to provide addition through either the top addition or the bottom addition. Submersible addition valves (89-299 series) were installed to maintain addition capability should the -20 ft, -40 ft building area flood. And the booster pump was added to increase the source flow capability and number of sources of light water.

The Remote Detection and Control (REDAC) system was provided to be able to monitor system parameters remotely and add light water if necessary after an area evacuation was required. Also, a 50-million gallon earthen basin was provided to contain contaminated water that would result from a loss of cooling or loss of circulation accident with ECS actuation.

Computers

Reactor monitoring and consequently safety was enhanced in 1964 by providing computer monitoring of critical process conditions. A GE-412 computer was installed in each control room for improved reactor temperature monitoring, calculation of the proximity to cladding burnout and better operating analysis. The computers were provided with control rod reversal capability if assembly operating temperatures increased to 1°C above prescribed thermal-hydraulic operating temperature limits. This reversal capacity prevented minor excursions from reaching the point where scram circuits were challenged.

Fuel Handling

A spray system was added to the reactor room in 1962 for cooling an irradiated assembly if dropped on the floor during discharge operations. The system consists of a header with 12 groups of fixed spray nozzles mounted on the reactor room wall. The spray pattern from the nozzles covers the area traversed by the discharge machine.

Many improvements were added to the charge and discharge machines in 1963. The ability to separately hold (chuck) both components of an assembly having separately dischargeable components ("double chucking") and a sleeve to hold down one while discharging the other were added. These features decreased the possibility of dropping components or of discharging one unintentionally with the other.

Emergency cooling for assemblies during discharge was enhanced by providing automatic sequencing to the secondary source if the primary source fails. Also, the distribution of flow to an assembly was improved by providing a better path into the top of the assembly.

An emergency shear was provided for cutting off the top portion of failed assemblies to facilitate enclosure in a failed assembly container (HARP).

Electrical Distribution System

The original supply of power to building equipment was distributed from four transformer rooms located within the reactor building. A fifth distribution station, known as the containment substation, was added in the early 60s and placed above ground level outside the building. This station will provide power to critical equipment in the event that flooding of the below-grade elevation disables the normal supply.

General

The number and type of accidents analyzed was expanded during this period to include anticipated transients without scram (ATWS). As a result, reactor operating restrictions on temperature and power were imposed in 1964. The radial power monitors (RPMs) were installed to provide scram protection for cluster (group of 6) and gang (group of clusters) temperature increases. And the maximum control rod drives speed was reduced to limit the power increase from a rod driveout accident. Explosive valves were added to the ink injection system to increase the reliability and speed of injection should the safety rods fail to drop.

Reactor power was increased several hundred MW in 1963 when operations with 5 PSIG blanket gas were established. R-Reactor operation was discontinued in 1964 due to reduced product demand.

1965-1970

ECS

In 1967, the bottom addition system was moved so that three systems now had addition capability. This increased capacity was designed to limit core damage to less than 1% for the worst-case loss of coolant accident as well as to provide additional redundancy. Also, it was recognized that the cold H_2O which the ECS would add to the reactor could produce, for current charges, a positive reactivity transient which may override the effect of safety rod insertion. So a 20,000 gallon storage header was added in line with the crosstie header and filled with a neutron poison solution (2% polyborate), sufficient to preclude a positive reactivity transient from either necessary or unwanted ECS actuation.

Seismic

The blast criteria used in the original design did not necessarily provide for the effects of earthquakes. The buildings were very resistant to external forces but their response to dynamic effects was not specifically analyzed at the time of the original design. The reactor building structures were analyzed in 1969 for their response to seismic criteria developed by Dr. George Housner of the California Institute of Technology. The structural analysis was made by John A. Blume and Associates of San Francisco. These independent consultants recommended a set of seismic criteria for the design and analysis of retrofitted SRP facilities. Reactor area buildings and associated systems and equipment were then classified according to their required seismic resistance. The classification applies to those features of each system that are essential to protect the public health and safety. The results of the studies concluded that remedial strengthening of the actuator towers and exhaust stacks was necessary to comply with the criteria. Resultant projects are discussed later in this report. Process water piping was determined to be adequately resistant to seismic stresses.

Other

Because the SRP reactors operated before formalized nuclear industry guides and standards existed, building design and construction did not necessarily conform to the later criteria. The first comprehensive, documented comparison of SRP reactors to licensed reactors was issued in 1967 after the AEC had issued a set of 70 criteria for licensees. Exact comparison with the criteria were made where system characteristics were similar; where exact comparison was not practical, an effort was made to define the intent of the criteria with respect to the SRP facilities and discuss compliance as appropriate. It was concluded "that the SRP reactors meet the overall intent of the 70 Criteria and, in most cases, meet the literally interpreted criteria."

L-Reactor operation was discontinued in 1968 due to decreased product demand.

1970-1975

Confinement System

A new carbon test facility was placed in operation for evaluating aging effects on carbon and other filter components.

ECS

Isolation valves were installed (1973 in P and K, 1974 in C) in each of the four ECW sources converging into the common polyborate storage header. This isolation limits the volume of water available to the storage header to prevent flooding of D_2O pump motors in the event of header failure. Such a failure without isolation would both produce the need for ECW addition and defeat the protection. The isolation valves are normally closed and would be opened automatically upon ECS actuation.

Also to preclude flooding of circulating pump motors from any cooling water leak or ECS actuation, four new sump pumps (2 rated at 4500 gpm; 2 at 2500 gpm) were installed in 1975 to replace the original pair of 2000-gpm pumps. The 2500-gpm pumps are submersible. The total 14,000 gpm removal capacity is capable of removing all ECS water even if all three addition systems were on-line.

A new hydro-starter was installed on the booster pump (one of the four ECW sources) after a history of minor starting problems. The original electric starter was maintained as a backup.

Remote start capability for the main cooling water pumps was provided to the central control room in 1973. These pumps could originally be shut off remotely to control a large cooling water leak. This ability to start the pumps provided greater assurance of ECW supply if light water addition were necessary during reactor shutdown while some of the pumps were off-line.

Thirty-six inch high dams were installed in the -40 ft level between the pump room and motor rooms in 1973-1974 to prevent a D_2O leak with ECS actuation from causing flooding of the D_2O pump motors. A one-way (motor room-to-pump room) gate was installed in the dam to allow flow from a postulated cooling water line break to reach the pump room sump pumps and take advantage of their removal capacity. The gate capacity was designed to match the sump pump capacity.

Automatic Incident Action

The capability for light water addition in the event of a large D_2O leak was automated beginning in 1973. The M-2 Automatic Incident Actuation (AIA) consoles contain electronic logic circuitry which utilizes two-out-of-three vote logic from in-reactor level sensors to determine the need for ECS actuation. Three types of liquid-level sensors, including absolute-pressure sensors, differential-pressure sensors, and conductivity cells, are used to provide protection from common mode or common cause sensor failure mechanisms. The system is self-bypassed for leaks of less than 1800 gpm.

System functions initiated by Incident Action originally included the following:

- Starting of the booster pump
- Opening of all ECW header isolation valves and supply valves for the two top addition systems
- Energizing of bottom addition supply valve circuitry to open on level control
- Set up of the ventilation/confinement system for optimum effectiveness

An interlock circuit was added in 1974-1975 to provide automatic closure of rotovalves (to prevent backflow of ECW through heat exchangers) in the two top addition system.

Roll Anchor Modification

An analysis of emergency cooling water hydraulic forces indicated that strengthening of the roll anchor stands for the plenum inlet lines was required in the three reactor areas. If ECS water were added to a full reactor tank through both top addition systems concurrently, the pressure generated under the top shield could have caused failure of the roll anchors. Roll anchor modifications were completed about 1975.

Computers

During 1970-1971, the online computers were modified to perform closed-loop control of the reactors in addition to the monitoring and rod reversal functions. Direct control was accomplished by adjusting control rod settings with stepping motors to control overall power level and selectively move rods for most effective power generation within the various reactor regions. The GE-412 computers remained online 99% of the time and controlled power ascension and level power as well as radial and axial flux shapes.

