WSRC-RP-91-17

LAND AND WATER USE CHARACTERISTICS IN THE VICINITY OF THE SAVANNAH RIVER SITE (U)

March 1991

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

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WSRC-RP-91-17

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LAND AND WATER USE CHARACTERISTICS IN THE VICINITY OF THE SAVANNAH RIVER SITE

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INTRODUCTION

Routine operations at the Savannah River Site (SRS) result in the release of small amounts of radionuclides to the atmosphere and to the Savannah River. The resulting radiological doses to the offsite maximum individual and the offsite population within 50 miles of the SRS are estimated on a yearly basis. These estimates are generated using dose models prescribed for the commercial nuclear power industry by the Nuclear Regulatory Commission (NRC)[1].

The NRC provides default values for dose model parameters for facilities not having enough data to develop site-specific values. A survey of land and water use characteristics for the Savannah River area has been conducted to determine as many site-specific values as possible for inclusion in the dose models used at the SRS. These site parameters include local characteristics of meat, milk, and vegetable production; river recreational activities; and meat, milk, and vegetable consumption rates.

The report that follows describes the origin of the NRC default values, the methodology for deriving regional data, the results of the study, and the derivations of region-specific usage and consumption rates.

SUMMARY

A survey of land and water usage characteristics in the region of the Savannah River Site has been completed. The survey suggests that many of the consumption rates provided by the NRC[1] as defaults for dose model parameters may not be appropriate for residents of the Southeast; the NRC values are from surveys of individuals in the North-Central United States[2]. Agricultural productivity was found to be quite different than the NRC recommendations; vegetation productivity in this region is less than average and pasture-grass productivity is higher than average. During 1979 to 1983, site-specific values for several parameters were determined[3,4]. These parameters included recreational river usage, commercial and sport fish harvests, and commercial invertebrate harvests. Results of this early survey were included in dosimetry estimates for the L-Reactor Environmental Information Document[5] and continue to be used in the computer code LADTAP[6]. Some of these values will change, however, as a result of the current study.

The sport and commercial fish harvest from the Savannah River and its estuary is down from 1980 while recreational usage of the river has been increased by as much as a factor of 20 over estimates determined in the previous survey. Drinking water usage and the effective populations using the domestic water supplies of Beaufort-Jasper and Port Wentworth have been updated, but are essentially unchanged.

Consumption of beef, milk, vegetables, and fish for southern households has been determined for an average and maximum

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individual. Average consumption rates determined from this study are slightly higher than the defaults suggested by the NRC. Maximum consumption rates, however, are typically lower than NRC values. The consumption rates for drinking water remain equal to the NRC default values (370 L/yr average; 730 L/yr maximum) to maintain comparability of SRS dose estimates with the Environmental Protection Agency (EPA) drinking water standard[7].

ORIGIN OF THE NRC DEFAULTS FOR DOSIMETRY MODELS

The NRC provides numerical data to estimate committed doses to individuals and populations from routine releases of radioactive materials[1]. These data are furnished in Appendix E of Regulatory Guide 1.109 for the various dose models presented therein. The NRC defaults for usage and consumption parameters examined in this study are given in Table 1.

Approximately half of the values in Table 1 were derived through the utilization of the HERMES code developed by the Hanford Engineering and Development Laboratory[2]. The majority of the usage and consumption data accessed by HERMES originated in a U.S. Department of Agriculture survey from 1965 on the consumption habits of families in the North-Central United States[8]. One third of the defaults in Table 1 are judgements of the NRC staff[1]. The remaining parameters (agricultural and garden productivity) are national averages obtained from the census bureau[9]. It is, therefore, appropriate that SRS-specific estimates of parameter values for the NRC dose models be determined since most of the default values are obtained from data that are nearly 20 years old, not specific to the southern U.S., and/or not adequately documented.

METHODOLOGY AND RESULTS

This survey focuses on the parameters necessary for estimating radiological dose to humans through several environmental pathways. These pathways include the ingestion of meat, milk, and vegetables contaminated by the deposition of radionuclides released to the atmosphere; the ingestion of drinking water, fish, and invertebrates contaminated by liquid effluents reaching the Savannah River; and external irradiation of humans engaged in recreational activities along or in the Savannah River. Irrigation of crops by farmers in Georgia and South Carolina using Savannah River water was also investigated.

Parameter values obtained from this study, the 1979-83 study, and the NRC are presented in Table 2 for comparison. References are provided for each of the values derived in this study. Appendix A contains calculations of all production, consumption and usage parameter values recommended for use in SRS dosimetry models as prescribed by the NRC.

Much of the information for this land and water use survey was obtained directly from the various state and county agencies within a 50-mile radius of the SRS and along the Savannah River. The majority of the information on livestock grazing habits, source of forage, beef preparation practices, vegetation production, etc. was obtained from a questionnaire mailed to county extension agents within the Central Savannah River Area (CSRA). A list of the agencies that have contributed to this effort appears in Appendix B.

In the sections that follow, the words "production" and "productivity" have specific meanings. "Production" is the total mass of vegetation (or meat or milk) harvested in a given county divided by the land area within that county, expressed in units of kg/m^2

(milk production expressed as L/m^2). "Productivity", however, is the average mass, in kilograms, of vegetation harvested in a typical square meter of garden or farm land, also expressed as kg/m^2. Productivity will only be used in conjunction with vegetation harvests.

Meat and Milk Production

Farmers in the south rely on year-round grazing of fresh, coastal bermudagrass[10]. Bermudagrass is the best hay plant for South Carolina and with adequate fertilization and frequent cuttings, yields of up to 8 tons per acre (1.8 kg/m^2) are common[11]. The diets of beef cattle in this region generally consist of about 75% pasture grass and 25% stored grass with total forage consumption averaging about 36 kg/day. Dairy cattle consume approximately 52 kg/day of which 56% is pasture grass, 25% is silage, and 19% is commercial grain[10].

Bermudagrass that is not consumed is cut and bailed every thirty days with storage times ranging from one month to one year, or at times up to two years[10]. Silage may be stored for up to one year before consumption[10]. Under these circumstances, the NRC stored-feed hold-up time of 90 days is considered conservative and will continue to be used in the SRS dosimetry models.

Most beef-cattle farmers in this region of the country operate on a cow-calf system; calves are raised locally until weaned (6 months) and then marketed to western feeder lots where their weights are increased before slaughter. These calves' average weight when sold is approximately 400 pounds. Ideally, cows producing calves each year remain with the area farmer whereas cows not producing calves are slaughtered locally. These cows slaughtered locally average about 800 pounds. For the purposes of this study, it is conservatively assumed that all calves are slaughtered at 400 pounds and all calfless cows are slaughtered at 800 pounds. Approximately 41% of a beef cow is processed into retail cuts and sold for human consumption[10]. All of this beef is assumed to be consumed locally. Figure 1 shows beef production, by county, for the 50-mile region surrounding the SRS.

Hogs and chickens are also raised on farms within 50 miles of the SRS. Retail cuts of locally produced pork (17 million pounds/year) are approximately half that of retail cuts of locally produced beef (32 million pounds/year). Chicken production in 1989 reached approximately 60 million pounds in Aiken County along. Hogs, however, do not graze; they are fed commercial feeds. Similarly, chickens are housed in covered shelters and eat feed provided by the parent companies responsible for marketing the final product[10]. For these reasons, the local consumption of pork and chicken is not considered in the determination of "meat" production or consumption.

The population of beef cattle within 50 miles of the SRS is approximately seven times larger than the population of milk cattle with only half of the counties in the region having milk cattle herds. Milk cows produce an average of about 20 liters of milk per day for three-quarters of the year. County-specific milk production is shown in Figure 2.

Beef and milk production was estimated assuming that cattle were evenly distributed over all land area in the county. Given other uncertainties in estimating radiological dose, exact locations of individual herds are insignificant and, therefore, locations of farm-lands within a given county were not determined. Production distributions of beef and milk as a function of distance and sector have been generated and are given in Tables 3 and 4. County-specific estimates of production were available for all counties within the 50-mile radius.

