TENNESSEE VALLEY AUTHORITY

FINAL

ENVIRONMENTAL STATEMENT

BELLEFONTE NUCLEAR PLANT

UNITS 1 AND 2

VOLUME 2

Appendix A

LAND USE IN THE VICINITY OF THE BELLEFONTE SITE

This appendix is supportive of Section 1.2, subsection 7, Land Use, which contains additional discusssion of land uses in the vicinity of the Bellefonte site.

Figure A-1 is an annotated topographic land use map, and figure A-2 is an aerial photo of about the same area. Land use data for Jackson County has been presented since the area shown in the figures is generally representative of the whole county. According to the 1967 Conservation Needs Inventory of the total land area of 719,000 acres, about 63 percent (449,000 acres) of Jackson County was forested; 32 percent (237,000 acres) was in agricultural use (cropland, pasture and range, and other) and 1.4 percent (10,000 acres) urban and developed. (The remainder is composed of land in Federal ownership and small land areas covered by water.) For comparison, the Top of Alabama Regional Council of Governments (TARCOG) area (Limestone, Madison, Jackson, Marshall, and DeKalb Counties) was 44 percent forested, 46 percent agricultural, and 6 percent urban and built up ("Agricultural Opportunities in the TARCOG Area," TVA). (Remainder is Federal land and small water areas.) Thus, Jackson County was more forested, less agricultural, and less urban than this larger area of which it is a part.

A more detailed discussion of individual land uses at the general area level follows.

1. Urbanized areas - Scottsboro, about 6 miles west-southwest of the site, is the nearest and most important emerging center with a 1970 population of 9,324. Hollywood is the town nearest the site with a 1970 population of 301. Recent annexations, which resulted in the city limits shown, increases the population to an estimated 865 (Preliminary Draft - "Sketch Development Plan - Town of Hollywood, Alabama," TARCOG). Other communities in the valley include Stevenson (1970 population - 2,390) and Bridgeport (1970 population - 2,908).

West of Scottsboro, on the Cumberland Plateau, are Woodville (1970 population - 322) and Paint Rock (1970 population - 226). East of Scottsboro, on Sand Mountain, are Section (1970 population - 702), Dutton (1970 population - 423), Pisgah (1970 population - 519), and Rainsville (1970 population - 2,099).

Most of these communities have boundaries far exceeding the actual developed area. Thus, they are in a position to accommodate additional development and, if they choose, to control it through an active planning program.

2. Industrial areas - The two most important industries in the area are located near Scottsboro. These are Revere Copper and Brass Corporation and Goodyear Tire and Rubber Company. Revere is on a 1,000-acre peninsula about 11 miles southwest of the site on the right bank of the Guntersville Reservoir. It employs approximately 1,100 people, but additional facilities are under construction which would bring the employment to 1,600. Goodyear now employs 200 people,

but tentative expansion plans indicate an eventual employment level of about 1,000. In addition, TVA's Widows Creek Steam Plant is about 15 miles northeast of the site with about 500 employees.

3. Forested land - In large measure, forested land is associated with either topographic or drainage features. On the Cumberland Plateau to the north and west of the site, the steep mountainous terrain has helped keep the land in forest production. To the south and east of the site, the escarpment reaching from Guntersville Reservoir to Sand Mountain is predominantly in forest. However, on the relatively flat Sand Mountain with soils suitable for agriculture, much of the forest has been cleared except in the natural stream banks.

4. Agriculture and open land - This category of land use is a mixture of cultivated, pastured, and unused land. Most of the cultivated land is located on Sand Mountain while the predominant use of agricultural land on Cumberland Plateau and in the valley is for pasture.

5. Site land use - Figure A-3 is a topographic map of the site vicinity. Land use of the site and the immediate vicinity is predominantly agriculture with some forested areas along the reservoir. Most of the land on the site was in pasture while about 65 percent of the surrounding agricultural land was cultivated based on photo interpretation of a 1971 aerial photograph. The photograph is reproduced as figure A-4.

A number of significant cultural features are also shown on figure A-4 which help reveal the character of the site and surrounding area. They are discussed as features of Old Town Bellefonte, the site, and the surrounding area. These are shown in figures A-5 through A-7, respectively.

(1) Old Town Bellefonte - Figure A-4 shows the location of the Old Town Bellefonte with respect to the proposed site. Figure A-5 shows low and ground-level shots of the whole area and individual structures. The structures have not been inhabited for a long time, nor has there been any apparent effort toward maintaining them.

(2) Features of the site - Figure A-6 shows the items located on the site. They include an old chapel, three frame dwellings, and two old family cemeteries.

An old chapel, known as Shipps Chapel, (item No. 8, figure A-6) has been most recently used as a residence. Based on its structural condition, it is clearly in a state of disrepair and has not been occupied for some time.

Items No. 7, 9, 10, and 11 of figure A-6 show former dwellings located on the site. At one time, they were suitable for occupation, but lack of maintenance and changing housing standards find them no longer acceptable abodes. None of them were occupied at the time acquisition proceedings began.

Two old family cemeteries are located within the bounds of the property being acquired by the project. Both are inactive with no evidence of upkeep or interments in several decades. The most recent tombstone inscription found in the Finnell Cemetery is 1872. Field estimates place the number of graves in Shipp and Finnell Cemeteries at four and six, respectively.

The Finnell Cemetery (item No. 12, figure A-6) is located in a pasture with no fence protecting it. It has obviously been used as pastureland. At least two monuments in this cemetery are broken.

The Shipps Cemetery (item No. 13, figure A-6) is surrounded, except for an entranceway, by a rock wall and located within lands that have been pastured. Cattle have grazed the cemetery area. At least one monument is broken and the entire cemetery is overgrown with weeds.

Under these conditions a substantially larger number of graves than indicated by the initial count could exist in each cemetery. However, it is impossible to make an exact determination without disturbing the cemetery areas.

(3) Surrounding area - Items of interest surrounding the site are indicated on figure A-7. Two exceptions to the generally rural development surrounding the plant site are the Town Creek Subdivision and Baker Sand and Gravel Company's loading facility, both of which are adjacent to the site. Farther away, near Hollywood, is a new technical-vocational school. Otherwise, the farmhouse and isolated store are generally typical cultural features of the site vicinity.

The subdivision is across the Town Creek embayment and is noted on figure A-4. Pictures of the types of structures contained in the subdivision are in figure A-7. They range from a mobile home found along the entrance road to small cabins to small "A-frames." This is a second-home development and is populated mostly on weekends and during summer vacations. The structures are not generally planned for year-round residency.

Baker Sand and Gravel loading facility is on the small peninsula adjacent to the southwestern corner of the site and noted as item 16 on figure A-4. A picture of this activity is on figure A-7. This facility is operated by only a small number of employees.

Item 15 on figure A-4 is the new Jackson County Technical School which opened in September 1972. The present enrollment is about 500 with 250 attending classes in the morning and 250 in the afternoon. The students are transported from the eight city and county high schools in Jackson County.

Figure A-8 indicates the projected major plant facilities, tentative highway and rail access connections, and approximate transmission line connections. Details of the impacts of these features of modified land use are discussed in sections 2.7, 2.9, and 2.2, respectively.

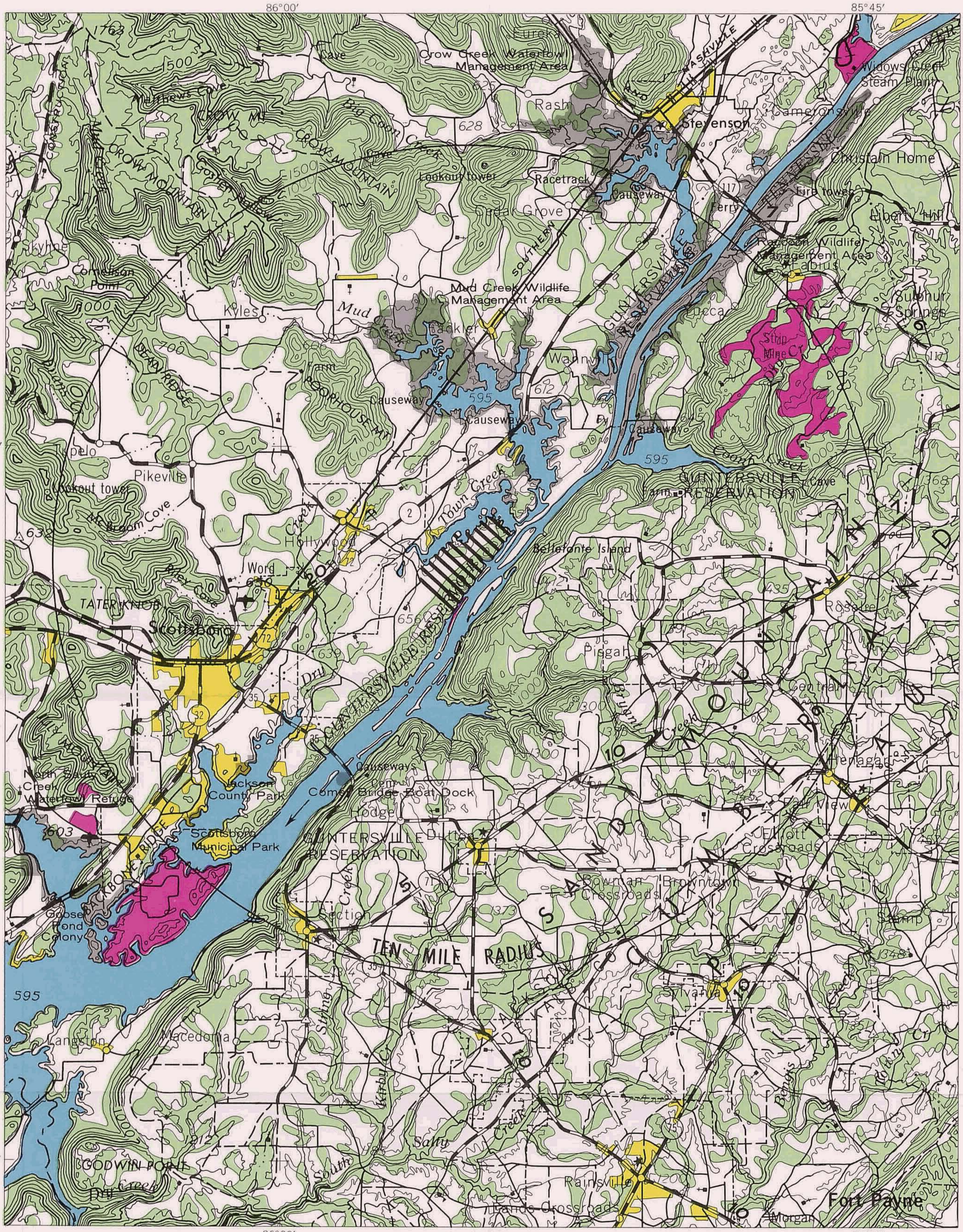


FIGURE A-1

EXISTING LAND USE WITHIN 10 MILES OF THE BELLEFONTE NUCLEAR PLANT SITE

(1971)

LEGEND

- URBANIZED
- INDUSTRIAL
- FOREST
- AGRICULTURE AND OPEN SPACE
- WATER
- BELLEFONTE SITE
- RECREATION AND WILDLIFE AREAS
- CITY LIMITS (1972)

SCALE OF MILES

1 0 1 2 3

JANUARY 1973

N

Contour interval 100 feet

Land use data compiled by TVA using color infrared photographs scale 1:120,000 obtained by NASA, Manned Space Flight Center, May 1971

FIGURE A – 2

Aerial Photograph Of The Bellefonte Nuclear Plant Site And Surrounding Area

Scale: 1:62,500

1 0 1 2 3 Miles

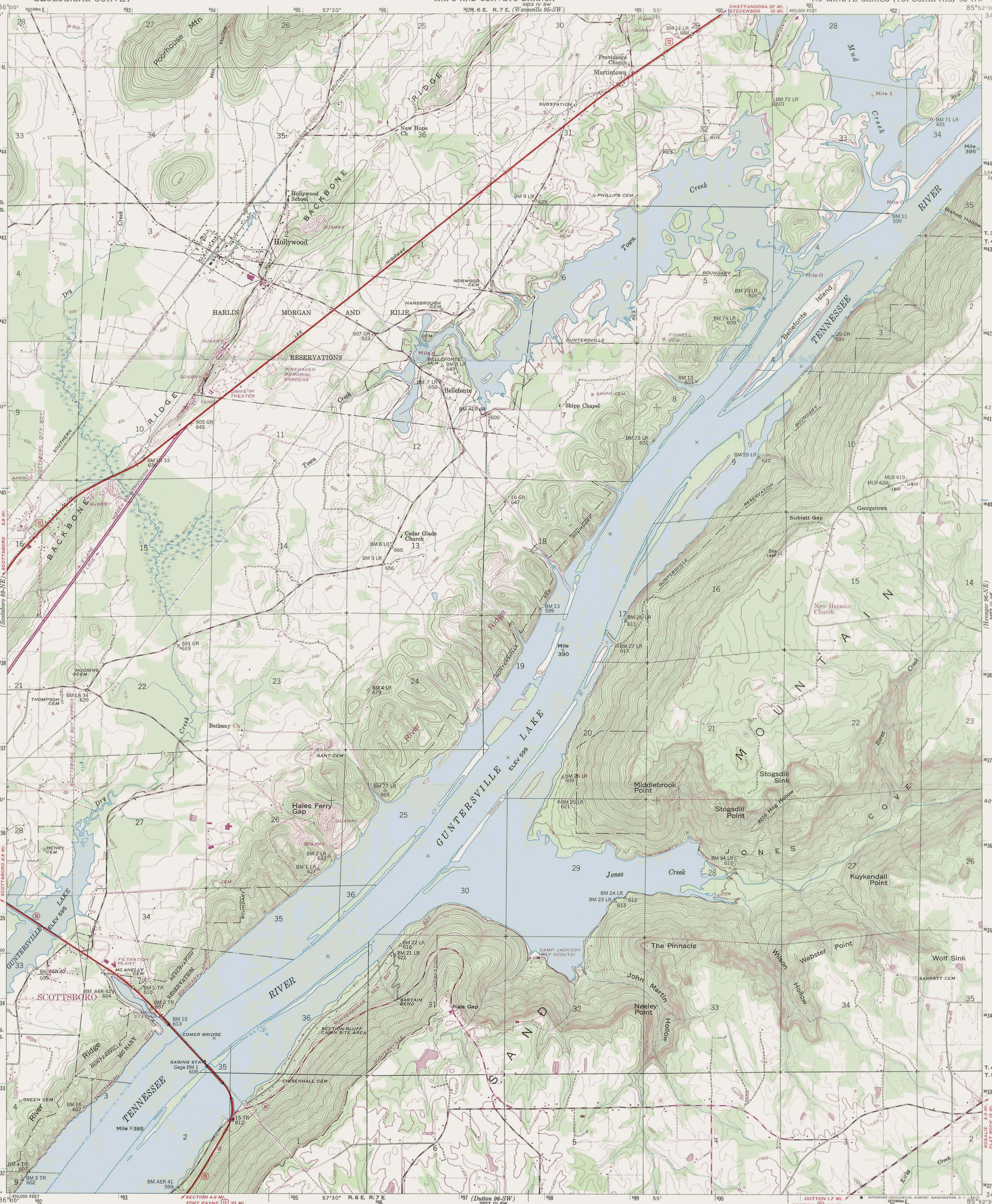
Date Prepared: Jan. 1973

Note:
Black and white enlargement of color infrared aerial photograph taken from 60,000 feet altitude by NASA in March, 1972.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UNITED STATES
TENNESSEE VALLEY AUTHORITY
MAPS AND SURVEYS BRANCH

HOLLYWOOD QUADRANGLE
ALABAMA-JACKSON CO.
7.5 MINUTE SERIES (TOPOGRAPHIC) 96-NW



Mapped and edited by Tennessee Valley Authority
Published by the Geological Survey

Control by USC&GS, USGS, and TVA

Topography by USGS and TVA by photogrammetric methods.
Map field checked by TVA,1947

Polyconic projection. 1927 North American datum
10,000 foot grid based on Alabama (East) rectangular coordinate system
1000 meter Universal Transverse Mercator Grid ticks, Zone 16, shown in blue

Revisions shown in purple and recompilation of woodland areas compiled by the Tennessee Valley Authority from aerial photographs taken 1970. This information not field checked

Fine purple dashed lines indicate selected fence and field lines visible on aerial photography. This information is unchecked

UTM GRID AND 1970 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24000

CONTOUR INTERVAL 20 FEET
DASHED LINES REPRESENT HALF-INTERVAL CONTOURS
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS

FOR SALE BY U.S. GEOLOGICAL SURVEY, WASHINGTON, D.C. 20242,
AND BY U.S. TENNESSEE VALLEY AUTHORITY, CHATTANOOGA, TENN. 37401 OR KNOXVILLE, TENN. 37902
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION
Heavy-duty — Poor motor road
Medium-duty — Wagon and jeep track
Light-duty — Foot trail
U. S. Route — State Route
In developed areas, only through roads are classified

HOLLYWOOD, ALA.
N3437.5-W8552.5/7.5

1947
PHOTOREVISED 1970
AMS 3853 III NW-SERIES V844

FIGURE A-3

APPENDIX B

Ecological Surveys

APPENDIX B1 - Fish

APPENDIX B2 - Terrestrial and Amphibious Fauna

APPENDIX B3 - Vegetation

APPENDIX B4 - Other Aquatic Life Surveys

Appendix B1

Fish

The fishery resource of Guntersville Reservoir has been surveyed in 1971 and 1972. The 1971 survey consisted of three cove-rotenone samples in each of four areas of the reservoir. Areas were defined as follows: Area I, TRM 349.4 to 350.0; Area II, TRM 361.0 to 364.1; Area III, TRM 372.0 to 382.3; Area IV, TRM 388.0 to 397.6. Area IV, which includes the Bellefonte site, is the area of principal interest in this discussion. Complete details are available in a report (Sheddan, 1972) from which data were extracted for presentation here.[1] A second survey, specifically designed to evaluate the fishery resource in the near vicinity of the Bellefonte site and employing several types of sampling gear, was performed in June 1972. Sampling stations and gear employed in the vicinity of the site (1971 and 1972) are shown in figure B1-1.

The two surveys yielded 50 species among 27 genera belonging to 14 families of fish (Table B1-1). For purposes of simplified presentation of data and general discussion, three conventions were adopted: (1) species were grouped into the six most common and important families and the remainder assigned to a seventh (other) category; (2) all fish exceeding 1 year of age were combined as adults except (3) species of genera commonly referred to as forage species, e.g.; *Notropis*, *Fundulus*, *Percina*, were combined in the young-of-the-year (YOY) category.

Of the six families, the Clupeidae represent important, primarily planktivorous and herbivorous forage species, the Centrarchidae and Percichthyidae represent predatory omnivorous or piscivorous sport species, and the Ictaluridae, Catostomidae, and Scianidae represent important omnivorous or piscivorous "rough" or commercial species.

In 1971, Area III dominated numerical and biomass standing stocks of adult fish (figures B1-2 and B1-3), the dominance being primarily due to the Clupeidae. Standing stocks of sport species were lowest in Areas II and III and highest in Areas I and IV. Area IV yielded the highest percentage of sport standing stocks and the lowest percentage of clupeid standing stocks.

Area II dominated standing stocks of young-of-the-year (YOY) fish; Area IV ranked second to Area II in standing stocks of sport species and first in percentage of sport standing stocks.

Standing stocks of white crappie (all ages) decreased downstream from Area IV through Area I, while standing stocks of YOY freshwater drum and channel catfish increased. Largest standing stocks of bluegills and largemouth bass were noted in Areas IV and II, largest standing stocks of redear sunfish were noted in Areas IV and I, and largest standing stocks of longear sunfish were found in Areas II and I.

Sheddan (1972) compared the results of this survey with the most recent surveys performed on four other lower main stream TVA reservoirs (Chickamauga, Wheeler, Pickwick, and Kentucky) and concluded that Guntersville ranks first in numerical standing stocks of harvestable sport species and fourth in commercial species.

Results of the 1972 cove surveys are presented in figures B1-4 and B1-5. The main stream cove, TRM 392, was also sampled as part of the Area IV survey in 1971 and is included for comparative purposes.

The 1972 survey confirms the observations of 1971 regarding the relative importance of sport species in Area IV.

The main stream cove (TRM 392) yielded greater standing stocks of adult fish than did the embayments with one exception. The large biomass contributed by catostomids in Town Creek is due to entrapment in the sample cove of a large school of adult smallmouth buffalo. Town Creek contained fewer fish than did Mud Creek, but these were of larger size.

The main stream cove contained more numbers, but significantly less biomass, of young fish than did the embayments. Town Creek contained the greatest numbers and biomass of young centrarchids in 1972.

An analysis by species of the standing stocks of the three coves is presented in Table B1-2, B1-3, and B1-4. The category of species, i.e., game, rough, forage, are those commonly used in the southeastern United States. Size categories, i.e., young, intermediate, adult, are arbitrary classifications. In general, the intermediate category is applied only to game and rough species and includes those fish of a species older than 1 year but which are not usually harvested by anglers or commercial fishermen.

Tables B1-5 through B1-8 present data obtained by electrofishing and gill netting concurrent with the standing stock estimates. Tables B1-9 and B1-10 present results of horizontal meter-net tows for larval and young fish. All tows were made after sunset and were of 5-minute duration using a 1-m diameter net. Three samples each were taken at the following locations:

1. Main channel (TRM 393) - Shoreline-surface
2. Main channel (TRM 393) - Channel-surface

3. Main channel (TRM 393) - Channel-5m depth
4. Secondary channel (TRM 393) - Channel-surface
5. Secondary channel (TRM 393) - Channel-5m depth
6. Mud Creek embayment - Channel-surface

Highest concentrations of larval and young fish were noted in shallower waters, i.e., Mud Creek embayment and shoreline-surface tows in the reservoir proper. Shad (Dorosoma spp.) and freshwater drum (Aplodinotus) dominated the main stream; shad and Lepomis spp. dominated the embayment sample. The secondary channel (that adjacent to the plant site) yielded higher concentrations of fish and eggs than did the main channel. These differences may be associated with production arising from the Crow Creek, Mud Creek, and Town Creek embayments. Town Creek was not sampled owing to navigational uncertainties at night, but based on the other results of the 1972 survey, larval fish samples from Town Creek would be expected to be roughly comparable to those of Mud Creek in numbers, with some variation in species concentration.

Shoreline-surface samples taken here are not directly comparable to those taken in Wheeler Reservoir and reported previously (TVA, 1972).[2] Most of the main stream shoreline area supports dense growths of Myriophyllum sp. and rendered meter-net sampling impossible in the strictly littoral zone. Observations made of these areas at sunset indicated that large numbers of fish either inhabit the vegetation or utilize it as a feeding area, where young fish and macroinvertebrates serve as the prey.

A short-term creel census was performed in the vicinity of the proposed site; results are summarized in Tables B1-11 through B1-14.

A survey of commercial fish landings from Guntersville Reservoir was performed in 1971 and appears as Table B1-15. Results of both the sport and commercial surveys are considered representative descriptions of the fishery resource of Guntersville Reservoir and of the lower main stream reservoirs of the TVA system.

1. Creel census report - Guntersville Reservoir - April 16 through July 1, 1972 -

(1) Introduction - An 11-week assessment of the sport fishing effort was made in two embayments in the vicinity of the proposed site. The selected survey areas (figure B1-1) were in the Town Creek, TRM 393, and Raccoon Creek, TRM 396, embayments having surface areas of 260 and 230 acres, respectively.

Data was collected between mid-April and July 1972. The survey was adjudged to begin at the peak of the spring fishing season.

(2) Methods - Since only one count could be made in each area in an 8-hour workday, the sample use count method was used to determine estimates of total fishing pressure and total catch. One 2-hour count period was assigned for each embayment for each day of a 5-day workweek. Fisherman interviews were conducted both before and after use counts.

For each week in the survey period 5 sample days and a fisherman-use count time (2-hour periods) for each of these days were systematically drawn. Nonuniform values based on knowledge of the fishery and the random selection process, were assigned to each possible sample period, each day of the week, and time of day (a.m. or p.m.) in which the use counts were made.

These values were then used to estimate the total pressure for the 5 days selected in a week by:

$$F_d = \frac{C/P_t}{P_p}$$

where

F_d = estimated total angler hours for the day

C = fisherman count for the day

P_t = probability of use count time

P_p = probability of period of day (a.m. or p.m.)

Estimates of fishing pressure for the week were calculated by:

$$F_w = \frac{\Sigma\ F_d}{\Sigma\ P_d}$$

where

F_w = estimated total angler hours for 5 days in a week

P_d = probability of fisherman use on the selected count day

The estimated total catch was determined by the product of the weekly estimated total pressure (angler hours) and the mean daily catch rate (catch per hour).

The estimated total weight of each species harvested was the average weight of that fish in all creels times the estimated total catch of the species.

The average expenditure per trip was calculated from data collected from a 10 percent sample of all interviews.

(3) Results -

(a) Fishing pressure - Estimated total fishing effort in the two survey areas over an 11-week period was 9,222 hours. The Town Creek embayment survey showed 4,860 hours fished and 1,043 trips, and the Raccoon Creek survey 4,362 hours in 1,136 trips (Table B1-11). Length of completed trips were 4.7 and 3.8 hours, respectively. Other fisherman-use characteristics were similar in both areas (Table B1-12). Fishing success averaged 70 percent; average party size was 2.2 persons.

(b) Catch - The survey results showed the catch composition in each cove to be very similar. The two areas combined, 198 hectares, yielded an estimated 12,310 fish weighing 2,829 kg. Catch per trip was 5.4 fish weighing 1.3 kg.

Seven species of fish were identified in the creel from each area. White crappie was the dominant species, making up 53 percent of the catch by number and 52 and 57 percent by weight (Tables B1-13 and B1-14). Bluegill, redear sunfish, and largemouth bass combined with white crappie made up more than 95 percent of the catch.

In spite of the relatively short survey period, the rate statistics presented should aptly describe the spring fishery.

REFERENCES FOR APPENDIX B1

1. Sheddan, T. L. 1972. Fish inventory data. Guntersville Reservoir, 1971. TVA Fisheries and Waterfowl Resources Branch. 16 pp. mimeo.

2. Tennessee Valley Authority, 1972. Environmental Impact Statement, Browns Ferry Nuclear Steam Plant Units 1, 2, and 3. 3 vols.

Table B1-1

TAXONOMIC LIST OF FISH SPECIES COLLECTED IN GUNTERSVILLE RESERVOIR, 1971 AND 1972*

Family Lepisosteidae

Spotted gar - Lepisosteus oculatus
Longnose gar - L. osseus
Shortnose gar - L. platostomus

Family Amiidae

Bowfin - Amia calva

Family Clupeidae

Skipjack herring - Alosa chrysochloris
Gizzard shad - Dorsoma cepedianum
Threadfin shad - D. petenense

Family Cyprinidae

Goldfish - Carassius auratus
Carp - Cyprinus carpio
Golden shiner - Notemigonus crysoleucas
Emerald Shiner - Notropis atherinoides
Whitetail shiner - N. galacturus
Spotfin shiner - N. spilopterus
Bluntnose minnow - Pimephales notarus
Fathead minnow - P. promelas

Family Catostomidae

Quillback - Carpiodes cyprinus
Smallmouth buffalo - Ictiobus bubalus
Bigmouth buffalo - I. cyprinellus
Black buffalo - I. niger
Spotted sucker - Minytrema melanops
Golden redhorse - Moxostoma erythrurum

Family Ictaluridae

Blue catfish - Ictalurus furcatus
Black bullhead - I. melas
Yellow bullhead - I. notatus
Channel catfish - I. punctatus
Flathead catfish - Pylodictis olivaris

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*Nomenclature that of American Fisheries Society Spec. Pub. No. 6, 3rd ed., 1970.

Table B1-1

TAXONOMIC LIST OF FISH SPECIES COLLECTED IN GUNTERSVILLE RESERVOIR, 1971 and 1972*
(continued)

Family Cyprinodontidae

Blackstripe topminnow - Fundulus notatus
Black spotted topminnow - F. olivaceus

Family Poeciliidae

Mosquitofish - Gambusia affinis

Family Atherinidae

Brook silverside - Labidesthes sicculus

Family Percichthyidae

White bass - Morone chrysops
Yellow bass - M. mississippiensis

Family Centrarchidae

Green sunfish - Lepomis cyanellus
Pumpkinseed - L. gibbosus
Warmouth - L. gulosus
Orangespotted sunfish - L. humilis
Bluegill - L. macrochirus
Longear sunfish - L. megalotis
Redear sunfish - L. microlophus
Smallmouth bass - Micropterus dolomieui
Spotted bass - M. punctulatus
Largemouth bass - M. salmoides
White crappie - Pomoxis annularis
Black crappie - P. nigromaculatus

Family Percidae

Fantail darter - Etheostoma flabellare
Redline darter - E. rufilineatum
Logperch - Percina caprodes
Sauger - Stizostedion canadense

Family Sciaenidae

Freshwater drum - Aplodinotus grunniens

Family Cottidae

Banded sculpin - Cottus carolinae

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*Nomenclature that of American Fisheries Society Spec. Pub. No. 6, 3rd ed., 1970.