Backup Shutdown System

Supplementary Safety System

Piping modifications were made to reduce the SSS response time (time interval between system actuation and arrival of gadolinium nitrate "ink" in the reactor). The modifications reduced the response time from 6 seconds to 0.7 seconds. Replacement of all SSS explosive valves with an improved design increased system reliability.

Automatic Backup Shutdown

The first of the Automatic Backup Shutdown (ABS) systems was installed in 1974 and called the Gang Temperature Monitor (GTM). The GTM is completely independent of the safety rod shutdown system. It actuates the SSS to inject gadolinium nitrate into the reactor tank when the coolant effluent temperatures of selected assemblies exceed prescribed limits. Specific incidents for which the ABS-GTM can provide protection are the gang (control) rod withdrawal and the total loss of AC pumping power without scram. The ABS-GTM provides a diverse reactor shutdown channel, and therefore, increases the overall reliability of reactor shutdown protection. No mechanism has been identified that could cause a common mode failure of both the safety rod and ABS GTM systems.

Seismic

The large process heat exchangers are mounted on railroad-car-type wheels and were recognized as susceptible to movement from seismic activity. The exchangers were braced in 1974 to preclude such movement which could damage the attached cooling or process water piping.

1975-1980

Confinement System

Type GX-176 coimpregnated (potassium iodide and triethylene diamine (IEDA)) carbon was installed in all three reactor confinement systems in 1976 to replace Type 416 unimpregnated carbon. Type GX-176 carbon retains organic iodides better than Type 416.

Studies begun in the early 1960s recognized the threat of overheating of the carbon filters from airborne fission product particles in the event of extensive core melting. Such overheating would seriously reduce the iodine-retention capacity of the carbon and even cause desorption of the collected iodine. The studies and possible solutions were refined through the years and culminated in 1979 with installation of the Confinement Heat Removal (CHR) System. The CHR system is designed to flood the building -40 ft level pump room floor with water in the event of a full-core meltdown in which molten core breaches the tank bottom and is deposited on the floor. The water would maintain air temperatures low enough to prevent failure of the confinement system filters. The water is supplied from the disassembly basin through two redundant pneumatic valves. The system is manually actuated from a dedicated console in the central control room when alarms indicate (1) both a large airborne activity release and reactor tank bottom temperature greater than 232°C at one of three reactor positions where heat sensors are located or (2) temperatures greater than 232°C at any two of the three reactor positions containing heat sensors. The heat sensors are in dedicated monitor pins in three blanket (outer ring) positions in the reactor.

The CHR system design provides for both automatic and manual actuation of the pneumatic valves. Initially, only the manual mode was made operational. Future plans call for activation of the automatic mode after reliability studies are completed.

ECS

Prior to 1977, the river water supply line was considered the primary source of emergency light water cooling supply because of its independence from the 186 cooling water supply basin and pumps. However, flushing tests in 1977 identified significant debris (leaves, sticks, clams, etc.) which could become lodged in reactor assembly flow channels and reduce the cooling capability. So this line was valved off as a primary source and assigned backup status. In 1978, the maintenance pressure for this line was reduced to 20 PSIG and the source is available as a last choice if the booster pump and both cooling water inlet headers fail.

The recognition of a debris problem prompted installation of a debris strainer in the polyborate storage header common to all ECS supply sources. Two redundant bypass check valves around the strainer are designed to open if debris pluggage of the strainer causes the strainer delta P to exceed prescribed limits.

Contaminated Water Storage Facilities

A 500,000 gallon storage tank and related piping were added to the 50,000,000 gallon contaminated water earthen storage basin beginning in 1979. Following a loss of coolant or loss of circulation accident with ECS actuation the first 60,000 gallons (approximate D_2O system capacity) will now flow to Building 106 and the next 500,000 gallons to the new storage tank which is vented back through the building ventilation/confinement system. Any remaining flow is diverted to the 50,000,000 gallon basin. These facilities assure that all expected radioactive releases from credible accidents would be contained within the filtered system. Figure J-3 shows the contaminated water removal facilities.

Computers

Control Computers

The GE-412 process control computer in each area was replaced beginning in 1978 with two new Interdata-M70 computers (Reference 4). These computers, which TE| are currently in use, perform basically the same functions as the GE-412 (e.g., monitoring of process data and performing closed-loop control operations). The two machines have identical capacity, but only one performs the primary functions at a given time; the other provides secondary data processing functions while in a standby status. Either is capable of performing all required on-line functions in the event one becomes unavailable.

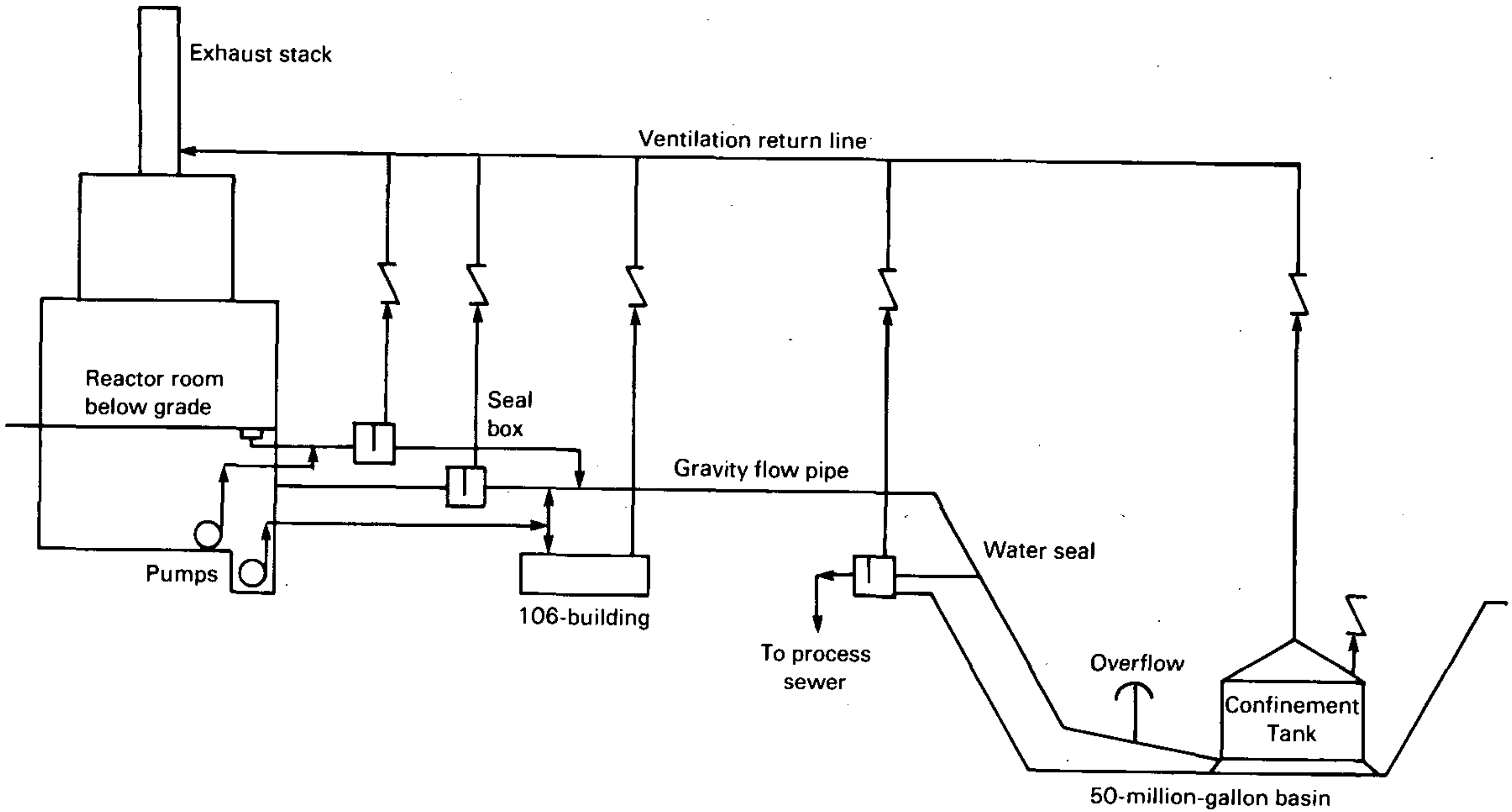

Figure J-3. Confinement tank.