Transport Time. The concentration of a given nuclide in cattle meat or milk at the time of human consumption is dependent on several factors, the most significant of which is the concentration of the nuclide in the animal's feed. For the purposes of dose estimation, it is assumed that some fraction of the nuclides ingested by beef or milk cattle are instantaneously distributed in cattle flesh and/or milk. Thereafter, the NRC dose

model accounts for radioactive decay before human consumption of meat or milk. Since cattle are assumed to feed continuously, the decay time is essentially the time required to process and deliver the final product to market. Transport times for slaughter-to-consumption and milking-to-consumption were determined from practices at local beef and milk processing facilities.

The commercial slaughtering of beef cattle is generally a six-day process. Cattle are slaughtered the first day, processed and packed the next, and shipped on the sixth day. The beef is cured for the four days between packing and shipping[10].

Generally, milk is collected every other day from local dairies and shipped to one of several processing plants in the Southeast. The process of homogenizing, pasteurizing, and packing the milk can be completed in about 36 hours. Accordingly, it is assumed that milk is collected and delivered on day one, processed on day two, and shipped, ready for consumption, on day three[12].

Agricultural Production

When considering ingestion dose as a result of radionuclide deposition on vegetation, agricultural production is divided into two subgroups; leafy vegetables and other above-ground vegetables. As defined by NUREG/CR-1004, these vegetables include lima beans, broccoli, cabbage, cauliflower, lettuce, green peas, spinach, and sweet corn[13]. Literature from the Clemson University Extension Cooperative describes planting and growing times for a number of vegetables that can be harvested in the South[14]. The average growing time, or time of exposure, for above-ground vegetables in South Carolina is approximately 70 days.

County-wide vegetable production was estimated from a survey of land and water usage distributed to 21 county extension agents in Georgia and South Carolina. Results from this survey suggest that vegetable production in the southeast is difficult to determine since much of the area relies on vegetables grown in home gardens.

Nearly half of the extension agents surveyed were, however, able to provide rough estimates of vegetable production. Vegetable production distributions were generated for both leafy and other vegetables. For those counties where the extension agent was unable to provide data, a production estimate was generated using the average production of counties surveyed that did provide estimates. Tables 5 and 6 give above-ground vegetable and leafy-vegetable production as a function of distance and sector. Total vegetable production is given by county in Figure 3.

Because of the lack of region-specific data, NRC defaults for most of the parameter values related to exposure through the vegetation consumption pathway will continue to be used in SRS dosimetry models. Only crop exposure time and agricultural and garden productivity will be changed to reflect data obtained in this study.

Average agricultural productivity for farms in the 50-mile region is estimated to be 0.7 kg/m^2. The estimate is the average response from the survey of county extension agents when asked to approximate "vegetable productivity". Average garden productivity, as determined from extension agent response, is approximately 0.2 kg/m^2. The NRC default for garden productivity, however, is an order of magnitude larger. For this reason, garden productivity is assumed, for the present time, to be equal to agricultural productivity.

Transport Time. Default values recommended by the NRC for vegetation transport times and the fraction of consumed vegetables produced in home gardens will continue to be used until the appropriate data can be gathered. The default transport time for population dose calculations provide for a 14-day hold-up for all vegetables. The maximum individual, however, is assumed to consume leafy vegetables after a one-day hold-up and produce after a 60-day hold-up[1].

Use of the Savannah River

Drinking Water. As stated earlier, drinking water consumption remains unchanged from the NRC default so that a direct comparison can be made with the EPA drinking water standard. The effective population and transit time, however, is site-specific.

The Cherokee Hill Water Treatment Facility in Port Wentworth, Georgia processes between 40 and 45 million gallons per day with a user population of 15,000[15]. The population consists of employees of the 29 industries in Port Wentworth's industrial park. Some of the larger industries in Port Wentworth include Union Camp Paper Company, the Savannah Sugar Refinery, and the Arcadia Chemical Plant. The survey of 1980 showed that two soft-drink bottling plants operated in Port Wentworth; no such plants are served by the Cherokee Hill facility as of 1990[16]. Water treated at Port Wentworth is not used in any homes except in the case of drought or fire.

Unlike Cherokee Hill, the domestic water treatment facility serving Beaufort and Jasper counties of South Carolina is completely committed to household use. Beaufort-Jasper serves an effective population of 50,000[17].

The most conservative estimate of transit time, the time of travel from the origin of discharge to the water-treatment facilities, is obtained when considering releases from L-Reactor flowing through L-Lake down Steel Creek to the Savannah River. Dye studies on L-Lake show that an effluent at the north end of the lake will require between 12 and 24 hours to reach the lake's southern end. An additional 12 hours is required for the contaminants to travel down Steel Creek. Hence, a conservative transit time for a radioactive effluent to reach the Savannah River after discharge is 24 hours. Comparatively, effluents from K-Reactor require approximately 84 hours to traverse Pen Branch and the Savannah River swamp to reach the Savannah River at Steel Creek. Travel times from Steel Creek down the Savannah River to the Beaufort-Jasper treatment facility average approximately 72 hours[18].

Fishing. For this study, fish harvests from the Savannah River and its estuary are divided into three categories: 1) sport fish harvest, 2) commercial fish harvest, and 3) sport & commercial invertebrate harvest (crabs, shrimp, oysters, and clams). The South Carolina Wildlife and Marine Resources Department (WMRD) and the Georgia Department of Natural Resources (GDNR) were instrumental in supplying the necessary fish and invertebrate harvest data. Data from the GDNR include commercial harvests from the Wassaw River since it is fed by the Savannah River near Savannah, Georgia.

The 1988 Savannah River creel survey, conducted by the GDNR, monitored fishing activity on the Savannah River from the Savannah River Lock and Dam downstream to the Atlantic Ocean from January 10, 1988 to December 24, 1988[19]. The principal species harvested in the freshwater portion were redbreast sunfish, bluegill, channel catfish, and crappie. The annual fish harvest from the river by sport fishermen has been estimated from this creel survey. For 1988, approximately 152,000 pounds (69,000 kg) of fish were harvested from the Savannah River and its estuary from sport fishing.

The South Carolina WMRD provided data on the commercial fish harvest in the Savannah River for 1989[20]. The GDNR provided similar data on the Savannah and Wassaw River areas for 1972 to 1989[21].

The South Carolina commercial fish harvest in 1989 and the Georgia 18-year average fish harvest were dominated by American shad[20,21]. Since shad spend the majority of their lives in the Atlantic and spawn in the fresh waters of the Savannah River, radionuclides in their flesh are assumed not to have reached equilibrium with radionuclides in the river. Therefore, human ingestion of shad is assumed not to contribute significantly to one's fish ingestion dose. The remaining Georgia and South Carolina

fish catch of 12,090 pounds (5480 kg) consisted primarily of carp, sturgeon, and catfish. For dose assessment, it is assumed that 50% of the fish harvest is edible[22].

Annual summaries of state-wide seafood harvests for the fifteen year period from 1975 to 1989 have been obtained from the South Carolina WMRD. The GDNR has provided data on invertebrate harvests from 1972 to 1989 for the inshore areas of the Savannah and Wassaw Rivers. Studies similar to the creel survey of sport fishing harvests, however, have not been conducted in recent years since the Savannah River is closed indefinitely to shellfish harvesting[23]. Even with the closure of the Savannah River to shellfishing, an annual commercial shellfish harvest has been estimated for the estuary to avoid the need for annual refinements to the fish harvest parameters. Since the river is closed to shellfishing, these estimates of the commercial shellfish harvest are known to be conservative and, therefore, the sport shellfish harvest for the Savannah River is assumed to be non-existent.