Table B1-2

DISTRIBUTION PER HECTARE BY SPECIES, MUD CREEK, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	Young-of-year		Intermediate		Adult	
	No.	Wt.(kg)	No.	Wt.(kg)	No.	Wt.(kg)
Game						
Yellow bass	33.0	.8	77.7	2.9	61.7	3.2
Green sunfish	-	-	3.2	t	1.1	.1
Warmouth	1.1	t	3.2	.1	-	-
Bluegill	421.3	3.8	171.3	4.7	60.6	5.0
Longear	-	-	6.4	.1	1.1	t
Redear	44.7	.4	135.1	3.2	206.4	19.5
Largemouth bass	290.4	.4	13.8	.6	10.6	3.0
White crappie	19.1	t	33.0	.9	18.1	2.7
Sauger	-	-	-	-	2.1	.9
Total	809.6	5.3	443.7	12.5	361.7	34.4
Rough						
Spotted gar	-	-	-	-	3.2	1.6
Longnose gar	12.8	t	-	-	-	-
Skipjack herring	-	-	-	-	5.3	1.1
Smallmouth buffalo	-	-	-	-	26.6	46.0
Spotted sucker	-	-	-	-	3.2	2.8
Black bullhead	-	-	1.1	.1	-	-
Yellow bullhead	36.2	.1	1.1	.1	2.1	1.0
Channel catfish	2.1	t	1.1	.1	4.3	.9
Drum	102.1	3.1	309.6	24.0	189.4	27.8
Total	153.2	3.3	312.9	24.3	234.1	81.2
Forage						
Gizzard shad	268.1	.2	-	-	1,221.3	58.4
Goldfish	-	-	-	-	1.1	t
Golden shiner	-	-	-	-	23.4	.9
Emerald shiner	-	-	-	-	35.1	.1
Fathead minnows	-	-	-	-	34.0	.1
Mosquitofish	-	-	-	-	1.1	t
Orangespotted sunfish	1.1	t	-	-	16.0	.1
Total	269.2	.2	-	-	1,332.0	59.6
All Fish	1,232.0	8.9	756.6	36.8	1,927.8	175.2

t = less than 0.1 kilogram

Table B1-3

DISTRIBUTION PER HECTARE BY SPECIES, TOWN CREEK, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	Young-of year		Intermediate		Adult	
	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Game						
Yellow bass	-	-	9.2	0.3	18.4	1.1
Green sunfish	-	-	5.7	.1	6.9	.2
Warmouth	-	-	5.7	.2	11.5	1.4
Bluegill	916.1	3.9	311.5	3.7	77.0	4.3
Redear	165.5	1.1	112.6	1.0	55.2	8.7
Largemouth bass	350.6	.4	19.5	1.1	14.9	4.3
White crappie	27.6	t	-	-	6.9	.6
Black crappie	-	-	1.1	.2	-	-
Total	1,459.8	5.4	465.3	6.6	190.8	20.6
Rough						
Spotted gar	-	-	-	-	46.0	31.3
Carp	-	-	-	-	19.5	41.3
Smallmouth buffalo	-	-	-	-	101.1	176.0
Bigmouth buffalo	-	-	-	-	1.1	3.8
Yellow bullhead	100.0	.1	1.1	.1	-	-
Channel catfish	-	-	-	-	13.8	6.4
Drum	2.3	.1	57.5	5.1	65.5	29.5
Total	102.3	.2	58.6	5.2	247.0	288.3
Forage						
Gizzard shad	12.6	t	-	-	155.2	17.1
Goldfish	-	-	-	-	8.0	t
Goldenshiner	-	-	-	-	49.4	2.1
Emerald shiner	-	-	-	-	26.4	t
Fathead minnow	-	-	-	-	16.1	t
Mosquitofish	-	-	-	-	25.3	t
Brook silverside	-	-	-	-	2.3	t
Orangespotted sunfish	-	-	-	-	36.8	.2
Total	12.6	t	-	-	319.5	19.5
All Fish	1,574.7	5.6	523.9	11.8	757.3	328.4

t = less than 0.1 kilogram

Table B1-4

DISTRIBUTION PER HECTARE BY SPECIES, TRM 392,
GUNTERSVILLE RESERVOIR, JUNE 1972

Species	Young-of-year		Intermediate		Adult	
	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Game						
White bass	1.8	t	-	-	-	-
Yellow bass	-	-	18.5	.4	121.3	5.5
Green sunfish	-	-	6.5	.2	1.8	.2
Warmouth	-	-	11.1	.3	13.9	1.4
Bluegill	-	-	584.6	18.9	338.9	26.8
Redear	-	-	410.2	14.9	80.6	9.4
Largemouth bass	204.6	.4	75.0	4.6	18.5	7.0
White crappie	406.5	.4	18.5	1.1	34.3	5.5
Sauger	-	-	-	-	.9	.1
Total	612.9	.8	1,124.4	40.4	610.2	55.9
Rough						
Spotted gar	5.6	t	2.8	1.9	16.7	9.2
Bowfin	-	-	-	-	.9	1.7
Skipjack	4.6	t	-	-	-	-
Carp	.9	t	-	-	8.3	17.2
Quillback	-	-	-	-	.9	.9
Smallmouth buffalo	1.8	t	11.1	2.8	32.4	19.1
Spotted sucker	-	-	-	-	7.4	2.2
Black bullhead	983.3	1.0	-	-	3.7	1.8
Yellow bullhead	-	-	13.9	.6	7.4	1.6
Channel catfish	-	-	-	-	8.3	5.2
Drum	-	-	307.4	18.9	148.5	21.4
Total	996.2	1.1	335.2	24.2	234.5	80.3
Forage						
Gizzard shad	1.8	t	-	-	1,378.6	113.2
Threadfin shad	13.9	t	-	-	-	-
Golden shiner	-	-	-	-	2.8	.1
Emerald shiner	-	-	-	-	39.8	.1
Fathead minnow	-	-	-	-	5.6	.3
Mosquitofish	-	-	-	-	31.5	t
Orangespotted sunfish	-	-	-	-	21.3	.4
Logperch	-	-	-	-	1.8	t
Total	15.7	t	-	-	1,479.6	114.2
All Fish	1,624.8	1.9	1,459.6	64.6	2,324.3	250.4

t = less than 0.1 kilogram

Table B1-5

FISH CATCH BY ELECTRO-FISHING, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	Mud Creek No.	Mud Creek Catch per hour	Town Creek No.	Town Creek Catch per hour	River Channel No.	River Channel Catch per hour	Totals Mean Catch per hour	Totals Percent of catch
Game								
White bass	-	-	-	-	1	1	0.3	0.1
Yellow bass	29	29	16	21.4	-	-	16.8	6.2
Green sunfish	-	-	1	1.3	-	-	0.4	0.1
Bluegill	92	92	54	72.0	58	58	74.0	27.9
Longear	2	2	-	-	2	2	1.3	0.5
Redear	42	42	20	26.7	9	9	25.9	9.7
Spotted bass	2	2	1	1.3	-	-	1.1	0.4
Largemouth bass	17	17	18	24.0	7	7	16.0	5.8
Black crappie	-	-	-	-	1	1	0.3	0.1
Sauger	1	1	-	-	-	-	0.3	0.1
Total	185	185	110	146.6	78	78	136.5	50.9
Rough								
Spotted gar	5	5	2	2.7	1	1	2.9	1.1
Carp	2	2	3	4.0	4	4	3.3	1.2
Smallmouth buffalo	9	9	2	2.7	6	6	5.9	2.3
Spotted sucker	1	1	-	-	4	4	1.7	0.7
Yellow bullhead	-	-	1	1.3	-	-	0.4	0.1
Channel catfish	2	2	1	1.3	-	-	1.4	0.4
Drum	8	8	12	16.0	3	3	9.0	3.2
Total	27	27	21	28.0	18	18	24.3	9.0
Forage								
Gizzard shad	150	150	60	80.0	75	75	101.7	39.0
Emerald shiner	-	-	-	-	3	3	1.0	0.4
Brook silverside	-	-	-	-	5	5	1.7	0.7
Logperch	1	1	-	-	-	-	0.3	0.1
Total	151	151	60	80.0	83	83	104.7	40.2
All Fish	363	363	191	254.6	179	179	265.5	

Table B1-6

FISH CATCH WITH GILL NETS (15 NET-NIGHTS), MUD CREEK, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	No.	No. per Net-Night	Wt., kg	Wt. per Net-Night kg	Percent of Catch No.	Percent of Catch Wt.
Game						
White bass	2	0.1	0.5	t	0.9	0.5
Yellow bass	1	.1	.2	t	.4	.2
Warmouth	3	.2	.5	t	1.3	.5
Bluegill	15	1.0	1.6	.1	6.4	1.5
Redear	18	1.2	2.4	.2	7.7	2.3
Largemouth bass	4	.3	1.4	.1	1.7	1.4
White crappie	1	.1	.2	t	.4	.2
Total	44	3.0	6.8	.4	18.8	6.6
Rough and Forage						
Spotted gar	38	2.5	25.4	1.7	16.3	24.5
Longnose gas	9	.6	11.6	.8	3.9	11.2
Shortnose gas	2	.1	1.7	.1	.9	1.6
Skipjack herring	12	.8	3.8	.3	5.2	3.7
Gizzard shad	64	4.3	10.8	.7	27.5	10.4
Carp	2	.1	2.8	.2	.9	2.7
Quillback	3	.2	2.9	.2	1.3	2.8
Smallmouth buffalo	8	.5	13.5	.9	3.4	13.0
Spotted sucker	3	.2	2.2	.1	1.3	2.1
Black bullhead	1	.1	.2	t	.4	.2
Yellow bullhead	3	.2	.9	.1	1.3	.9
Channel catfish	42	2.8	19.0	1.3	18.0	18.4
Flathead catfish	1	.1	1.7	.1	.4	1.6
Drum	1	.1	.2	t	.4	.2
Total	189	12.6	96.7	6.5	81.2	93.4
All Fish	233	15.6	103.5	6.9		

t = less than 0.1 kilogram

Table B1-7

FISH CATCH WITH GILL NETS (15 NET-NIGHTS), TOWN CREEK, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	No.	No. per Net-Night	Wt., kg	Wt. per Net-Night kg	Percent of Catch No.	Percent of Catch Wt.
Game						
White bass	2	0.1	0.7	t	1.7	1.3
Yellow bass	-	-	-	-	-	-
Warmouth	6	.4	.7	t	5.0	1.3
Bluegill	4	.3	.5	t	3.3	.9
Redear	16	1.1	2.0	.1	13.3	3.7
Largemouth bass	-	-	-	-	-	-
White crappie	9	.6	1.7	.1	7.5	3.1
Total	37	2.5	5.6	.4	30.8	10.3
Rough and Forage						
Spotted gar	6	.4	4.6	.3	5.0	8.4
Longnose gar	13	.9	24.7	1.6	10.8	45.2
Shortnose gar	-	-	-	-	-	-
Skipjack herring	9	.6	3.1	.2	7.5	5.7
Gizzard shad	31	2.1	5.0	.3	25.8	9.2
Carp	-	-	-	-	-	-
Quillback	1	.1	1.1	.1	.8	2.0
Smallmouth buffalo	-	-	-	-	-	-
Spotted sucker	4	.3	3.3	.2	3.3	6.0
Black bullhead	-	-	-	-	-	-
Yellow bullhead	-	-	-	-	-	-
Channel catfish	18	1.2	7.0	.5	15.0	12.8
Flathead catfish	-	-	-	-	-	-
Drum	1	.1	.2	t	.8	.4
Total	83	5.5	49.0	3.2	69.2	89.7
All Fish	120	8.0	54.6	3.6		

Table B1-8

FISH CATCH WITH GILL NETS (15 NET-NIGHTS), TRM 394, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	No.	No. per Net-Night	Wt., kg	Wt. per Net-Night kg	Percent of Catch No.	Percent of Catch Wt.
Game						
White bass	5	0.3	1.3	.1	2.1	1.2
Yellow bass	-	-	-	-	-	-
Warmouth	-	-	-	-	-	-
Bluegill	18	1.2	2.0	.1	7.7	1.8
Redear	84	5.6	12.4	.8	35.9	11.4
Largemouth bass	1	.1	.3	t	.4	.3
White crappie	11	.7	1.8	.1	4.7	1.7
Total	119	7.9	17.8	1.1	50.9	16.4
Rough and Forage						
Spotted gar	5	.3	3.2	.2	2.1	3.0
Longnose gar	41	2.7	68.0	4.5	17.5	62.7
Shortnose gar	-	-	-	-	-	-
Skipjack herring	22	1.5	8.8	.6	9.4	8.1
Gizzard shad	27	1.8	4.4	.3	11.5	4.1
Carp	-	-	-	-	-	-
Quillback	-	-	-	-	-	-
Smallmouth buffalo	-	-	-	-	-	-
Spotted sucker	3	.2	2.5	.2	1.3	2.3
Black bullhead	-	-	-	-	-	-
Yellow bullhead	-	-	-	-	-	-
Channel catfish	2	.1	.7	t	.9	.6
Flathead catfish	1	.1	.8	t	.4	.7
Drum	14	.9	2.2	.1	6.0	2.0
Total	115	7.7	90.6	6.1	49.1	83.6
All Fish	234	15.6	108.4	7.2		

t = less than 0.1 kilogram

Table B1-9

TOTAL CATCH BY SPECIES, LARVAL FISH
GUNTERSVILLE RESERVOIR, JUNE 21, 1972

	Sample Location (See Text)					
	1	2	3	4	5	6
Total Volume, M^{3*}	1114.4	1122.8	1104.8	1198.3	1138.4	1131.2
Mean Volume, M^3	371.5	374.3	368.3	399.4	379.5	377.1
Species						
Dorsoma spp	4067	37	181	69	295	10080
D. cepedianum	18	15	42			
D. petenense	2	16	2	24	6	634
Lepomis spp	37	7	2	6	2	197
Pomoxis sp	1					1
Ictalurus punctatus				1	2	1
I. furcatus		3	3	1	1	
Aplodinotus grunniens	723	32	77	171	519	6
Cyprinus carpio	7	1	1	6	2	
Notropis spp	122	2	5	3	7	4
Unidentified fish			16	2	11	
Eggs	11	123	22	2035	1722	16
Total Fish	4977	113	329	283	845	10923
Number/100 m^3	446.6	10.1	29.8	23.6	74.2	965.6
Eggs/100 m^3	1.0	11.0	2.0	169.8	151.3	1.4

*Triplicate samples each station

Table B1-10

CATCH/100 m^3, LARVAL FISH, GUNTERSVILLE RESERVOIR
JUNE 21, 1972 - FIGURES IN PARENTHESES INDICATE RANGE

Sample Location	Shad	Non-Shad	Total Catch
1	366.7 (254.1-546.6)	79.9 (44.7-124.9)	446.6 (298.8-670.5)
2	6.1 (2.6-11.3)	4.0 (3.4-4.5)	10.1 (7.1-14.7)
3	20.4 (16.0-24.7)	9.4 (5.9-14.8)	29.8 (23.3-39.6)
4	7.8 (7.7-7.9)	15.9 (10.7-23.2)	23.6 (18.4-31.1)
5	26.4 (13.8-41.1)	47.8 (40.8-55.0)	74.2 (61.8-81.8)
6	947.2 (556.3-1177.3)	18.5 (15.3-21.4)	965.6 (571.6-1198.7)

Table B1-11

WEEKLY TRIP AND FISHING-HOUR ESTIMATES FROM TWO EMBAYMENTS ON GUNTERSVILLE RESERVOIR - APRIL 16-JULY 1, 1972

Week	Embayment: Town Creek		Embayment: Raccoon Creek	
	Trips	Hours Fished	Trips	Hours Fished
4/16-4/22	270	1,258	220	1,025
4/23-4/29	151	704	276	1,286
4/30-5/6	180	839	179	834
5/7-5/13	39	182	80	373
5/14-5/20	90	419	68	317
5/21-5/27	69	322	65	303
5/28-6/3	101	471	94	438
6/4-6/10	76	354	44	205
6/11-6/17	41	191	38	177
6/18-6/24	14	65	33	154
6/25-7/1	12	56	39	182
Total	1,043	4,860	1,136	4,362

Table B1-12

USE-RATE CHARACTERISTICS AND EXPENDITURES OF FISHERMEN IN TWO GUNTERSVILLE RESERVOIR EMBAYMENTS

Item	Embayment	
	Town Creek	Raccoon Creek
Percent successful trips	71.8	70.0
Length completed trip (hours)	4.7	3.8
Average party size	2.2	2.1
Trips per acre (weekly average)	0.37	0.45
Expenditures per trip	$6.69	$7.13

Table B1-13

ESTIMATED CATCH BY SPECIES, WEIGHT, AND NUMBER FISH CAUGHT PER HOUR FROM TOWN CREEK EMBAYMENT - APRIL 16-JULY 1, 1972

Species	Total Number	Total Weight kg	Average Weight kg	Number Per Hour	Estimated Total Number	Estimated Total Weight
White crappie	740	170.2	0.23	0.68	3,304	766.1
Bluegill	331	37.1	0.11	0.31	1,506	171.2
Redear sunfish	176	21.7	0.12	0.16	777	95.5
Largemouth bass	145	66.9	0.46	0.13	631	290.1
White bass	9	2.6	0.29	0.01	48	13.9
Black crappie	7	2.1	0.29	0.07	37	10.9
Yellow bass	1	0.2	0.23	Tr.	5	1.2
Total	1,402	300.8			6,308	1,348.9

Table B1-14

ESTIMATED CATCH BY SPECIES, WEIGHT AND NUMBER FISH
CAUGHT PER HOUR FROM RACCOON CREEK EMBAYMENT - APRIL 16-JULY 1, 1972

Species	Total Number	Total Weight kg	Avg. Weight kg	Number per hour	Estimated Total Number	Estimated Total Weight
White crappie	775	185.2	0.24	0.73	3,184	761.1
Bluegill	320	36.2	0.11	0.30	1,308	148.7
Largemouth bass	183	100.4	0.55	0.17	741	404.5
Redear sunfish	151	19.4	0.13	0.14	610	77.7
White bass	20	5.3	0.26	0.02	87	23.0
Channel catfish	5	6.6	1.32	0.01	43	57.2
Black crappie	2	0.7	0.34	<0.01	22	7.6
Total	1,456	353.8			5,995	1,479.8

Table B1-15

COMMERCIAL FISHERMAN SURVEY - 1971
GUNTERSVILLE RESERVOIR*

Species	Total Kilograms Caught	Total Kilograms to Dealers
Catfish	300,500	294,300
Buffalo	315,700	315,400
Carp	97,400	71,000
Drum	24,200	22,500
Spoonbill	13,600	13,600
Others**	64,700	64,700
Total	816,100	781,500

*Source: Fisheries and Waterfowl Resources Branch, TVA. Data correlated with Regional Office, National Marine Fisheries Survey, NOAA.

**Includes quillback, sucker, gizzard shad, and turtles.

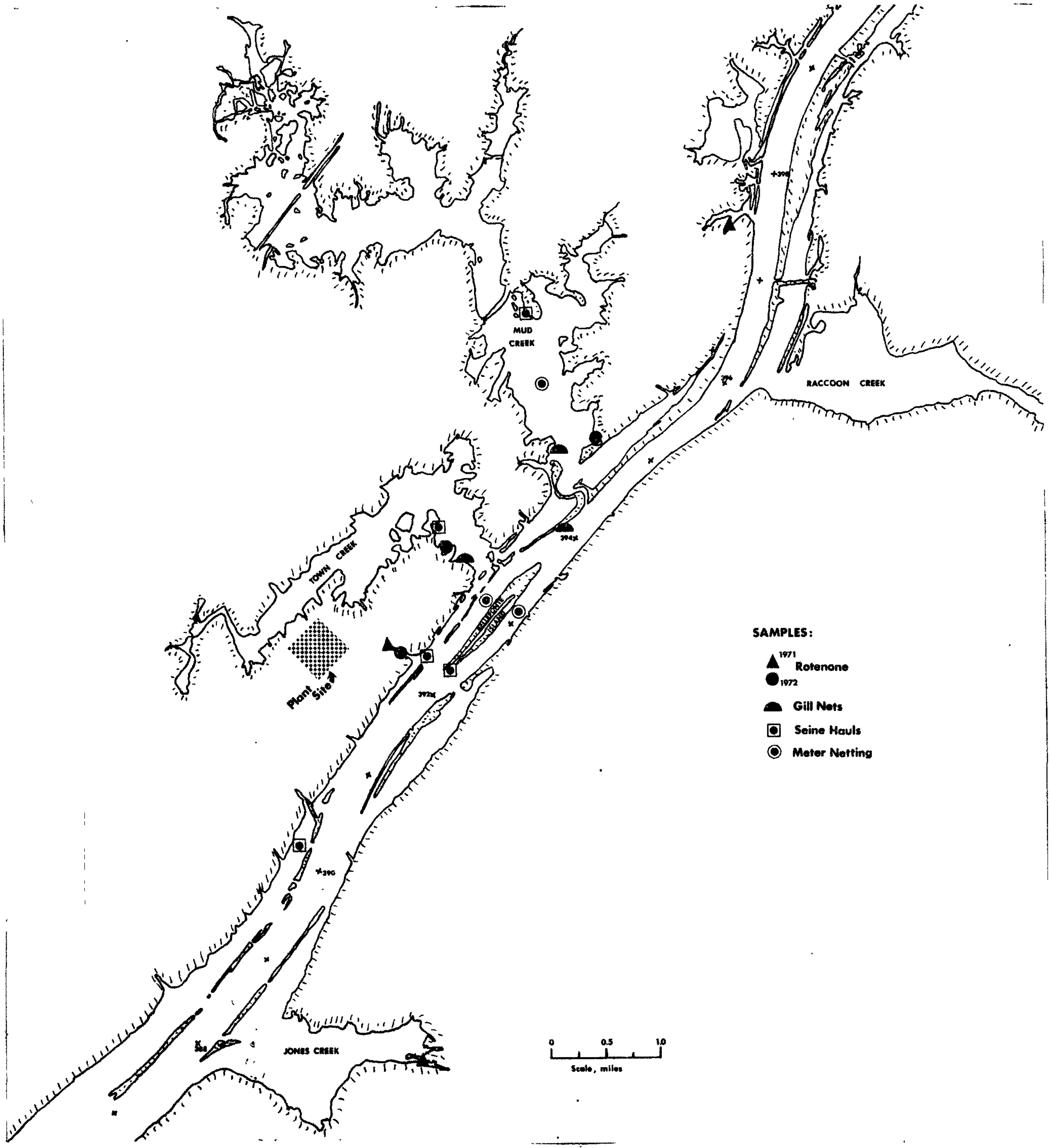
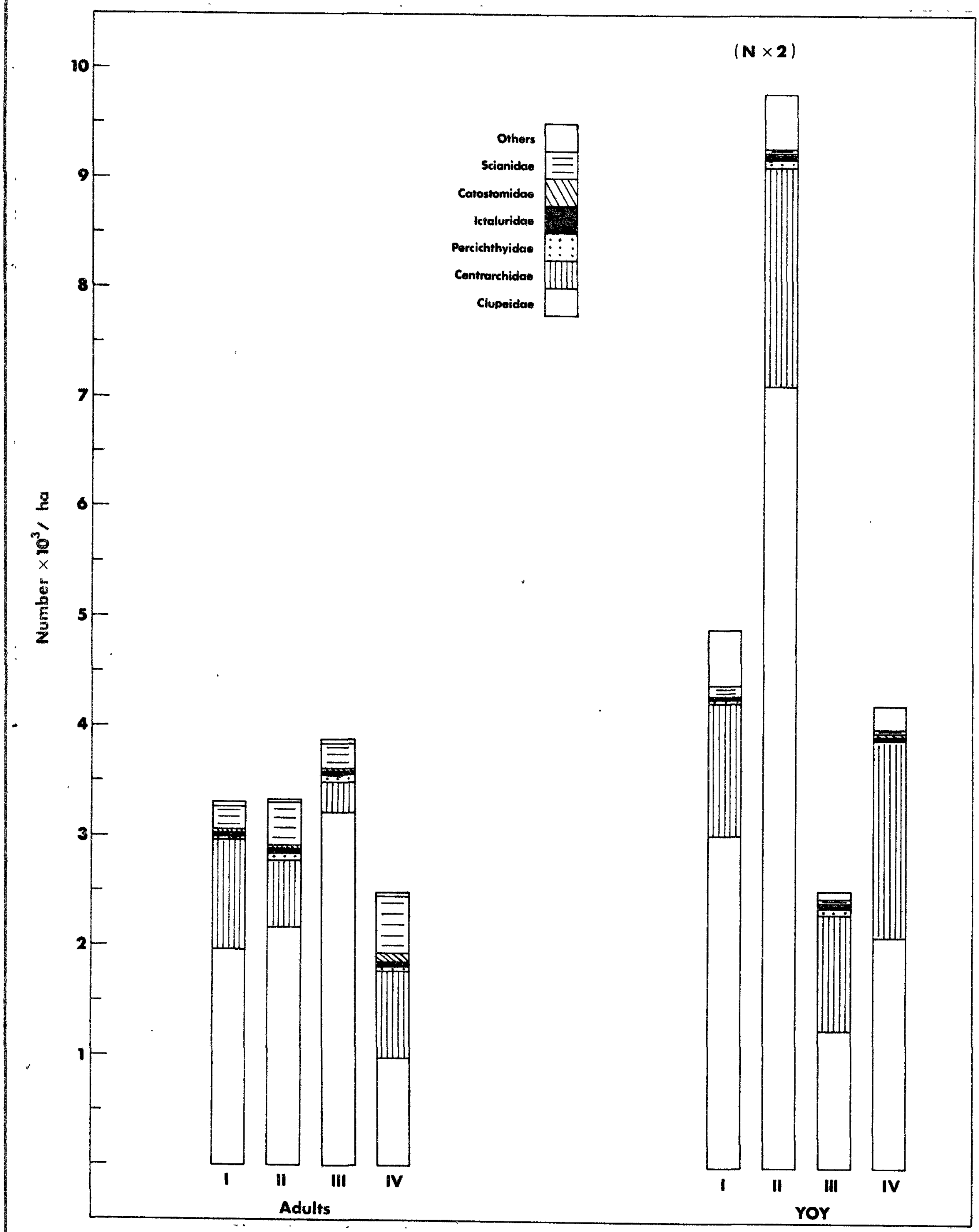


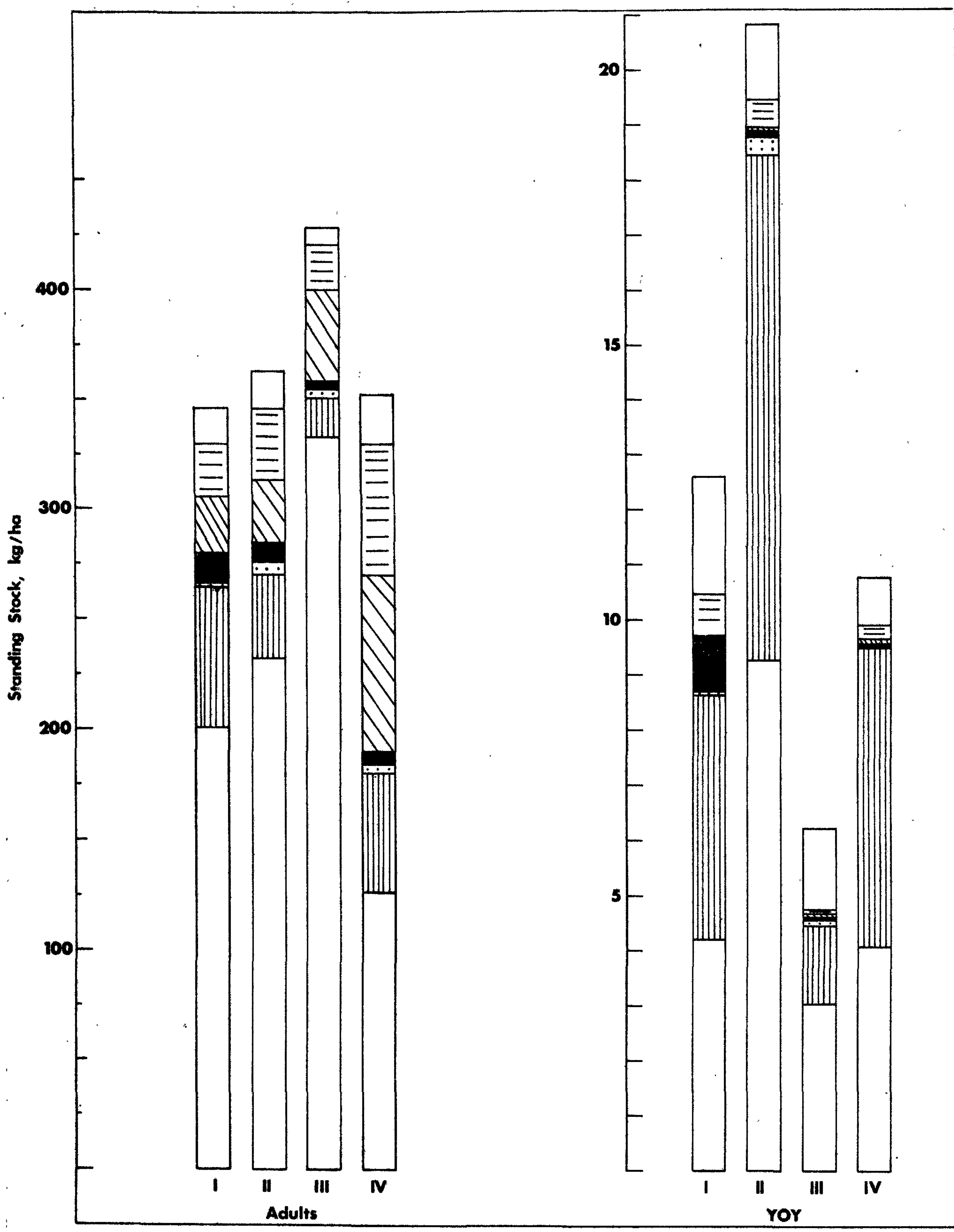
Figure B1-1

SAMPLING STATIONS FOR GUNTERSVILLE RESERVOIR FISH SAMPLING (1972) AND ROTENONE SAMPLING (1971)



Roman Numerals refer to areas defined in the text. YOY = Young of the Year. Adults = Juveniles and Adults.

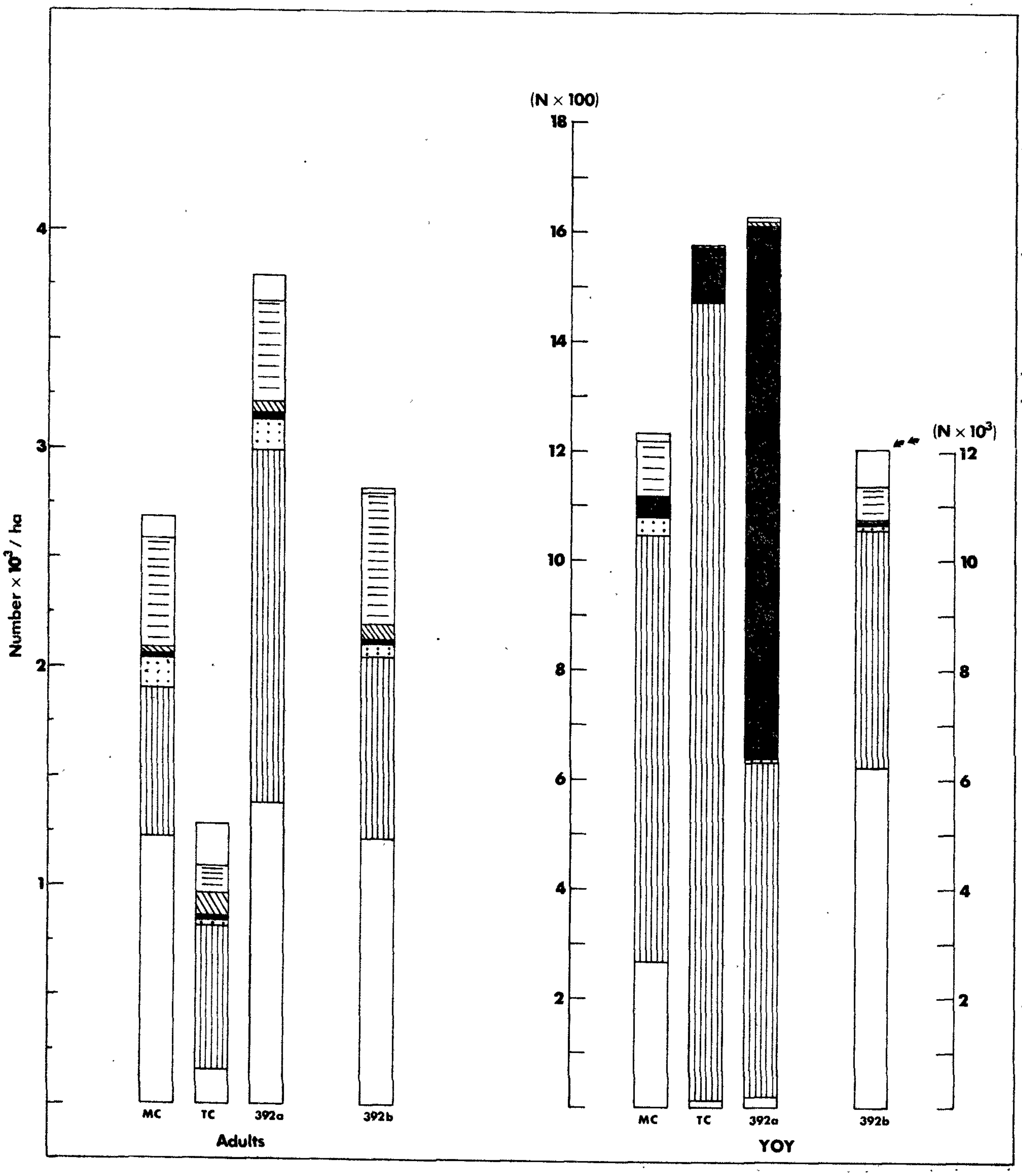
Figure B1-2
NUMBERS OF FISH PER HECTARE TAKEN IN COVE ROTENONE SAMPLES, GUNTERSVILLE RESERVOIR
JULY-AUGUST, 1971



Roman Numerals refer to areas defined in text. YOY = Young of the Year. Adults = Juveniles and Adults.