TE Improvements over the GE-412 monitoring include:

(1) Faster scan of temperature input signals (approximately 30 seconds compared to the previous five minute scan period).

(2) Monitoring continuity and continued control capability when one control system fails (only secondary data processing functions will be interrupted).

(3) Improved input-output capability and more effective communication with reactor operator through cathode ray tube (CRT) displays.

(4) Increased reliability (dual, redundant computers and improved methods for both hardware and programming fault detection).

(5) Future applications (extra memory capacity for automatic alarm analysis and monitoring during reactor shutdown).

Safety Computers

In addition to the new process control computers, dual safety computers were installed in each area beginning in 1977 to provide scram protection from low flow or high temperatures in reactor assemblies. Prior to this, scram protection for high temperature was provided by the radial power monitor (RPM, installed 1964), which monitored the average temperature of groups of six assemblies versus prescribed scram setpoints. Flow protection had been provided by the Flow Monitor, a pressure switch safety circuit which shut down the reactor if any assembly monitor pin delta P dropped below prescribed setpoints. The safety computers offered the following major improvements over the RPM and Flow Monitor:

(1) Overtemperature scram protection for all individual reactor positions rather than only clusters in the central 60%.

(2) Rapid scan time. All temperatures are scanned each 0.36 second. Flows are scanned each 0.15 second.

(3) Reduced dependence on manual operations such as setpoint adjustments and instrument bypass.

(4) Ability to reject spurious signals.

(5) Increased reliability through dual redundant computers, frequent internal operability testing, etc.

(6) Replacement of obsolete flow sensors and instrumentation.

(7) Future applications - capability for different levels of protective action, such as liquid reactor poison injection in addition to safety rod scram (ABS-SC, discussed below).

Automatic Backup Shutdown Using Safety Computers (ABS-SC)

Although the ABS-GTM provides diverse protection for certain anticipated transients without safety rod scram action, it was recognized that faster time response and more comprehensive protection was desired. The capability was added to the safety computers beginning in 1979 to back up the safety computer scram relays and supplement the safety rod scram action with automatic injection of the SSS poison (ink) if certain adverse conditions were detected. If reactor assembly effluent temperatures continue to increase or do not decrease sufficiently following scram initiation, ink will be injected. The system takes advantage of the existing redundancy of the Safety Computers since each computer can independently take ABS action.

An external review by qualified consultants in the industry confirmed the effectiveness of ABS-SC in coping with anticipated transients without safety rod scram action.

Fuel Handling

The charge and discharge machines were equipped beginning in 1977 with computerized positioning and fuel and target position identification. This greatly reduced the possibility for inadvertent criticality which might be caused by placing a fuel (^{235}U) in a target (^{238}U) position.

The assembly cooling system on the discharge machine was improved in 1978. Two independent sources of D_2O and two of H_2O were provided with automatic sequencing through their predescribed hierarchy. The supply for the sources was improved and in-line filters provided, and two methods of directing the water to the top of the assembly were provided. Monitoring of system flows and pressures was updated and expanded.

Seismic

Improvements were made beginning in 1976 to meet the seismic requirements for resistance to maximum predictable earthquakes. Projects included:

1. Strengthening the base of the actuator towers and eliminating the spring action of the supporting girders. The spring action increases the response of the tower to dynamic forces.

2. Strengthening the building exhaust stack.

3. Improving the lateral support for the emergency cooling system (ECS) piping and the supplementary safety system (SSS) piping.

1980-1983

ECS

Beginning in 1981, the bottom addition system was converted to a top addition system. Addition valves in each area were updated to a more reliable design.

Automatic Backup Shutdown

ABS-SC protection was expanded in 1982 to provide for backup ink injection for all scram circuits. New digital inputs inform the computers of the current status (bypassed, online, actuated) of all other safety circuit relays. When any safety circuit calls for scram action, the safety computers back up the signal using their own "echo scram" relays. Then an immediate assessment of reactor temperature conditions determines if ink injection is required to achieve sufficient reactor shutdown.

Uninterruptible Power Supplies for Scram Circuits

Uninterruptible power supplies (UPS) were provided to all scram circuits in 1982 and to the Safety Computers (including ABS logic) in 1983. The UPS will maintain the computers and scram circuits online a minimum of 5 minutes following loss of all offsite power.

Fuel Handling

The chuck fingers on the machines were lengthened in 1981 to assure the assembly would be held in the mast if the chuck released the assembly and it rested on the rinse water collection pan beneath it.

A computer system was added in 1982 to control the order of charging of the assemblies, further eliminating manual input and increasing protection against criticality from misload errors.

Seismic

A weld examination program was completed in 1983 to establish the quality of carbon steel piping welds in the cooling water and ECS systems. Samples from over 100 welds in the L-Area system piping were destructively examined and quantitatively characterized as to quality. Also, a large number of additional welds were radiographed and inspected by an outside consultant. The analyses concluded that the quality of the welds in these systems meets the structural requirements of a design basis earthquake.

Studies in Progress

Confinement

The program toward continuous study of improved confinement of radioactive releases includes efforts in several areas:

- Experiments are in progress to determine the effectiveness and feasibility of using solid adsorbents (mordenites, zeolites) for adsorption of noble gases. The program to assess technical feasibility and economic practicality continues with high priority.

- Fuel melt experiments with irradiated SRP fuel samples are planned. The goal is better characterization of the source term to be expected from a fuel melt accident; analyses of the Three Mile Island damaged core material suggest the current assumptions may be vastly overconservative. An improved source term may greatly reduce offsite dose expectations.

- Studies are continuing to evaluate several confinement/containment system design alternatives. Cost estimates and measures of effectiveness are being developed for tall stacks, internal building containment, a containment dome, and a system for temporary holdup of airborne contamination to allow for decay of short-lived products before filtration/release.

ECS

The primary design basis accidents for the ECS are the very large cooling water or process water leaks or the loss of D_2O circulation. Concepts are now being developed for coping with smaller leaks which may propagate to a need for ECS actuation. Ideas include increased D_2O makeup capacity or collection and recirculation of the D_2O leakage. Recirculation of the leakage and/or ECS water back to the reactor inlet lines would reduce the amount of contaminated water which exits the building and provide a non-exhaustive supply of cooling water.

A second booster pump has been proposed and basic data written to provide an improved source of ECS water.

Fuel Handling

Two safety improvements packages for the charge and discharge machines are scheduled for installation in 1983-1985. The projects will provide:

- Expanded computer control of C&D operations
- A directable spray nozzle for cooling a dropped assembly
- Closed circuit television camera monitoring to enhance visual observation of C&D operations
- Improved supply of power for the machines with better handling facilities for the moving cable system
- Assembly temperature monitoring capability
- Better personnel access to the machines and controls to facilitate routine or emergency maintenance

Seismic

Studies to date have provided seismic analyses of and necessary bracing for important systems and building structures. A continuing program is in progress to:

- Complete assessments of the overall integrity of the CW, PW, and ECS piping with respect to weld and pipe failure characteristics
- Complete a stress analysis of the piping systems to define maximum points of stress and magnitudes during a design basis earthquake

- Define the spectrum of piping leaks and consequences thereof
- Establish acceptability bands for seismic safety margins
- Estimate seismic risk
- Retrofit bracing, etc., if necessary to bring risks within acceptable range

Three Mile Island Followup

The March 28, 1979, accident at Three Mile Island (TMI) had significant implications for nuclear power generating facilities. Because the SRP reactors are operated at essentially atmospheric pressures, and because of the absence of the auxiliary systems for electric power generation, a similar incident is not possible at Savannah River. However, there are many lessons to be learned in the areas of operator response, technical personnel availability, instrumentation adequacy, and accident propagation. To take advantage of any possible lessons, a committee was formed on April 4, 1979, to assess implications of the TMI incident for SRP operations. Recommendations were formulated for any changes in operation or improvement programs indicated by lessons apparent from the TMI experience. Three areas in which changes were indicated are discussed below along with the status of each.