Previously, the WMRD provided estimates of the 1989 blue crab commercial harvest from the Savannah River estuary[20]. The ratio of the 1989 Savannah River blue crab harvest by South Carolina fishermen to the state-wide annual average blue crab harvest (0.022) was used to estimate other invertebrate harvests from the Savannah River.

One hundred, thirty-four thousand pounds of blue crabs were harvested by South Carolina fishermen from the Savannah River estuary in 1989[20]. The 18-year average annual harvest of crabs by Georgia fishermen is 1.24 million pounds[21]. Assuming that fourteen percent of the average crab is edible[24], the annual edible portion of the crab harvest is 192,000 pounds(87,000 kg).

The average South Carolina annual shrimp (headless) and clam (meat only) harvests from the Savannah River estuary are estimated to be 76,000 pounds and 5,500 pounds, respectively[20]. The annual average Georgia shrimp harvest (from 1978 to 1989) is approximately 616,000 pounds (headless)[21]. Clam meat harvested by Georgia fishermen averages 4,200 pounds annually[21]. Assuming that 90% of a headless shrimp is edible and 100% of clam meat is edible, the edible portion of shrimp and clams harvested from the Savannah River is estimated to be 625,000 pounds (284,000 kg) and 9,800 pounds (4,500 kg), respectively.

South Carolina oyster catches have been estimated using a state-specific factor converting bushels of harvested oysters to pounds of edible meat. The conversion factor for oysters taken off the coast of South Carolina is 3.18 lbs/bushel[24]. Approximately 408,000 bushels of oysters are harvested annually by South Carolina commercial fishermen (2.2% of those assumed to come from the Savannah River area). Georgia commercial harvests of oysters are presented in units of pounds of meat. The average oyster harvest by Georgia fishermen over the past 18 years is about 1,370 pounds per year. Therefore, it is estimated that about 30,000 pounds (13,600 kg.) of oyster meat could potentially be harvested from the Savannah River area.

It is estimated that an additional 14,000 pounds of miscellaneous shellfish would be harvested from the river. Assuming 10% of the harvest is edible, approximately 1,400 pounds (640 kg) of miscellaneous Savannah River shellfish are harvested annually for ingestion.

If half of the sport fishing harvest is assumed edible, approximately 35,000 kg of edible fish meat are taken from the freshwater and estuarine sections of the Savannah River annually. The total edible portion of the commercial fish and invertebrate harvests from the Savannah River and its estuary are estimated to be 2740 kg/yr and 390,000 kg/yr, respectively.

Recreation on the Savannah River. Shoreline, swimming, and boating usage of the Savannah River has been estimated for residents of Georgia and South Carolina. A study conducted by the GDNR gives an assessment of outdoor recreation for 1989[25].

This assessment approximates, for a given recreational activity, the participating fraction of the population, the average frequency of participation, and average hours per outing. Data are available on, among others, water-skiing, canoeing/rafting, motorboating-/sailing, swimming at beaches, and warm-water fishing (as opposed to cold-water, mountain-stream fishing).

The following assumptions were made for the purposes of estimating recreational usage of the Savannah River: 1) water recreational characteristics are the same for Georgia and South Carolina residents, 2) all warm-water fishing, boating, and swimming in the Georgia counties that border the Savannah River takes place in the river, 3) recreational water usage in South Carolina's Lower Savannah and Low Country regions is indicative of Savannah River recreational usage, 4) the population for 1990 is 631,200[26], and 5) 40% of the population within 50 miles of the SRS resides in South Carolina, 60% in Georgia.

Annual shoreline, swimming, and boating usage has been determined for the 50-mile population (in units of person-hours) and for the maximum individual (in units of hours). Population usage is the product of the 50-mile population, the fraction participating, the annual frequency of participation, the average hours per outing, and a "usage factor". The usage factor accounts for the fraction of the population that participates in water recreational activities at locations other than the Savannah River. For example, if the usage factor were equal to unity, every person within 50 miles of the SRS would be using only the Savannah River for water recreation. Usage factors are typically less than 15% and are estimated for each activity.

Maximum usage is estimated from average usage using the age-specific NRC defaults for shoreline activities as a guide[1]. Average usage for shoreline, swimming, and boating is simply the average outings per capita (percent participating times frequency of participation) multiplied by the average hours per outing. The NRC suggests increasing average usage by 50% to estimate maximum usage[1]. Maximum usage is then divided by a population weighting factor to determine usage as a function of age (adult, teen, and child) (see Appendix A).

Irrigation. The Water Resources Management Program of the GDNR and the Clemson University Extension Cooperative provided information regarding irrigation practices along the Savannah River from Clark's Hill reservoir to the Atlantic Ocean. The only known use of Savannah River water for irrigation is by a dairy farmer in Edgefield, upstream of the SRS[27]. Irrigation, therefore, is not considered a pathway for ingestion of radionuclides.

Consumption Rates

The rates of consumption of meat, milk, vegetables, fish, and invertebrates suggested by the NRC[1] have been revised for the SRS using data gathered by the U.S. Department of Agriculture[8]. The NRC default values are derived from consumption rates of individuals living in the North-Central United States[2]. This study utilizes consumption rate data for individuals living in the South.

Average and maximum, age-specific consumption rates for individuals within 50 miles of the Savannah River Site are given in Table 7. The NRC default consumption rates are also presented in the table. Rates of consumption for adults as determined in this study are compared to the 1979-83 survey and the NRC defaults in Table 8.

Average Individual. Average consumption rates were taken directly from the food consumption survey conducted by the U.S. Department of Agriculture during 1977 and 1978[8]. Consumption rates for the average adult, teen, and child living in the South are higher than those suggested by the NRC except for meat consumption.

On the surface it appears that meat consumption in southern states is a factor of two less than meat consumption in the North-Central states. The NRC, however, included beef, pork, and poultry in the default value for meat consumption[1]. As suggested

earlier, for the area within 50 miles of the SRS, the potential for contamination through the meat consumption pathway exists only for grazing beef cattle.

Values for average leafy vegetable consumption were not specified by the NRC but are used in the SRS dosimetry models. Therefore, average leafy vegetable consumption rates for this region have been estimated.

Maximum Individual. The estimates of maximum consumption generated by this study are generally lower than the NRC defaults. The NRC values were estimated by multiplying average consumption times maximum-to-average consumption ratios[2]. The validity of the these ratios for use at the SRS is in question, however, since they were approximated from dietary surveys of Hanford workers and elementary school children in Richland, Washington[28,29]. Consumption rates for the maximum individual at the SRS were derived from the average rates given above and the variation observed in weekly consumption of meat, milk, vegetables, and seafood in southern households[8].

Maximum consumption rates could reasonable be estimated by increasing average consumption rates by two standard deviations. Variability data, however, on individual consumption are not available. Standard deviations of weekly household consumption, therefore, were utilized to estimate reasonable consumption rates for maximum individuals.

Maximum consumption was determined in this study by increasing average individual consumption by a variability ratio. This ratio is three times the standard deviation of the average household consumption divided by the average household consumption. Three standard deviations were chosen since the variation in weekly household consumption rates is expected to be less than the variation in individual consumption. Details of the generation of maximum consumption rates can be found in Appendix A.

CONCLUSIONS

Values of dosimetry model parameters for land and water usage in the vicinity of the Savannah River Site have been updated for 1990. Estimates of annual doses to the public are not anticipated to change significantly due to refinements resulting from this study. Generally, dosimetry parameter values recommended in this report are not significantly different from values previously determined at SRS or from NRC default values.

The updated parameter values indicate that cattle are grazing a larger fraction of the time but consuming less pasture grass. The time required to process cows milk has been decreased by 25% and the processing time for beef has been decreased by 70% over the NRC default values. Pasture-grass productivity for the SRS region has been increased by a factor of three over the previous study's value and the average vegetable growing/exposure time has been increased by 17%.