Figure B1-3

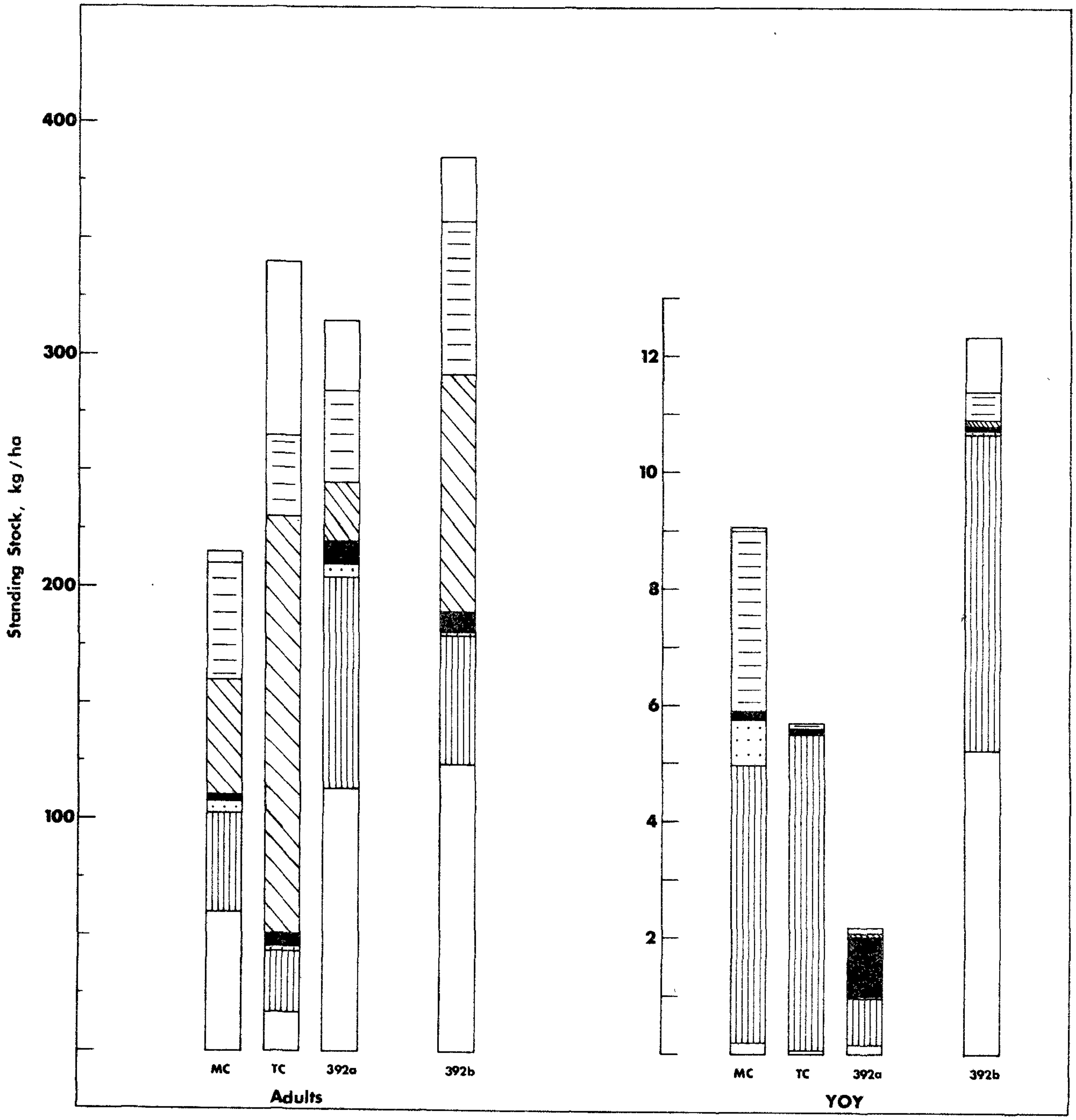
STANDING STOCK BIOMASS OBTAINED FROM COVE ROTENONE SAMPLES, GUNTERSVILLE RESERVOIR, JULY-AUGUST, 1971



Roman Numerals refer to areas defined in text. YOY = Young of the Year. Adults = Juveniles and Adults. MC = Mud Creek, TC = Town Creek. 392a = TRM 392, sampled in 1972. 392b same cove sampled in 1971 survey as part of area IV.

Figure B1-4

NUMBERS OF FISH PER HECTARE TAKEN IN COVE ROTENONE SAMPLES IN THE VICINITY OF THE BELLEFONTE SITE, JUNE, 1972



Roman Numerals refer to areas defined in the text. YOY = Young of the Year. Adults = Juveniles and Adults. MC = Mud Creek. TC = Town Creek. 392a = TRM 392, sampled in 1972. 392b = same cove sampled in 1971 survey as part of area IV.

Figure B1-5
STANDING STOCK BIOMASS OBTAINED FROM COVE ROTENONE SAMPLES IN THE VICINITY OF THE BELLEFONTE SITE, JUNE, 1972

Appendix B2

TERRESTRIAL AND AMPHIBIOUS FAUNA

1. Introduction - There is a paucity of scientifically documented information concerning the terrestrial and amphibious fauna of either the Bellefonte site area or of the Jackson County, Alabama, area.. As is the case throughout much of the Tennessee Valley, lists of species on a county-by-county basis are not available. Counties having large metropolitan areas and communities where colleges or universities are located are more likely to have been inventoried by botanists, zoologists, and ecologists.

Time limitations preclude an intensive terrestrial faunal assessment of the plant site; however, a compilation of species lists was accomplished from review of literature based on study of the entire state and areas near the proposed site that are physiographically and ecologically similar. Lists of mammals and birds found in Wheeler National Wildlife Refuge and expected to be found in northeastern Alabama are listed with annotations. Herptiles expected to frequent the area are listed and discussed by Dr. Bob Mount of Auburn University. Due to the location of this plant site relative to state and Federal waterfowl areas, a separate section dealing with waterfowl is included. Much of it is based on the North Alabama Land Use Study accomplished by TVA Division of Forestry, Fisheries, and Wildlife Development by Klein, et al., with specific waterfowl inputs by J. H. Burbank, TVA Waterfowl Biologist.

The proximity of the plant site to Wheeler National Wildlife Refuge affords the oportunity to generalize on the fauna of the area based on species lists compiled on the refuge. It cannot be categorically assumed that any species known at Wheeler Refuge will occur 30 miles up the Valley on the plant site. Some species listed, especially certain birds, are not likely to be seen in northeastern Alabama, but their distributional limits encompass the plant site area and they therefore are included. Those that have been seen in the area and likely to nest there are annotated.

No lists of insects or microfauna are available.

2. Endangered species - After careful review of fauna suspected to inhabit or migrate through the Bellefonte site and those animals whose distributional limits encompass the site, it was found that several species listed by the Department of the Interior Office of Rare and Endangered Species as threatened with extinction could conceivably be found in the area at certain times during the year. The Southern Bald Eagle (Haliaeetus leucocephalus leucocephalus) is commonly seen on Watts Bar and Chickamauga Lakes upstream from Guntersville, and these birds are occasionally seen at Wheeler National Wildlife Refuge. The American Peregrine Falcon (Falco peregrinus arrotum) and Red-cockaded Woodpecker (Dendrocopos borealis) have been seen on Wheeler refuge. These two species are rare. Bachman's Warbler (Vermivora bachmanii) and Kirtland's Warbler (Dendroica kirtlandii) could conceivably migrate through the area, but neither have been recorded at the Wheeler refuge. The Indiana Bat (Myotis sodalis), another endangered species, is a cave dweller and would be unlikely in

the area. No known caves are located on the plant site. Rare and endangered species are listed in Table B2-1.

3. Mammals - A qualitative assessment of Bellefonte site mammal populations was made based on a comprehensive vegetative analysis of the area, knowledge of past area land use practices, review of a list of mammals found on Wheeler National Wildlife Refuge, and Burt's A Field Guide to the Mammals. Species known to occur at Wheeler refuge and those whose distributional limits include the plant site area are listed in Table B2-2.

Of larger mammals, the White-tailed Deer (*Odocoileus virginianus*) is an important resident and is abundant based on browse sign and random pellet group counts. The majority of the 640 acres of wooded area has been subjected to cutting during the past few years, creating a lush growth of hardwood sprouts, herbaceous plants, and shrubs, thus producing an ideal habitat situation for deer. Opening of forested areas through cutting has doubtless benefited myriad other species of mammals such as the Gray Fox (*Urocyon cinereoargenteus*), Raccoon (*Procyon lotor*), Woodchuck (*Marmota monax*), Red Fox (*Vulpes fulva*), Opossum (*Didelphis virginiana*), and Cottontail Rabbit (*Sylvilagus floridanus*). Gray Squirrel (*Sciurus carolinensis*) appears to be present in good numbers even though forested areas have been heavily cut.

About 530 acres of the Bellefonte site are now in an "open" stage either as pasture or early successional old fields. The ragweed type and to a lesser extent broom sedge-lespedeza provide rabbits with a fairly favorable food and cover situation and should improve as the plant association naturally changes from annuals to perennials.

Populations of small mammals on the Bellefonte site are probably high, both in wooded and open areas, with such species as Shorttail Shrew (Blarina brevicauda), Pine Vole (Pitymys pinetorum), Golden Mouse (Peromyscus nuttalli), and Eastern Wood Rat (Neotoma floridana) being common residents. Several species of bats, namely Gray Myotis (Myotis grisescens), Red Bat (Lasiurus borealis), and Eastern Pipistrel (Pipistrellus subflovus) are common to Wheeler Refuge and probably frequent the plant site environs. Muskrat (Ondatra zibethica), Mink (Mustela vison), and an occasional River Otter (Lutra canadensis) frequent the littoral areas, Muskrat being the most numerous and the Otter extremely rare. The variety of habitat niches within the several open and forested types provides a wide range of food and habitat situations for a diverse and abundant mammalian fauna.

4. Birds - The list of birds given in Table B2-3 is a composite listing of species which likely nest and winter in the Bellefonte area and those that migrate through Jackson County. Some dominant year-round residents include the Crow (Corvus brachyrhynchos), Blue Jay (Cyanocitta cristata), Cardinal (Richmondena cardinalis), Red-tailed Hawk (Buteo jamaicensis), Sparrow Hawk (Falco sparverius), Mourning Dove (Zenaidura macroura), Screech Owl (Otus asio), Belted Kingfisher (Megaceryle alcyon), Pileated Woodpecker (Dendrocopus pileatus), Downy Woodpecker (Dendrocopus pubescens), Tufted Titmouse (Parus bicolor), Starling (Sturnus vulgaris), and Field Sparrow (Spizella pusilla). The variety of wooded and open areas and extensive edge create favorable habitats for a wide variety of avian species.

5. Waterfowl - The principal wintering grounds for migrant waterfowl in north Alabama are on Guntersville and Wheeler Lakes, and the bulk of wintering geese and ducks use the state and Federal waterfowl and wildlife management areas where food is plentiful and they are afforded some measure of protection. Roughly one-third of Alabama's wintering ducks and over 95 percent of the state's total wintering Canada Goose (Branta canadensis) population are found on the area from Guntersville to the upper end of Pickwick Lake.

The Wood Duck (Aix sponsa) is the only duck that nests in significant numbers in the state of Alabama. Black Ducks (Anas rubripes) and Mallards (Anas platyrhynchos platyrhynchos) are conspicuously present in the region during the breeding season, and both species successfully nest albeit in considerably less numbers than the wood duck; however, the potential for increasing nesting populations for these two species exists; Canada geese are present in the region only during the winter months. Free-flying Canadas that nest and spend the entire year on reservoirs such as Guntersville and Wheeler may become a reality in the near future as TVA continues its resident Canada goose program throughout the Valley. Seventy-five percent of ducks wintering in north Alabama are "puddle ducks," namely, mallards, black ducks, wood ducks, teal, and gadwall. Shallow bays, mud flats, sloughs, wooded bottom lands, and conterminous farming lands both on refuges and private areas provide for a fairly attractive habitat situation on these reservoirs.

Public management and refuge areas comprise about 34 percent of the total TVA land and water acreage in north Alabama. Table B2-4 lists major waterfowl areas on Pickwick, Wheeler, and

Guntersville Lakes, their size, and governing agency. These areas are leased from TVA with the single exception of Wheeler Refuge which is completely controlled by the Bureau of Sport Fisheries and Wildlife.

The Bellefonte plant site is located less than 1/2 mile from the State of Alabama Mud Creek waterfowl area which includes over 8,000 acres of land and water. Mud Creek affords sportsmen some 23,000 man-days of recreational activity annually, 1,200 of which are waterfowl and over 3,000 upland game. The other areas on Guntersville and Wheeler are heavily used by both hunter and nonhunter alike as shown in Table B2-5.

Town Creek embayment of Guntersville Lake borders the northern periphery of the peninsula on which the site is located while a series of narrow, linear islands border the area on the south side. Up-to-date assessment of year-round waterfowl use of the plant site environs is not possible because of time limitations. Several waterfowl float counts have been conducted around the peninsula from Town Creek embayment bridge to a point on the main channel side of the area about 1/4 mile upstream from the old ferry crossing. These float trips have revealed that wood ducks are nesting successfully on or near the peninsula, but five float trips in May and June of 1972 and again in late August and September indicate that the immediate area is not a significant wood duck nursery. Littoral area associated vegetation appears to afford birds fairly good brood habitat, but there is a paucity of large trees (>14 inches d.b.h.), thus suggesting that nesting habitat may be a limiting factor. Additional studies will be needed, however, before conclusive data can be gathered and conclusions drawn regarding the complete waterfowl resource of the area. Emergent, submersed and floating aquatic macrophytes are discussed elsewhere in this survey, and a partial list is also included in Table B2-6. Presence of these plants insofar as waterfowl are concerned is important particularly in view of the value of many of these species as waterfowl food plants. Aquatic plant life can provide escape and loafing cover as well as a direct source of food and also increase numbers of aquatic invertebrates which are an important waterfowl dietary item.[1]

6. The reptiles and amphibians of Jackson County, Alabama - a summary of current knowledge - Jackson County, Alabama in the northeastern corner of the state, lies wholly within the Tennessee River drainage. The topography varies from nearly flat to mountainous and the soil from heavy clay to sandy loam. The Tennessee River flows through the county from near the northeastern corner to the southwestern corner and is the county's dominant feature. Sand Mountain, the uppermost element of the Appalachian Ridge and Valley Province in Alabama, parallels the river on the southeast and rises rather abruptly from the river valley. In the northern portion of the county, the valley interdigitates with broad fingers of the Cumberland Plateau.

There are no published accounts dealing specifically with the reptiles and amphibians of Jackson County. An account by Penn (1940) provided an annotated list of species and subspecies collected in Mentone, DeKalb County, and vicinity, and this was used for many years as a source of reference to the herpetology of northeastern Alabama. Within recent years, field crews from Auburn University have made a number of trips to Jackson County for the purpose of making comprehensive collections of reptiles and amphibians. Most of the specimens obtained have been placed in the Auburn University Museum. These collections together with some made in nearby areas and some in other museums, provide the basis for this report. The report is in the form of an annotated checklist. Literature citations on individual forms are included where appropriate.

Following is a summary listing of the forms, an indication of their current status in the county, and the probable effects of various environmental modifications on their relative abundance. A total of 81 species, representing 20 families, are thought to occur in Jackson County.

Amphibians - Class Amphibia

Frogs and Toads - Order Anura

Spadefoot Toads - Family Pelobatidae

Eastern Spadefoot Toad - Scaphiopus holbrooki

Not recorded from Jackson County but almost certainly present. Breeds in flooded depressions of a temporary nature following heavy rains. Seldom seen except at night during wet weather. Nearest recorded locality: 0.5 mi. N of Ider, DeKalb County.

Toads - Family Bufonidae

American Toad - Bufo americanus americanus

Fairly common throughout, breeding during late winter and early spring, mostly in wet-weather pools and ponds. Not often seen during months of June through January.

Fowler's Toad - Bufo woodhousei fowleri

Abundant throughout, breeding from April through July in streams, lakes, and ponds. Hybridizes occasionally with Bufo americanus.

Treefrogs - Family Hylidae

Northern Cricket Frog - Acris crepitans crepitans

Common throughout where permanent water occurs. Breeds over a long period in a variety of habitats, ranging from small ponds to large streams.

Northern Spring Peeper - Hyla crucifer crucifer

Common throughout, but breeding only in late winter and spring. Seldom seen at other times. Breeding habitats usually consist of transient pools and ponds formed by heavy rains.

Mountain Chorus Frog - Pseudacris brachyphona

Although not recorded from Jackson County, this species almost certainly occurs there. Breeds in upland situations in temporary accumulations of water during winter. Seldom seen except at the breeding sites.

Upland Chorus Frog - Pseudacris triseriata feriarium

Common throughout, breeding during winter and early spring in shallow, flooded ditches and depressions. Seldom seen during summer months.

Gray Treefrog - *Hyla versicolor* (or *H. chrysocelis*)

Abundant throughout, breeding during spring and summer in temporary or semi-permanent ponds and pools. The common "treefrog" of Jackson County.

Barking Treefrog - *Hyla gratiosa*

This species is chiefly Coastal Plain in affinity, but it has been reported on several occasions in upland provinces, as far north as Kentucky. In Alabama a specimen from the vicinity of Ider, on Sand Mountain in DeKalb County, indicates the possibility of its occurrence in Jackson County also. This species breeds in permanent and semi-permanent ponds, preferably shallow ones.

Narrow-mouthed Toads - Family Microhylidae

Eastern Narrow-mouthed Toad - *Gastrophryne carolinensis*

Abundant throughout, breeding during warm, rainy weather in flooded fields, roadside ditches, and ponds, and around the heavily vegetated margins of lakes. Secretive and seldom seen abroad except during breeding.

True Frogs - Family Ranidae

Bullfrog - *Rana catesbeiana*

Common throughout the county in places where streams and permanent bodies of water provide suitable habitat.

Green Frog - *Rana clamitans melanota*

Common throughout. Inhabits streams, sloughs, and ponds with tree-lined margins.

Leopard Frog - Rana Pipiens sphenocephala (X pipiens?)

Leopard frogs occur in Jackson County, but the few specimens examined do not permit precise subspecific allocation of the population. Leopard frogs breed in a variety of permanent and semi-permanent aquatic habitats.

Pickerel Frog - Rana palustris

Fairly common throughout. Breeds in woodland pools, quiet areas in small streams, and occasionally in other aquatic situations.

Salamanders - Order Caudata

Giant Salamanders - Family Cryptobranchidae

Hellbender - Cryptobranchus alleganiensis alleganiensis

This large aquatic salamander, declining throughout its range, has not been recorded from Jackson County in recent years, but its presence is likely. Optimal habitats are clean, free-flowing streams with large rocks or underwater crevices to provide hiding and nesting sites. Channelization and impoundment of streams are almost certainly detrimental to hellbenders and in some cases may eliminate them entirely. The ecology and status of this remarkable animal are now under investigation by Dr. Max Nickerson, Milwaukee Public Museum.

Waterdogs - Family Necturidae

Mudpuppy - Necturus maculosus maculosus

Occurs in the Tennessee River and several of its tributaries in Jackson County. Usually collected by fishing at night. Channelization and "snagging" are detrimental to this animal, as are most forms of water pollution.

Newts - Family Salamandridae

Red-spotted Newt - *Notopthalmus viridescens viridescens*

Records are lacking, but this form is almost certainly present in the county. Woodland pools and ponds, especially those without fish, are the most favorable habitats, but some other aquatic environments, such as streams, may support newt populations.

Mole Salamanders - Family Ambystomatidae

Members of this family breed almost altogether in temporary pools and ponds that fill during winter and spring rains. Alterations which drain or fill such places are extremely detrimental to these animals and entire populations can be eliminated by depriving them of their breeding sites. They cannot breed in ponds stocked with predatory fish.

Spotted Salamander - *Ambystoma maculatum*

Locally common where breeding sites are available nearby. It is a woodland species.

Small-mouthed Salamander - *Ambystoma texanum*

Occurs in the Tennessee Valley eastward at least to Marshall County. It is not recorded from Jackson County, but it can easily escape detection because of its secretive nature. It should be considered problematical.

Marbled Salamander - *Ambystoma opacum*

Inhabits wooded floodplains and is locally common in the county.

Eastern Tiger Salamander - *Ambystoma tigrinum tigrinum*

A secretive, burrowing form, seldom encountered except at the breeding sites. Although there are no records from Jackson County, its presence is a virtual certainty. Tolerates land-clearing better than most other members of its genus.

Woodland Salamanders - Family Plethodontidae

Norther Dusky Salamander - *Desmognathus fuscus fuscus*

Common throughout the county along small shaded watercourses, springs, and seepage areas. Probably the most common salamander in Jackson County.

Appalachian Seal Salamander - *Desmognathus monticola monticola*

A form inhabiting the margins of small, rocky streams, this salamander occurs locally in Jackson County. Records from north of the Tennessee River are confined to a few small tributaries of the Paint Rock River near the Tennessee-Alabama boundary.

Blue Ridge Mountain Salamander - *Desmognathus ochrophaeus* ("*D. ocoee*")

Initially reported in Alabama from near Higdon in Jackson County by Valentine (1961), this species has now been recorded from several other Sand Mountain localities by Folkerts (1968). This form is restricted to shaded, wet cliff faces, especially near waterfalls.

Zigzag Salamander - *Plethodon dorsalis dorsalis*

A small, completely terrestrial salamander of the shaded forest floor, this form is common throughout most of the county where suitable habitat permits its existence. Land-clearing and tree harvesting by clear-cutting are thought to be detrimental to this salamander.

Slimy Salamander - Plethodon glutinosus

Common throughout the county, where it lives in forested areas. Capable of surviving in drier habitats than most salamanders of Alabama. Does not need water to breed.

Spring Salamander - Gyrinophilus porphyriticus porphyriticus

Local in Jackson County below the Tennessee River. Inhabits springs and small brooks in moist woods. Likely to be found near the edge of Sand Mountain in the vicinity of waterfalls.

"Tennessee Cave Salamander" - Gyrinophilus palleucus ssp.

This aquatic salamander is known in Alabama from a few caves north of the Tennessee River, including McFarland's Cave, Lim Rock Blowing Cave, Jessee Elliot Cave, Blowing Cave, and Saltpeter Cave in Jackson County. The last two are the lower and upper entrances respectively of a cave system in the base of Cave Mountain on the edge of North Sauty Creek. The Jackson County specimens are intergrades between the subspecies G. p. palleucus and G. p. necturoides (Brandon, 1966). This salamander listed in Rare and Endangered Vertebrates of Alabama (1972).

Northern Red Salamander - Pseudotriton ruber ruber

Common in most of the moist, forested habitats in Jackson County. Breeds in springs and small streams.

Green Salamander - Aneides aeneus

An inhabitant of moist cliff faces and rock exposures, this salamander spends most of its daylight hours secreted in narrow crevices. Exposing its habitats to full sunlight for long periods of the day by cutting the sheltering trees is detrimental to this species. A completely terrestrial species, the cliff salamander nests in rock crevices or, less frequently, in rotting trees. It is locally common in Jackson County.

Long-tailed Salamander - Eurycea longicauda longicauda

A species usually associated with damp woodlands in the vicinity of creeks and springs, which apparently serve as breeding sites. Locally common in Jackson County.

Cave Salamander - Eurycea lucifuga

Inhabits damp, rocky woodlands, where it is most common in the vicinity of caves, bluffs, and coves. Locally common in Jackson County.

Two-lined Salamander - Eurycea bislineata ssp.

A common salamander in Jackson County, where it may be found around small streams, springs, and seepages in forested areas. The subspecific allocation of the Jackson County populations, as well as most others in Alabama, must await a taxonomic reconsideration of the species complex.

Four-toed Salamander - Hemidactylium scutatum

Not recorded from Jackson County but may occur there. An elusive species, it is found around boggy areas and woodland pools. It is not known to be abundant anywhere in Alabama.

Reptiles - Class Reptilia

Turtles - Order Testudinata

Snapping Turtles - Family Chelydridae

Alligator Snapping Turtle - Macroclemys temmincki

Occurs infrequently in streams in the Tennessee River system but has not been reported in Jackson County. Its occurrence in the county is questionable.

Snapping Turtle - *Chelydra serpentina*

Common in Jackson County, where it occurs in a variety of permanently aquatic habitats.

Mud and Musk Turtles - Family Kinosternidae

Common Musk Turtle (Stinkpot) - *Sternothaerus odoratus*

A common turtle in Jackson County, occurring in ponds, lakes, and sluggish streams.

Stripe-necked Musk Turtle - *Sternothaerus minor peltifer*

This predominantly stream-dwelling turtle is uncommon in Jackson County.

Eastern Mud Turtle - *Kinosternon subrubrum subrubrum*

A fairly common resident of the county, this turtle inhabits ponds, lakes, and swamps. It is seldom found in streams.

Common Turtles - Family Testudinidae

Eastern Box Turtle - *Terrapene carolina carolina*

A common terrestrial turtle in Jackson County, preferring wooded or partially wooded habitats.

Map Turtle - *Graptemys geographica*

A stream-dwelling species, the map turtle may be found in the Tennessee River and some of its tributaries in Jackson County. The adult females feed almost exclusively on molluscs.

Ouachita False Map Turtle - *Graptemys pseudogeographica oauchitensis*

Common in Jackson County, but confined to the Tennessee River.

Painted Turtle - *Chrysemys picta dorsalis* X *marginata*

Common in the Tennessee River and in some of the ponds and backwater lakes in Jackson County. As is indicated by the scientific name, the Jackson County populations are intergradient between two subspecies.

Pond Slider - *Pseudemys scripta* ssp.

Common in the Tennessee River and in many other permanently aquatic habitats in Jackson County. The populations of the area have been placed in the subspecies *P. s. troosti*, but Davidson (1971) has recently questioned the validity of that subspecies.

River Cooter - *Pseudemys concinna concinna*

Fairly common in the Tennessee River in Jackson County. Not known to occur in other streams within the county.

Softshell Turtles - Family Trionychidae

Midland Smooth Softshell - *Trionyx muticus muticus*

Occurs in Jackson County in the Tennessee River where it is fairly common.

Eastern Spiny Softshell - *Trionyx spiniferus spiniferus*

Infrequent in the Tennessee River and possibly other streams in Jackson County.

Snakes and Lizards - Order Squamata

Iguanid Lizards - Family Iquanidae

Green Anole - Anolis carolinensis carolinensis

Uncommon in Jackson County below the Tennessee River, rare above the river. Mostly arboreal, feeds on a variety of insects.

Northern Fence Lizard - Sceloporus undulatus hyacinthinus

Common in forested areas and woodlots throughout the county.

Whiptail Lizards - Family Teidae

Six-lined Racerunner - Cnemidophorus sexlineatus sexlineatus

Common in the county, where it frequents open areas such as field roads, roadside right of ways, and weedy waste places.

Lateral-fold Lizards - Family Anguidae

Eastern Slender Glass Lizard - Ophisaurus attenuatus longicaudus

Infrequent in the county. Occurs in a variety of habitats but most likely to be found in weedy forest-edge habitat and waste places.

Skinks - Family Scincidae

Ground Skink - Scinella laterale

Common in forest communities throughout the county. A ground-dwelling species.

Five-lined Skink - Eumeces fasciatus

The most abundant "blue-tailed lizard" in Jackson County, this skink is found chiefly in forested areas and along watercourses.

Broad-headed Skink - Eumeces laticeps

Uncommon in the county, this skink tends to be arboreal and inhabits forested areas with large trees and those which have cavities. Land-clearing, conversion of hardwood forests to pine, and removal of "wolf trees" and den trees from timber stands are particularly detrimental to this species.

Southeastern Five-lined Skink - Eumeces inexpectatus

A "Blue-tailed lizard" of ridge tops and dry woods. Infrequent in most of Jackson County.

Common Snakes - Family Colubridae

Eastern Smooth Earth Snake - Virginia valeriae valeriae

Although not reported from Jackson County, this small, forest-floor snake is thought to occur there.

Northern Red-bellied Snake - Storeria occipitomaculata occipitomaculata

Occurs infrequently in Jackson County, where it inhabits forested areas and waste places and hides under rocks, logs, and piles of debris.

Brown Snake - Storeria dekayi dekayi X wrightorum

A common snake in Jackson County, this species is found in a variety of habitats, including open forests, forest-edges, and waste places. It also occurs in residential areas in cities and towns, and is capable of maintaining itself in vacant lots, weedy lawns, and parks.

Midland Water Snake - Natrix sipedon pleuralis

Common in most kinds of permanently aquatic habitats in Jackson County. Usually termed "water moccasin" by residents.

Yellow-bellied Water Snake - Natrix erythrogaster flavigaster

Infrequent in Jackson County, this snake occurs in streams and around the margins of lakes and ponds, especially if they are tree-lined.

Queen Snake - Regina (=Natrix) septemvittata

Common in the Tennessee River and most other streams in Jackson County. Feeds almost exclusively on crawfish and requires overhanging vegetation.

Eastern Garter Snake - Thamnophis sirtalis sirtalis

Abundant in Jackson County, where it occurs in most kinds of terrestrial habitats. Especially favored are forest-edges, stream-edges, and waste places.

Eastern Ribbon Snake - Thamnophis sauritis sauritis

Relatively common in Jackson County, this semi-aquatic form is found most frequently in the vicinity of water. Stream-edge habitat is favored, along with marshy places and the weedy or brushy margins of ponds and lakes.

Eastern Hog-nosed Snake - Heterodon platyrhinos

Relatively common in the county, this snake prefers open woods, fields, and waste places. Feeds almost exclusively on toads. Called "spreading-adder" by local residents.

Ring-necked Snake - Diadophis punctatus ssp.

One of the most common snakes in Jackson County, this species is found in forested areas, forest-edges, and waste places. It hides beneath rocks, logs, and piles of debris. The Jackson County populations are derived from an intermixture of three subspecies - punctatus, edwardsi, and stictogenys.

Worm Snake - Carphophis amoenus ssp.