Technical

The TMI implications for the technical arena were assessed by SRL and SRP personnel and led to acceleration of major projects already being developed in the areas of alarm diagnosis and system availability monitoring. Other changes of less magnitude are also discussed below.

Diagnosis of Multiple Alarms (DMA)

The Diagnosis of Multiple Alarms (DMA) system is a pioneering application of computer-based diagnosis of malfunctions in operation. This system, developed at SRL-SRP, is designed to aid operators in managing abnormal reactor conditions by automatically analyzing patterns of alarms and sensor inputs. During 1982, the installation of the DMA system was completed in all SRP reactors. Work on this system is continuing with the development of closed-circuit television systems to make possible visual recognition and assessment of leaks in reactor cooling systems. Four cameras are currently installed for evaluation in the P-Reactor process areas.

The heart of the DMA system is the alarm logic tree. These are similar to fault-trees developed in process hazard analysis work. Simple alarm trees define the general problem. More complex alarm trees pinpoint the location within the plant. There are currently 45 logic trees to recognize conditions that could lead to the loss-of-coolant or loss-of-circulation accidents. Any diagnosis is displayed on a large television in the control room. The message defines the root cause of the alarms and identifies the correct emergency procedure to be used.

Essential Equipment Monitor (EEM)

Also beginning in 1982, the Essential Equipment Monitor (EEM) was installed in all areas. The EEM will continuously monitor ECS valves and other essential equipment and give an immediate indication of a majority of electrical failures. A programmable controller in the central control room will scan fault sensing circuits and initiate an alarm for such failures as an open or bad connection, loss of ground, short to ground, or loss of voltage. EEM monitoring will significantly decrease critical equipment unavailability from these common electrical problems and help ensure compliance with operating requirements. The system is in a test mode in all three operating reactors and will be made operational when checkout and procedures for response to alarms are complete.

Postaccident Monitoring

In response to review of postaccident monitoring adequacy, a project was authorized to provide radiation monitoring equipment with increased monitoring range and life expectancy. Such monitoring upgrade is being provided for both airborne and liquid effluent streams under accident conditions. Assessment of confinement system seals indicates sufficient radiation tolerance for system function for extended accident conditions.

Postaccident monitoring and control improvements also include:

- The reactor remote control facilities are scheduled for computerization and upgrade. Control of an evacuated reactor area will be possible from the existing remote facility as well as from another reactor control room.

- Evacuation signals for reactor buildings are being improved by upgrade of area communications systems. Work is complete in 2 of the 3 operating areas.

Other

Other items included in the technical/design area are:

- Concepts have been documented and are currently being evaluated for improving the ECS design to better cope with small leaks which may propagate to accident conditions. A small flow rate light water addition system or increased D_2O makeup are being considered.

- A preliminary report on mechanisms to retain noble gases from a fuel melt release has been issued. The alternatives are being evaluated in terms of cost and benefit.

- A probabilistic risk assessment (PRA) is being conducted for the reactor safety systems to extend earlier analyses of risks versus all postulated accidents. An outside contractor has begun work on a systematic analysis of the electric power system and other systems analyses will follow.

Many TMI-related technical analyses were completed with no resultant action deemed necessary. Studies continue on various other subjects and status is formally reported to DOE-SR periodically.

Training

Assessment of the Reactor Department training program revealed inadequate documentation of the training methods, material covered, and program format. A detailed description was subsequently written entitled "Reactors Personnel Selection, Qualification and Training Manual." Many parts of the training program have been strengthened as a result of the assessment and are described in the Training Manual.

- Position titles, job descriptions, and responsibilities are well defined and understood.
- Level of knowledge requirements were established and detailed for all certified personnel training and retraining programs.
- Specific tasks and training requirements for certified operators and supervisors are being delineated through POSITION TASK ANALYSES performed by an independent contractor. The Training Manual will include qualification and training requirements identified by these analyses.
- Realistic accident scenarios were developed and documented in training material.
- Procedure writer qualifications were established and included in the manual.

In addition to the better definition and documentation of the training program several other changes are being effected:

- A fifth operating shift was effectively established by providing additional operations staffing to allow certified personnel to be relieved for continued training and recertification.
- The training period was lengthened from 9 months to 1 year to facilitate additional classroom training and control room experience.
- An independent certification board was established to review each operator or supervisor candidate. The board of SRL and SRP technical personnel will review the program and oral and written examination performance to accept or reject the candidate.

Simulator

The most significant addition to the Reactor Department training program will be the building of a reactor control room simulator. An experienced outside contractor, Singer-Link, is developing the computer models necessary to provide real-time instrument response to a variety of postulated accidents. A full-size replica of the K-Reactor central control room will be provided. The control room will look, respond, and sound like the K-Reactor control room.

All controls, instruments, and alarms that could be involved in significant training exercises will be interactive with the computer complex. The few controls, instruments, and alarms that are not interactive with the computer complex will appear normal to the operators.

Most of the instruments in the control room will be simulated in a manner to appear real to the operator, but internally will be designed or modified to be compatible with a standard set of drive signals developed for the simulator computer complex. The control and safety computers will be stimulated (receive the same signals as they do in a real control room) so that future control and safety computer software changes can be implemented in the simulator more easily.

The simulator is expected to be operational by 1985.

Programmatic

Procedures Upgrade

Numerous deficiencies identified in procedure format and standardization resulted in increasing the procedure writer staff three-fold to expedite improvements. Items being addressed include:

- All operating, emergency, and master control procedures were reviewed for relationship to or implications from the TMI experience.
- All procedures are being converted to a standard format to facilitate usage, revisions, and training. This effort is more than 80% complete.
- Bases sheets for all emergency procedures are being developed or updated to provide reference documentation of basic concepts and logic.

Quality Assurance

The Savannah River Quality Assurance (QA) program has been formally documented and implementation continues at a rapid pace. Reactor programs have been affected in several major areas:

- Training in basic QA principles and programs were incorporated into all reactor supervisory training and retraining courses.
- A formal program was implemented to incorporate QA requirements into operating procedures. The system consists of a QA assessment and development of detailed Action Plans based on the results. The Action Plans are implemented through normal procedures. Assessment of existing reactor facilities is complete. Resultant procedure upgrade is about 80% complete.
- Surveillance of reactor operating procedures by an independent QA group was increased. Fifteen audits were conducted by the SRP QA Department (wholly independent of operational responsibility) in 1982. Audits included effectivity of compliance to established written procedures as well as determination of whether findings were generic or isolated.

Other

Other programmatic changes effected since the (TMI) review began include:

- Reactor Incident report reviews were incorporated as a mandatory part of the continued training for certified reactor supervisors and operators. Lessons learned from each incident are reviewed with maintenance, operations, and engineering personnel as appropriate.

- Shift checklists were converted to reactor procedures and formalized procedures for shift turnover were provided.

- A document is being prepared to provide plantwide standardization of tool calibration requirements. Tools will be calibrated proportional to need as determined by frequency, precision, and tolerance demands.

- The commitment of Du Pont to the ALARA (As Low As Reasonably Achievable) radiation dose reduction program is being documented. The document describes drills used as part of the radiological controls and the program for conducting internal audits.

- The Maintenance Information and Control (MIAC) system was upgraded to ensure better control of equipment availability and to improve the ability to detect equipment performance trends.

APPENDIX K

SCOPING COMMENTS

Pursuant to the National Environmental Policy Act of 1969 and the Energy and Water Appropriations Act, 1984, Public Law 98-50, the Department of Energy (DOE) initiated the preparation of an environmental impact statement (EIS) on the proposed restart of L-Reactor on an expedited schedule. A Notice of Intent (NOI) was published in the Federal Register on July 19, 1983. The NOI announced (1) a 22-day scoping period, inviting comments on a proposed scope for the EIS, and (2) four scoping meetings to be held in two cities in South Carolina and two cities in Georgia to receive oral comments.