Fish and invertebrate harvests from the Savannah River and its estuary are essentially unchanged in terms of their significance to dose. Shoreline, swimming, and boating usage, however, has been increased over usage values from the 1979-83 study by about one order of magnitude. The contribution to total dose, however, for recreational river use is still expected to be insignificant.

The domestic water supply systems serving Port Wentworth, Georgia and Beaufort and Jasper Counties in South Carolina have seen slight decreases over the past decade in average daily flow and effective populations. Soft drink bottling plants once existing on the Port Wentworth industrial supply system are no longer operating and the industrial work

force in that area has decreased over the past ten years. Apparently, growth of the water systems did not occur as expected.

The most significant changes are seen in the average and maximum consumption rates for the South. The NRC selected consumption surveys from the North-Central and North-Western portions of the country for the basis of their consumption rate default values[2]. Consumption rates of individuals in the South, however, can be quite different than those of individuals in the North[8].

Maximum consumption rates estimated in this study are somewhat less than the NRC default values. Rates suggested here, however, have been determined from consumption data obtained from southern households and are more appropriate and more defensible for the SRS region. Additionally, average consumption rates for "meat" have been decreased by about 50% from the NRC values. The NRC includes beef, pork, and poultry while this study, for reasons described earlier, only considers beef.

RECOMMENDATIONS

A copy of the questionnaire mailed to the Georgia and South Carolina county extension agents is shown in Appendix C. Problems with the questionnaire arose because the phrases used to describe the dose model parameters are not ordinarily used by the farming community. Future studies will contain a questionnaire that has been developed with input and review by extension agents and other individuals familiar with the farming industry.

The values of several parameters relating to garden-vegetable production and productivity will remain equal to the NRC defaults since reliable data for the SRS region have not been obtained. Surveys of local farmer's markets during the peak summer months and detailed questionnaires aimed at local gardeners and commercial farmers will be conducted in the future to acquire the necessary information. Data from these surveys would be integrated into the dose models as they become available.

As explained earlier, the commercial fish harvest is dominated by American Shad. These catches are not included in the total harvest since they are not full-time residents of the Savannah River. A study should be conducted to ensure concentrations of dose-dominant nuclides are present in shad at insignificant levels.

Most of the data used in the preparation of this report were gathered by federal, state, and local agencies (e.g., the U.S. Department of Agriculture, the Georgia Department of Natural Resources, and the Aiken County Extension Cooperative). The cycles on which the multitudes of agricultural or fisheries data are obtained and analyzed typically range from 1 to 10 years. Consumption rates are surveyed each decade, the agricultural census is updated every five years, and the time between the last two sport-fishing harvest surveys was approximately eight years. It would seem counterproductive to conduct comprehensive land and water use surveys for the Savannah River Site on a frequency of anything less than 5 years since the majority of pertinent data are not updated on a shorter frequency.

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33. "Food Consumption, Prices, and Expenditures", AER-138, U.S. Dept. of Agriculture, Washington, DC, December 1974.

Table 1. NRC Default Values for Land Usage and Individual Consumption

	NRC Default	Units	NRC Ref.
Land Usage Statistics			
Beef-cow forage consumption (wet)	50	kg/day	2
Milk-cow forage consumption (wet)	50	kg/day	2
Pasture-grass exposure time	30	days	2,30
Transport time (feed-milk-man)	4	days	sp
Holdup time (pasture grass, forage)	0	days	sp
Holdup time (stored feed)	90	days	sp
Fraction of time milk-cow on pasture	0.75	-	31
Fraction of time beef-cow on pasture	0.75	-	31
Time from slaughter to consumption	20	days	sp
Crop exposure time	60	days	2,30
Fraction of leafy vegetables from garden	1.0	-	sp
Fraction of other vegetables from garden	0.76	-	sp
Transport time (leafy veg, produce; pop)	14	days	sp
Transport time (leafy veg.; MI)	1	days	sp
Transport time (produce; MI)	60	days	sp
Agricultural productivity (pasture grass)	0.7	kg/sq m	32
Agricultural productivity (produce/veg.)	2.0	kg/sq m	9
Vegetable garden productivity	2.0	kg/sq m	9
Average Individual Usage			
Other vegetable consumption	190	kg/yr	2,33
Meat consumption	95	kg/yr	2,33
Milk consumption	110	L/yr	2,33
Water consumption	370	L/yr	2
Invertebrate consumption	1.0	kg/yr	2,33
Maximum Individual Usage			
Leafy vegetable consumption	64	kg/yr	2,33
Other vegetable consumption	520	kg/yr	2,33
Meat consumption	110	kg/yr	2,33
Milk consumption	310	L/yr	2,33
Water consumption	730	L/yr	2
Fish consumption	21	kg/yr	2
Invertebrate consumption	5	kg/yr	2,33
Recreational shoreline usage	12	hr/yr	2

sp=NRC staff position

Table 2. SRS-Specific Parameter Values for Dose Estimates

	Units	NRC Default	1979-83 Survey	This Survey	Ref.
Land Usage Statistics					
Beef-cow forage consumption (wet)	kg/day	50	50	36(a)	10
Milk-cow forage consumption (wet)	kg/day	50	50	52(a)	10
Pasture-grass exposure time	days	30	30	30	10,11
Agricultural productivity (pasture grass)	kg/sqm	0.7	0.501	1.8	10
Transport time (feed-milk-man)	days	4	4	3	12
Holdup time (pasture grass, forage)	days	0	0	0	1
Holdup time (stored feed)	days	90	90	90	1
Fraction of time milk-cow on pasture	-	0.75(b)	0.58	1.0	10
Fraction of time beef-cow on pasture	-	0.75(b)	0.79	1.0	10
Fraction of intake from pasture (milk cow)	-	1(b)	0.45	0.56	10
Fraction of intake from pasture (beef-cow)	-	1(b)	0.85	0.75	10
Time from slaughter to consumption	days	20	20	6	10
Fraction of leafy vegetables from garden	-	1.0	0.75	1.0	1
Fraction of other vegetables from garden	-	0.76	0.76	0.76	1
Transport time (leafy veg, produce;pop)	days	14	14	14	1
Transport time (leafy veg; MI)	days	1	1	1	1
Transport time (produce; MI)	days	60	60	60	1
Agricultural productivity (produce/veg.)	kg/sq m	2.0	0.894	0.7	**
Vegetable garden productivity	kg/sq m	2.0	0.632	0.7	**
Crop exposure time	days	60	60	70	14
Water Usage Statistics					
Edible sport fish harvest (d)	kg/yr	-	9.1E+04*	3.5E+04	19
Edible commercial fish harvest (c)	kg/yr	-	3.2E+04*	2.7E+03	20,21
Edible commercial invertebrate harvest	kg/yr	-	3.0E+05*	3.9E+05	10,21
Edible fraction of harvest: Fish(whole)	-	-	0.50	0.50	22
Crab (whole)	-	-	-	0.14	24
Shrimp(headless)	-	-	-	0.90	23
Oysters(meat)	-	-	-	1.00	23
Clams(meat only)	-	-	-	1.00	23
Population shoreline usage	per-hrs	-	1.1E+05	9.6E+05	25
Population swimming usage	per-hrs	-	8.5E+03	1.6E+05	25
Population boating usage	per-hrs	-	2.3E+05	1.1E+06	25
Drinking Water					
Effective population - Beaufort/Jasper	persons	-	5.1E+04	5.0E+04	17
Effective population - Port Wentworth	persons	-	2.0E+04	1.5E+04	15
Transit time from discharge to river	hours	-	24	24	18
Transit time, river entry to treatment facility	hours	-	72	72	18

* Values are for total harvest (not only edible portion).
** Values obtained from questionnaire.
(a) dry weight converted to wet weight assuming 75% of plant mass is water.
(b) not specifically given in Reg. Guide 1.109 but obtained from GASPAR manual, NUREG-0597.
(c) approximately 96% of 1989 harvest was American shad(not full time residents of Savannah River and not included here).
(d) sport invertebrate harvest not included due to closure of Savannah River to invertebrate fishing.