This worm snake is common in the county and is usually found hiding under logs, rocks, and piles of debris in forested areas. The populations above the Tennessee River in Jackson County are predominantly C. a. amoenus in genetic constitution, those below mostly C. a. helenae.

Northern Black Racer - Coluber constrictor constrictor

Common in the county in waste places, old fields, open forests, and forest-edge habitat.

Eastern Coachwhip - Masticophis flagellum flagellum

Not recorded from Jackson County but thought to be present in small numbers below the Tennessee River. This snake has not been found above the Tennessee River in Alabama. Favored habitats are dry, open woods and broken terrain, especially where the soil is sandy.

Rough Green Snake - Opheodrys aestivus

Common in Jackson County, where it occurs in a variety of habitats. Especially favored are heavily vegetated margins of streams and lakes.

Northern Pine Snake - Pituophis melanoleucas melanoleucas

This large snake, rare throughout much of its range, persists in considerable numbers on Sand Mountain and on the Cumberland Plateau of Jackson County.

Rat Snake - Elaphe obsoleta obsoleta X spiloides

Common in the county around waste places, old-house sites, and in other habitats where small rodents are likely to abound. Most terrestrial habitats with at least some cover can support rat snake populations.

Corn Snake - Elaphe guttata guttata

Relatively common in Jackson County, this largely nocturnal species is most likely to be found in areas where small rodents are abundant. Abandoned farm land offers optimal habitat.

Northern Scarlet Snake - Cemophora coccinea copei

Infrequent in Jackson County above the Tennessee River, relatively common below the river. This secretive snake is seldom encountered except at night.

Scarlet Kingsnake - Lampropeltis triangulum elapsoides

Not recorded from Jackson County but thought to occur there in small numbers. A small, secretive snake, it is mostly noctural in habits.

Milk Snake - Lampropeltis triangulum triangulum X syspila

Milk snakes have been collected in Jackson County from both sides of the Tennessee River but are uncommon in the area. The Jackson County milk snakes apparently prefer dry habitats with rock outcrops, such as the tops of the bluffs overlooking the Tennessee River. The population is intergradient between the eastern milk snake and red milk snake, as is indicated by the scientific name applied. The red milk snake is listed in Rare and Endangered Vertebrates of Alabama (1972). The subspecific status of the Jackson County population had not been determined at the time the list was prepared.

Mole Snake - *Lampropeltis calligaster rhombomaculata*

Although records of this secretive species from Jackson County are lacking, it is thought to occur there. It is a nocturnal, burrowing form, usually found in forested or broken terrain.

Black Kingsnake - *Lampropeltis getulus niger*

Common throughout the county where there is sufficient cover to permit the development of populations of small rodents and other small reptiles. Old house places, abandoned farms, and damp woods are favored habitats.

Southeastern Crowned Snake - *Tantilla coronata coronata*

Common on the tops of ridges and other dry, forested habitats in Jackson County. Usually found under rocks or in rotting pine logs.

Pit Vipers - Family Viperidae, Subfamily Crotalinae

Northern Copperhead - *Agkistrodon contortrix mokeson*

Common in forested areas and broken farmland throughout the county. The populations below the Tennessee River show some influence from the southern copperhead, *A. c. contortrix*.

Eastern Cottonmouth - *Agkistrodon piscivorus piscivorus*

Not recorded from Jackson County but thought to be present in small numbers in some of the low, swampy habitats in the Tennessee Valley portion. Nearest authenticated records are from DeKalb and Limestone Counties.

Carolina Pigmy Rattlesnake - *Sistrurus miliarius miliarius*

Not recorded from Jackson County but thought to be present in small numbers in some of the upland portions above and below the Tennessee River.

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1. Qualitative assessment of plant-waterfowl relationship based on information taken from following sources:

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Table B2-1

Rare and Endangered Vertebrates of Jackson County[a]

Species	Rare-1[b]	Rare-2[b]	Endangered[b]
Southeastern Shrew	X		
Southeastern Myotis		X	
Hoary Bat		X	
Indiana Myotis			X
Sharpshinned Hawk		X	
Cooper Hawk		X	
Golden Eagle		X	
Bald Eagle			X
Osprey			X
Peregrine Falcon			X
Bewick's Wren		X	
Ruffed Grouse			X
Red Milk Snake		X	
Tennessee Cave Salamander			X

a. From Rare and Endangered Vertebrates of Alabama, Alabama Department of Conservation and Natural Resources, Div. of Game and Fish, June 1972.

b. Rare-1: A rare species or subspecies that, although not presently threatened with extinction, is in such small numbers that it may be endangered if its environment worsens.

Rare-2: A species or subspecies that may be quite abundant where it occurs, but is known in only a few localities or in a restricted habitat within Alabama.

Endangered: An y species or subspecies occurring in Alabama threatened with extinction through (a) the destruction, drastic modification, or severe curtailment of its habitat; (b) its over-utilization for commercial or sporting purposes; (c) the effect on it of disease or predation; or (d) other natural or man-made factors affecting its continued existence.

Table B2-2

MAMMALS LIKELY TO BE FOUND ON THE BELLEFONTE NUCLEAR PLANT SITE[1] AND THOSE WITH RANGES ENCOMPASSING THE JACKSON COUNTY AREA

Common Name	Scientific Name
Virginia Opossum*	Didelphis virginiana
Eastern Mole*	Scalopus aquaticus
Least Shrew*	Cryptotis parva
Shorttail Shrew*	Blarina brevicauda
Southeastern Shrew	Sorex longirostris
Small Short-Tailed Shrew	Cryptotis parva
Smokey Shrew	Sorex fumeus
Keen Myotis	Myotis keeni
Little Brown Myotis	Myotis lucifugus
Indiana Myotis[2]	Myotis sodalis
Southeastern Bat	Myotis austroriparius
Gray Myotis*	Myotis grisescens
Evening Bat*	Nycticeius humeralis
Eastern Pipistrel*	Pipistrellus subflovus
Big Brown Bat*	Eptesicus fuscus
Red Bat*	Lasiurus borealis
Hoary Bat	Lasiurus cinereus
Silver-Haired Bat*	Lasionycteris noctivagans
Eastern Big-Eared Bat	Corynorhinus macrotis
Raccoon*	Procyon lotor
Lontail Weasel*	Mustela frenata
River Otter*	Lutra canadensis
Shorttail Weasel	Mustela erminea
Mink*	Mustela vison
River Otter	Lutra canadensis
Spotted Skunk*	Spilogale putorius
Striped Skunk*	Mephitis mephitis
Red Fox*	Vulpes fulva
Coyote*	Canis latrans
Gray Fox*	Urocyon cinereoargenteus
Bobcat*	Lynx rufus
Woodchuck*	Marmota monax
Eastern Chipmunk*	Tamias striatus
Eastern Gray Squirrel*	Sciurus carolinensis
Eastern Fox Squirrel*	Sciurus niger
Southern Flying Squirrel*	Glaucomys volans
Beaver*	Castor canadensis
Eastern Harvest Mouse*	Reithrodontomys humulis
White-Footed Mouse*	Peromyscus leucopus
Golden Mouse*	Peromyscus nuttalli
Deer Mouse*	Peromyscus maniculatus
Cotton Mouse*	Peromyscus gossypinus
Rice Rat*	Oryzomys palustris
Hispid Cottonrat*	Sigmodon hispidus
Eastern Woodrat*	Neotoma floridana
Southern Bog Lemming	Synaptomys cooperi
Oldfield Mouse	Peromyscus polionotus

Table B2-2 (continued)

Common Name	Scientific Name
Prairie Vole*	Pedomys ochrogaster
Pine Vole*	Pitymys pinetorum
Muskrat*	Ondatra zibethica
Norway Rat*	Rattus norvegicus
Cotton Rat	Sigmodon hispidus
Black Rat	Rattus rattus
House Mouse*	Mus musculus
Eastern Cottontail*	Sylvilagus floridanus
Swamp Rabbit*	Sylvilgus aquaticus
White-Tailed Deer*	Odocoileus virginianus
Feral Domestic Dog	Canis familiaris
Feral Domestic Cat	Felis domestica

1. Species determination based on information taken from a Field Guide to the Mammals by Burt and Mammals of Wheeler National Wildlife Refuge, Bureau of Sport Fisheries and Wildlife.

2. Endangered species as listed by USFWS, Office of Rare and Endangered Species.

*Asterisk denotes those species found on Wheeler National Wildlife Refuge.

Table B2-3

A CHECKLIST OF BIRDS WHOSE RANGES INCLUDE
THE BELLEFONTE NUCLEAR PLANT SITE[1]

Common Name	S	S	F	W	Scientific Name
Common Loon	u		u	u	Gavia immer
Horned Grebe			u	u	Podiceps auritus
Pied-billed Grebe*	c	r	c	u	Podilymbus podiceps
White Pelican	o		o	o	Pelecanus erythrorhynchos
Anhinga	r	r			Anhinga anhinga
Double-crested Cormorant			r	r	Phalacrocorax auritus
Great Blue Heron	c	u	c	c	Ardea herodias
Green Heron*	c	c	u		Butorides virescens
Louisiana Heron	r	r			Hydranassa tricolor ruficolis
Little Blue Heron	c	c			Florida caerulea
Common Egret	c	c	u	r	Casmerodius albus
Snowy Egret	u	c			Leucophoyx thula thula
Cattle Egret	c	c	u	r	Bubulcus ibis
Black-crowned Night Heron	c	c	c	u	Nycticorax nycticorax
Yellow-crowned Night Heron*	c	c	u		Nyctanassa violacea
Least Bittern*	u	u	r		Ixobrychus exilis
American Bittern	u		u		Botaurus lentiginosus
Glossy Ibis		r			Plegadis chihi
Wood Ibis		o	o		Mycteria americana
White Ibis	o	o	o		Eudocimus albus
Whistling Swan	o	o		o	Olor columbianus
Canada Goose	u	u	a	a	Branta canadensis
Snow Goose	r		c	c	Chen hyperborea
Brant	r			r	Branta lernicla
Blue Goose	r		c	c	Chen caerulescens
Mallard*	u	u	c	c	Anas platyrhynchos
Black Duck*	u	u	c	c	Anas rubripes
Gadwall	u		c	c	Anas strepera
Pintail	r		c	c	Anas acuta
Cinnamon Teal	r			r	Anas cyanoptera cyanoptera
Green-winged Teal	r		c	c	Anas carolinensis
Blue-winged Teal	c	r	c	u	Anas discors
American Widgeon	u		c		Mareca americana
Shoveler	c		c	c	Spatula clypeata
Wood Duck*	c	c	c	c	Aix sponsa
Redhead	r		u	u	Aythya americana
Ring-necked Duck	u		c	c	Aythya collaris
Canvasback	u		u	u	Aythya valisineria
Greater Scaup			o	o	Aythya marila
Lesser Scaup	u		c	c	Aythya affinis
Common Goldeneye			u	u	Bucephala clangula
Bufflehead	r		u	c	Bucephala albeola
Oldsquaw			u	u	Clangula hyemalis
White-winged Scoter				o	Melanitta fusca deglandi
Common Scoter		r			Oidemia nigra

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Turkey Vulture	u	u	u	u	Cathartes aura
Black Vulture*	u	u	u	u	Coragyps atratus
Mississippi Kite	o		o		Ictinia misisippiensis
Sharp-shinned Hawk	u	u	c	c	Accipiter striatus
Cooper's Hawk*	c	o	c	c	Accipiter cooperii
Red-tailed Hawk*	u	u	c	c	Buteo jamaicensis
Red-shouldered Hawk*	c	c	c	c	Buteo lineatus
Broad-winged Hawk	r		u		Buteo platypterus
Rough-legged Hawk				o	Buteo lagopus
Golden Eagle			r		Aquila chrysaetos
Bald Eagle[2]	r	r	r	r	Haliaeetus leucocephalus
Marsh Hawk	u		c	c	Circus cyaneus
Swainson's Hawk			r		Buteo swainsonii
Osprey	r	r	r	r	Pandion haliaetus
Peregrine Falcon	r		r	r	Falco peregrinus
Pigeon Hawk	r		u	u	Falco columbaris
Sparrow Hawk*	c	c	c	c	Falco sparverius
Ringnecked Pheasant*	u	u	u	u	Phasianus colchicus torquatus
Bobwhite*	c	c	c	c	Colinus virginianus
Turkey	r	r	r	r	Meleagris gallopavo
Sandhill Crane	o		o	x	Grus canadensis
King Rail*	c	c	u		Rallus elegans
Virginia Rail	u	r	u		Rallus limicola
Sora	u		c		Prozana carolina
Yellow Rail			r		Coturnicops noveboracensis
Purple Gallinule	r	r			Porphyrula martinica
Common Gallinule	o	o	o		Gallinula chloropus
American Coot	c	u	c	c	Fulica americana
Semipalmated Plover	c		u		Charadrius semipalmatus
Killdeer*	c	c	c	c	Charadruis vociferus
Golden Plover	u		u		Pluvialis dominica
Black-bellied Plover	u		u		Squatarola scuatarola
Ruddy Turnstone	r		u		Arenaria interpres
Whimbrel	r		o		Numenius phaeopus
American Woodcock*	u	u	u	u	Philohela minor
Common Snipe	c		c	u	Capella gallinago
Upland Plover	u		u		Bartramia longicauda
Spotted Sandpiper	c	c	c		Actitis mucularia
Solitary Sandpiper	c		c		Tringa solitaria
Baird's Sandpiper	r			r	Erolia bairdii
Willet	o	o	o		Catoptrophorus semipalmatus
Greater Yellowlegs	a		a	u	Totanus melanoleucus
Lesser Yellowlegs	a		a		Totanus flavipes
Pectoral Sandpiper	c		c		Erolia melanotos
White-rumped Sandpiper	o		o		Erolia fuscicollis

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Knot			o		Calidris canutus
Least Sandpiper	c	u	c	u	Erolia minutilla
Dunlin			u		Erolia alpina
Short-billed Dowitcher	o		o		Limnodromus griseus
Long-billed Dowitcher	x		o		Limnodromus scolopaceus
Stilt Sandpiper			u		Micropalama himantopus
Semipalmated Sandpiper	c		c		Ereunetes pusillus
Western Sandpiper	u		u		Ereunetes mauri
Buff-breasted Sandpiper			o		Tryngites subruficollis
Marbled Godwit	r				Limosa fedoa
Sanderling			u		Crocethia alba
American Avocet			o		Recurvirostra americana
Northern Phalarope				r	Lobipes lobatus
Wilson's Phalarope			r		Steganopus tricolor
Herring Gull	u		c	a	Larus argentatus
Ring-billed Gull	u		c	a	Larus delawarensis
Laughing Gull	o			o	Larus atricillas
Franklin's Gull		o		o	Larus pipixcan
Bonaparte's Gull	u		u	u	Larus philadelphia
Forster's Tern	u	u	u		Sterna forsteri
Common Tern	u	u	u		Sterna hirundo
Caspian Tern	u	u	u		Hydroprogne caspia
Sooty Tern		r			Sterna fuscata
Least Tern	u	u			Sterna albifrons
Black Tern	u	u	c		Chlidonias niger
Rock Dove*	c	c	c	c	Columba livia
Mourning Dove*	c	c	a	c	Zenaidura macroura
Ground Dove	o	o	o	o	Columbigallina passerina
Yellow-billed Cuckoo*	c	c	u		Coccyzus americanus
Black-billed Cuckoo	r	r			Coccyzus erythropthalmus
Barn Owl*	u	u	u	u	Tyto alba
Screech Owl*	c	c	c	c	Otus asio
Great Horned Owl	r	r	u	u	Bubo virginianus
Barred Owl*	u	u	u	u	Strix varia
Short-eared Owl	r		r	u	Asio flammeus
Chuck-will's-Widow*	c	c	u		Caprimulgus carolinensis
Whip-poor-will	r		r		Caprimulgus vociferus
Common Nighthawk*	c	c	c		Chordeiles minor
Chimney Swift*	c	c	c		Chaetura pelagica
Ruby-throated Hummingbird*	c	c	c		Archilochus colubris
Belted Kingfisher*	u	u	u	u	Megaceryle alcyon
Yellow-shafted Flicker*	c	c	c	c	Colaptes auratus
Pileated Woodpecker*	u	u	u	u	Dryocopus pileatus
Red-bellied Woodpecker*	c	c	c	c	Centurus carolinus
Red-headed Woodpecker*	c	c	u	r	Melanerpes erythrocephalus

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Yellow-bellied Sapsucker	u		c	c	_Sphyrapicus varius_
Hairy Woodpecker*	c	c	c	c	_Dendrocopos villosus_
Downy Woodpecker*	c	c	c	c	_Dendrocopos pubescens_
Eastern Kingbird*	c	c	c		_Tyrannus tyrannus_
Great-crested Flycatcher*	c	c	u		_Myiarchus crinitus_
Eastern Phoebe*	c	u	c	c	_Sayornis phoebe_
Yellow-bellied Flycatcher			r		_Empidonax flaviventris_
Acadian Flycatcher	c	c	u		_Empidonax virescens_
Traill's Flycatcher	o	o	o		_Empidonax traillii_
Least Flycatcher	u		u		_Empidonax minimus_
Eastern Wood Pewee*	c	c	u		_Contopus virens_
Olive-sided Flycatcher	o		o		_Nuttallornis borealis_
Vermilion Flycatcher			r		_Pyrocephalus rubinus_
Horned Lark*	u	u	c	c	_Eremophila alpestris_
Tree Swallow*	u		u		_Iridoprocne bicolor_
Bank Swallow	u	u	u		_Riparia riparia_
Rough-winged Swallow*	a	c	a		_Stelgidopteryx ruficollis_
Barn Swallow*	a	c	a		_Hirundo rustica_
Cliff Swallow	u		u		_Petrochelidon pyrrhonota_
Purple Martin*	c	c	a		_Progne subis_
Blue Jay*	c	c	c	c	_Cyanocitta cristata_
Common Crow*	c	c	a	a	_Corvus brachyrhynchos_
Carolina Chickadee*	c	c	a	a	_Parus carolinensis_
Tufted Titmouse*	c	c	a	a	_Parus bicolor_
White-breasted Nuthatch	u		u	u	_Sitta carolinensis_
Red-breasted Nuthatch (erratic)	r		u	u	_Sitta canadensis_
Brown Creeper			r	r	_Certhia familiaris_
House Wren	u	u	u		_Troglodytes aedon_
Winter Wren			u	u	_Troglodytes troglodytes_
Bewick's Wren	r	r	c	c	_Thryomanes bewickii_
Carolina Wren*	c	c	c	c	_Thryothorus ludovicianus_
Long-billed Marsh Wren			u		_Telmatodytes palustris_
Short-billed Marsh Wren	r		u	u	_Cistothorus platensis_
Mockingbird*	c	c	c	c	_Mimus polyglottos_
Catbird*	c	c	c	u	_Dumetella carolinensis_
Brown Thrasher*	c	c	c	u	_Toxostoma rufum_
Robin*	u	u	c	c	_Turdus migratorius_
Wood Thrush*	c	c	c		_Hylocichla mustelina_
Hermit Thrush			c	c	_Hylocichla guttata_
Swainson's Thrush	u		u	r	_Hylocichla ustulata_
Gray-cheeked Thrush	u		u	r	_Hylocichla minima_
Veery	u		r		_Hylocichla fuscescens_
Eastern Bluebird*	u	u	u	r	_Sialia sialis_
Blue-gray Gnatcatcher	c	r	c		_Polioptila caerulea_
Golden-crowned Kinglet					_Regulus satrapa_

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Ruby-crowned Kinglet	u		c	c	*Regulus calendula*
Water Pipit	u		c	c	*Anthus spinoletta*
Cedar Waxwing (erratic)	u		u	c	*Bombycilla cedrorum*
Loggerhead Shrike*	u	u	u	u	*Lanius ludovicianus*
Starling*	c	c	a	a	*Sturnus vulgaris*
White-eyed Vireo	c	c	u		*Vireo griseus*
Yellow-throated Vireo	c	c	u		*Vireo flavifrons*
Solitary Vireo			u		*Vireo solitarius*
Red-eyed Vireo*	c	c	u		*Vireo olivaceus*
Philadelphia Vireo					*Vireo philadelphicus*
Warbling Vireo			r	r	*Vireo gilvus*
Black-and-White Warbler	c	c	c		*Mniotilta varia*
Prothonotary Warbler*	c	u			*Protonotaria citrea*
Swainson's Warbler (tower kill)	r	r			*Limnothlypis swainsonii*
Worm-eating Warbler	r	r			*Helmitheros vermivorus*
Golden-winged Warbler	r				*Vermivora chrysoptera*
Blue-winged Warbler	r				*Vermivora pinus*
Tennessee Warbler	u		u		*Vermivora peregrina*
Orange-crowned Warbler	r		r		*Vermivora celata*
NashvilleWarbler			u		*Vermivora ruficapilla*
Parula Warbler	r	r	r		*Parula americana*
Yellow Warbler	c	u	c		*Dendroica petechia*
Magnolia Warbler	u		u		*Dendroica magnolia*
Cape May Warbler	u		u		*Dendroica tigrina*
Black-throated Blue Warbler	r				*Dendroica caerulescens*
Myrtle Warbler	c		c	u	*Dendroica coronata*
Black-throated Green Warbler	c		c		*Dendroica virens*
Cerulean Warbler	u		u		*Dendroica cerulea*
Blackburnian Warbler	u		u		*Dendroica fusca*
Yellow-throated Warbler	c		c		*Dendroica dominica*
Chestnut-sided Warbler	r		r		*Dendroica pensylvanica*
Bay-breasted Warbler	u		r		*Dendroica castanea*
Blackpoll Warbler	u				*Dendroica striata*
Pine Warbler	c	u	u	u	*Dendroica pinus*
Prairie Warbler	c	u	c		*Dendroica discolor*
Palm Warbler	c		u		*Dendroica palmarum*
Ovenbird	c		u		*Seiurus aurocapillus*
Northern Waterthrush	c		c	r	*Seiurus noveboracensis*
Louisiana Waterthrush	u	c			*Seiurus motacilla*
Kentucky Warbler	u	u			*Oporornis formosus*
Connecticut Warbler	r				*Oporornis agilis*
Mourning Warbler	r		r		*Oporornis philadelphia*
Yellowthroat*	c	c			*Geothlypis trichas*
Yellow-breasted Chat*	c	c			*Icteria virens*
Hooded Warbler	c	c	u		*Wilsonia citrina*

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Wilson's Warbler	r		r		*Wilsonia pusilla*
Canada Warbler	r		u		*Wilsonia canadensis*
American Redstart	a	c	u		*Setophaga ruticilla*
House Sparrow*	c	c	c	c	*Passer domesticus*
Bobolink	c		u		*Dolichonyx oryzivorus*
Eastern Meadowlark*	c	c	c	c	*Sturnella magna*
Western Meadowlark	r				*Sturnella neglecta*
Red-winged Blackbird*	c	c	a	a	*Agelaius phoeniceus*
Orchard Oriole*	c	c			*Icterus spurius*
Baltimore Oriole	r		r		*Icterus galbula*
Rusty Blackbird	u		c	a	*Euphagus carolinus*
Brewer's Blackbird			u	u	*Euphagus cyanocephalus*
Common Grackle*	c	c	a	a	*Quiscalus quiscula*
Brown-headed Cowbird	u	u	a	a	*Molothrus ater*
Scarlet Tanager	u		r		*Piranga olivacea*
Summer Tanager*	c	c	u		*Piranga rubra*
Cardinal*	c	c	c	c	*Richmondena cardinalis*
Rose-breasted Grosbeak	u	u			*Pheucticus ludovicianus*
Blue Grosbeak	u	u	u		*Guiraca caerulea*
Indigo Bunting*	c	c	u		*Passerina cyanea*
Dickcissel	u	c			*Spiza americana*
Evening Grosbeak	o		o	o	*Hesperiphona vespertina*
Purple Finch	u		u	c	*Carpodacus purpureus*
Common Redpoll				r	*Acanthis flammea*
Pine Siskin				o	*Spinus pinus*
American Goldfinch*	c	a	c	a	*Spinus tristis*
White-winged Crossbill	r			r	*Loxia leucopter*
Rufous-sided Towhee*	c	c	c	c	*Pipilo erythrophthalmus*
Savannah Sparrow	u		c	c	*Passerculus sandwichensis*
Grasshopper Sparrow*	u	c	u	r	*Ammodramus savannarum*
LeConte's Sparrow			r	r	*Passerherbulus caudacutus*
Henslow's Sparrow	r			u	*Passerherbulus henslowii*
Sharp-tailed Sparrow			r		*Ammospiza caudacuta*
Vesper Sparrow	u		u	u	*Pooecetes gramineus*
Lark Sparrow	r	r			*Chondestes grammacus*
Bachman's Sparrow	r	r			*Aimophila aestivalis*
Slate-colored Junco	u		c	a	*Junco hyemalis*
Oregon Junco				r	*Junco oreganus*
Tree Sparrow	o			o	*Spizella arborea*
Chipping Sparrow	c	u	c	c	*Spizella passerina*
Field Sparrow*	c	c	c	a	*Spizella pusilla*
White-crowned Sparrow	u		u	c	*Zonotrichia leucophrys*
White-throated Sparrow	u		c	c	*Zonotrichia albicollis*
Fox Sparrow	u		u	c	*Passerella iliaca*
Harris Sparrow				r	*Zonotrichia querula*

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Swamp Sparrow	u		c	a	Melospiza georgiana
Song Sparrow	u		u	c	Melospiza melodia
Lapland Longspur				o	Calcarius lapponicus

1. List compiled using Birds of Wheeler National Wildlife Refuge, USFWS Refuge Leaflet 145-R4, 1969, and Alabama Birds by Imhof.

2. Classified as a threatened species by USFWS Office of Rare and Endangered Species.

*Birds nesting on Wheeler National Wildlife Refuge are denoted by an asterisk.

S March-May
S June-August
F September-November
W December-February

a Abundant
c Common
u Uncommon
o Occasional
r Rare

Table B2-4

STATE AND FEDERAL WATERFOWL MANAGEMENT AREAS - NORTH ALABAMA[1]

Area	Lake	Land and Water Acreage	Manager	Owner
Seven Mile Island--hunting	Pickwick	4,685	State	TVA
Mallard-Fox Creek--hunting	Wheeler	2,460	State	TVA
Swan Creek--hunting	Wheeler	6,242	State	TVA
Wheeler NWR--refuge	Wheeler	35,000	BSFW	BSFW
North Sauty Creek--refuge	Guntersville	5,200	State	TVA
Mud Creek--hunting	Guntersville	8,193	State	TVA
Crow Creek--refuge	Guntersville	2,512	State	TVA
Crow Creek--hunting	Guntersville	2,161	State	TVA
Raccoon Creek--hunting	Guntersville	7,080	State	TVA
Totals State		38,533		
Totals Federal		35,000		
Grand Total		73,533		

1. From North Alabama Land Use Plan by Klein, et al, TVA Division of Forestry, Fisheries, and Wildlife Development.

Table B2-5

PRESENT PUBLIC USE, NORTH ALABAMA STATE AND FEDERAL WATERFOWL AREAS (5-YEAR AVERAGE 1965-70)[1]

Use	Area									Total	Season Length (days)	Man-Day's Use Per Season-Day
	Seven-Mile Island	Swan Creek	Mallard-Fox	Mud Creek	Raccoon Creek	Crow Creek	Crow Creek Refuge	North Sauty Refuge	Wheeler NWR[2]			
	in man-day's effort											
Duck Hunting	350	10,100	2,050	700	600	100	200	300	-	14,400	40	360
Goose Hunting[3]	-	1,900	700	500	200	200	200	600	-	4,300	70	60
Upland Game Hunting	2,600	4,950	4,850	3,100	2,500	1,850	850	950	3,600	25,250	90	280
Trapping	1,500	6,200	3,800	450	350	450	-	-	-	12,750	90	140
Other Outdoor Recreation[4]	16,000	50,000	40,000	18,500	14,700	8,000	5,000	11,300	187,500	351,000	300	1,170
Total	20,450	73,150	51,400	23,250	18,350	10,600	6,250	13,150	191,100	407,700	-	-

1. From North Alabama Land Use Plan by Klein, et al, TVA Division of Forestry, Fisheries, and Wildlife Development

2. 1969-70 season only

3. For that part outside duck hunting season

4. Fishing, artifact hunting, picnicking, camping, birding, etc.

Table B2-6

Partial list of aquatic macrophytes near the proposed Bellefonte Nuclear Plant Site, Guntersville Reservoir[1]

Waterfowl* Cover	Waterfowl* Food	Scientific name	Common name	Growth form
7	6	Myriophyllum spicatum	Eurasian watermilfoil	Submersed
7	1	Ceratophyllum demersum	Coontail	Submersed
7	3	Potamogeton crispus	Crispyleaf pondweed	Submersed
7	2	Potamogeton nodosus	American pondweed	Submersed
7	4	Najas minor	Spinyleaf naiad	Submersed
7	1	Najas guadalupensis	Southern naiad	Submersed
7	6	Egeria densa	Egeria	Submersed
7	4	Elodea canadensis	Elodea	Submersed
7	2	Heteranthera dubia	Waterstargrass	Submersed
7	2	Chara sp.	Muskgrass	Submersed
3	7	Saururus cernuus	Lizardtail	Emergent
5	7	Alternanthera philoxeroides	Alligatorweed	Emergent, Floating Mat
1	3	Nelumbo lutea	American lotus	Emergent, Floating Leaf
1	2	Justicia americana	Waterwillow weed	Emergent
3	2	Eleocharis quadrangulata	Spikerush	Emergent
4	3	Eleocharis acicularis	Midget spikerush	Emergent
4	7	Ludwigia palustris	Waterpurslane	Emergent
1	5	Scirpus cyperinus	Woolgrass	Emergent
1	3	Scirpus validus	Softstem bulrush	Emergent
1	4	Scirpus americanus	Three-square	Emergent
3	4	Juncus effusus	Common bulrush	Emergent
3	5	Hibiscus militaris	Marshmallow	Emergent
2	2	Zizaniopsis miliacea	Giant cutgrass	Emergent
3	5	Polygonum sagittatum	Tear-thumb	Emergent
3	2	Polygonum hydropiperoides	Smartweed	Emergent
3	1	Polygonum pensylvanicum	Smartweed	Emergent
5	6	Echinodorus cordifolius	Burhead	Emergent
5	7	Carex sp.	Sedge	Emergent
5	5	Cyperus pseudovegetus	Sedge	Emergent
5	6	Cyperus sp.	Sedge	Emergent
2	4	Typha latifolia	Cattail	Emergent
2	4	Cephalanthus occidentalis	Buttonball	
7	3	Lemna perpusilla	Duckweed	Floating
7	2	Spirodela polyrhiza	Giant duckweed	Floating
7	4	Azolla caroliniana	Mosquito fern	Floating

*Ranking:
- 1 = High
- 2 = Good
- 3 = Fair
- 4 = Low
- 5 = Little
- 6 = Unknown
- 7 = No known use

Appendix B3

VEGETATION

1. Summary - The vegetation survey made in September 1972 encompasses an area of 1,090 acres at the proposed Bellefonte Nuclear Plant site. Boundaries of the study area are shown on the vegetation map (figure B3-1).