By August 14, 1983 (the scoping period officially closed on August 10, 1983), 27 individuals had offered oral comments at the scoping meetings, several on behalf of organizations. Written comments were received from 27 individuals and organizations, 12 of which were written copies of oral testimony. DOE has considered late comments to the extent practicable.

More than 270 separate comments and recommendations were expressed in the scoping comments. This appendix identifies and discusses the areas of interest expressed by the commentors; annotated copies of transcripts and letters respond to each point. In addition to environmental issues, a number of comments deal with procedural and administrative concerns. This appendix also includes transcripts of the statements and copies of the written letters.

Table K-1 lists scoping topics raised in the comments and recommendations, and presents a cross-index of the sections in the EIS that address these topics.

Tables K-2 and K-3 list the speakers who provided statements and their oral statements, respectively. Tables K-4 and K-5 list authors of scoping letters and their letters, respectively. Tables K-3 and K-5 are also annotated with references to EIS sections where a subject is addressed, or with statements that present DOE's response to a comment or recommendation.

Copies of the oral statements and scoping letters are available for public inspection at the DOE Public Reading Room, 211 York Street, NE, Aiken, South Carolina. Copies are also available for public inspection at the following locations:

Freedom of Information Reading Room
Room 1E-190
U.S. Department of Energy
Forrestal Building
1000 Independence Ave, SW
Washington, DC 20585

U.S. Department of Energy
211 York Street, NW
Federal Building,
Aiken, South Carolina 29801

Augusta Regional Library
902 Greene Street
Augusta, Georgia 30901
(404) 724-1871

Warren C. Gibbs Memorial Library
326 North Bel Air Road
Evans, Georgia 30809
(404) 863-1946

Burke County Library
Fourth Street
Waynesboro, Georgia 30830
(404) 554-3277

Statesboro Regional Library
124 South Main Street
Statesboro, Georgia 30458
(912) 764-7573

Atlanta Public Library
1 Margaret Mitchell, NW
Atlanta, Georgia 30303
(404) 688-4636

Richland County Public Library
1400 Sumter Street
Columbia, South Carolina 29201
(803) 779-9084

South Carolina State Library
1500 Senate Street
Columbia, South Carolina 29201
(803) 758-3181

Aiken-Bamberg-Barnwell-Edgefield
Regional Library
1307 Georgia Avenue
North Augusta, South Carolina 29841
(803) 648-8961

Allendale-Hampton-Jasper
Regional Library
War Memorial Building
Court House Square
Allendale, South Carolina 29810
(803) 584-3513

Charleston County Library
404 King Street
Charleston, South Carolina 29403
(803) 723-1645

Chatham County Public Library
2002 Bull Street
Savannah, Georgia 31499
(921) 234-5127

Screven-Jenkins Regional Library
302 East Ogeechee Street
Sylvania, Georgia 30467
(912) 564-7526

Washington Memorial Library
1180 Washington Avenue
Macon, Georgia 30467
(912) 744-0800

Aiken County Public Library
435 Newberry Street
Aiken, South Carolina 29801
(803) 649-2352

Orangeburg County Free Library
510 Lories NE
P.O. Box 1367
Orangeburg, South Carolina 29115
(803) 531-4636

Beaufort County Library
710 Craven Street
Beaufort, South Carolina 29304
(803) 524-0762

Spartanburg County Library
333 South Pine Street
Spartanburg, South Carolina 29304
(803) 596-3505

Greenville County Library
300 College Street
Greenville, South Carolina 29601
(803) 242-5000

Table K-1. Scoping topics and EIS sections

Scoping topic	EIS section
Accident analysis	4.2.1, 4.3.2.3, 4.4.1, 4.4.5, App. G
Alternatives--cooling	4.4.2
Alternatives--production	Chapter 2
Atmospheric effects	4.1.1.6, 4.1.2.1, 4.2.2.1, 4.3.1, 5.1.1.3, 5.1.2.2, App. B
Cumulative radiological effects	5.1.2, 5.2.6, 3.7.1
Emergency planning	4.2.1.3, App. G, App. H
Endangered species	3.6.1.4, 3.6.2.3, 4.1.1.4, 7.3, App. C
Fisheries	3.6.2, 4.1.1.2, 4.4.2, 5.2.4.2, 5.2.5, App. C
Ground-water contamination	4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, App. F
Ground-water usage	4.1.1.3, 5.2.3
Health effects	3.7.1, 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, 6.1.4, App. B, App. G
Mitigation measures	4.4
Monitoring	Chapter 6
Need	1.1
NEPA procedures	Foreword
Radioactive waste	4.1.2.8, 4.3, 4.6, 5.1.2.8
Radiocesium remobilization	3.7.2, 4.1.2.4, App. B, App. D
Radiological effects	3.7.1, 4.2.1, 5.1.2, 5.2.6, App. B, App. D, App. G
Regulatory requirements	Chapter 7
Safety alternatives	4.4.1, 4.4.5
Seepage basins	4.1.2.2, 4.4.3.2, 5.1.1.2, 5.1.2.1
Socioeconomic effects	4.1.1.1, 4.2.1.5, 5.1.1.1, 5.2.1
SRP and regional effects	3.7.1, 5.2
Surface-water use	4.1.1.2, 5.1.1.4, 5.2.2, App. D
Thermal effects	4.1.1.4, 4.4.2, 4.4.3.4, 5.2.4, 5.2.5.1
Tritium	4.1.2.1, 4.1.2.2, 4.2.1.4, 4.3.2.3, 4.4.3.2, 4.4.3.5, 4.4.5, 5.1.2.1, 5.1.2.2, 5.2.6
Wetland impacts	4.1.1.4, 4.4.2, 5.1.1.2, 5.2.4, App. C, App. I
Wildlife	3.6, 4.1.1.4, 4.4.2, App. C, App. I

Table K-2. Scoping meeting speakers

Witness	Hearing appearance	Representing	Page
Barnes, Travis	8/1 am	State Representative, Georgia 90th District	K-5
Benedict, Lawrence	8/5 am	The Georgia Conservancy, Coastal Citizens for a Clean Environment	K-55
Brown, Virginia	8/5 am	League of Women Voters of Savannah-Chatham	K-62
Denton, John	8/2 am	Self	K-33
Dillon, Zaida	8/4 am	Self	K-50
DuTeau, Gary	8/1 pm	Self	K-13
Dykes, Virginia	8/1 am	Self	K-28
Gordon, Judith	8/1 pm	Sierra Club, South Carolina and Georgia Chapters	K-6
Graber, Susan	8/4 pm	Self	K-49
Harrington, Ann	8/4 pm	Self	K-51
Hart, Frances	8/2 am	Energy Research Foundation	K-16
Heath, Melissa	8/5 am	Self	K-64
Jones, Beatrice	8/2 pm	Self	K-35
Kelly, Mary	8/2 am	League of Women Voters of South Carolina	K-20
LeMay, Geraldine	8/5 am	League of Women Voters of Georgia	K-52
Lowe, Michael	8/2 am	Palmetto Alliance, Inc.	K-25
Maclean, John	8/5 pm	Several individuals	K-67
Matthews, Ken	8/5 am	Savannah Chamber of Commerce	K-59
McDaniels, William	8/2 am	Self	K-26
Price, Sister Helena	8/4 pm	Self	K-48
Reed, Joel	8/5 am	Self	K-61
Seymour, Mary Lou	8/2 pm	Self	K-42
Stallings, James	8/2 am	Self	K-22
Stoney, S. David	8/1 pm	Self	K-9
Tilson, Elwin	8/5 pm	Self	K-65
Tsagos, Zoe	8/4 am	League of Women Voters of northern Beaufort County	K-44
Wise, Barbara	8/2 pm	Self	K-39