Table 3. Beef Production Grid (kg/yr)

Sector	10-20 Mi	20-30 Mi	30-40 Mi	40-50 Mi
N	5.3E+04	8.8E+04	2.5E+05	9.8E+05
NNE	5.3E+04	8.8E+04	2.0E+05	4.1E+05
NE	7.1E+04	1.7E+05	3.5E+05	4.5E+05
ENE	8.3E+04	2.0E+05	4.6E+05	5.7E+05
E	8.3E+04	1.9E+05	3.4E+05	5.1E+05
ESE	8.3E+04	1.9E+05	2.2E+05	2.5E+05
SE	1.2E+05	2.1E+05	2.6E+05	3.0E+05
SSE	1.1E+05	1.9E+05	2.6E+05	2.9E+05
S	9.4E+04	1.5E+05	2.0E+05	2.7E+05
SSW	9.5E+04	1.8E+05	2.9E+05	3.9E+05
SW	9.5E+04	1.7E+05	2.7E+05	3.2E+05
WSW	9.5E+04	1.6E+05	2.3E+05	4.0E+05
W	5.8E+04	1.0E+05	2.1E+05	4.1E+05
WNW	4.8E+04	6.2E+05	1.3E+05	2.9E+05
NW	5.8E+04	8.0E+04	2.8E+05	2.7E+05
NNW	5.3E+04	8.8E+04	3.3E+05	6.2E+05

Table 4. Milk Production Grid (L/yr)

Sector	10-20 MI	20-30 Mi	30-40 Mi	40-50 Mi
N	4.2E+04	6.9E+04	1.0E+06	5.3E+06
NNE	4.2E+04	6.9E+04	2.1E+05	5.0E+05
NE	3.2E+04	1.0E+06	2.7E+06	2.0E+06
ENE	2.5E+04	1.2E+06	4.4E+06	5.2E+06
E	2.5E+04	1.4E+06	3.9E+06	4.9E+06
ESE	2.5E+04	5.6E+05	3.0E+04	4.9E+05
SE	2.5E+03	0.0E+00	0.0E+00	0.0E+00
SSE	4.8E+05	8.6E+05	1.2E+06	1.2E+06
S	1.0E+06	2.1E+06	3.0E+06	3.5E+06
SSW	9.9E+05	3.8E+06	7.4E+06	7.6E+06
SW	9.9E+05	2.2E+06	5.8E+06	4.8E+06
WSW	9.9E+05	1.7E+06	2.4E+06	3.5E+06
W	6.7E+05	1.3E+06	2.2E+06	3.6E+06
WNW	2.3E+05	1.1E+06	1.2E+06	2.0E+06
NW	4.2E+04	3.8E+05	1.4E+06	1.0E+06
NNW	4.2E+04	6.0E+04	1.7E+06	3.4E+06

Table 5 Vegetable Production Grid (kg/yr)

Sector	10-20 Mi	20-30 Mi	30-40 Mi	40-50 Mi
N	3.4E+05	5.7E+05	8.0E+05	8.3E+05
NNE	3.4E+05	5.7E+05	4.8E+05	2.9E+03
NE	3.4E+05	6.5E+05	9.4E+05	4.5E+05
ENE	3.4E+05	6.2E+05	1.1E+06	1.3E+06
E	3.4E+05	5.7E+05	8.4E+05	1.3E+06
ESE	3.4E+05	2.1E+06	1.8E+06	1.0E+06
SE	2.3E+06	4.3E+06	2.9E+06	1.0E+06
SSE	1.6E+06	2.8E+06	3.4E+06	1.0E+06
S	6.9E+04	5.2E+05	8.0E+05	9.3E+05
SSW	2.5E+02	1.2E+05	2.4E+05	1.0E+05
SW	2.5E+02	5.1E+02	1.2E+03	3.1E+05
WSW	2.5E+02	4.2E+02	7.7E+03	2.6E+03
W	4.4E+04	2.3E+04	1.7E+04	2.1E+03
WNW	2.5E+05	3.8E+04	4.3E+04	1.0E+06
NW	3.4E+05	4.1E+05	8.0E+05	1.0E+06
NNW	3.4E+05	5.7E+05	8.0E+05	1.0E+06

Table 6. Leafy-Vegetable Production Grid (kg/yr)

SECTOR	10-20 Mi	20-30 Mi	30-40 Mi	40-50 Mi
N	1.7E+04	2.8E+04	3.9E+04	4.0E+04
NNE	1.7E+04	2.8E+04	2.4E+04	3.4E+04
NE	1.7E+04	4.3E+04	7.9E+04	4.6E+04
ENE	1.7E+04	3.3E+04	1.0E+05	1.3E+05
E	1.7E+04	1.4E+04	1.2E+04	9.2E+04
ESE	1.7E+04	9.7E+04	9.1E+04	4.5E+04
SE	1.2E+05	2.1E+05	1.4E+05	5.0E+04
SSE	8.2E+04	1.4E+05	1.7E+05	5.0E+04
S	3.4E+03	2.5E+04	3.9E+04	4.5E+04
SSW	9.5E+01	6.1E+03	1.3E+04	6.3E+03
SW	9.5E+01	2.7E+02	9.9E+02	1.3E+03
WSW	9.5E+01	1.6E+02	2.2E+02	3.0E+02
W	1.7E+03	1.4E+02	2.2E+02	5.0E+04
WNW	1.2E+04	1.4E+02	1.9E+04	5.0E+04
NW	1.7E+04	1.9E+04	3.9E+04	5.0E+04
NNW	1.7E+04	2.8E+04	3.9E+04	5.0E+04

Table 7. Suggested Age-Specific Consumption Rates for Offsite Dosimetry at the SRS

Average Individual Consumption

	Units	Adult	Teen	Child	Infant
Land Usage Statistics					
Leafy vegetable consumption	kg/yr	21(ns)	14(ns)	8.5(ns)	-
Other vegetable consumption	kg/yr	163(190)	205(240)	171(200)	-
Meat consumption*	kg/yr	43(95)	27(59)	17(37)	-
Milk consumption	L/yr	120(110)	218(200)	186(170)	186(170)
Water Usage Statistics					
Water consumption	L/yr	370(370)	260(260)	260(260)	260(260)
Invertebrate consumption	kg/yr	2.0(1.0)	1.5(0.75)	0.7(0.33)	-
Fish consumption	kg/yr	9.0(6.9)	6.8(5.2)	2.9(2.2)	-

Maximum Individual Consumption**

	Units	Adult	Teen	Child	Infant
Land Usage Statistics					
Leafy vegetable consumption	kg/yr	43(64)	28(42)	17(26)	-
Other vegetable consumption	kg/yr	276(520)	334(630)	276(520)	-
Meat consumption*	kg/yr	81(110)	48(65)	30(41)	-
Milk Consumption	L/yr	230(310)	297(400)	244(330)	244(330)
Water Usage Statistics					
Water consumption	L/yr	730(730)	510(510)	510(510)	330(330)
Fish consumption	kg/yr	19(21)	14(16)	6(6.9)	-
Invertebrate consumption	kg/yr	8.0(5)	6.1(3.8)	2.7(1.7)	-
Recreational shoreline usage	hr/yr	23(12)	128(67)	27(14)	-
Swimming usage	hr/yr	8.9(ns)	50(ns)	10(ns)	-
Boating usage	hr/yr	21(ns)	117(ns)	25(ns)	-

Values in parentheses are NRC defaults (ns - not specified).