Acreages of the major vegetation types and their percents of the total study area are:

Type	Acreage	Percent
Cultivated land	228	21
Broom Sedge-Lespedeza	153	14
Ragweed	87	8
Elm-Ash-Soft Maple	185	17
Oak-Hickory	164	15
Mixed Conifers and Hardwoods	164	15
Black Locust	65	6
Oak-Gum	44	4

The cultivated land includes mostly fields of fescue and lespedeza, some of which have been gathered as hay in 1972. The two old field communities, broom sedge-lespedeza and ragweed, include small pockets of communities in which other species such as bitterweed or coreopsis may be dominant. Some of these enclaves may be separate communities while others may simply be manifestations of differential grazing by cattle.

Most of the forest land has been heavily logged in the last few years. The heavy logging, combined with the moderate to heavy grazing that has occurred in some strands, has been quite disruptive to the community structure. Opening up the canopy has allowed more light to filter down to the ground level with the result that average total ground cover percentages are relatively high. Similarly, the high level of grazing has tended to keep the shrub stratum percent cover comparatively low. In the table below are listed the average total percent covers for the ground vegetation and shrub stratum in each of the forest types and the percent of sampled plots that were logged in each type.

Type	Average Percent Ground Cover	Average Percent Shrub Cover	Percent of Plots Heavily Logged
Black Locust	77	10	75
Elm-Ash-Soft Maple	73	10	67
Oak-Hickory	46	17	60
Oak-Gum	45	7	0
Mixed Conifers and Hardwoods	34	24	40

With the exception of the oak-gum plots which were not cut but which are heavily grazed, there seems to be a good relationship between percent logging and total percent cover for ground vegetation. There is also an apparent inverse relationship between percent logging and percent shrub cover which at first glance seems conflicting since it might be expected that shrub cover would increase with the opening up of the canopy. At least three factors contribute to reducing the expected shrub cover level. First of all, logging is so recent that shrubs for the most part have not had time to become established in the stands. Secondly, the logging operation itself has opened up pathways to allow cattle easier entrance into the stands. Finally, the fallen brush makes ideal habitat for wildlife and encourages concentrations of deer which have been browsing heavily in the area.

As a whole, the Bellefonte site contains an average growing stock of 870 cubic feet of merchantable timber per acre and a sawtimber volume of 2,040 board feet per acre. (See Tables B3-1, B3-2, and B3-3 for a summary, broken down by hardwoods, softwoods, species, and diameter class.) These figures are below the averages of 950 cubic feet and 2,670 board feet, respectively, for Jackson County, Alabama[1] and 900 cubic feet and 3,230 board feet for the entire Tennessee River Valley.[2]

The vegetation on the plant site is typical of limestone valleys and hills throughout the region.[3,4]

Following construction of the nuclear plant, the impact area will be resurveyed periodically to assess vegetational changes. Some vegetational change is inevitable from the normal process of succession. The vegetation surveys planned as part of the scheduled monitoring program are expected to reveal any significant vegetational changes.

2. <u>Site Description</u> - The proposed Bellefonte Nuclear Plant site is on a peninsula, at about TRM 392, bounded by Guntersville Reservoir to the east and the Town Creek embayment to the west and north. The topography consists of river terrace and small hills. The elevation ranges from 595 feet at mean reservoir level to approximately 800 feet. Approximately 58 percent of the land is forested. The remaining portion has been used primarily for pasture and hay with fescue and lespedeza being the main crops.

Soils over the Bellefonte site show a highly mosaic pattern and do not correlate well with vegetation. Soils of the river terraces belong to the Etowah-Jefferson-Monogahela-Talbott association.

These are for the most part Alfisols and Ultisols[5] (Red-Yellow Podzols in the old Baldwin et al. classification system)[6,7] derived from limestone. Clay content is typically high. Fertility ranges from low to very high and is generally high where drainage is adequate. The cherty hills are covered by soils of the Fullerton-Clarksville-Greendale association. These soils are typically Alfisols and Ultisols derived from limestone. Fertility is low and presently the soils support only forest.

3. Field Procedures - A square grid was laid over the study area so that circular 1/5-acre plots were located at 1,035-foot intervals. Only plots falling in forest or abandoned fields were used. Thus, over the entire area 52 plots were sampled. Forested plots were permanently located so that the exact location could be resurveyed at later dates during the monitoring program. Old field plots were not permanently marked; however, their locations are noted by the intersection of the transect lines. Pole, sawtimber, and reproduction data were then collected.[8]

Four 1/100-acre subplots were located at the cardinal points around the periphery of each 1/5-acre plot. In each subplot, all tree stems between 1 and 5 inches DBH were recorded and classified as "understory." All small tree species under 1 inch DBH and over 18 inches tall and all shrub species over 18 inches tall were noted and classified as "shrub stratum." Percent cover was recorded for each shrub stratum species according to the following code:

1 -- less than 5 percent

2 -- 5 to 25 percent

3 -- 26 to 50 percent

4 -- 51 to 75 percent

5 -- 76 to 95 percent

6 -- over 95 percent

In addition, the general condition of the dominant species collectively was noted with a small description given of any unusual or unhealthy patterns developing.

Beginning at the four cardinal points and moving toward the center of each plot, quadrats 10.75 feet long by 1 foot wide were established. In these quadrats the ground cover (including all tree and shrub species less than 18 inches high) was recorded by species and percent cover, and the general condition of the dominant species was noted (as was done for shrubs and small trees).

A vegetation type was subjectively determined for each plot in the field.

Data on solids were obtained from a Soil Conservation Service survey.[9]

4. Data Analysis - Plots were grouped according to the vegetation types established in the field. Within each type, frequencies were established for all species to estimate the importance of their occurrence in the type. Data from all plots in all types were then combined, and an importance value index was established for each species within each of the four vegetation strata (i.e., trees, understory, shrub stratum, and ground cover). The importance value (IV) was measured in three ways. For the trees:

$$IV = (\text{Relative Density} + \text{Relative Frequency} + \text{Relative Basal Area}) \div 3$$

where

$$\text{Relative Density} = \frac{\text{Number of trees of a single species}}{\text{Total number of all trees}} \times 100,$$

$$\text{Relative Frequency} = \frac{\text{Number of occurrences of a single species}}{\text{Total number of occurrences of all species}} \times 100,$$

$$\text{Relative Basal Area} = \frac{\text{Basal area of a single species}}{\text{Total basal area of all species}} \times 100.$$

For the understory:

$$IV = \frac{\text{Relative Density} + \text{Relative Frequency}}{2}$$

For shrub stratum and ground cover:

$$IV = \frac{\text{Relative Frequency} + \text{Relative Cover}}{2}$$

where

$$\text{Relative Cover} = \frac{\text{Percent cover of a single species summed over all subplots or quadrats}}{\text{Sum of the percent covers of all species in all subplots or quadrats}} \times 100.$$

By dividing the appropriate denominator Importance Values are assigned to a linear scale ranging from 0 to 100. Since the sum of IV's of all species within a particular stratum totals 100, each Value can be viewed as a measure of the relative percentage of importance of that species in the stratum.

Tables B3-4 through B3-7 list all of the species and their importance values in the order of the values for each of the four vegetation strata. These values will provide a simple index of change in species composition between surveys.

5. Community Types - Each plot was assigned a vegetation type in the field. The plots were then generalized to describe particular community stands, and the stands were lined out on a vegetation map of the Bellefonte site (figure B3-1). In nature, stand boundaries are generally diffuse or non-existent, and those shown on the map should not be construed as hard, permanent, and exact. The map boundaries

are merely attempts to compartmentalize and classify phenomena which are in reality continuously variable.

In some of the community types described below, percent frequencies for trees are often lower than might be expected for typical stands within the type. The reason for the lower values is that extensive logging has eliminated the merchantable timber within the stands and thereby reduced species frequencies.

(1) Elm-ash-soft maple - Twenty-nine percent of the forested plots were classified as elm-ash-soft maple. Winged elm, ash, and sweet gum were the remaining dominants in the heavily cut-over stands. These stands were found on all topographic sites within the Bellefonte region. Nine percent were in large sawtimber, 36 percent were in small sawtimber, 45 percent were in pole size stands, and 9 percent were classified as seedling and sapling stands. These figures reflect the fact that most of the forested land has been heavily logged. Species and frequencies of occurrence are listed in the table below.

Scientific Name	Common Name	Percent Frequency
Ulmus sp.	Elm	55
Fraxinus sp.	Ash	55
Liquidambar styraciflua	Sweet Gum	55
Lirodendron tulipifera	Yellow Poplar	46
Acer negundo	Box Elder	36
A. rubrum	Red Maple	36
Celtis occidentalis	Hackberry	36
Robinia pseudoacacia	Black Locust	18

Scientific Name	Common Name	Percent Frequency
Acer saccharum	Sugar Maple	18
Cercis canadensis	Redbud	18
Carya sp.	Hickory	9
Gleditsia triacanthos	Honey Locust	9
Juniperus virginiana	Eastern Red Cedar	9
Pinus taeda	Loblolly Pine	9
Quercus falcata	Southern Red Oak	9
Q. muehlenbergii	Chinquapin Oak	9
Q. prinus	Chestnut Oak	9
Salix nigra	Black Willow	9
Tilia heterophylla	Basswood	9

The dominant understory trees - elm, ash and red maple - suggested that the stands were relatively stable and regenerating themselves. Hickories, persimmon, elm, and hackberry were the more common shrub stratum species while grasses and assorted vines made up the bulk of the ground cover. Listed below are the more common species in each of the below-canopy strata, along with the percent frequencies of each.

Scientific Name	Common Name	Percent Frequency
Understory:		
Ulmus sp.	Elm	46
Fraxinus sp.	Ash	23
Acer rubrum	Red Maple	14
Ulmus alata	Winged Elm	11

Scientific Name	Common Name	Percent Frequency
Shrub Stratum:		
Carya sp.	Hickory	36
Diospyros virginiana	Persimmon	21
Ulmus sp.	Elm	16
Celtis sp.	Hackberry	14
Hydrangea arborescens	Wild Hydrangea	11
Berchemia scandens	Supplejack	11
Smilax rotundifolia	Catbrier	11
Vitis rotundifolia	Muscadine	11
Ground Cover:		
Poaceae	Grass	86
Parthenocissus quinquefolia	Virginia Creeper	18
Robinia pseudoacacia	Black Locust	11
Simlax rotundifolia	Catbrier	11
Vitis rotundifolia	Muscadine	11

(2) Oak-Hickory - Twenty-six percent of the forested land was classified in the oak-hickory type. These stands consisted of oaks and hickories with the more common associates including sweet gum, black locust, and sugar maple. Stands were found on moderate to well drained soils on the high terraces and hilly slopes. Twenty percent of the stands were in large sawtimber, 30 percent were in small sawtimber, 40 percent were in pole size timber, and 10 percent were in the seedling and sapling stand size. Listed below are the forest tree species and their frequencies of occurrence in the oak-hickory plots.

Scientific Name	Common Name	Percent Frequency
Quercus muehlenbergii	Chinquapin Oak	30
Q. shumardii	Shumard Oak	30
Liquidambar styraciflua	Sweet Gum	30
Carya sp.	Hickory	20
Quercus velutina	Black Oak	20
Robinia pseudoacacia	Black Locust	20
Acer saccharum	Sugar Maple	20
Fraxinus sp.	Ash	20
Quercus alba	White Oak	10
Q. coccinea	Scarlet Oak	10
Q. falcata var. *pagodaefolia*	Cherrybark Oak	10
Q. prinus	Chestnut Oak	10
Q. stellata	Post Oak	10
Tilia heterophylla	Basswood	10
Sassafras albidum	Sassafras	10
Ulmus alata	Winged Elm	10
Carpinus caroliniana	Blue Beech	10
Cercis canadensis	Redbud	10
Gleditsia triacanthos	Honey Locust	10

Ash, hickory, and elm were the most important understory species, with redbud, hickory, persimmon, and ash being the shrub stratum dominants. The ground cover was composed largely of assorted grasses, Virginia creeper, hackberry, and muscadine. The paucity of oaks in the lower strata suggested that the stands may have been moving away from a dominant oak-hickory type. Percent frequencies for the more common lower stratal species are listed below.

Scientific Name	Common Name	Percent Frequency
Understory:		
Fraxinus sp.	Ash	33
Carya sp.	Hickory	30
Ulmus sp.	Elm	23
Cornus sp.	Dogwood	18
Juniperus virginiana	Eastern Red Cedar	15
Ulmus alata	Winged Elm	15
Shrub Stratum:		
Cercis canadensis	Redbud	30
Carya sp.	Hickory	25
Diospyros virginiana	Persimmon	25
Fraxinus sp.	Ash	23
Robinia pseudoacacia	Black Locust	20
Ulmus Alata	Winged Elm	20
Vitis rotundifolia	Muscadine	18
Ground Cover:		
Poaceae	Grass	53
Parthenocissus quinquefolia	Virginia Creeper	50
Celtis occidentalis	Hackberry	33
Vitis rotundifolia	Muscadine	30
Campsis radicans	Trumpet Creeper	15

Scientific Name	Common Name	Percent Frequency
Sassafras albidum	Sassafras	13
Phytolacca americana	Poke	13
Fraxinus sp.	Ash	13

(3) Mixed Conifers and Hardwoods - Twenty-six percent of all forest stands were grouped as mixed conifers and hardwoods. These stands were found on well drained soils on all topographic sites. Some stands were dominated by red cedar, some by loblolly or Virginia pine, some by other species. The differences between plots were not significant, so for the purposes of this study they were combined into a single broad type. (Two, small, almost pure stands of pole size loblolly pine are shown in figure B3-1. Since the stands are small enough that no plots were located in them, they are not included as a separate type.)

In general, logging has been less intense in these mixed stands. Twenty percent were in large sawtimber and 60 percent were in small timber, while only 20 percent were pole size. The species found in the plots and their frequencies of occurrence are listed below.

Scientific Name	Common Name	Percent Frequency
Pinus virginiana	Virginia Pine	80
P. echinata	Shortleaf Pine	50
P. taeda	Loblolly Pine	50
Juniperus virginiana	Eastern Red Cedar	40

Scientific Name	Common Name	Percent Frequency
Liriodendron tulipifera	Yellow Poplar	40
Quercus nigra	Water Oak	30
Carya sp.	Hickory	20
Fraxinus sp.	Ash	20
Ulmus sp.	Elm	20
Cercis canadensis	Redbud	10
Maclura pomifera	Osage Orange	10
Prunus serotina	Black Cherry	10
Quercus coccinea	Scarlet Oak	10
Q. falcata	Southern Red Oak	10
Q. falcata var. *pagodaefolia*	Cherrybark Oak	10
Q. muehlenbergii	Chinquapin Oak	10
Q. stellata	Post Oak	10
Robinia pseudoacacia	Black Locust	10
Ulmus alata	Winged Elm	10

Elm, eastern red cedar, hickory, dogwood, and winged elm were the chief understory species. The shrub stratum was dominated by winged elm and redbud. Grasses and assorted vines were most prominant in the ground cover.

The mixed conifers and hardwoods type is a temporary type of diverse origins. The makeup of the understory and shrub layers suggest that the bulk of the stands will probably change toward the elm-ash-soft maple type rather than the oak-hickory type.

The more common species at each level in the community are listed below, along with their precent frequencies.

Scientific Name	Common Name	Percent Frequency
Understory:		
Ulmus sp.	Elm	38
Juniperus virginiana	Eastern Red Cedar	28
Carya sp.	Hickory	20
Cornus sp.	Dogwood	20
Ulmus alata	Winged Elm	20
Cercis canadensis	Redbud	18
Fraxinus sp.	Ash	18
Liquidambar styraciflua	Sweet Gum	15
Quercus muehlenbergii	Chinquapin Oak	13
Shrub Stratum:		
Ulmus alata	Winged Elm	45
Cercis canadensis	Redbud	35
Berchemia scandens	Supplejack	23
Juniperus virginiana	Eastern Red Cedar	23
Celtis occidentalis	Hackberry	23
Cornus sp.	Dogwood	23
Fraxinus sp.	Ash	23
Lonicera japonica	Japanese Honeysuckle	23
Ground Cover:		
Poaceae	Grass	55
Parthenocissus quinquefolia	Virginia Creeper	48
Berchemia scandens	Supplejack	38
Lonicera japonica	Japanese Honeysuckle	33
Cassia obtusifolia	Sicklepod	20

Scientific Name	Common Name	Percent Frequency
Celtis occidentalis	Hackberry	20
Anisostichus capreolata	Cross Vine	18
Prunus serotina	Black Cherry	18
Smilax glauca	Sawbrier	18
Ulmus alata	Winged Elm	18

(4) Black Locust - Eleven percent of all wooded stands were classified as black locust. These were found on the lower slopes and terraces on well drained soils. Half of the stands were in pole size timber while the remaining half were split equally between small sawtimber and seedling-sapling stand sizes. The frequencies of the few tree species present are listed below.

Scientific Name	Common Name	Percent Frequency
Robinia pseudoacacia	Black Locust	100
Diospyros virginiana	Persimmon	50
Celtis occidentalis	Hackberry	25
Pinus taeda	Loblolly Pine	25
Prunus serotina	Black Cherry	25

The understory was dominated by elm and hackberry with redbud and black cherry playing lesser roles. Black locust was the most important shrub stratum species while grasses almost totally dominated the ground vegetation. Below are the more common understory, shrub stratum, and ground vegetation species listed in order of their frequencies.

Scientific Name	Common Name	Percent Frequency
Understory:		
Ulmus sp.	Elm	38
Celtis occidentalis	Hackberry	31
Cercis canadensis	Redbud	19
Prunus serotina	Black Cherry	19
Quercus velutina	Black Oak	13
Sassafras albidum	Sassafras	13
Shrub Stratum:		
Robinia psuedoacacia	Black Locust	25
Carya sp.	Hickory	13
Diospyros virginiana	Persimmon	13
Lonicera japonica	Japanese Honeysuckle	13
Ground Cover:		
Poaceae	Grass	100
Campsis radicans	Trumpet Creeper	19
Polyganum sp.	Smartweed	19
Celtis occidentalis	Hackberry	13
Lonicera japonica	Japanese Honeysuckle	13
Parthenocissus quinquefolia	Virginia Creeper	13
Rubus sp.	Blackberry	13

(5) Oak-Gum - Eight percent of all sampled forest stands belonged to the oak-gum type. These stands were composed largely of cherrybark oak, water oak, and sweet gum. The stands were confined for the most part to bottom land sites on which

drainage is poor. Two-thirds of the stands were classified as small sawtimber and one-third were pole size stands. Listed below are the tree species and their percent frequencies.

Scientific Name	Common Name	Percent Frequency
Quercus falcata var. *pagodaefolia*	Cherrybark Oak	100
Q. nigra	Water Oak	67
Liquidambar styraciflua	Sweet Gum	67
Quercus phellos	Willow Oak	33
Carya sp.	Hickory	33
Celtis occidentalis	Hackberry	33
Fraxinus sp.	Ash	33
Juglans nigra	Black Walnut	33

Oaks, hackberry, and elm were typical understory dominants. Hickory and supplejack were characteristic shrub stratum species; while grasses, supplejack, and hackberry were most common in the ground vegetation. Species and frequencies in each stratum are listed below.

Scientific Name	Common Name	Percent Frequency
Understory:		
Quercus falcata var. *pagodaefolia*	Cherrybark Oak	25
Q. nigra	Water Oak	25
Celtis occidentalis	Hackberry	25
Ulmus sp.	Elm	25

Scientific Name	Common Name	Percent Frequency
Rhamnus caroliniana	Carolina Buckthorn	25
Carpinus caroliniana	Blue Beech	17
Cercis canadensis	Redbud	17
Cornus sp.	Dogwood	17
Juniperus virginiana	Eastern Red Cedar	17
Morus rubra	Mulberry	17
Ulmus alata	Winged Elm	17
Viburnum prunifolium	Black Haw	17
Shrub Stratum:		
Berchemia scandens	Supplejack	25
Carya sp.	Hickory	25
Smilax rotundifolia	Catbrier	17
Callicarpa americana	French Mulberry	17
Ground Cover:		
Poaceae	Grass	92
Berchemia scandens	Supplejack	50
Celtis occidentalis	Hackberry	50
Anisostichus capreolata	Cross Vine	42
Smilax bona-nox	Bullbrier	33
Callicarpa americana	French Mulberry	25
Lonicera japonica	Japanese Honeysuckle	25
Vitis rotundifolia	Muscadine	25

(6) Broom Sedge-Lespedeza - Nine plots representing 32 percent of the open land were classified as broom sedge-lespedeza. Broom sedge, sericea lespedeza, and assorted

other grasses dominated the communities. The average percent cover for all species was 94 percent. The more important species found in the sample plots are listed below with their frequencies of occurrence.

Scientific Name	Common Name	Percent Frequency
Lespedeza sp.	Lespedeza	89
Andropogon virginicus	Broom Sedge	81
Poaceae	Grass	50
Vernonia altissima	Ironweed	31
Coreopsis tripteris	Coreopsis	28
Solanum carolinense	Horse-nettle	22
Eupatorum coelestinum	Mistflower	17
Festuca sp.	Fescue	17
Rubus sp.	Blackberry	17
Ambrosia artemisiifolia	Ragweed	17
Eupatorum serotinum	Thoroughwort	14
Houstonia sp.	Bluets	11

(7) *Ragweed* - Eighteen percent of the open land was placed in the ragweed community type. Average percent cover for all species was 96 percent. Ragweed and grasses dominated the community. Below are listed the more common species and their frequencies of occurrence.

Scientific Name	Common Name	Percent Frequency
Poaceae	Grass	90
Ambrosia artemisiifolia	Ragweed	85

Scientific Name	Common Name	Percent Frequency
Helenium amarum	Bitterweed	65
Lespedeza sp.	Lespedeza	60
Andropogon virginicus	Broom Sedge	25
Cassia obtusifolia	Sicklepod	10
Festuca sp.	Fescue	10
Solanum carolinense	Horse-nettle	10
Vernonia altissima	Ironweed	10

6. Rare or Endangered Species - No plants found on the proposed Bellefonte Nuclear Plant site are classed as rare or endangered.[10] All of the species noted are fairly typical of the region and have generally broad distribution patterns.

7. Glossary - The following definitions are provided to define technical terms as they are used only herein.

Basal Area: The total cross-sectional area of all trees of a given species measured at 4.5 feet above ground, expressed on a cross-sectional area per unit area of land basis.

Cover: The area occupied by a plant or group of plants. Percent cover is determined by visually projecting the total area of a plant onto a horizontal plane surface (such as the ground) of fixed dimensions and then estimating what percentage of that plane is occupied by the aerial projection.

DBH: The diameter of a tree measured at 4.5 feet above ground level.

Density: The number of stems of a particular species per unit area.

Distribution: The range of area occupied by a particular species.

Dominant: A plant species playing a major role in a community, determined by its relatively high cover or basal area.

Frequency: The number of plots or quadrats in which a species is found divided by the total number of plots or quadrats sampled. Percent frequency = frequency x 100. Thus frequency usually is relative only to the plots within a type; in the case of calculating the importance value index, however, frequency refers to all plots in all types.

Ground cover: All of the herbaceous plants and all woody plants less than 18 inches high within a given area.

Growing stock: The total volume per acre of all merchantable trees 5 inches DBH or larger.

Higher plants: Ferns, club mosses and flowering plants.

Merchantable timber: All sound, commercially valuable trees. In the study area this excludes blue beech and redbud.

Shrub stratum: The total of all woody vines and shrubs over 18 inches high and all trees over 18 inches high but less than one inch DBH within a given area.

Stand size: A classification system describing the volume of all timber in an acre area around the sampling site. There are four classes:

1. Large sawtimber - Stands of sawtimber trees containing a minimum of 1,500 board feet volume per acre in

living merchantable trees with more than 50 percent of the net board foot volume in trees 15 inches DBH or larger.

2. Small sawtimber - Stands of sawtimber trees containing a minimum of 1,500 net board feet per acre in living merchantable trees with 50 percent or less of the board foot volume in large trees 15 inches DBH and up.

3. Poletimber - Stands with less than 1,500 board feet per acre having at least 30 sound trees 5 inches DBH or larger per acre.

4. Seedlings and saplings - Stands with less than 1,500 board feet or 30 trees 5 inches DBH or larger per acre, but with at least 100 seedlings or saplings per acre.

Tree diameter class: A classification system used in measuring the wood volume in either cubic or board feet of a particular species. Each class represents a 2-inch range in DBH. Thus, for example, the 12-inch diameter class includes all trees from 11 to 12.99 inches DBH.

Tree size class: A classification system used in measuring the volume in cubic feet of wood of a particular species. There are two classes.

1. Pole - Applies to all hardwood species from 5 to 10.99 inches DBH and all softwoods from 5 to 8.99 inches DBH.

2. Sawtimber - Applies to all hardwood species 11 inches or over in DBH and all softwoods 9 inches or over in DBH.

Type: An association of dominant plant species normally occurring together.

Understory: All trees from 1 to 4.99 inches DBH.

Vegetation: The totality of all plants within a given area.

Volume: The total volume per acre of merchantable wood in all trees measured in cubic feet for trees 5 inches DBH and larger or in board feet for softwoods 9 inches DBH and larger and hardwoods 11 inches DBH and larger.

8. Nomenclature - Scientific nomenclature throughout this report for trees follows that of Little (1953)[11] and for other plants that of Radford, Ahles, and Bell (1969).[12]

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Table B3-1

Volume of Merchantable Sawtimber by Species and Tree Diameter Expressed on a Board Feet Per Acre Basis

Species or Species Group	Tree Diameter Class in Inches 10	12	14	16-Larger	All Diameters
Loblolly Pine	54	52	60	147	313
Shortleaf Pine	21	23	-	-	44
Virginia Pine	81	101	47	35	264
Eastern Red Cedar	18	-	18	-	36
All Softwoods	174	176	125	182	657
Black Oak	-	23	10	-	33
Cherrybark Oak	-	13	24	16	53
Shumard Oak	-	9	13	-	22
Southern Red Oak	-	6	-	-	6
Scarlet Oak	-	12	-	-	12
Water Oak	-	7	22	30	59
Chestnut Oak	-	-	-	173	173
Chinquapin Oak	-	34	40	-	74
Post Oak	-	-	13	17	30
White Oak	-	-	-	102	102
Basswood	-	-	-	40	40
Black Gum	-	-	11	-	11
Sweetgum	-	41	22	128	191
Red Maple	-	23	44	-	67
Yellow Poplar	-	-	48	27	75
Box Elder	-	7	-	-	7
Black Willow	-	-	-	18	18
Ash	-	40	-	37	77
Elm	-	-	6	-	6
Hickory	-	35	42	-	77
Sugar Maple	-	-	-	135	135
Hackberry	-	-	7	14	21
Black Locust	-	36	8	21	65
Honey Locust	-	6	-	15	21
Sassafras	-	5	-	-	5
All Hardwoods	*	297	310	773	1,380
All Species	174	473	435	955	2,037
Percent	9	23	21	47	

*Hardwood trees in this class are pole timber.

Table B3-2

Volume of Merchantable Trees by Species and Diameter Expressed on a Cubic Feet Per Acre Basis

Species or Species Group	Tree Diameter Class in Inches 6	8	10	12	14	16-Larger	All Diameters
Loblolly Pine	-	7	17	12	12	25	73
Shortleaf Pine	5	10	6	6	-	-	27
Virginia Pine	4	10	24	25	10	7	80
Eastern Red Cedar	5	19	5	-	4	-	33
All Softwoods	14	46	52	43	26	32	213
Black Oak	1	-	-	8	3	-	12
Cherrybark Oak	3	-	9	4	6	4	26
Shumard Oak	2	9	4	3	3	-	21
Southern Red Oak	-	0	3	2	-	-	5
Scarlet Oak	1	2	4	4	-	-	11
Water Oak	3	-	-	2	5	7	17
Chestnut Oak	-	9	8	-	-	35	52
Chinquapin Oak	3	7	6	10	10	-	36
Post Oak	-	-	7	-	3	3	13
White Oak	-	-	-	-	-	17	17
Basswood	-	-	-	-	-	8	8
Black Gum	-	-	-	-	3	-	3
Sweetgum	14	4	9	12	5	23	67
Red Maple	3	4	18	7	13	-	45
Yellow Poplar	-	-	6	-	11	6	23
Box Elder	3	2	10	2	-	-	17
Black Willow	-	2	-	-	-	4	6
Ash	12	23	4	13	-	8	60
Black Cherry	5	3	-	-	-	-	8
Elm	12	11	6	-	2	-	31
Hickory	3	9	3	10	11	-	36
Sugar Maple	3	3	-	-	-	26	32
Persimmon	1	5	-	-	-	-	6
Black Walnut	1	-	7	-	-	-	8
Winged Elm	2	-	3	-	-	-	5
Hackberry	4	17	5	-	2	3	31
Black Locust	4	9	25	10	2	6	56
Honey Locust	-	-	-	2	-	4	6
Osage Orange	1	-	-	-	-	-	1

Table B3-2, Contd.

Species or Species Group	6	8	10	12	14	16-Larger	All Diameters
Sassafras	-	-	-	1	-	-	1
All Hardwoods	81	119	137	90	79	154	660
All Species	95	165	189	133	105	186	873
Percent	11	19	22	15	12	21	

Table B3-3

Volume of All Merchantable Trees by Species and Tree Size Class Expressed on a Cubic Feet Per Acre Basis

Species or Species Group	Tree Size Class Pole	Sawtimber	All Classes
Loblolly Pine	7	66	73
Shortleaf Pine	15	12	27
Virginia Pine	14	66	80
Eastern Red Cedar	23	9	32
All Softwoods	59	153	212
Black Oak	1	11	12
Cherrybark Oak	13	13	26
Shumard Oak	16	5	21
Southern Red Oak	3	2	5
Scarlet Oak	8	4	12
Water Oak	3	13	16
Chestnut Oak	17	35	52
Chinquapin Oak	15	21	36
Post Oak	7	6	13
White Oak	-	17	17
Basswood	-	8	8
Black Gum	-	3	3
Sweetgum	27	40	67
Red Maple	25	20	45
Yellow Poplar	6	17	23
Box Elder	15	2	17
Black Willow	2	4	6
Ash	39	21	60
Black Cherry	8	-	8
Elm	29	2	31
Hickory	15	21	36
Sugar Maple	6	26	32
Persimmon	6	-	6
Black Walnut	8	-	8
Winged Elm	5	-	5
Hackberry	26	6	32
Black Locust	37	19	56
Honey Locust	-	6	6
Osage Orange	1	-	1
Sassafras	-	1	1
All Hardwoods	338	323	661
All Species	397	476	873
Percent	46	54	100

Table B3-4

Tree Species Found in the **Bellefonte** Nuclear Plant Site Vegetation Survey, Arranged According to Importance Value Index.