Table K-3. Scoping statements and EIS sections or DOE's responses

Comment number	Statement	Scoping topic	EIS section or DOE comment
	STATEMENT OF THE HONORABLE TRAVIS BARNES STATE REPRESENTATIVE, 90TH DISTRICT, GEORGIA		
	I think maybe that some of y'all have gone to a lot of trouble. You may feel like people who have organized a banquet and have all the places set and nobody comes, but I think it is important that you all are taking this extra precaution before the reactivation of this L-Reactor.		
	Really, I have no criticisms. In fact, I want to commend the Department of Energy. I have been receiving almost on a bi-weekly basis a lot of information about the L-Reactor and what possibly is its impact.		
	This is written for engineers, and my training was philosophy and theology, so I have had a little bit of a tough time with it. Yet I think the fact you all are having hearings and taking a second look at any effect the L-Reactor will have in its reactivation on this area is good.		
	As you may well all know, there are over 350,000 people in the metropolitan area of Augusta and we do have a concern about any environmental impact it might have on our area, both as far as		
A1	individuals biologically, perhaps, the chance of emissions, and particularly our neighbors to the south of us who are concerned	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, 6.1.4, Appendix B, Appendix G
A2	about groundwater affecting their drinking water, perhaps, of the many thousands of people. So we are glad that the government is taking a second look and making sure that the public interest is fully protected. And really my only question I would have to you would be: Have all of these precautions been made and are we double-checking, double-checking the possible	Groundwater use	Sections 4.1.1.3, 5.2.3
A3	effect of any emissions or any effect on the atmospheric conditions	Atmospheric effects	Sections 4.1.1.6, 4.1.2.1, 4.2.2.1, 4.3.1, 5.1.1.3, 5.1.2.2, Appendix B
A4	as well as the groundwater?	Groundwater use	Sections 4.1.1.3, 5.2.3

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	STATEMENT OF JUDITH E. GORDON REPRESENTING SOUTH CAROLINA AND GEORGIA SIERRA CLUB		
	I am Judith E. Gordon representing the South Carolina and Georgia chapters of the Sierra Club with a membership of about 5,000 in the two-state area. I thank you for this opportunity to express the environmental concerns of the Sierra Club with respect to the proposed restart of the L-Reactor at the Savannah River Plant.		
B1	In its public notice, DOE has identified several environmental issues to be addressed. However, I did not see listed one of the most important issues; that is, the destruction of wetlands habitat.	Wetland impacts	Sections 4.1.1.4, 4.4.2, 5.1.1.2, 5.2.4, Appendix C, Appendix I
	The percentage of SRP wetlands that will be affected by L-Reactor restart varies with how the calculations are made and with how wetlands are defined. Nonetheless, by DOE's own calculations, only 36 percent of Savannah River Plant wetlands have not been affected by thermal discharges.		
	Since loss of wetlands has become a priority--of priority in environmental concerns, both at federal and state levels, I request that in assessing wetland losses, DOE take into account:		
	1. The literature from the federal agencies concerned, for example, studies done by the Fish & Wildlife Service of the Department of the Interior.		
	2. Studies done by South Carolina and Georgia state agencies on the importance of wetlands and their rate of loss.		
	There are other concerns I would like to emphasize using the categories suggested by the Department of Energy.		
B2	No. 1. Socioeconomics: Since an Environmental Impact Statement typically discusses the jobs provided by the facility, I believe the other side of the economic coin should also be discussed in the EIS; specifically, what mitigating measures will the Department of Energy implement to lessen the job crisis	Socioeconomics	Section 4.6

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	that will ensue when the aging reactors at the Savannah River Plant are shut down, including eventually the L-Reactor itself.		
B3	2. Endangered Species: The EIS should certainly incorporate the results of ongoing research being done at the Savannah River lab on river ecology and the Shortnose Sturgeon. It should also include a Woodstork study currently under way at the Savannah River Ecology Lab.	Endangered species	Sections 3.6.1.4, 3.6.2.3, 4.1.1.4, Appendix C
B4	3. Fisheries: The EIS should estimate the cumulative effects on fish passage from all thermal plumes in the river area, not just that of L-Reactor.	Fisheries	Sections 5.2.4.2, 5.2.5.1
B5	4. Radiological Effects and Safety: The EIS should address the estimated contamination and hazards resulting from a worst possible accident at the L-Reactor; nothing less than that.	Accident analysis	Sections 4.2.1, 4.4.1, Appendix G
B6	No. 5. Groundwater Contamination: In view of the reported contamination of the Tuscaloosa Aquifer, the EIS should explain what errors were made in previous studies that assured the public that there was no reason to be concerned about pollution of aquifers. This should be contrasted with explanations of how the various wastes from the L-Reactor restart would be handled to prevent further contamination.	Groundwater contamination	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F. Mitigation of groundwater contamination at SRP will be the subject of a separate NEPA review.
	Finally, I would like to make two general comments that I feel DOE should consider in the preparation of this EIS.		
	Number one, as a government agency, the Department of Energy should set an example such that everyone would be aware of the concern of the federal government for environmental quality.		
B7	In particular, the federal government surely would not be in the position of exempting itself from standards that it expects private industry to meet, and I make this point in particular reference to the water standards set by the State of South Carolina and the attempts to have these put aside so that the reactors at SRP can be allowed to discharge hot water into the streams on site.	Regulatory requirements	Chapter 7 The DOE is responsible for assuring health and safety for its own facilities. In addition, the DOE will be in compliance with all applicable Federal and State regulations.
B8	Number two, if the Department of Energy expects to establish credibility for its statements and actions, then it is time that it quit monitoring itself and establish a fund through	Monitoring	Chapter 6 In addition to the SRP monitoring programs, both the States of South

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	which independent agencies would monitor both radioactive and nonradioactive discharges from the facilities contracted by DOE. It is doubtless too late to begin this process for the EIS in question, but it should certainly be possible for future endeavors.		Carolina and Georgia have implemented State-wide environmental monitoring programs. Also, the State of South Carolina monitors SRP activities for compliance with State regulations and administration of environmental laws.
B9	There is one more thing I would like to add which is not in the statement, and I would like to say that I think it would certainly be an advantage to everyone if the comments--the comment period on the EIS could be extended to 45 days rather than 30 days. I think it is going to require that amount of time to effectively judge the EIS.	Procedures	Foreword

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	STATEMENT OF DR. DAVID STONEY, JR.		
	My name is David Stoney, Jr., and I am employed as a researcher and teacher at a local medical college. I have a Ph.D. in physiology. I am here tonight to express my concerns as a private citizen about some of the aspects about the restart of the L-Reactor.		
	I appreciate the opportunity to be here. I am glad we are finally going about this thing right.		
	As a remark at the beginning of things, I would like to say that I felt that some information was left out of the background information that Mr. Sires presented regarding this L-Reactor suit and its consequences.		
	For example, the suggestion by Mr. Robert Morgan in the spring of 1981 to a Subcommittee of the Senate, I believe, that an exemption from the National Environmental Policy Act requirements would be beneficial. Some items like that, I think, fill out the background on this dispute.		
	I would like to address two or three issues that I think are important and that I am not certain will be covered with sufficient detail and the in-depth analysis that is deserved in the Environmental Impact Statement.		
C1	First of all, the radiologic effects of the routine and accidental releases of radioactivity from the Savannah River Plant. I note that you plan to give us finally the cumulative dose commitments from routine operations of the L-Reactor.	Cumulative radiological effects	Sections 5.1.2, 5.2.6
	I think those cumulative dose commitments from the L-Reactor should be combined with cumulative dose commitments from all the other radioactivity-producing activities and facilities at the Savannah River Plant.		
	These, I believe, should be explicitly presented and the health effects from those dose commitments should also be explicitly set forth in the Environmental Impact Statement.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
C2	The estimates of the health effects should reflect, first, those due to the operation of the L-Reactor in the context of the entire Savannah River Plant operations, as well as in the context of neighboring nuclear facilities, such as the Vogtle Plant, which will be coming on line presumably in the near future. So we should see not only the incremental effects from the L-Reactor but how those effects add to what is already being produced from the Savannah River Plant.	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix B
C3	In addition to estimating the health effects from the total radioactivity dose commitment from Savannah River Plant activities, I think those commitments, those health effects should be taken also in the context of the increased radioactive background, if you will, in the Northern Hemisphere by the activity of all other nuclear facilities, mostly commercial nuclear facilities. I have read, for example, in the 1982 edition of the Encyclopedia Britannica that they anticipate by the year 2000 a doubling of background radiation due mostly to commercial nuclear facilities.	Health effects	Sections 3.7.1, 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix B
C4	Let's take a look at the total health effects, not only from the L-Reactor but also from all the other Savannah River Plant activities, look at that dose on top of the dose we are getting from the rest of the world, if you will. I expect to see in the Environmental Impact Statement at least three sets of data about health effects. One, those incremental effects associated with the restart of L-Reactor; two, those effects associated with the entire Savannah River Plant and neighboring nuclear facilities activities, including those from the L-Reactor; and finally, those associated with global Northern Hemispheric nuclear activities, including our own regional contributions thereto. Only then, when we look at all of that data, can the citizens of this area really know what the health effects are.	Health effects	Section 3.7.1, 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix B