* Consumption rates from this report do not include the consumption of pork or poultry

**Teen, child, and infant consumption values are determined using the age-specific ratios of NRC defaults.

Table 8. Comparison of Consumption Rates for Adult Average and Maximum Individuals

Adult Average Individual

	Units	NRC Default	1979-83 Survey	This Survey	Ref
Land Usage Statistics					
Leafy vegetable consumption	kg/yr	ns	30	21	8
Other vegetable consumption	kg/yr	190	190	163	8
Meat consumption	kg/yr	95	95	43	8
Milk consumption	L/yr	110	110	120	8
Water Usage Statistics					
Water consumption	L/yr	370	370	370	1
Invertebrate consumption	kg/yr	1.0	1.0	2.0	8
Fish consumption	kg/yr	6.9	11.3	9.0	8

Adult Maximum Individual

	Units	NRC Default	1980 Survey	This Survey	Ref
Land Usage Statistics					
Leafy vegetable consumption	kg/yr	64	64	43	8
Other vegetable consumption	kg/yr	520	520	276	8
Meat consumption	kg/yr	110	110	81	8
Milk consumption	L/yr	310	310	230	8
Water Usage Statistics					
Water consumption	L/yr	730	730	730	1
Fish consumption	kg/yr	21	34	19	8
Invertebrate consumption	kg/yr	5	5	8	8
Recreational shoreline usage	hr/yr	12	20	23	8