Scientific Name	Common Name	Importance Value Index
Liquidambar styraciflua	Sweetgum	9.74
Pinus virginiana	Virginia Pine	7.60
Fraxinus sp.	Ash	7.10
Robinia pseudoacacia	Black Locust	6.53
Pinus taeda	Loblolly Pine	5.82
Carya sp.	Hickory	4.61
Ulmus sp.	Elm	4.47
Quercus muehlenbergii	Chinquapin Oak	4.13
Acer rubrum	Red Maple	4.05
Juniperus virginiana	Eastern Red Cedar	3.79
Quercus prinus	Chestnut Oak	3.49
Q. Falcata var. pagodaefolia	Cherrybark Oak	3.02
Pinus echinata	Shortleaf Pine	2.81
Celtis sp.	Hackberry	2.79
Quercus nigra	Water Oak	2.73
Liriodendron tulipifera	Yellow Poplar	2.70
Acer saccharum	Sugar Maple	2.55
Quercus shumardii	Shumard Oak	2.20
Acer negundo	Box Elder	2.12
Quercus velutina	Black Oak	1.71
Cercis canadensis	Redbud	1.57
Tilia heterophylla	Basswood	1.40
Quercus coccinea	Scarlet Oak	1.36
Prunus serotina	Black Cherry	1.34
Quercus stellata	Post Oak	1.26
Q. alba	White Oak	1.19
Gleditsia tricanthos	Honey Locust	.99
Juglans nigra	Black Walnut	.95
Quercus falcata	Southern Red Oak	.83
Nyssa sylvatica	Black Gum	.81
Ulmus alata	Winged Elm	.75

Table B3-4, Contd.

Scientific Name	Common Name	Importance Value Index
Diospyros virginiana	Persimmon	.74
Salix nigra	Black Willow	.54
Sassafras albidum	Sassafras	.43
Quercus phellos	Willow Oak	.39
Carpinus carolinanan	Blue Beech	.36
Maclura pomifera	Osage Orange	.36

Table B3-5

Understory Species Found in the Bellefonte Nuclear Plant Site Vegetation Survey, Arranged According to Importance Value Index.

Scientific Name	Common Name	Importance Value Index
Ulmus sp.	Elm	12.68
Celtis sp.	Hackberry	7.88
Fraxinus sp.	Ash	7.48
Juniperus virginiana	Eastern Red Cedar	7.48
Carya sp.	Hickory	6.50
Ulmus alata	Winged Elm	6.44
Cornus florida	Flowering Dogwood	4.82
Cercis canadensis	Redbud	4.50
Liquidambar styraciflua	Sweetgum	3.52
Quercus prinus	Chestnut Oak	3.40
Acer rubrum	Red Maple	3.05
Quercus coccinea	Scarlet Oak	2.81
Carpinus caroliniana	Blue Beech	2.46
Nyssa sylvatica	Black Gum	2.34
Kalmia latifolia	Mountain Laurel	2.15
Acer saccharum	Sugar Maple	1.93
Viburnum prunifolium	Black Haw	1.76
Quercus muehlenbergii	Chinquapin Oak	1.60
Fagus grandifolia	American Beech	1.42
Morus rubra	Mulberry	1.27
Quercus alba	White Oak	1.22
Prunus serotina	Black Cherry	1.20
Quercus falcata	Southern Red Oak	1.07
Q. nigra	Water Oak	1.00
Acer negundo	Box Elder	1.00
Robinia pseudoacacia	Black Locust	.94
Diospyros virginiana	Persimmon	.94
Pinus echinata	Shortleaf Pine	.94
Quercus velutina	Black Oak	.87
Liriodendron tulipifera	Yellow Poplar	.75
Rhamnus caroliniana	Carolina Buckthorn	.67
Gleditsia triacanthos	Honey Locust	.60

Table B3-5, Contd.

Scientific Name	Common Name	Importance Value Index
Quercus falcata var. pagodaefolia	Cherrybark Oak	.60
Oxydendrum arboreum	Sourwood	.47
Quercus phellos	Willow Oak	.40
Q. stellata	Post Oak	.40
Sassafras albidum	Sassafras	.40
Tilia heterophylla	Basswood	.27
Ilex decidua	Possum Haw	.20
Lindera benzoin	Spicebush	.20
Pinus taeda	Loblolly Pine	.20
P. virginiana	Virginia Pine	.20

Table B3-6

Shrub Stratum Vegetation Found in the Bellefonte Nuclear Plant Site Vegetation Survey, Arranged According to Importance Value Index.

Scientific Name	Common Name	Importance Value Index
Ulmus alata	Winged Elm	6.74
Cercis canadensis	Redbud	6.10
Lonicera japonica	Japanese Honeysuckle	5.78
Carya sp.	Hickory	5.18
Rubus sp.	Blackberry	5.04
Diospyros virginiana	Persimmon	4.97
Robinia pseudoacacia	Black Locust	4.12
Fraxinus sp.	Ash	3.96
Cornus sp.	Dogwood	3.81
Berchemia scandens	Supplejack	3.34
Vitis rotundifolia	Muscadine	3.32
Juniperus virginiana	Eastern Red Cedar	2.86
Celtis sp.	Hackberry	2.65
Sassafras albidum	Sassafras	2.21
Carpinus caroliniana	Blue Beech	2.07
Ulmus sp.	Elm	1.81
Quercus velutina	Black Oak	1.77
Liriodendron tulipifera	Yellow Poplar	1.75
Quercus coccinea	Scarlet Oak	1.74
Acer rubrum	Red Maple	1.73
Smilax rotundifolia	Catbrier	1.60
Quercus prinus	Chestnut Oak	1.59
Lindera benzoin	Spicebush	1.53
Kalmia latifolia	Mountain Laurel	1.51
Vaccinium corymbosum	Highbush Blueberry	1.24
Ampleopsis cordata	Heartleaf Ampleopsis	1.18
Campsis radicans	Trumpet Creeper	1.18
Liquidambar styraciflua	Sweetgum	1.18
Rhamnus caroliniana	Carolina Buckthorn	1.18
Acer saccharum	Sugar Maple	1.17
Prunus serotina	Black Cherry	1.12

Table B3-6, Contd.

Scientific Name	Common Name	Importance Value Index
Quercus muehlenbergii	Chinquapin Oak	1.12
Callicarpa americana	French Mulberry	1.04
Smilax bona-nox	Bullbrier	.99
Ilex decidua	Possum Haw	.98
Hydrangea quercifolia	Oakleaf Hydrangea	.97
Vitis palmata	Red Grape	.96
Quercus stellata	Post Oak	.90
Acer negundo	Box Elder	.90
Hydrangea arborescens	Wild Hydrangea	.70
Oxydendrum arboreum	Sourwood	.62
Rhus copallina	Winged Sumac	.56
Fagus grandifolia	American Beech	.48
Morus rubra	Mulberry	.42
Rhus radicans	Poison Ivy	.34
Bumelia lycioides	Southern Buckthorn	.34
Cocculus carolinus	Coralbeads	.28
Nyssa sylvatica	Black Gum	.28
Quercus falcata	Southern Red Oak	.28
Aesculus octandra	Buckeye	.14
Alnus serrulata	Common Alder	.14
Euonymous americanus	Strawberry Bush	.14
Ostrya virginiana	Ironwood	.14
Parthenocissus quinquefolia	Virginia Creeper	.14
Pinus taeda	Loblolly Pine	.14
Quercus alba	White Oak	.14
Q. shumardii	Shumard Oak	.14
Rhododendon nudiflorum	Pinxter-flower	.14
Salix nigra	Black Willow	.14
Sambucus canadensis	Elder	.14
Smilax glauca	Sawbrier	.14
Vaccinium arboreum	Sparkleberry	.14
Viburnum prunifolium	Black Haw	.14
Quercus phellos	Willow Oak	.14

Table B3-7

Ground Cover Vegetation Found in the Bellefonte Nuclear Plant Site Vegetation Survey, Arranged According to Importance Value Index.

Scientific Name	Common Name	Importance
Poaceae	Grass	32.50
Lespedeza sp.	Lespedeza	7.60
Andropogon virginicus	Broom Sedge	6.27
Parthenocissus quinquefolia	Virginia Creeper	4.52
Lonicera japonica	Japanese Honeysuckle	3.53
Ambrosia artemisiifolia	Ragweed	3.25
Vitis rotundifolia	Muscadine	2.32
Celtis sp.	Hackberry	2.32
Phytolacca americana	Poke	1.56
Coreopsis tripteris	Coreopsis	1.54
Berchemia scandens	Supplejack	1.50
Campsis radicans	Trumpet Creeper	1.42
Helenium amarum	Bitterweed	1.34
Rubus sp.	Blackberry	1.24
Vernonia altissima	Ironweed	1.24
Festuca sp.	Fescue	1.22
Cercis canadensis	Redbud	1.08
Rhus radicans	Poison Ivy	1.03
Anisostichus capreolata	Cross Vine	1.02
Polyganum sp.	Smartweed	.92
Ulmus alata	Winged Elm	.85
Smilax rotundifolia	Catbrier	.82
S. glauca	Sawbrier	.78
Solanum carolinense	Horse-nettle	.72
Impatiens capensis	Jewel-weed	.72
Robinia pseudoacacia	Black Locust	.69
Desmodium sp.	Beggar's Lice	.69
Prunus serotina	Black Cherry	.65
Eupatorum serotinum	Thoroughwort	.64
E. coelestinum	Mistflower	.62
Smilax bona-nox	Bullbrier	.58

Table B3-7, Contd.

Scientific Name	Common Name	Importance Value Index
Fraxinus sp.	Ash	.58
Acer negundo	Box Elder	.58
Cornus sp.	Dogwood	.56
Sassafras albidum	Sassafras	.52
Acer rubrum	Red Maple	.52
Diospyros virginiana	Persimmon	.50
Carya sp.	Hickory	.47
Asplenium platyneuron	Black Spleenwort	.46
Houstonia sp.	Bluets	.41
Quercus stellata	Post Oak	.40
Liquidambar styraciflua	Sweetgum	.36
Boehmeria cylindrica	False Nettle	.36
Sedum sp.	Stone Crop	.34
Cassia fasciculata	Partridge Pea	.34
Dioscorea villosa	Wild Yam	.30
Solanum americanum	Deadly Nightshade	.28
Erechtites hieracifolia	Fireweed	.28
Solidago sp.	Goldenrod	.26
Chimaphila maculata	Pipsissewa	.26
Cocculus carolinus	Coralbeads	.26
Polystichum acrostichoides	Christmas Fern	.26
Quercus muehlenbergii	Chinquapin Oak	.26
Q. phellos	Willow Oak	.26
Ampleopsis cordata	Heartleaf Ampleopsis	.24
Galium sp.	Bedstraw	.24
Iva annua	Marsh Elder	.24
Hibiscus sp.	Hibiscus	.24
Carpinus caroliniana	Blue Beech	.21
Euonymus americanus	Strawberry Bush	.20
Liriodendron tulipifera	Yellow Poplar	.20
Philadelphis inodorus	Mock-orange	.20
Quercus alba	White Oak	.20
Q. prinus	Chestnut Oak	.20

Appendix B4

OTHER AQUATIC LIFE SURVEYS

1. Introduction - Surveys to assess the limnological characteristics of the proposed site area near Bellefonte, Alabama, were conducted in April, September, and November 1971 and in July, August, September, and October 1972. Shorelines, embayments, tributary areas, and the Tennessee River were examined and sampled. Ten stations, located between TRM 390.8 and TRM 392.3 along the right bank and in the middle of the navigation channel and alternate channel (figure B4-1), were selected for detailed investigation in 1972.

2. Methods and sample locations - A rough approximation of bottom topography was established by means of a series of sonar profiles determined along selected transects near the proposed site. The line transects for the Bellefonte site are shown in the offset in figure B4-2. Five such profiles were made between TRM 391.2 and TRM 392.8 (figure B4-2). The recordings were used to graph the general topographic features of the reservoir bottom and, when possible, to indicate large differences in sediment composition; thus the illustrations are not to scale. Areas for sampling benthic sediment and macroinvertebrates were tentatively designated from this knowledge. The final sampling stations were then determined from the results of trial sampling.

The detailed sampling in 1972 included three bottom samples at each sampling point shown in figure B4-1. The samples were separated for analysis of sediment and benthic macroinvertebrates.

Organic and volatile solids content along with particle size composition were determined from the sediment portion of these samples. The percentages of volatile solids were determined by ashing subsamples at 600°C in a muffle furnace for 6 hours. Samples were cooled and weighed repeatedly until a constant weight was determined. Particle size was determined by using Krumbein and Pettijohn's standard pipette analysis techniques[1] (Table B4-1). Replicate samples for analyses of benthic macroinvertebrates were washed free of sediment on graded screens in the field, and the material collected from the screens was preserved with ethanol and returned to the laboratory for processing. All macroinvertebrates were identified, counted, and weighed. Neither age nor length was determined, but a general impression of population structure was obtained by observation of the specimens. Preliminary identifications reported here were to genera for all organisms except Amniocolidae snails. The total wet weight obtained in replicate samples was used to calculate biomass in terms of grams per square meter (Table B4-2).

Duplicate samples of phytoplankton were taken in warm weather at the surface and 1 and 3 meters below the surface in July. The samples were poured into 100-ml Nalgene bottles and preserved by adding 2 ml of formalin. Phytoplankton were identified to genera and counted by using an inverted microscope at 312.5X. The raw enumerations and identifications were coded and processed by TVA computer programs. The percentage composition of the phytoplankton and the predominant genera that occurred at the site are shown in Tables B4-3 and B4-4, respectively.

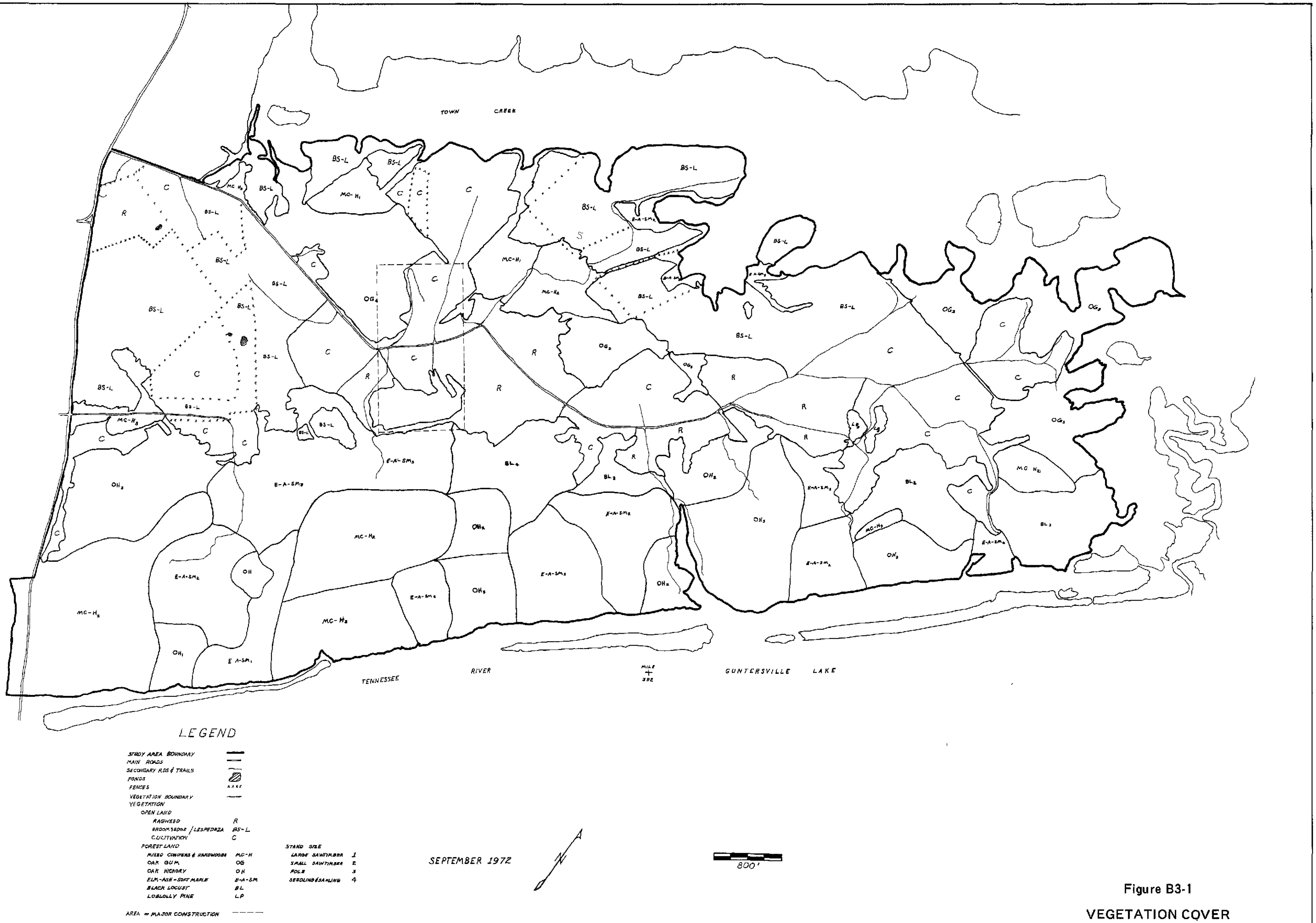


Figure B3-1

VEGETATION COVER
BELLEFONTE NUCLEAR PLANT SITE

Also in July, vertical qualitative zooplankton samples were collected by lowering a plankton net, 1/2 meter in diameter and equipped with a No. 20 net (173 mesh per inch), to the bottom and raising it to the surface in a single haul. All samples were taken from midchannel. In the embayments horizontal tows were made adjacent to watermilfoil beds.

In October preliminary quantitative zooplankton samples were collected with a Van Dorn water sampler at the same stations used in July. Duplicate samples composed of 7 liters of water were collected at the surface, middle, and near the bottom of the vertical water column. The zooplankters were concentrated by pouring the water through a Wisconsin plankton net bucket, preserved with ethanol, and returned to the laboratory for identification and enumeration with the aid of a compound microscope at 100X. Genera and species found are reported in Table B4-5. Those occurring most frequently are indicated with asterisks.

Concentrations of chlorophyll _a_ pigment were determined by filtering collected water through 1.2mu Millipore membrane filters; extracting the pigment in a dark refrigerator for 24 hours with a solution of 90 percent acetone, which dissolves the filter and its collected residue; and reading individual stock of pigment reported as chlorophyll _a_ per unit of volume was estimated (Table B4-6). A mean concentration was determined for each depth.

3. General observations - The bottom of the reservoir at Bellefonte near areas of proposed construction impact has a smooth gradient and the channel banks slope gradually to a depth of 25 to 30 feet at midchannel. The sediment is basically fine, dominated by very fine sand. Little volatile material is present--only 0.1 to 0.6 percent of the weight was lost by ashing the samples at 600°C. The results of trace metal analysis of bottom sediments in the vicinity of the Bellefonte site are shown in Table B4-7.

The macroinvertebrate fauna of the channel bottom and slopes is limited in diversity, but that of the shoreline, island slopes, overbank macrophyte beds, and embayments was diverse. Additional careful shoreline work will be necessary to document the fauna more fully. The rooted macrophyte flora was surveyed to determine species and to map the distribution of watermilfoil. The partial list of flora is shown in Table 1.2-17, in section 1.2, and a map illustrating distribution of watermilfoil is shown in figure B4-3. The macrophyte fauna in a downstream watermilfoil bed surveyed in 1969-70 is presented in Table B4-8.

Chrysophyta and Chlorophyta (diatoms and green algae) are the dominant phytoplankters. The actual abundance of various forms is very unevenly distributed within and between given water masses. These phytoplankters are preyed on by a diverse sooplankton assemblage. In turn, many of the zooplankters are preyed on by other more active zooplankters such as Chaoborus and Leptodora. Each step in the trophic network increases the diversity of pathways. Additionally, many zooplankters and macroinvertebrates are associated with the macrophyte beds.

Present sample data would suggest that a limited topographic diversity and restricting sediment composition are reducing the diversity of macroinvertebrates in the Tennessee River near the proposed Bellefonte site. Macrophyte beds and shoreline development provide multilevel stratification and diverse habitats for shoreline organisms, and samples reflect this diversity of physical habitat.

REFERENCES FOR APPENDIX B4

1. Krumbein, W. C., and F. J. Pettijohn. 1938. Manual of Sedimentary Petrography. Appleton-Century-Crofts, Inc., New York. 549 pp.

Table B4-1

SIEVE ANALYSIS AND PERCENTAGE OF VOLATILE SOLIDS IN THE BENTHIC SEDIMENTS

COLLECTED AT BELLEFONTE - AUGUST 1972

Station TRM, Bank	Particulate Sizes (percent) Very Fine Sand (1/8-1/16 mm)	Coarse Silt (1/32 mm)	Medium Silt (1/64 mm)	Fine Silt (1/128 mm)	Very Fine Silt (1/256 mm)	Coarse Clay (1/512 mm)	Medium Clay (1/1024 mm)	Organic Content
390.8, right	60.55	5.51	3.61	0.36	8.13	0.70	5.56	0.6
391.3, right	52.54	11.71	6.87	3.45	7.79	3.46	2.47	0.3
391.6, right	51.07	0.48	7.87	13.18	7.37	3.47	2.45	0.1
392.0, right	62.85	6.18	6.32	7.90	4.08	1.24	2.62	0.2
392.3, right	54.04	5.54	10.75	7.20	4.59	2.00	2.98	0.3

Table B4-2

NUMBER AND WET WEIGHTS OF BENTHIC FAUNA TAKEN IN EACH PONAR DREDGE AT THE BELLEFONTE STATIONS - JULY 1972

Sample	Sampling Location (TRM, right bank) 390.8			391.3			391.6			392.0			392.3		
Organism	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Amphipoda															
Gammarus sp.					1	1									
Diptera															
Chaoborus sp.	1	1				2									
Chironomus sp.	1	2		3	22	29					1	3	1		
Chrysops sp.					1										
Coelotanypus sp.						1		3					1	1	1
Pentaneura sp.				3	1	3	1	1		2	5	6	1	2	2
Ephemeroptera															
Caenis sp.					1	1									
Hexagenia sp.		1	No organisms	6			10	10			9	10	3	4	4
Pelecypoda															
Corbicula sp.	4	2		3	2	1	6	3	10	6	4	8	6	12	20
Oligochaeta															
Branchiura sp.		1		2											
Total wet weight per dredge sample (g)	16.567	16.901	-	112.612	00.062	00.071	01.145	01.180	57.590	00.150	00.853	00.792	00.318	00.670	01.446
Avg. weight g/m^2		287.3			645.4			342.9			10.27			13.92	

Table B4-3

PERCENT COMPOSITION OF SUMMER PHYTOPLANKTON SAMPLES - BELLEFONTE SITE

PHYTOPLANKTON COMPOSITION (PERCENT) AT INDICATED DEPTH (M)

	TRM 391.3			TRM 392.3		
	Surf.	1	3	Surf.	1	3
Chrysophyta	68.85	64.30	71.85	65.10	81.15	68.50
Chlorophyta	23.80	30.40	21.50	31.00	14.45	21.60
Cyanophyta	4.70	3.70	5.30	1.40	4.40	8.75
Euglenophyta	0.45	0.60	0.45	1.40		1.15
Pyrrophyta		0.60	0.90	1.10		

Table B4-4

PREDOMINANT GENERA OF PHYTOPLANKTON THAT OCCURRED IN THE EPILIMNION AT BELLEFONTE SITE (JULY 6, 1972)

Chrysophyta (Diatoms)

Asterionella sp.
Cocconeis sp.
Cyclotella sp.
Cymbella sp.
Diatoma sp.
Dinobryon sp.
Eunotia sp.
Fragilaria sp.
Gyrosigma sp.
Melosira sp.
Navicula sp.
Nitzschia sp.
Rhizosolenia sp.
Stephanodiscus sp.
Synedra sp.
Tabellaria sp.

Chlorophyta (Greens)

Ankistrodesmus sp.
Carteria sp.
Chlamydomonas sp.
Chlorella sp.
Cosmarium sp.
Dictyosphaerium sp.
Eudorina sp.
Kirchneriella sp.
Pandorina sp.
Pediastrum sp.
Protococcus sp.
Scenedesmus sp.
Staurastrum sp.
Tetraedron sp.
Tetraspora sp.

Cyanophyta (Bluegreens)

Anabaena sp.
Aphanizomenon sp.
Arthrospira sp.
Coelosphaerium sp.
Merismopedia sp.
Oscillatoria sp.

Euglenophyta (Euglenoids)

Euglena sp.
Phacus sp.

Pyrrophyta (Browns)

Ceratium sp.
Cryptomonas sp.
Glenodinium sp.
Gymnodinium sp.
Peridinium sp.

Table B4-5

ZOOPLANKTON AT THE BELLEFONTE STATIONS - JULY 6 AND OCTOBER 3, 1972

Organisms	TRM 391.3 July	TRM 391.3 October	TRM 392.3 July	TRM 392.3 October
Argulus japonicus	X			
Asplanchna sp.	X	X	X	X
Bosmina longirostris*	X	X	X	X
Brachionus angularis*	X	X	X	X
Brachionus bennini	X			
Brachionus bidentata	X		X	
Brachionus budapestinensis	X	X	X	
Brachionus caudatus	X	X	X	X
Brachionus calyciflorus*	X	X	X	X
Brachionus nilsoni	X			
Brachionus quadridentatus	X		X	
Ceriodaphnia lacustris	X			X
Cyclops vernalis	X	X	X	X
Daphnia parvula			X	
Daphnia retrocurva	X	X	X	X
Diaphanosoma leuchtenbergianum	X	X	X	X
Diaptomus pallidus	X	X	X	
Diaptomus reighardi	X		X	
Ergasilus sp.	X			X
Euchlanis sp.	X			
Ilyocryptus spinifer	X	X	X	
Keratella sp.*	X	X	X	X
Keratella cochlearis	X	X	X	X
Keratella earlinae			X	
Leptodora kindtii	X		X	
Mesocyclops edax	X	X	X	X
Moina micrura		X		
Monostyla sp.	X			
Nitocra lacustris	X		X	
Platyias patulus	X		X	X
Platyias quadricornis	X			
Ploesoma sp.			X	
Polyarthra crystallina				X
Scapholeberis kingi			X	
Sida crystallina	X		X	
Simocephalus serrulatus		X		
Synchaeta sp.	X		X	X
Trichocera sp.			X	
Total	30	16	27	16

*Zooplankters that occurred most frequently in the quantitative samples collected on October 3, 1972

Table B4-6

VERTICAL CHLOROPHYLL "a" ESTIMATES FROM SUMMER SHADES

Bellefonte, July 6, 1972

Depth (m)	TRM 391.3 Sample 1	TRM 391.3 Sample 2	TRM 391.3 Avg.	TRM 392.3 Sample 1	TRM 392.3 Sample 2	TRM 392.3 Avg.
	mg/m³					
0.0	2.28	2.17	2.23	3.15	4.02	3.59
1.0	2.50	2.50	2.50	2.50	4.02	3.26
3.0	2.28	3.15	2.72	3.38	4.02	3.70

Table B4-7

Trace Metal Analyses of Bottom Sediments

In Vicinity of the Bellefonte Nuclear Plant Site

Stream*	Metals Content of Sediment (µg/g) (dry weight)												
	Iron	Manganese	Copper	Zinc	Chromium	Aluminum	Nickel	Silver	Lead	Mercury	Barium	Cadmium	Beryllium
TRM													
366.0 RB	32,000	4,600	16	170	32	29,000	27	2	9	0.11	<5	1	2
366.0 MC	38,000	4,500	41	450	58	40,000	55	2	20	1.5	<8	2	2
366.0 LB	37,000	3,600	36	35	52	36,000	39	.7	28	1.1	<8	1	2
368.9 MC	45,000	1,400	23	160	52	45,000	26	2	18	0.42	<7	1	3
368.9 LB	30,000	2,200	31	340	35	25,000	48	2	20	1.0	<7	1	2
390.8 RB	18,000	1,500	23	240	26	17,000	54	2	15	0.46	<4	1	0.8
392.3 RB	19,000	1,100	16	120	21	16,000	19	1	11	0.29	<4	0.8	0.8

Samples collected August 31, 1972

*RB - right bank
MC - mid-channel
LB - left bank

Table B4-8

BENTHIC POPULATION MEANS AND STANDARD DEVIATIONS CALCULATED FOR A 9- BY 9-INCH EKMAN DREDGE SAMPLE - GUNTERSVILLE RESERVOIR, JAGGER BRANCH (HONEYCOMB CREEK) - MARCH 25, 1969 - APRIL 14, 1969

	March 25, 1969 24-Hour Prebenthic Subplots						April 2, 1969 24-Hour Postbenthic Subplots						April 14, 1969 2-Week Postbenthic Subplots					
	A		B		C		A		B		C		A		B		C	
	X̄[a]	s[b]	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s
Gastropoda																		
Basommatophora																		
Physidae																		
Physa	4.11	4.29	4.00	5.76	6.00	7.00	6.20	3.70	5.50	4.51	0.60	0.89	2.00	2.00	2.60	2.51	0.75	0.96
Planorbidae																		
Gyraulus	77.33	117.49	22.17	31.16	44.33	51.25	112.60	106.02	70.00	17.09	21.20	8.64	79.00	67.16	38.20	25.12	32.25	28.27
Mesogastropoda																		
Hydrobiidae																		
Marstonia	4.78	6.06	2.00	2.76	2.33	4.04	2.80	3.83	0.33	0.58			11.20	13.26	0.20	0.45	1.75	0.50
Pleuroceridae																		
Pleurocera	0.22	0.44	1.00	1.27	0.33	0.58			0.75	1.50					0.20	0.45		
Pelecypoda																		
Heterodonta																		
Corbiculidae																		
Corbicula	0.44	0.88	6.17	6.11	0.67	0.58	0.60	0.89	1.25	0.96	0.80	0.84	0.20	0.45	3.20	1.79		
Crustacea																		
Amphipoda							0.20	0.45										
Oligochaeta	0.11	0.33									0.40	0.55	1.00	1.41	1.20	0.84	1.25	0.50
Hirudinea											0.20	0.45						
Insecta																		
Ephemeroptera																		
Ephemeridae																		
Hexagenia	0.11	0.33									0.20	0.45	0.20	0.45	0.80	1.30		
Baetidae																		
Caenis	1.89	2.26	0.17	0.41			0.80	0.84	0.50	1.00			0.60	1.34	0.40	0.55		
Heptageniidae																		
Stenonema							0.20	0.45										
Lepidoptera																		
Pyralididae																		
Nymphula	0.11	0.33	0.33	0.52	1.00	1.00	0.60	0.89	1.25	1.50	0.20	0.45			0.40	0.55		
Odonata																		
Coenagrionidae																		
Enallagma	3.11	1.90	0.50	1.23	1.67	2.89	6.80	6.22	2.00	1.41	0.60	0.89	4.60	6.07	4.80	1.92	1.00	1.41
Libellulidae	0.11	0.33			0.33	0.58					0.20	0.45						
Diptera[c]	9.22	9.16	5.33	5.12	4.67	3.06	2.20	3.49	4.00	2.16	2.20	2.39	3.20	3.12	7.80	5.17	8.50	2.89

a. Population Mean
b. Population Standard Deviation
c. Family Chironomidae makes up 90 percent of the order Diptera

Table B4-8
(continued)