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
C5	I second Dr. Gordon's call, and I point out to Mr. Cumbee and to this hearing that several other people--for example, Dr. Cochran and Dr. Scheer of the Natural Resources Defense Council--have called for a release of information about the consequences of a full core meltdown accident at the L-Reactor. According to your published statement, apparently you intend to do that. You indicate consideration of postulated beyond design basis accidents and probabilities. Mr. Sires didn't mention that, I don't believe, in his verbal address. Am I to understand that you do intend to consider a full core meltdown accident, Mr. Sires?	Accident analysis	Section 4.2.1, Appendix G
C6 C7	I believe that the Environmental Impact Statement should fully analyze the health and environmental effects, indeed the social and the economic effects, of accidents up to a full core meltdown.	Health effects Socieconomic effects	Section 4.2.1.5, Appendix G Appendix G
C8	This is what would be required for any commercial nuclear reactor. It is what the people of this area want to know; what is the bottom rung for producing plutonium for bombs here. We deserve to know it; we want to know it.	Regulatory	See Comment B7
C9	In this regard, there is one area that I have spoken to before that is not considered in your outline of scoping areas. This is the question of what happens in the case of radiologic emergency at the Savannah River Plant. We need to know, and I think the Environmental Impact Statement should spell out the mechanisms for dealing with us, the surrounding populations in the event of a major radiologic accident at Savannah River Plant. There are tens of millions of curies of radioactivity in the inventory of L-Reactor, or at least there will be after its startup. I want to know what to do with my grandchildren if there is a full core meltdown at the L-Reactor with the wind blowing 15 knots right to Augusta. What are at least the control, the communication procedures in the event of such an accident? We want to know.	Emergency planning	Section 4.2.1.3, Appendix H

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
C10	Mr. Cumbee, thank you for the opportunity to speak to these issues. I look foward to reviewing the draft EIS document. I request specifically that the period for review of the draft EIS be the full 45-day period as suggested by law. I think the population deserves that chance to look at what will be, for the first time, I think, a fairly direct consideration of Savannah River Plant activities.	NEPA procedures	Foreword

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	STATEMENT OF GARY DUTEAU		
	I am a private citizen here in Augusta. I have been in business here, and I am now farming a little bit in South Carolina. I'm still associated in business here in Augusta and a resident.		
	Now, I would like to preface my remarks by saying, of course, as you know, there are millions of people like myself who object to the procedures which the government has sometimes used in order to determine what is safe for the public. Now, I'm a college-educated man, and I am very familiar with the issues. I have read extensively on it. I have followed the nuclear development and I am familiar with the weapons issue.		
D1	I am opposed to an unending manufacture of nuclear weapons; and as I say, these issues--these attitudes that I have are reflected in many people of the population, not all of whom may be here. I do not know exactly how well you encouraged people to come. I found out about this through a friend.	Need	Section 1.1 Consideration of the rationale in establishing the need is beyond the scope of the EIS.
	I think that the chemical industry which is involved here, DuPont being a leading member of that group, and I think the American Government has very frequently, when something like this--when it comes to nuclear energy, when it comes to chemical waste, has gone off half cocked, assumed that anything they decided would be in the public interest because they have that trust.		
	I think we could probably list thousands of examples which originally begin with ignorance on the part of the government because they feel like they know enough to decide an issue. Now, we are talking about an Environmental Impact Statement, I realize, and that is an attempt to educate yourself as the government, as the company who is going to be doing this work, with potential dangers to the public and to the environment.		
	Now, Love Canal, Agent Orange, 2,000, I think it is, chemical waste dumps which are hazardous around this country where companies have walked off and left their garbage laying around; very deadly.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
D2	One thing I object to specifically, and I think this is indicative of the problem here, and the scope of it is through ignorance, originally feeling it was going to be easy to take care of, we wound up with, I think, around 27 or over 20 million gallons of radioactive waste. We have had many leaks into the environment. That's common knowledge now. Have many safety problems. The chemical industry in general has a tremendous number. Right now thousands of plants are releasing their effluents into streams illegally and legally.	Radioactive waste	Sections 4.1.2.8, 4.3, 4.6, 5.1.2.8
D3	To be direct, then, I think a full and comprehensive study should be undertaken, particularly evacuation in the case of a core meltdown or other significant accident.	Emergency planning	Section 4.2.1.3, Appendix H
D4	I think they should study the problems within the company of foreseeing and preventing problems which they have not demonstrated their ability to do, at least real well. They have projected ahead and discovered many things that could be problems, but by and large, we have had many releases, unsafe releases of gas, unscheduled, and I think that in the study, we should examine why those things happen; human error, I guess.	Accident analysis	Section 4.2.1.2
D5	Also, an evacuation plan and the effects of the releases; cancer, specifically.	Health effects	Section 4.2.1.5, Appendix G
D6	How well the aquifer can be protected, I think, should be included in the study. I personally do not think that it's necessary to do it but, of course, if the government--if the members in the government decide they will impose this, then I think that they owe it to the public to attempt to protect them from that which they have not been able to do so far due to their own mistakes, lack of knowledge especially in foreseeing what could be problems, waiting until they have problems rather than looking ahead with a study. Now, from what I have heard, there is some question as to whether or not there will even be an Environmental Impact Statement that is very broad in scope. Originally they felt it was unnecessary, and now we are here to find out if the public objects to such a cursory examination.	Groundwater contamination	Sections 4.1.1.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F. See Comment B6.

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	I would like to see it as thorough as possible.		
	That's all I have to say.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	STATEMENT OF MRS. FRANCES CLOSE HART		
	I am Frances Hart, and I'm making these comments on behalf of the Energy Research Foundation of Columbia, South Carolina. My comments are largely based on written comments which will be submitted for the record by the National Resources Defense Council on behalf of plaintiff groups in the EIS lawsuit.		
	We assume that the Department of Energy, in accordance with the National Environmental Policy Act, will address clearly and fully the environmental impacts of the L-Reactor, particularly those which have been repeatedly identified as matters of concern in litigation, Congressional and administrative hearings, and statements, letters and other comments of federal and state officials and technical personnel, and the public. We assume that DOE will make a concerted effort to fill the existing gaps in knowledge regarding the impacts of the L-Reactor which have been previously pointed out.		
E1	We also anticipate that DOE will give objective consideration to all reasonable alternatives keeping in mind the following statement taken from a Council on Environmental Quality Memorandum to federal agencies concerning NEPA regulations:	Alternatives	Chapter 2, Section 4.4
	"The phrase 'range of alternatives'...includes all reasonable alternatives, which must be rigorously explored and objectively evaluated.... In determining the scope of alternatives to be considered the emphasis is on what is 'reasonable' rather than on whether the proponent or applicant likes or is capable of carrying out a particular alternative. Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant."		
	Specific comments on the proposed scope of the EIS include the following:		
E2	The draft EIS should contain a justification for the proposed startup of the L-Reactor, particularly in regard to the timing,	Need	Section 1.1
E2	which has relevance for the operational alternatives which would eliminate or reduce the environmental harm and hazards	Alternatives	Section 4.4