Figure 1 Beef Production by County

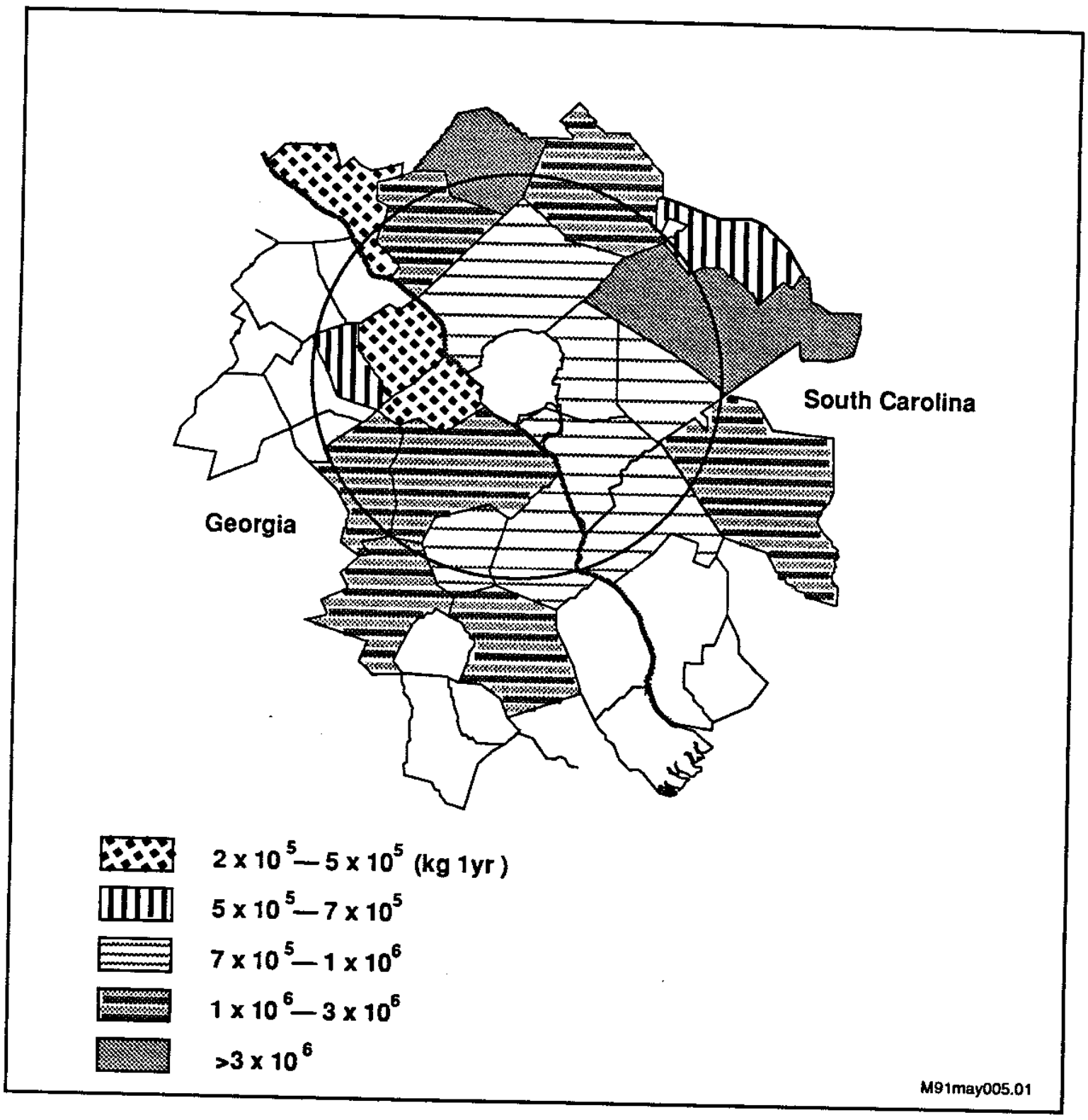


Figure 2 Milk Production by County

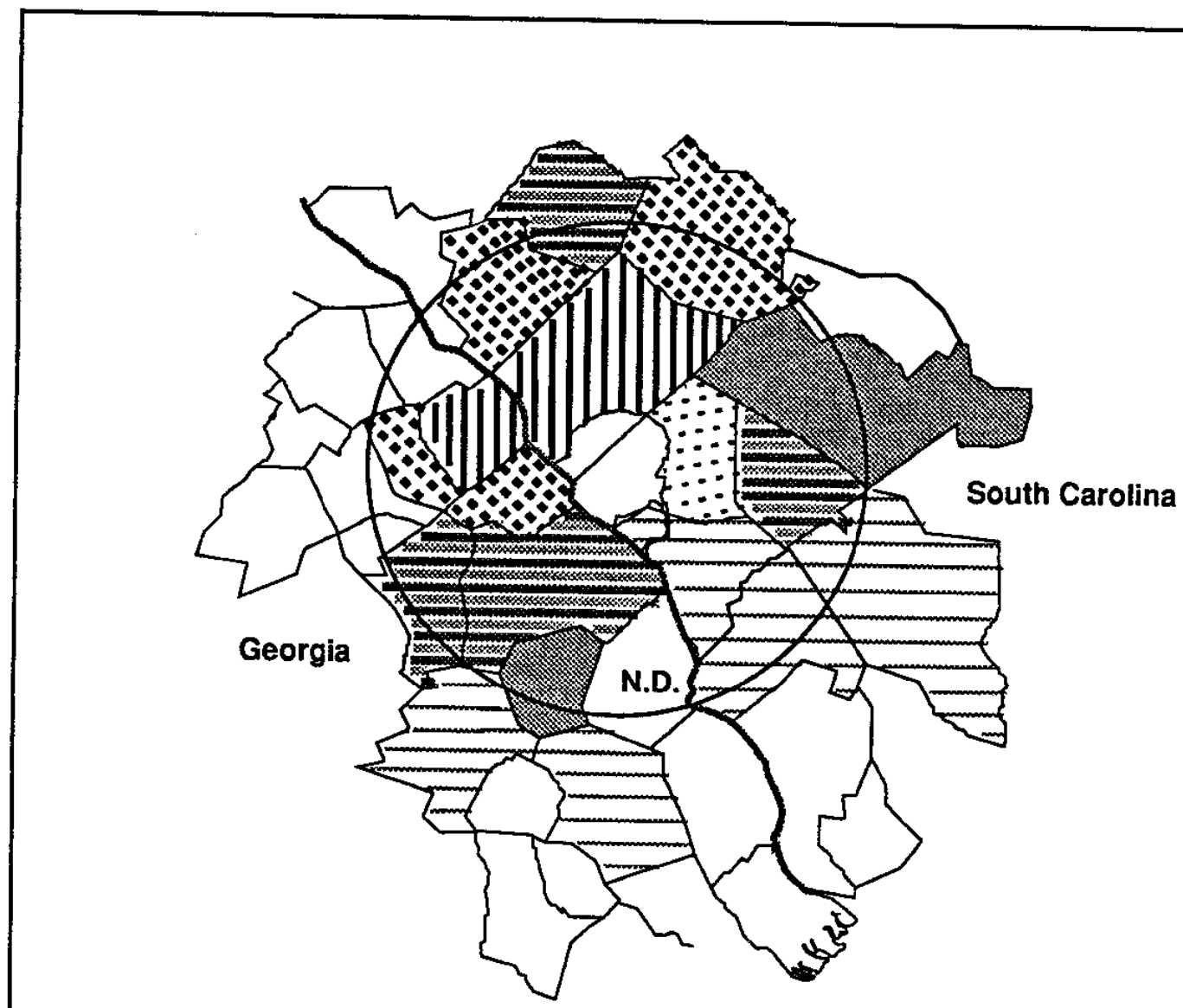
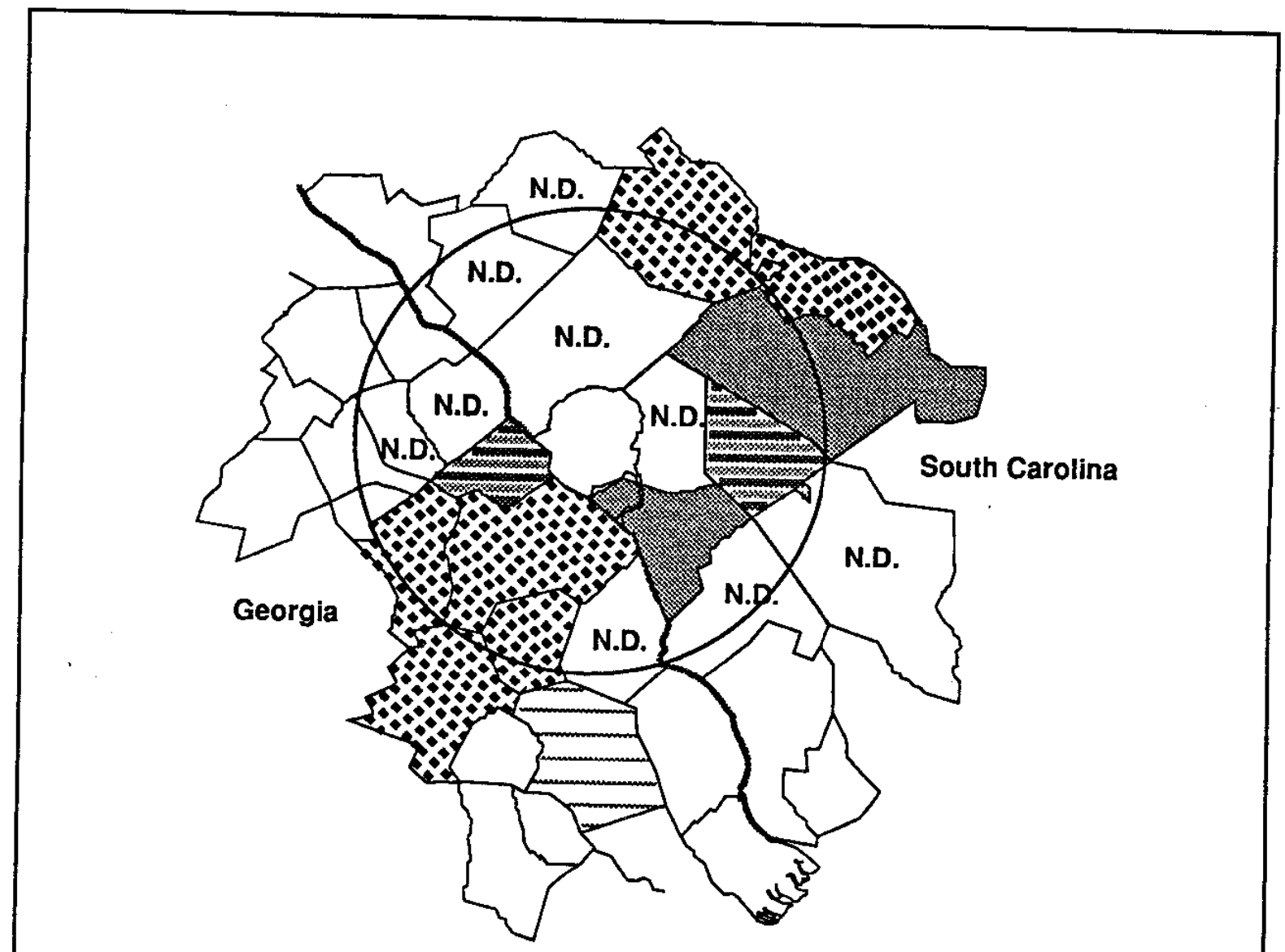


Figure 3 Vegetable Production by County



APPENDIX A

ADULT VEGETABLE CONSUMPTION RATES

Vegetable	Avg. Consumption	Variability Factor	Max. Consumption
Fresh Veg.	66 kg/yr	0.40	92 kg/yr
Fruits	60 kg/yr	1.00	120 kg/yr
Grains	37 kg/yr	0.73	64 kg/yr
Total	163 kg/yr		276 kg/yr
Leafy Veg*	21 kg/yr	1.03	43 kg/yr

* includes "dark-green, leafy", "lettuce", and "cabbage".
(see Reference 8)

MISCELLANEOUS ADULT CONSUMPTION RATES

Food Category	Avg. Consumption	Variability Factor	Max. Consumption
Invertebrate (shellfish)	2 kg/yr	2.90	8 kg/yr
Fish(fresh)	9 kg/yr	1.14	19 kg/yr
Milk(fresh fluid)	120 L/yr	0.89	230 L/yr
Beef	43 kg/yr	0.88	81 kg/yr

Maximum Consumption Estimation (Fresh Vegetables):

Weekly household consumption = 3.35 lb
1 standard deviation = 0.45 lb
3 standard deviations = 1.35 lb

Variability Factor = 1.35/3.35 = 0.40

Max. Consumption = (66 kg/yr)(1+0.40) = 92 kg/yr

BEEF PRODUCTION WITHIN 50 MILES OF THE SAVANNAH RIVER SITE.

County	Fractional Area w/in 50-miles	All Beef Cattle	Beef Cattle that have Calved	Slaughtered Beef* (million lbs/yr)	Beef Production** w/in 50-miles (million lbs/yr)
South Carolina (a)					
Aiken	1.0	9900	6900	5.2	2.1
Allendale	1.0	7000	1900	4.8	2.0
Bamberg	1.0	7600	2700	5.0	2.1
Barnwell	1.0	6650	2900	4.2	1.7
Calhoun	0.1	5300	3300	2.9	0.1
Colleton	0.2	12950	8200	7.1	0.6
Edgefield	0.9	12300	7800	6.7	2.5
Hampton	0.7	8300	3800	5.1	1.5
Lexington	0.5	14600	7500	8.7	1.8
McCormick	0.2	4350	4000	1.9	0.2
Orangeburg	0.5	30750	10500	20.4	4.2
Saluda	0.4	28650	13800	17.4	2.9
Georgia (b)					
Bulloch	0.1	19000	-	7.6	0.3
Burke	1.0	18000	-	7.2	3.0
Columbia	0.9	4800	-	1.9	0.7
Emanuel	0.1	14000	-	5.6	0.2
Jefferson	0.5	17000	-	6.8	1.4
Jenkins	1.0	11000	-	4.4	1.8
McDuffie	0.5	7600	-	3.0	0.6
Richmond	1.0	2700	-	1.1	0.5
Screven	0.9	13000	-	5.2	1.9
50-Mile Total					32.1

* In SC, all calves assumed slaughtered at 400 lbs and those cows that don't calf slaughtered at 800 lbs. In GA, all cattle & calves are assumed to be slaughtered as calves at 400 lbs.
** Production assumes 41% (by weight) of cow is packaged as retail cuts.
(a) SC data from county-specific "Agricultural Statistics for 1989".
(b) GA data from "Georgia County Guide", 1990.