	April 28, 1969 1-Month Postbenthic Subplots						May 26, 1969 2-Month Postbenthic Subplots						June 30, 1969 3-Month Postbenthic Subplots					
	A		B		C		A		B		C		A		B		C	
	$\bar{X}$[a]	s[b]	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Gastropoda																		
Basommatophora																		
Physidae																		
Physa			0.20	0.45			0.25	0.50	0.20	0.45								
Planorbidae																		
Gyraulus	8.00	8.37	13.40	17.39	18.80	17.48	0.50	1.00										
Mesogastropoda																		
Hydrobiidae																		
Marstonia			0.40	0.89	1.00	2.24					0.20	0.45	0.50	0.84				
Pleuroceridae																		
Pleurocera			0.40	0.89					0.60	1.34					0.40	0.89		
Pelecypoda																		
Heterodonta																		
Corbiculidae																		
Corbicula	1.00	0.82	3.60	2.07	0.60	0.89			1.80	1.64	0.60	0.89	0.17	0.41	2.00	1.87	1.20	1.30
Crustacea																		
Amphipoda			0.20	0.45	0.60	1.34	0.25	0.50										
Oligochaeta	1.75	1.26	1.00	1.23	0.20	0.45	1.75	1.50	2.80	2.59	1.00	0.71	2.00	1.27	9.40	4.39	6.80	3.42
Hirudinea	0.25	0.50																
Insecta																		
Ephemeroptera																		
Ephemeridae																		
Hexagenia									0.40	0.55					1.20	0.84		
Baetidae																		
Caenis	18.75	14.59	6.00	6.12	27.60	24.79					0.20	0.45			0.40	0.55		
Heptageniidae																		
Stenonema													0.33	0.87				
Lepidoptera																		
Pyralididae																		
Nymphula	0.25	0.50																
Odonata																		
Coenagrionidae																		
Enallagma	7.75	12.87	8.60	10.07	9.60	8.79												
Libellulidae	0.25	0.50	0.20	0.45	0.20	0.45												
Diptera[c]	4.25	3.69	3.20	1.92	10.40	4.78	106.50	43.78	53.60	19.42	52.00	7.52	18.50	6.80	28.20	9.58	25.00	9.49

a. Population Mean
b. Population Standard Deviation
c. Family Chironomidae makes up 90 percent of the order Diptera

Table B4-8
(continued)

	October 8, 1969 6-Month Postbenthic Subplots						March 31, 1970 1-Year Postbenthic Subplots					
	A		B		C		A		B		C	
	$\bar{X}$ [a]	s [b]	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Gastropoda												
Basommatophora												
Physidae												
Physa												
Planorbidae												
Gyraulus												
Mesogastropoda												
Hydrobiidae												
Marstonia												
Pleuroceridae												
Pleurocera									0.20	0.45		
Pelecypoda												
Heterodonta												
Corbiculidae												
Corbicula	1.40	0.55	1.80	1.10	0.25	0.50	72.40	148.00	6.00	6.89	2.40	2.30
Crustacea												
Amphipoda			0.40	0.55								
Oligochaeta	0.20	0.45	0.40	0.55			2.80	1.92	0.40	0.55	10.60	9.86
Hirudinea					0.25	0.50			0.20	0.45	0.20	0.45
Insecta												
Ephemeroptera												
Ephemeridae												
Hexagenia			0.40	0.89	4.75	5.74	0.20	0.45	8.40	6.19	0.20	0.45
Baetidae												
Caenis			0.20	0.45								
Heptageniidae												
Stenonema	0.40	0.55										
Lepidoptera												
Pyralididae												
Nymphula					0.25	0.50						
Odonata												
Coenagrionidae												
Enallagma												
Libellulidae												
Diptera [c]	56.00	27.48	25.00	7.65	20.50	2.52	3.20	4.44	43.80	11.93	6.40	4.83

a. Population Mean
b. Population Standard Deviation
c. Family Chironomidae makes up 90 percent of the order Diptera

Table B4-8
(continued)

	March 25, 1969 24-Hour Presurface Subplots						April 2, 1969 24-Hour Postsurface Subplots						April 14, 1969 2-Week Postsurface Subplots					
	A		B		C		A		B		C		A		B		C	
	$\bar{X}$[a]	s[b]	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Gastropoda																		
Basommatophora																		
Physidae																		
Physa	4.88	5.08	11.00	6.25	13.33	7.23	7.33	6.43	5.67	7.23	20.00	14.41	3.60	6.95	1.25	0.96	1.00	0.82
Planorbidae																		
Gyraulus	60.75	76.22	350.67	72.76	238.67	72.59	352.33	275.96	186.67	87.50	273.40	124.43	69.00	60.19	85.75	31.02	126.75	82.15
Mesogastropoda																		
Hydrobiidae																		
Marstonia	0.13	0.35															0.50	0.58
Pleuroceridae																		
Pleurocera																		
Pelecypoda																		
Heterodonta																		
Corbiculidae																		
Corbicula																		
Crustacea																		
Amphipoda									0.33	0.58					0.50	0.58		
Oligochaeta																		
Hirudinea																		
Insecta																		
Ephemeroptera																		
Ephemeridae																		
Hexagenia							1.00	1.73										
Baetidae																		
Caenis	2.88	4.61					0.33	0.58	0.33	0.58	0.20	0.45	2.80	1.10	1.25	1.50	2.25	1.89
Heptageniidae																		
Stenonema																		
Lepidoptera																		
Pyralididae																		
Nymphula	0.38	0.52	3.33	1.53	3.00				0.67	0.58	3.20	3.27						
Odonata																		
Coenagrionidae																		
Enallagma	9.25	7.70	2.67	1.53	2.33	2.08	19.33	10.97	19.33	13.65	12.00	5.20	11.40	5.60	11.50	5.00	15.00	4.32
Libellulidae			0.67	1.16													0.25	0.50
Diptera[c]	7.88	19.90	0.33	0.58	1.00	1.00	0.33	0.58	13.00	19.05	1.20	1.64			1.00	1.00	0.75	0.96

a. Population Mean
b. Population Standard Deviation
c. Family Chironomidae makes up 90 percent of the order Diptera

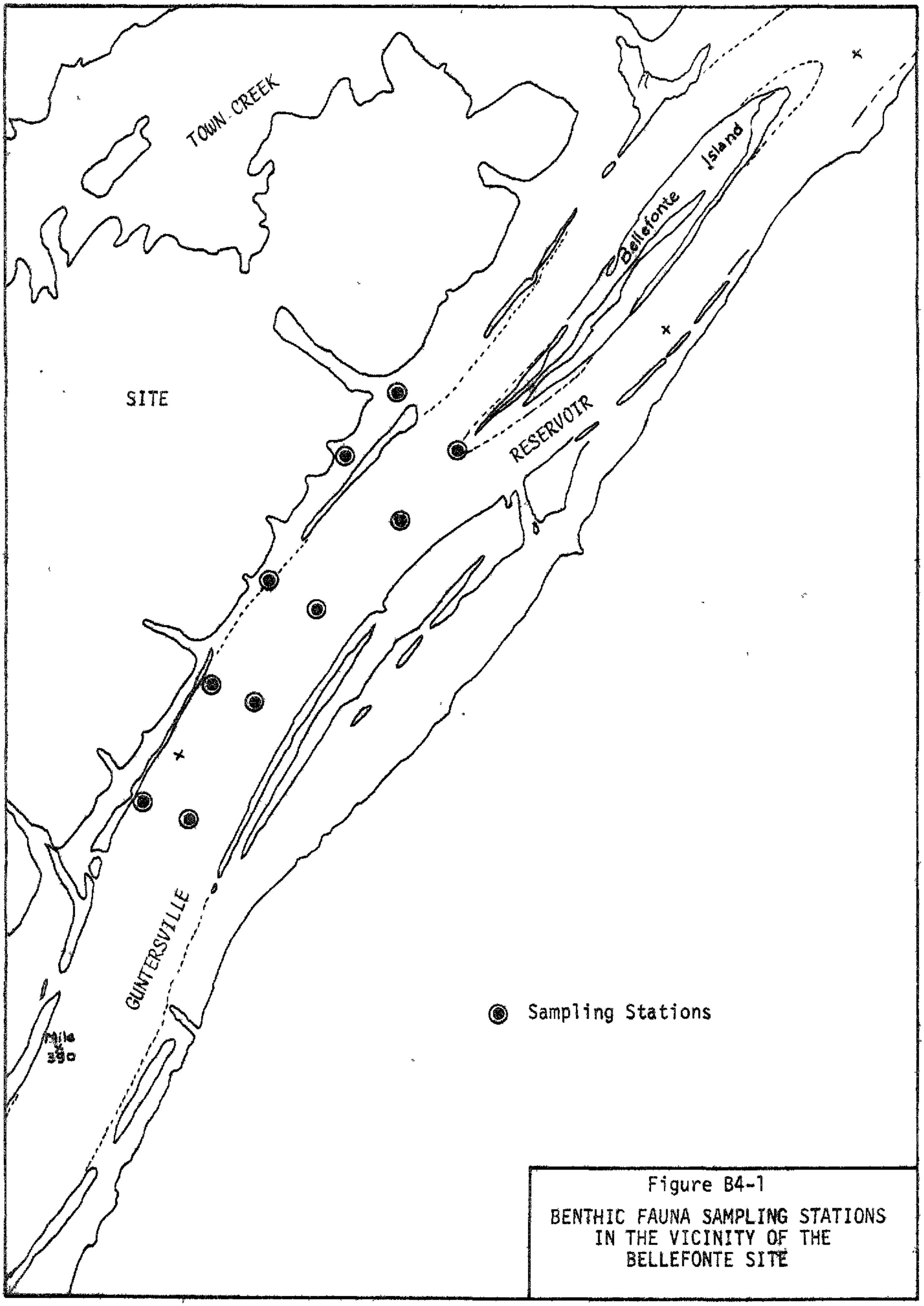
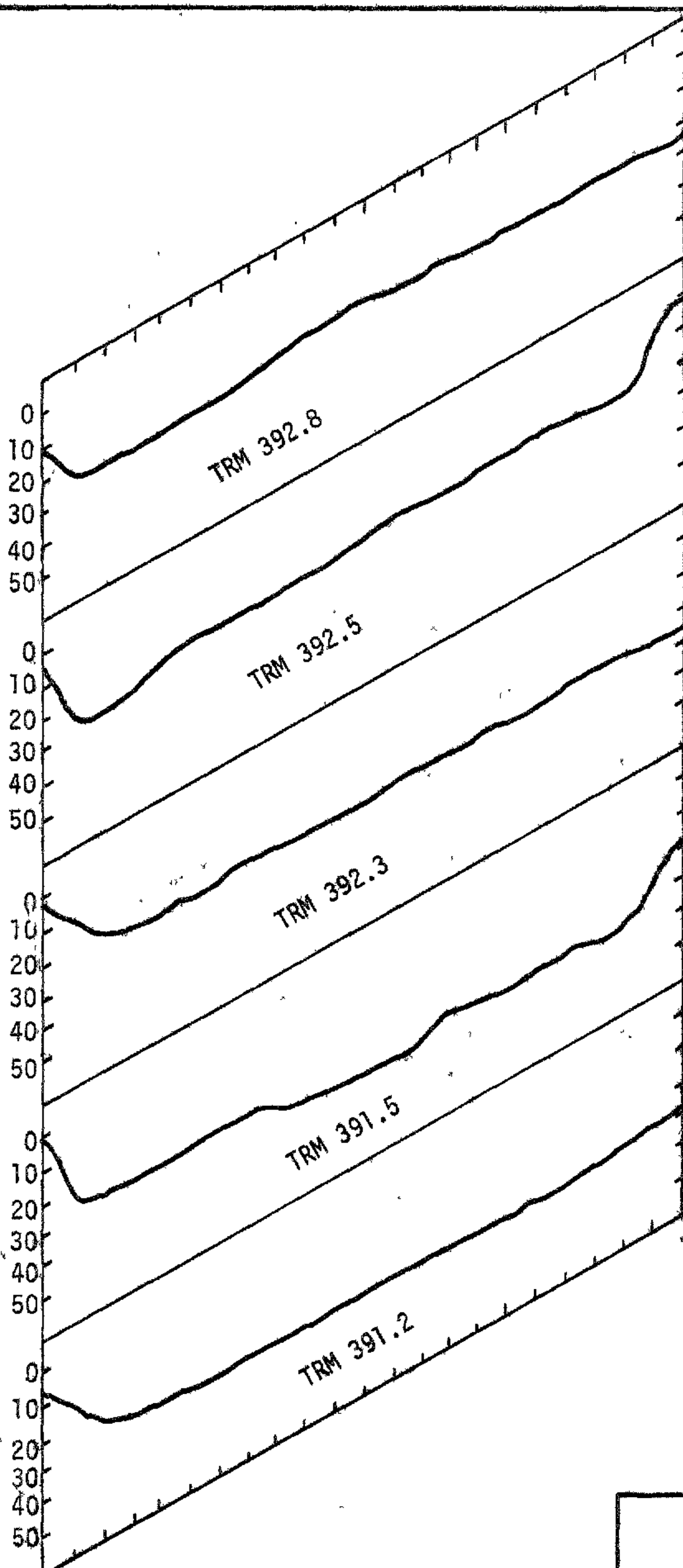
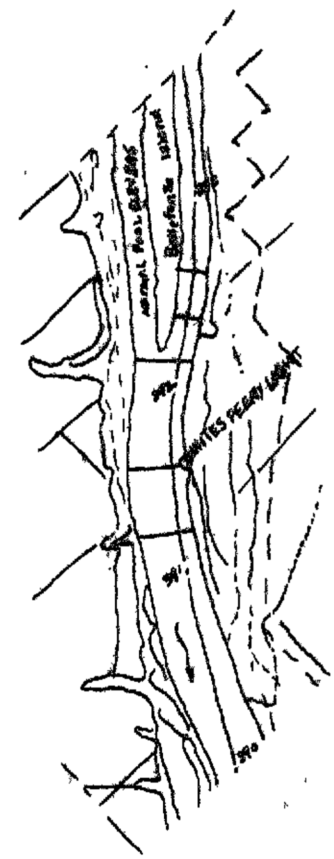


Figure B4-1

BENTHIC FAUNA SAMPLING STATIONS IN THE VICINITY OF THE BELLEFONTE SITE

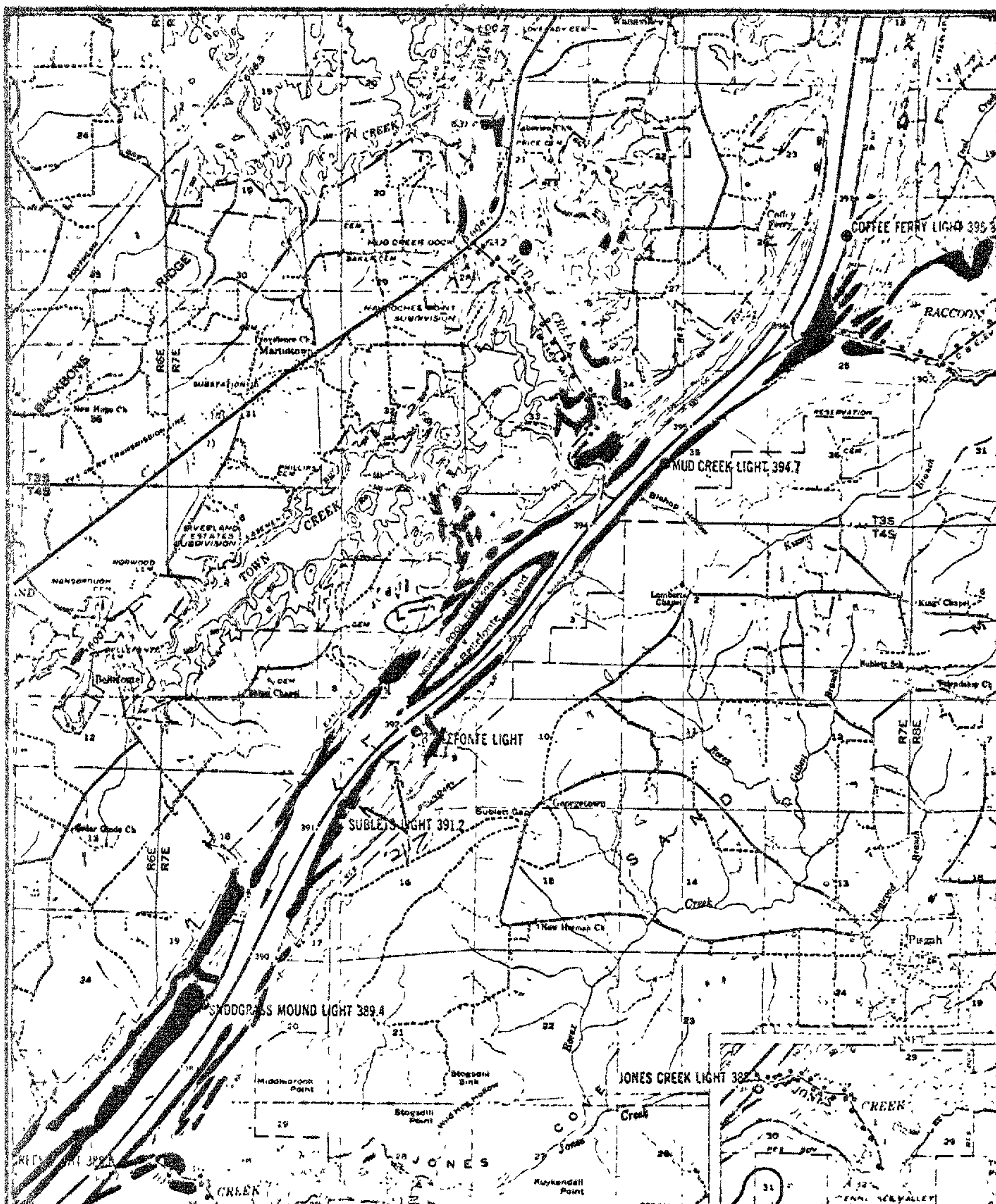




Offset Indicates areas mapped.

Figure B4-2

TOPOGRAPHIC FEATURES OF GUNTERSVILLE RESERVOIR IN THE VICINITY OF THE BELLEFONTE SITE



Shaded Area is Eurasian Watermilfoil Colonies.

Figure B4-3

WATERMILFOIL INVASION NEAR BELLEFONTE PLANT SITE
Samples and Observations were Done on July 18, 1972

Appendix C

AN ARCHAEOLOGICAL SURVEY OF THE BELLEFONTE POWER PLANT SITE

By

Carey B. Oakley

In Cooperation With

The Tennessee Valley Authority

September 6, 1972

AN ARCHAEOLOGICAL SURVEY OF THE BELLEFONTE POWER PLANT SITE

At the request of the Tennessee Valley Authority, an archaeological survey was conducted to locate any aboriginal sites that might be disturbed by the construction of the Bellefonte power plant. Field reconnaissance began on August 22, 1972, and continued through August 25, 1972. All phases of this survey were directed by Mr. Carey B. Oakley, Research Associate in Archaeology, Department of Anthropology, University of Alabama. He was assisted by anthropology students from the University of Alabama.

1. Natural setting - The property proposed for the site of the Bellefonte power plant is located on a broad peninsula, isolated by the Tennessee River on the southeastern border and by Town Creek on the northwestern and northeastern boundaries. At one time, this peninsula comprised a larger land mass, but the majority of the associated flood plain was inundated by the construction of Guntersville Dam.

Soils of this area vary from a silty loam to a cherty clay. The latter usually overlies outcroppings of Bangor limestone which can be seen exposed in the numerous gullies of this region. This formation is responsible for the series of limestone hills that run parallel with the Tennessee River. Most of the terrain has been subjected to severe sheet erosion, leaving only the basic subsoils and associated bed rock formations. The climate is considered temperate, with hot humid summers and mild winters. This environment is favorable for the growth of hardwood forests, intermixed with stands of loblolly and shortleaf pines (Swenson 1954).

2. Previous archaeological research - During the 1930's, a program of archaeological salvage was conducted in the Guntersville Reservoir. At that time some 343 archaeological sites were recorded in Jackson and Marshall Counties. Forty-one of these sites were selected for excavation. These investigations revealed a generalized chronology, indicating extensive utilization by prehistoric Indians for several thousand years (Webb 1951). More recent archaeological research has been conducted in Marshall and DeKalb Counties. Several bluff shelters in the Sand Mountain area have yielded information about the early inhabitants who occupied this region some 8,000 to 10,000 years ago (Clayton 1965).

3. The survey - The methods involved in this survey consisted of walking the proposed construction area and checking the numerous gullies, roadbeds, and other bare spots which afforded a break in the thick grass cover. Portions of the property which are marginal to the Guntersville Lake were examined with the aid of a boat. Test pits were excavated in the sites located in order to ascertain the amount and significance of the archaeological deposits. This method of surveying has been an accepted technique by the archaeological profession for many years and results in valid conclusions with regard to the particular importance of a specific site.

Five habitational areas were investigated, two of which were recorded during the original Guntersville Basin Survey.

(1) 1 Ja 35 (Elevation 580'-600') - Reverification of a previously recorded site (Site Survey Files, Mound State Monument, Moundville, Alabama). At the time of this survey only a small marginal portion of the site remained above the present lake level. Sparse amounts of lithic material were collected from the eroding shoreline. The lack of any appreciable cultural deposit would suggest that the major portion of this occupational area lies well within the existing reservoir.

(a) Material analysis -

1 limestone tempered plain sherd
4 projectile points broken unidentifiable
1 side end scraper
1 spokeshave
4 unidentifiable worked stone
1 core
41 flakes
6 decortication flakes
18 utilized flakes
8 utilized decortication flakes
2 bifacial retouch flakes
5 chunks
2 hammerstones
fire cracked rocks present on site

(b) Cultural affiliation - Archaic, Woodland.

(2) 1 Ja 36 (Elevation 580'-600') - Reverification of a previously recorded site (Site Survey Files, Mound State Monument, Moundville, Alabama). 1 Ja 36 is located on a natural levee immediately adjacent to the original bank of the Tennessee River and its confluence with a small unnamed inlet. Today, only a small segment of this site remains in the form of an enlongated island. Inundation of the majority of the site precluded any intensive examination.

(3) 1 Ja 300 (Elevation 600'-620') - This site is situated on a low knoll, overlooking the right bank of a small unnamed inlet, approximately 300 feet northwest of 1 Ja 36. The results of 6 randomly spaced test pits reveal an occupational area of approximately 200 feet by 250 feet. A more restricted shell concentration, about 50 feet in diameter, is located in the central portion of the site. Recent logging operations have damaged approximately 10 percent of the site, leaving about 90 percent relatively undisturbed. Depth of the cultural deposit varies from 18 inches near the center and thinning to about 1 foot toward the site limits. Although this deposit is comparatively shallow, it is significant since the area has never been cultivated.

(a) Material analysis -

1 shell tempered plain sherd

23 limestone tempered plain sherds

3 limestone tempered brushed sherds

9 projectile points: 5 stemmed; 2 pentagonal; 1 round base; 1 triangular

3 unidentifiable projectile point fragments

1 spokeshave-scraper

1 side-end scraper

1 core

10 unidentifiable worked stone

3 bifacial retouch flakes

128 flakes

29 decortication flakes

16 utilized flakes

3 utilized decortication flakes

19 chunks

1 hammer-abrader stone

1 hammer-anvil stone

a quantity of mussel shell and fire cracked rock was present on the surface

(b) Cultural affiliation - Archaic, Woodland, Mississippian.

(4) 1 Ja 301 (Elevation 640'-660') - This site is situated on a high knoll adjacent to 2 limestone hills. Slight amounts of lithic debris are scattered over an area of about 75 feet by 100 feet. Test pits revealed sterile soil beneath a thin plowzone.

(a) Material analysis -

1 projectile point broken unidentifiable

1 unidentifiable worked stone

23 flakes

4 decortication flakes

(b) Cultural affiliation - Archaic.

(5) 1 Ja 302 (Elevation 595'-620') - This site is located in one of the few areas of the peninsula in which a process of soil accumulation has occurred. The site area is presently covered by an extensive growth of secondary vegetation. One test revealed an 8-inch plowzone composed of a sandy loam soil which overlies a darker occupational flood deposit with a thickness of 18 inches. It is estimated that 1 Ja 302 encompasses an area of about 100 feet by 150 feet.

(a) Material analysis -

3 limestone tempered plain sherds
1 projectile point: 1 side notched
3 flakes
1 decortication flake
12 fire cracked rocks
miscellaneous shell fragments

(b) Cultural affiliation - Woodland.

4. Summary and recommendations - 1 Ja 300 is the most important occupational area recorded during this survey. An analysis of the cultural material indicates that this site was occupied during the Archaic, Woodland, and Mississippian cultural periods. The bulk of the deposit may be attributed to an extensive Woodland occupation.

In order to appreciate the importance of 1 Ja 300, reference must be made to the previous archaeological investigations of the Guntersville Reservoir. At that time several major habitational areas were excavated which generally correspond to the cultural sequences represented at this site. However, archaeological methods involved in these earlier investigations were quite different from those of today. The method of vertical slicing of archaeological deposits did not permit the close control of artifactual material. Today's techniques of horizontal stripping of thinner levels insures closer control within an archaeological deposit. Also, these earlier excavations were conducted prior to the discovery of the radiocarbon method of absolute dating. It is because of this fact that only a relative chronology was established for this region.

An extensive investigation of 1 Ja 300 should yield an ample amount of cultural material in association with the necessary radiocarbon samples which would clarify and enhance the archaeological data currently available. In addition, an excavation of this deposit should give important inferences as to the horizontal distribution of specialized work areas within the site limits. In many cases the larger habitational sites are too complex to isolate these individual work areas.

The analysis of the lithic debris from 1 Ja 301 suggests an intermittent campsite utilized during Archaic times. The slight amount of cultural material recovered and the extensive amount of sheet erosion of this site suggests that additional archaeological investigations would be unproductive.

Cultural material recovered from 1 Ja 302 reveals a Woodland occupation of some duration. Limited excavations are recommended in order to correlate this deposit with that of 1 Ja 300.

The property proposed for the Bellefonte power plant was never extensively utilized by the prehistoric Indian. The isolation of most of this area from an available watersource was probably the major contributing factor to this paucity of aboriginal sites. 1 Ja 301 is the only site which may be considered as an inland occupational area. Sites 1 Ja 300 and 1 Ja 302 represent riverine occupational areas which are positioned on the flood plain between the Tennessee River and the adjacent limestone hills. This situation is also true for 1 Ja 35 and 1 Ja 36.

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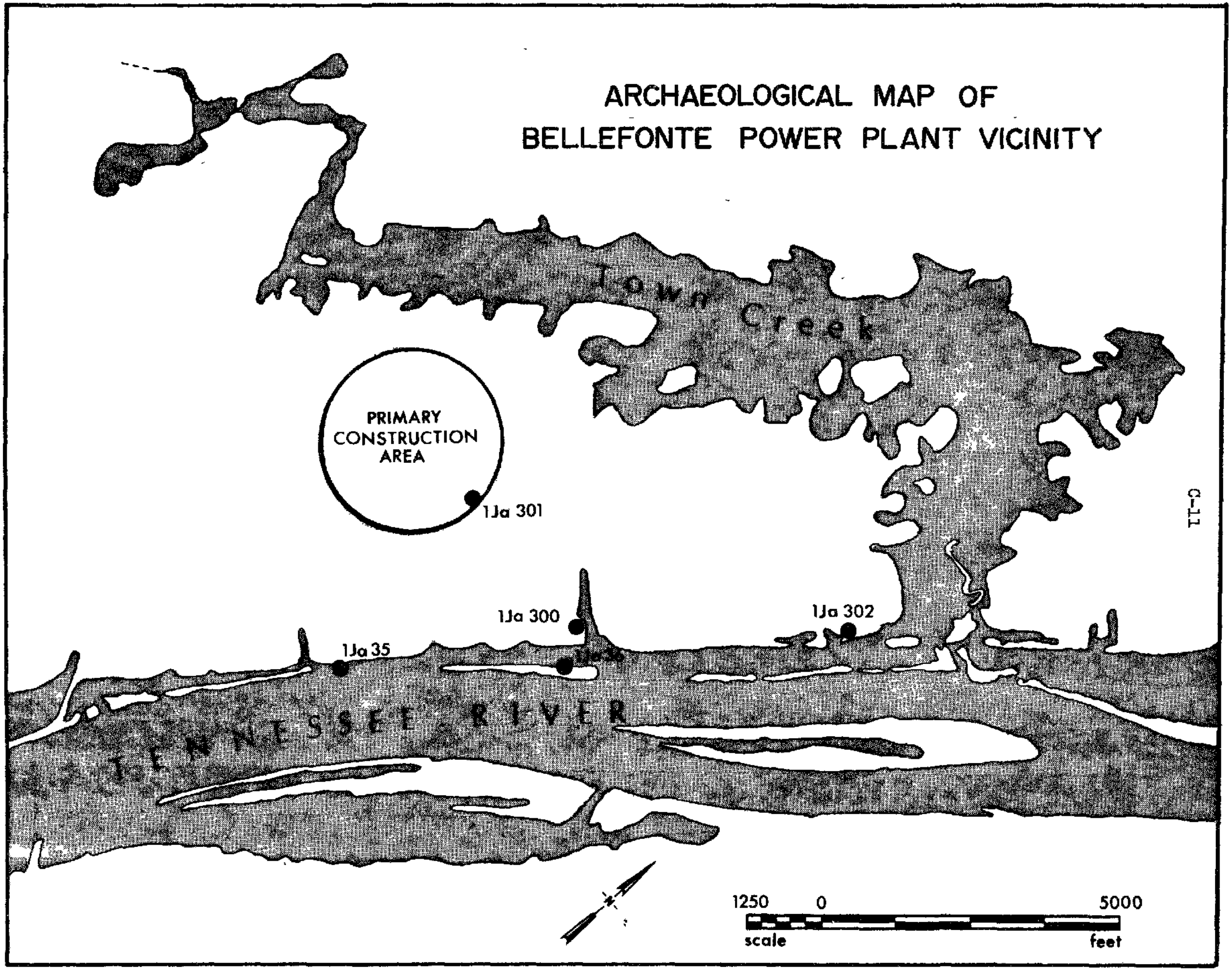
ARCHAEOLOGICAL MAP OF
BELLEFONTE POWER PLANT VICINITY
Town Creek
PRIMARY
CONSTRUCTION
AREA
1Ja 301
1Ja 300
1Ja 302
1Ja 35
TENNESSEE RIVER
1250
0
5000
scale
feet

CURRICULUM VITAE - CAREY B. OAKLEY, JR. - AGE 26

EDUCATION: University of Tennessee, B.S. 1968, Major: Anthropology; University of Alabama, M.A. (January 1971) Anthropology.

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ARCHAEOLOGICAL FIELD EXPERIENCE: June - August 1960 - University of Alabama, Walter F. George Reservoir (Chattahooche River), Crew Member.
June - August 1961 - University of Alabama, Stanfield Whorley Shelter (3 weeks), Logan Martin Reservoir (Coosa River), Crew Member.
June - August 1962 - University of Alabama, Logan Martin Reservoir, Lock 3 Reservoir (Coosa River), Field Assistant.
June - August 1963 - University of Alabama, Stanfield Whorley Shelter (6 weeks), Lock 3 Reservoir (6 weeks), Student Crew Member and Field Assistant, respectively.
June - August 1964 - University of Alabama, Lock 3 Reservoir, Field Assistant.
June - September 1965 - University of Tennessee, Nickajack Reservoir (Tennessee River), Field Assistant.
June - September 1966 - University of Tennessee, Old Stone Fort (State Park), Elk River Reservoir, Field Assistant.
June - September 1967 - Tellico Reservoir (Little Tennessee River), Field Assistant.
March - September 1968 - Tellico River Reservoir, Field Assistant.
June - July 1969 - University of Alabama, Rollins-Bluff Shelter, Supervisor.
September 1969 - September 1970 - University of Alabama, Pinson Cave Project (Near Birmingham), Supervisor.
April 1972 - Present - University of Alabama, Bear Creek Project, Principal Investigator.