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	associated with operation as proposed in the Environmental Assessment.		
E3	There are substantial questions as to the immediacy of the need for the plutonium to be produced by the L-Reactor, whose startup was initially called for in 1980.	Need	Section 1.1 See Comment D1
	For example, the number of warheads for the MX missiles now scheduled to be deployed has been reduced from approximately 2,000 to 1,000. It is estimated that the L-Reactor will produce each year enough plutonium for some 75 to 100 nuclear warheads. Thus, the reduction in the MX program alone suggests that operation of the L-Reactor may be delayed without risk to our nation's security in order to implement mitigation measures prior to startup.		
	DOE representatives have repeatedly testified before congressional committees that the L-Reactor is needed to meet a possible shortfall in nuclear weapon materials in the early 1990's. As a result of other production initiatives, DOE is now already ahead of its targets to boost the production of these materials. And recently the House Armed Services Committee found that "there is no basis to assume that large numbers of nuclear weapons will be produced in the years beyond 1990."		
E4	The draft EIS should consider as a reasonable alternative a delay in the operation of the L-Reactor for an extended period to allow the implementation of mitigation alternatives combined with production alternatives if necessary.	Alternatives	Sections 2.3, 4.4
E5	In order to provide a rational basis for this decision, the draft EIS must provide and disclose to the public, to the fullest extent possible, data in response to the following:	Need	Section 1.1
	1. Identify each material production alternative through 1995;		
	2. Identify by year the plutonium-equivalent production capability of each alternative;		
	3. Identify for each year the plutonium-equivalent inventory, stockpile, and future requirements;		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	4. Indicate precisely which, if any, weapons systems and requirements would have to be delayed if the L-Reactor operation was postponed one, two, three, or four years; and 5. Indicate whether and how a delay in L-Reactor operation of one or two years would affect the production of warheads already scheduled to 1988, or plutonium contingency needs in the "out years."		
E6	The draft EIS should fully disclose both the capital and operational costs of each cooling water alternative, with complete documentation of such costs and scheduling to permit meaningful outside review.	Alternative cooling	Section 4.4.2 Selection of thermal mitigation measures for all SRP thermal discharges will be the subject of a separate NEPA review.
E7	The draft EIS should consider the costs as well as the benefits associated with employment and related economic impacts of L-Reactor operations. Continuing or increased reliance on the Savannah River Plant could present indirect costs to the area, such as the drain on skilled technical personnel who are thus not available to the private sector. The area's dependence on this one source of employment and economic stimulation could present problems should national developments bring about a decrease in SRP's operating budget.	Socioeconomic effects	Sections 4.1.1.1, 5.1.1.1, 5.2.1
E8	Socioeconomic benefits from implementation of various mitigation alternatives must be weighed against supposed costs of delay.	Alternatives	Section 4.4.1.6
E9	An accidental release could have serious implications for economic development in the region, particularly those areas downstream and downwind of SRP, and socioeconomic effects in the larger Savannah River Basin of such releases, and of water contamination, should be assessed.	Socioeconomics	Section 4.2.1.5
E10	The draft EIS should describe the increase in the withdrawal of Savannah River water for cooling purposes and any indications of existing and potential conflicts in the use of this resource, such as the proposed hydroelectric facility on the Augusta Canal. Concerns about adequacy of freshwater supplies in coastal areas and suggested increased use of the Savannah River for drinking water must be taken into account. And adequacy of river flow in times of drought, a concern expressed by the Corps of Engineers, must be addressed.	Surface water use	Sections 4.1.1.2, 5.1.1.4, 5.2.2

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
E11	*The dose commitments from the routine operations of the* L-Reactor, including radiocesium transport, and from L-Reactor accidental releases should be measured against the same standards applied to commercial nuclear reactors and using the same methodology. The draft EIS should clearly identify where those standards, namely 10 CFR Parts 50 and 100, would be exceeded by the L-Reactor and by SRP as a multi-reactor site.	*Regulatory requirements*	Sections 4.1.2, 4.2, 5.1.2, 5.2.6, Appendix B, Appendix G
E12	Impacts from cesium transport should be evaluated particularly with regard to the flooding of Creek Swamp Plantation and possible concentrations in fish such as the largemouth bass, which can have a concentration factor as high as 10,000. The impacts must be considered in light of consumption of fish downstream of Creek Swamp Plantation.	Radiocesium	Sections 3.7.2, 4.1.2.4, 4.2.2.5, Appendix B, Appendix D
E13	The draft EIS should fully analyze the impacts of all possible reactor accident sequences, including so-called Class 9 accidents, as is required of all commercial reactors and using the same methodology. Environmental, social, and economic effects of accidents up to a full-core meltdown should be considered. Costs and impacts from construction of containment domes for SRP's reactors should be included in the draft.	Accident analysis	Section 4.2.1.5, Appendix G
E14		Safety alternatives	Section 4.4.1.6, Appendix G
E15	The draft should include a liquid pathways assessment to analyze the effects of L-Reactor accidental releases on ground and surface waters, as well as drinking water from the Savannah River.	Accident analysis	Sections 4.2.1, 4.3.2.3, Appendix G
E16	Finally, the draft EIS should contain a clear explanation of the sources and consequences of the existing groundwater contamination at SRP in all areas which will in any way be affected by L-Reactor startup, including the M-Area. It should provide full documentation as to the possible movement of contaminants to deep aquifers. The discussion in the draft EIS should provide a basis for selection of an alternative to the *present outdated reliance on seepage basins. Plans for com*pliance with federal and state environmental regulations, such as the Clean Water Act and the Resource Conservation and Recovery Act, should be discussed.	Groundwater contamination	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F
E17		Seepage basin alternative	Section 4.4.3
E18		*Regulatory requirements*	*Chapter 7*

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	STATEMENT OF DR. MARY KELLY		
	I am Dr. Mary T. Kelly, First Vice-President and Natural Resources Coordinator for the League of Women Voters of South Carolina. We offered testimony at the February 9, 1983, Senate Armed Services Committee hearing in support of preparation of an EIS before restart of the L-Reactor. At that time we contended that the Environmental Assessment was inadequate, that the Savannah River Plant and its nuclear production facilities were sited back in the fifties, not on the basis of the most environmentally suited area, but on the basis of political		
F1	acceptability. No comprehensive environmental impact study has ever been done. We seriously doubt, if a study as mandated by the National Environmental Policy Act of 1969 had been required, that this facility would have been sited in a seismically active area of high rainfall, on top of a major aquifer, and impacting a river used as a drinking water source for a large number of Georgia and South Carolina citizens. Those considerations still prevail. There is still need for such a comprehensive study which would take into consideration the impact of the total facility plus the impact of other nuclear operations under the control of the Nuclear Regulatory Commission adjacent to or in reasonable proximity to the	NEPA procedures	The Savannah River Plant was sited, constructed and started operations in the early 1950's; this was well before the National Environmental Policy Act of 1969 that required EIS be prepared on major Federal actions.
F2	Savannah River Plant. Cumulative environmental and health effects need to be considered. Unfortunately, under the terms of an expedited EIS process for one reactor, evaluation of the true broad and long-range impact will still not be adequately addressed.	Cumulative (radiological) effects	Section 5.2.6
	In many respects, the ability of the citizens of South Carolina and its regulatory agencies to deal with DOE has greatly improved since the February 9 hearing. This scoping meeting and the EIS are the result of the amendment to the Energy and Water Development Appropriations Act of 1984 and the ruling by Federal Judge Jackson in the suit brought by the Natural Resources Defense Council. Various League organizations, including those of Georgia and South Carolina, are plaintiffs in that suit. Judge Jackson ruled that the L-Reactor restart is indeed illegal in that it is a significant environmental action. A ruling on the requested injunction to halt the restart until the completion of the EIS process is still awaited.		