SWIMMING, BOATING, AND SHORELINE ACTIVITIES

South Carolina Usage Fractions

Activity	Unit	State Total	Lower Savannah*	Low Country*	F
Surf/Bank Fshing	L.Ft.	$3.2x10^5$	5606	7205	0.041
Other Fishing	Facilities	171	14	9	0.14
Boat Ramps	Lanes	101	11	1	0.12
Beach Areas	Sq.Ft.	$5.6x10^7$	$2.8x10^5$	$1.5x10^6$	0.032

Data from the South Carolina Department of Parks and Recreation.
* Lower Savannah and Low Country regions as defined by the SC Department of Parks and Recreation.

Georgia Usage Fractions

Activity	Unit	State Total	River Counties*	F
Warmwater Fishing	Acres	46965	4000	0.085
Lake(Beach)Swimming	Sq.Ft.	$3.4x10^6$	90815	0.027
Boating/Sailing	Acres	27917	1583	0.057

Data from Georgia Department of Natural Resources.
* Total fishing acres, beaches, boating acres in Georgia counties along Sav. River (includes Burke, Chatham, Effingham, and Screven).

ACTIVITY USAGE RATES

Activity	Percentage Participating	Average Annual Frequency	Hours per Occasion	per Capita Usage (hrs/yr)
Swimming Usage				
Lake Swimming	41.80	8.12	2.61	8.86
				8.9
Boating Usage				
Canoe Trails	12.42	6.13	2.25	1.71
Boating/Sailing	22.92	18.77	4.38	18.8
				21
Shoreline Usage				
Warmwater Fishing	26.77	19.15	4.44	22.8
				23

Weighted Usage Fractions

Activity	State Usage Fraction	Population Fraction*	Weighted Usage Fraction
Swimming			
SC, beach areas	0.032	0.40	0.013
Ga, lake swimming	0.027	0.60	0.016
			0.029
Boating			
SC, boat use average**	0.13	0.40	0.052
Ga, boating/sailing	0.057	0.60	0.034
			0.086
Shoreline			
SC, surf/bank fishing	0.041	0.40	0.016
Ga, warmwater fishing	0.085	0.60	0.051
			0.067

* assumes 40% of population lives in SC and 60% of population lives in Georgia.
** average of "other fishing" and "boat ramps" fractions.

ESTIMATION OF SWIMMING, BOATING, AND SHORELINE USAGE

Usage = Average Usage (hrs/yr) X Population X Weighted Usage Fraction

Swimming Usage = 8.9 hrs/yr X 631,200 persons X 0.029
= 162,000 person-hours per year

SHORELINE USAGE ESTIMATION FOR AN AVERAGE & MAXIMUM INDIVIDUAL

Average Individual (23 hrs/yr, all ages; NRC default = 8.3 hrs/yr)

Maximum Individual (35 hrs/yr, all ages; increased over average usage by 50% as determined from NRC default value; NRC default = 12 hrs/yr)

	NRC Defaults	Normalization Factor*	Population Fraction
Adult	12 hrs/yr	1.00	0.703
Teen	67 hrs/yr	5.58	0.111
Child	14 hrs/yr	1.17	0.186

Adult Usage = [35 hrs/yr] / [(1)(0.703) + (5.58)(0.111) = (1.17)(0.186)] = 23 hrs/yr
Teen Usage = (23 hrs/yr)(5.58) = 128 hrs/yr
Child Usage = (23 hrs/yr)(1.17) = 27 hrs/yr

*Normalization factor obtained from ratios of NRC default values.

APPENDIX B - Contributing Agencies

Water Treatment Facilities
City of Savannah Industrial and Domestic Water Supply
William Weil, Harry Jue
P.O. Box 4038, Port Wentworth, GA 31407
(912) 964-0698

Beaufort-Jasper Water Treatment
John Curnutt
(803) 524-7322

Water Resources
Georgia Department of Natural Resources
Dennis Schmitt
Route 2, Box 219R, Richmond Hill, Ga.
(912) 727-2112

Georgia Department of Natural Resources
Gina G. Tritaik
One Conservation Way, Brunswick, Ga.
(912) 264-7218

South Carolina Wildlife & Marine Resources Dept.
Andrew Applegate
P. O. Box 12559, Charleston, SC 29412
(803) 795-6350

Georgia Parks and Recreation
Shirley Teston
(404) 656-3877

South Carolina Recreation Parks
Tony Bebber
(803) 734-0189

South Carolina Water Resources Commission
Lyle McElveen
1201 Main St., Suite 1100, Columbia, SC 29201
(803) 737-0800

Georgia Department of Natural Resources
Steven Tribble
(404) 656-6538

Irrigation
Georgia Department of Natural Resources
Owen McKeon
205 Butler Street, Atlanta
(404) 656-3094

Clemson University Extension Cooperative
Charles Privett
(803) 656-4069

Consumption Data
U.S. Department of Agriculture
Mary Hama
(301) 436-8485

Livestock and Agricultural Data
South Carolina Agricultural Statistics Service
Henry Power, Jr.
P.O. Box 1911, Columbia, SC 29202
(803) 765-5333

Aiken County Extension Service
Terry Mathis
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Borden
Jack Dawson
Macon, Georgia
(800) 868-4558

Coburg Dairy Products
Vicki Smith
Charleston, SC
(803) 554-4870

APPENDIX C

SAVANNAH RIVER LABORATORY
Land Use Survey, 1990-91

BEEF CATTLE

Number of beef cattle: _____
Beef production: _____lbs./yr
Holdup (time from slaughter to consumption): _____days
Grain ingestion rate: _____lbs./day per cow
Water ingestion rate: _____gal./day per cow
Source of water: (well, pond, etc.) _____
Fraction of grain from pasture (not stored): _____
Grain growing time: _____days
Specific months of growing season: _____to_____
Grain storage time: _____days

MILK CATTLE

Number of milk cattle: _____
Milk production: _____gal./day
Holdup (time from milking to consumption): _____days
Hay ingestion rate: _____lbs./day per cow
Water ingestion rate: _____gal./day per cow
Source of water: (well, pond, etc.) _____
Fraction of hay from pasture (not stored): _____
Hay growing time: _____days
Specific months of growing season: _____to_____
Hay storage time: _____days

VEGETABLES

Pasture grass productivity _____lbs./acre
Other crop productivity: _____lbs./acre
Garden vegetation productivity: _____lbsl/acre
Leafy veg. production: _____lbs./yr
Other vegetable production: _____lbs./yr
Leafy veg. growing time: _____days
Other veg. growing time: _____days
"Other" vegetables includes_____

Comments:_____

Prepared by:_____Date:_____
Title:_____Phone:_____

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Cummins, C.L.	735-11A
DeHart, T.S.	735A
Ebra-Lima, O.M.	773A
Evans, A.G.	773A
Fledderman, P.D.	735A
Goodson, E.C.	703-41A
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Hetrick, C.S.	735A
Hitchner, M.J.	773A
Hoel, D.	735-11A
Lorenz, R.	735-16A
Loring, W.	735-15A
Marter, W.L.	773-42A
Moore, D.B.	773A
O'Kula, K.R.	773-41A
Papouchado, L.	773A
Reinig, W.C.	703A
Richardson, D.C.	773A
Roberts,J.S.	742A
Stevenson, D.A.	735-15A
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CLASSIFICATION *(If Unclassified, so state. Also include UCNI)*
Unclassified

AUTHORS
D. M. Hamby

ORIGINATING DEPT. OR CORPORATE AUTHOR
SRL/ETS

TITLE
Land & Water Use Characteristics in the Vicinity of the Savannah River Site (U)

ADDRESSEE
D.M. Hamby
773A, A-1014

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