TEACHING EXPERIENCE: Introductory Anthropology, Southeastern Archaeology, Archaeological Field Methods, New World Archaeology.

TEACHING OBJECTIVES: Archaeological Field Methods and Techniques.

SPECIALIZATION: Southeastern Archaeology.

PAPERS: 1968 - Alabama Academy of Science, "A Comparison of Ceramic Effigy Heads from Moundville and those from the Gulf Coast Area"; 1969 - Alabama Archaeological Society - Annual Meeting, "A Re-evaluation of Alabama's Site Survey System"; 1970 - Alabama Academy of Science, "A Preliminary Report on the Pinson Cave Excavations."

HONORARY SOCIETIES: Alpha Kappa Delta (National Sociology Honor Society).

Appendix D

RADIOLOGICAL ANALYSIS FOR TRANSPORTATION OF SPENT FUEL AND RADIOACTIVE WASTE

1. Normal shipment - The direct external radiation dose from the normal shipment of irradiated fuel elements and radioactive waste has been estimated.

Three cases are considered. These cases are: (1) the dose rate versus distance from a stationary shipping container under normal conditions; (2) the dose to an individual from the passing shipping container; and (3) the population dose due to the passage of the shipping container (see figure D-1).

The dose rates and doses are estimated by considering the source to be an isotropic point source located at the centerline of the shipping container. Under normal conditions the dose rate shall not exceed 10 mrem/h at 6 feet from the container surface. The source strength, I, produces 10 mrem/h at 6 feet + R_c, where R_c is the container half thickness. The average gamma-ray energy is calculated to be about 1 MeV.

The dose rate as a function of distance from the shipping container is calculated by

$$DR = \frac{I\ e^{-ur}\ B(E,\ Z,\ ur)}{r^2}\ , \qquad (1)$$

where

I = source output, $\left(\frac{\text{mrem-ft}^2}{\text{h}}\right)$,

r = source to receptor distance, (ft),

u = linear attenuation coefficient, (ft^{-1}), = $2.5 \times 10^{-3}\ ft^{-1}$,

$B(E, Z, ur)$ = linear buildup factor for air and is given by

$$1 + Kur, \tag{2}$$

where

$$k = \frac{u - u_{en}}{u_{en}}$$

and u_{en} is the linear energy-absorption coefficient.

The results of the dose rate calculations for a stationary shipping container are shown in figure D-2.

The total dose delivered to an individual at a given distance from the centerline of the right of way by a passing shipping container passing with a constant speed of 20 mi/h is calculated by

$$D(d) = \int_{-\infty}^{\infty} DR\ dt \quad , \tag{3}$$

where

$$dt = \frac{dx}{v} \quad ,$$

and

x = the distance along the shipping route, (ft),

v = the velocity, $\frac{ft}{h}$,

therefore,

$$D(d) = \frac{2I}{v} \int_{0}^{\infty} \frac{e^{-ur}}{r^2} B(E, Z, ur)dx \quad , \tag{4}$$

where

I = source output, $\left(\frac{mrem\text{-}ft^2}{h}\right)$,

$r = (x^2 + d^2)^{1/2}$, (ft),

d = the distance normal to the centerline of the container's line of travel at which a person is located, (ft),

B(E, Z, ur) and u are as defined for equation 1.

The dose to an individual at varying distances, d, from a passing shipping container is given below.

d (ft)	Dose (mrem)
100	2.9×10^{-4}
200	1.0×10^{-4}
350	5.9×10^{-5}
600	9.7×10^{-6}
1,000	1.5×10^{-6}
1,500	2.6×10^{-7}
2,200	5.4×10^{-8}

The population dose within 1/2 mile of the route of travel is calculated by considering the integrated dose at 6 intervals between 100 and 2,640 feet from the right of way centerline. The computation is based on the assumption that 100 people per square mile are uniformly distributed along the route of travel. An actual population dose may be computed by multiplying the population dose based on 100 persons per square mile by the ratio of the actual population density to the assumed population density. Using these assumptions a population dose of 1.59×10^{-6} man-rem/mi per shipment is calculated.

In these calculational estimates, the attenuation due to manmade structures, trees, and other scatterers and/or absorbers is not considered.

2. Transportation accident - The principal potential environmental effects from an accident involving irradiated fuel are those from direct radiation resulting from increased radiation levels and from gaseous release of noble gases and iodine.

The direct external radiation dose rate from a transportation accident has been evaluated. Under accident conditions the dose rate shall not exceed 1,000 mrem/h at 3 feet from the container surface. The dose rate is estimated using equation 1 and a source strength which produces 1,000 mrem/h at 3 feet + R_c. The results are shown in figure D-3.

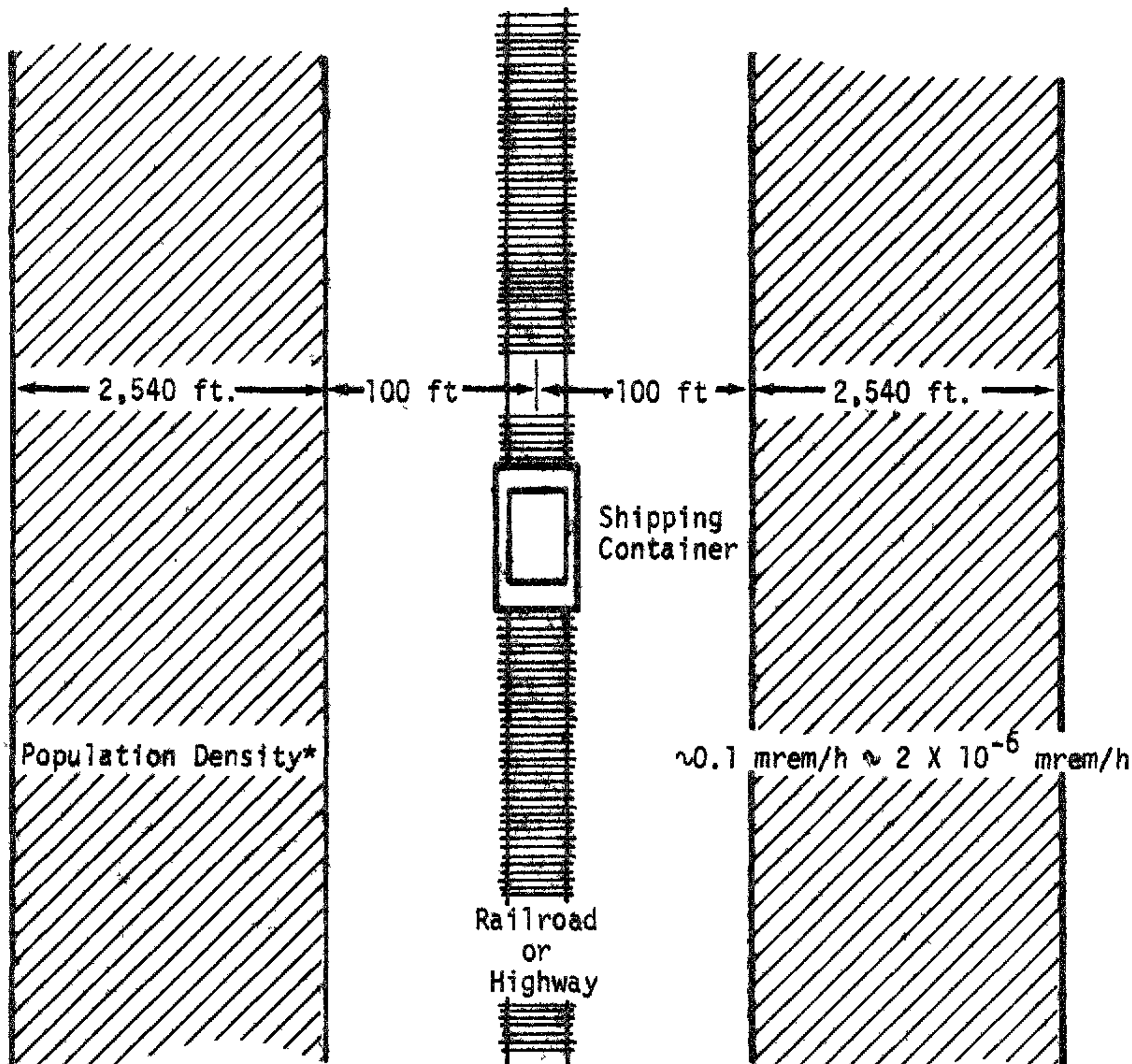
It is assumed that there would be no gaseous releases without a substantial quantity of decay heat in the shipping container plus the addition of external heat such as from a fire. Thus, it is assumed that the thermal currents surrounding the container carry any released fission gases to a height of 10 meters before they are dispersed in the environment. Doses to the whole body, skin, and thyroid have been calculated and are plotted vs. distance in figure D-4. These dose curves represent the envelope of the doses for Pasquill stability conditions A through F with a wind speed of 1 m/s. For a specific accident (with a wind speed of 1 m/s and for one particular Pasquill stability condition) the maximum doses would be equal to the "plateau" doses shown in figure D-4, but the "plateau" doses would not prevail over the entire range of distance between 50 and 1,300 feet. For wind speeds in excess of 1 m/s the doses would be lower than shown in figure D-4 by a factor equal to the reciprocal of the wind speed. Assuming a person stands 50 feet from the cask during the entire accident, the resulting whole-body dose is about 2 mrem, the skin dose is about 86 mrem, and the thyroid dose is about 5 rem. Assuming an average population density of 100 persons per square mile, the whole body dose due to gaseous releases is 0.07 man-rem, the population skin dose is 2.5

man-rem, and the iodine inhalation population dose is 150 man-rem. TVA considers the average population to be the most realistic number to use in analyzing transportation accidents because of the small fraction of the total distance traveled in high population density areas and because accidents in such areas generally occur at lower speeds and therefore would be less severe.

Doses to a truck driver who remains near the truck during a transportation accident are about 2 mrem to the whole body, about 86 mrem to the skin, and about 5 rem to the thyroid. The whole-body dose to the driver due to direct radiation from the shipping cask can be estimated from figure D-3.

Consideration has been given to the radiological impact of the shipment of tritiated water. The low-energy direct radiation from tritium will be shielded by the shipping container and will not be a source or radiation exposure during normal transportation. Calculations have been performed for an accidental release of the entire contents of a 3,700-gallon container of tritiated water with a tritium concentration of 2.5 uCi/cc. A conservative upper limit for the resulting radiation dose is computed by assuming that all of the tritium evaporates into the atmosphere and is blown directly to an individual who remains at the maximum dose point for the entire period of release to the atmosphere. With these assumptions the maximum whole-body dose is computed to be 440 mrem, which is less than the annual dose limit to an individual in the genreal public specified in 10 CFR Part 20. This dose decreases rapidly with distance, as shown in figure D-5, and at 600 feet is 23 mrem. Figure D-5 has been prepared assuming Pasquill stability condition

F and a wind speed of 1 m/s. For Pasquill stability condition A through E and wind speeds of 1 m/s, the dose at 50 feet from the cask will be about the same as shown in figure D-5 (440 mrem), but the doses at downwind distances beyond 50 feet would be lower than shown in the figure. For wind speeds above 1 m/s, doses may be predicted by multiplying the doses calculated for a wind speed of 1 m/s by a factor equal to the reciprocal of the wind speed. If a uniform average population density of 100 persons per square mile is assumed, the population dose within 50 miles is less than 0.1 man-rem.



When Container is moving at 20 mph:

Maximum Individual Exposure = 0.00029 mrem/trip
Average Individual Exposure = 0.000016 mrem/trip

* Assume 100 persons/mi^2 for spent fuel shipments and for radioactive waste shipments.

Figure D-1

SPENT FUEL AND RADIOACTIVE WASTE SHIPMENTS POPULATION EXPOSURE DISTRIBUTION

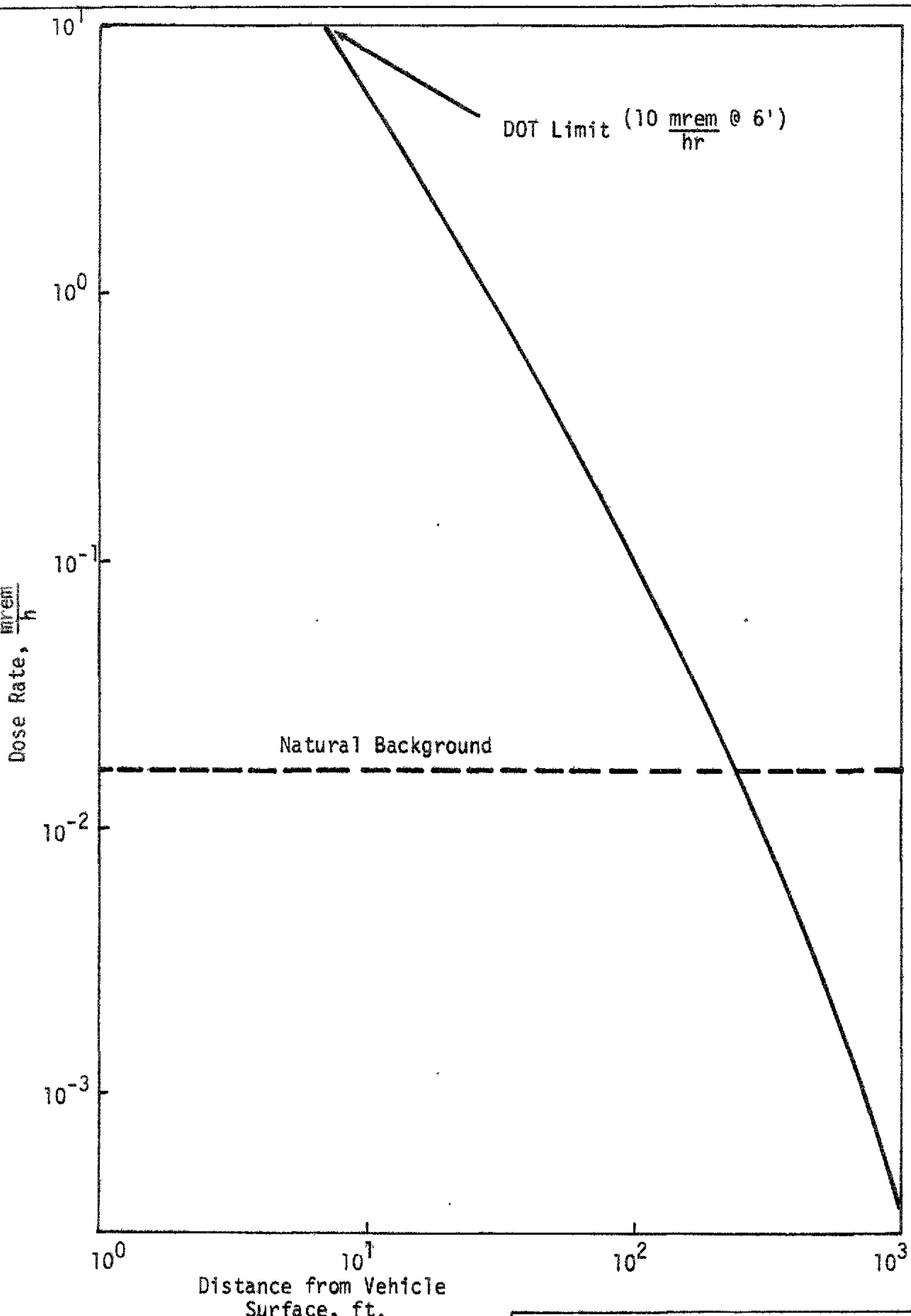


Figure D-2

DOSE RATE VS DISTANCE FROM A STATIONARY SHIPPING CONTAINER, NORMAL CONDITIONS

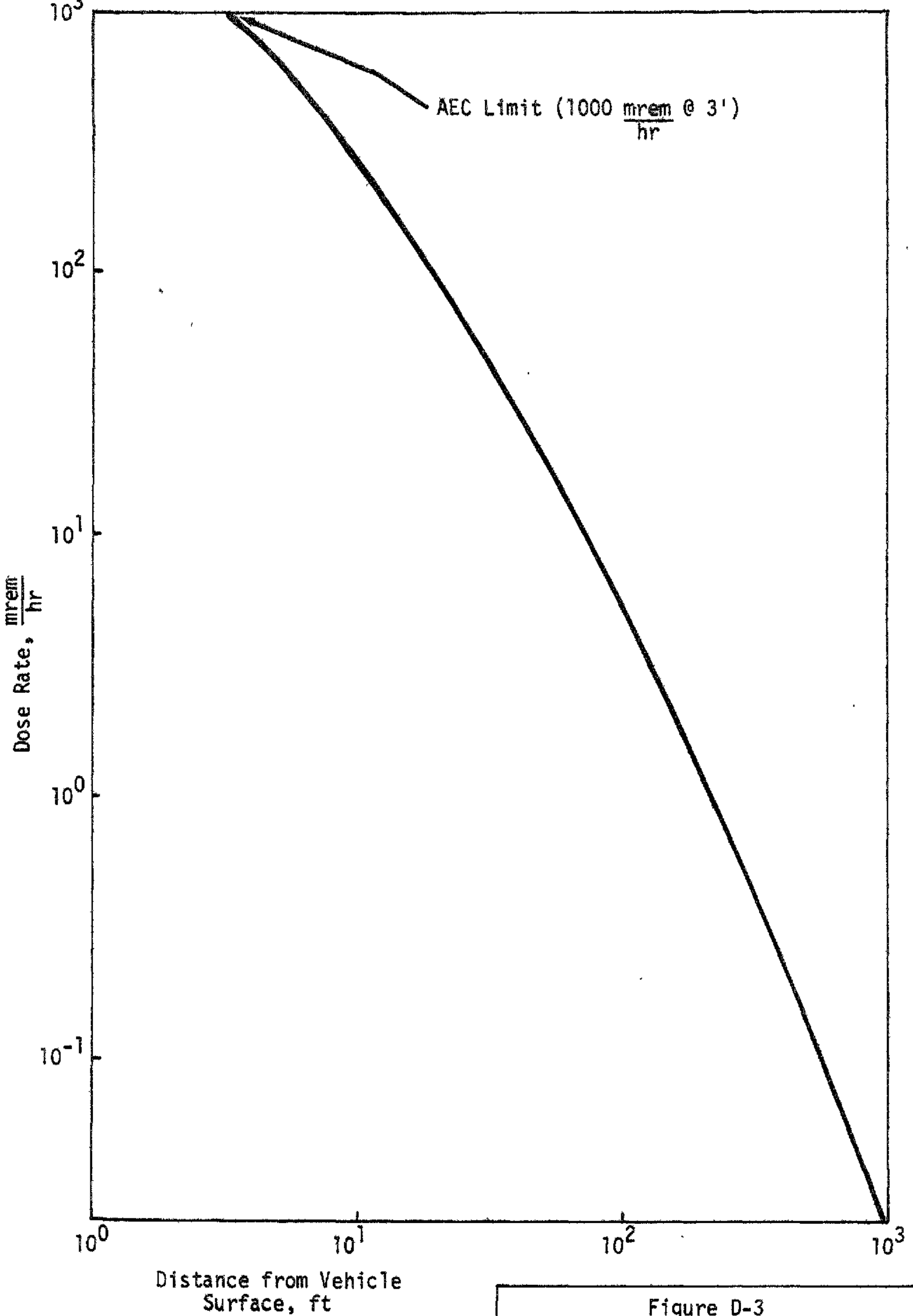


Figure D-3

DOSE RATE VS DISTANCE FROM A STATIONARY SHIPPING CONTAINER, ACCIDENT CONDITIONS

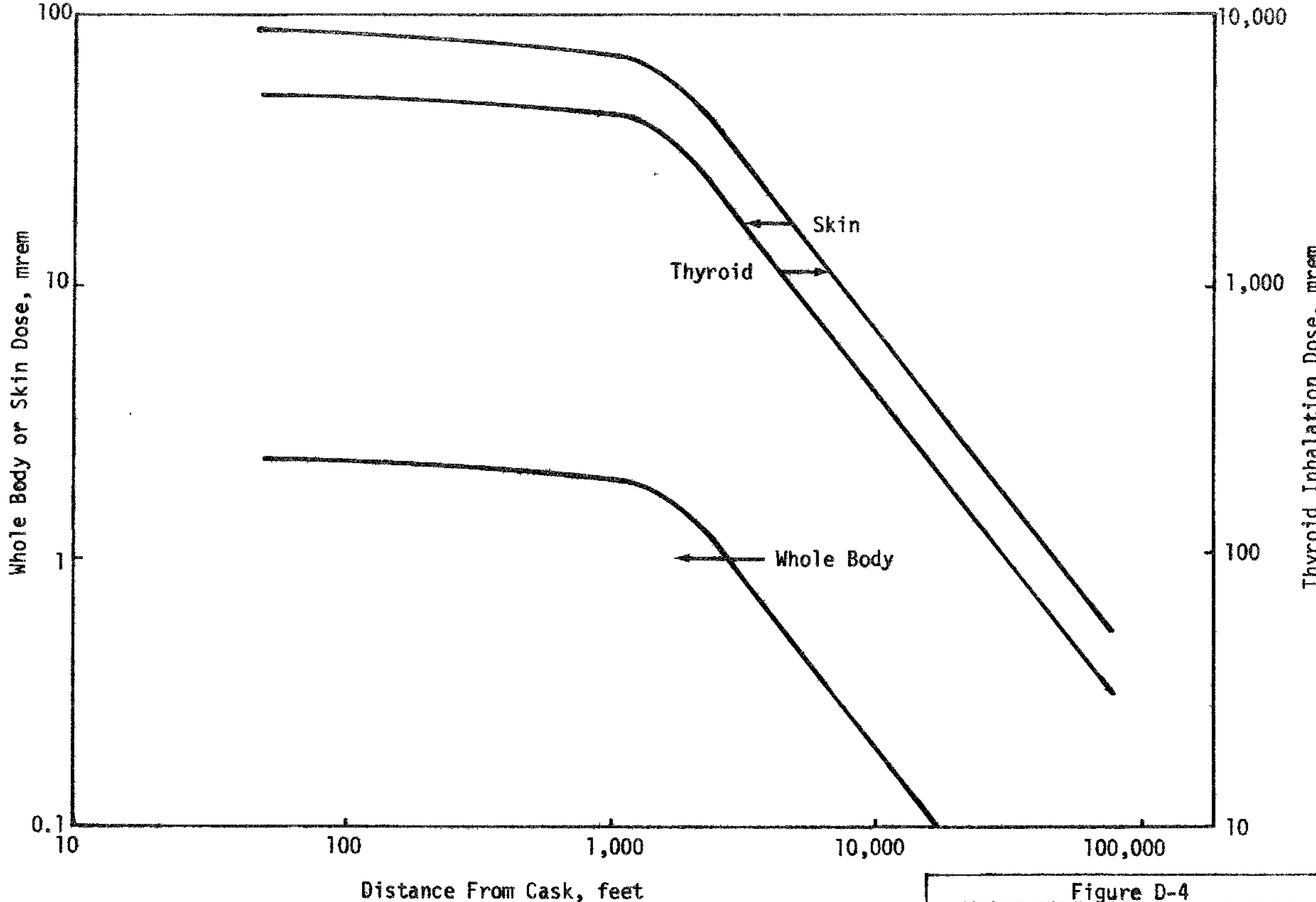


Figure D-4
WHOLE BODY, SKIN, AND THYROID INHALATION DOSES VS DISTANCE FOR RELEASE OF 1000 Ci OF NOBLE GASES AND 10 Ci OF I-131 DURING A SPENT FUEL TRANSPORTATION ACCIDENT

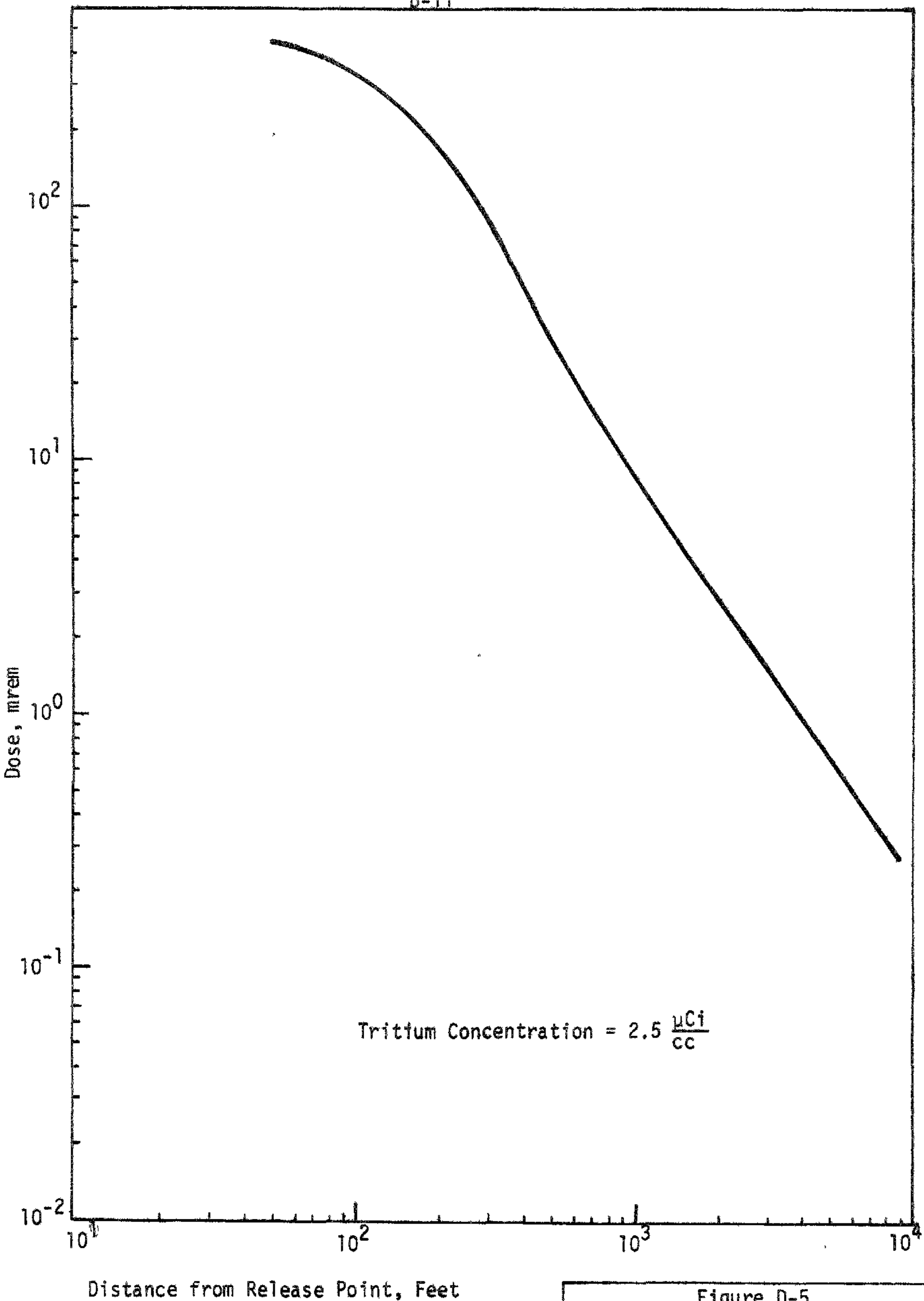


Figure D-5
Whole Body Dose vs Distance for Release of 3,700 Gallons of Tritiated Water During Transportation Accident

Appendix E

RELATION OF 10 CFR PART 71 ACCIDENT REQUIREMENTS TO ACTUAL SHIPPING ENVIRONMENT

1. Performance requirements of 10 CFR Section 71.36 - The domestic transportation of radioactive materials is regulated at the Federal level by both the Atomic Energy Commission and the Department of Transportation. The primary aim of the regulations is, of course, to protect the public by rigorously restricting the amount of radiation to which people are exposed. The regulations given in 10 CFR Section 71.36 are written in terms of performance specification requirements for hypothetical accident conditions.

The following discussion is directed toward relating the 10 CFR Part 71 accident conditions to similar conditions which might be experienced as a result of a transportation accident.[1]

It should be noted that there is a wide margin of safety in the container design itself. The container is required to withstand the accident conditions imposed pursuant to 10 CFR Part 71 with only relatively minor damage to the container and no release of the contents except for a small amount of coolant and a small quantity of noble gases. For example, the IF-300 shipping cask is designed to absorb the total effects of the impact with only minor deformation of the outer fins that have been provided for impact protection. No credit is taken for deformation of the outer steel shell. Thus, because of the relative strength of the shell as opposed to the impact energy-absorbing fins, there is a wide margin between the damage that would be experienced by the cask in absorbing the energy of the 30-foot free fall and that which would be required to breach the container such that there could be a release of the radioactive contents. It is estimated that the amount of energy involved to sustain a significant breach would be from five to ten times that which the cask experience in a 30-foot free fall.

Thus, as pointed out below, it is unlikely that the casks will experience conditions as severe as those imposed by the 10 CFR Part 71 requirements, and in any event, conditions far more severe than those would be required to result in a substantial breach of a container. As shown in the analysis below, the proposed tests are representative of conditions at least as severe as those which would be experienced by containers in transport. Further, since the tests are required to be applied to the containers in sequence, the cumulative severity of conditions to which the containers are subjected in all probability far exceeds that to which the containers would ever be subjected as a result of an accident in the course of transportation. It is highly improbable that a container would be subjected to conditions as severe as even one of these conditions, let alone all three in the sequence provided for the test.

(1) <u>30-foot free fall</u> - The shipping cask is required to withstand a 30-foot free fall onto an essentially unyielding surface. This requires that all the energy of the impact be absorbed by deformation of the container. In addition, the container impact must be considered from all possible orientations to assure that the impact protection provided is adequate regardless of the orientation of

the fall. Based on previous design experience, it is estimated that a shipping cask will decelerate (stop) on impact within a distance of 2 to 8 inches.[2] To provide a basis for this comparison it has been assumed that a shipping cask would decelerate completely within 6 inches after impact with the unyielding surface. Table E-1 shows a comparison of the various forces which would be generated by the stopping of the shipping cask, an overweight truck, or an automobile traveling at various speeds on striking an unyielding surface.

As indicated in the table, a 45,000-pound shipping cask traveling at 30 mi/h, which is the terminal velocity following a 30-foot free fall, would create 2,700,000 pounds of force if stopped within a distance of 6 inches. A 130,000-pound cask, which is equivalent to the IF-300, would generate about 7,800,000 pounds of force. A loaded truck, weighing 75,000 pounds and traveling at 60 mi/h, coming in contact with the unyielding surface is assumed to decelerate within 10 feet. Under these conditions, the truck would generate a maximum of 900,000 pounds of force, or about one-third of the force that would be generated by the 45,000-pound cask as a result of the 30-foot free fall. Likewise, a 5,000-pound automobile traveling at 80 mi/h hitting an unyielding surface is assumed to stop in only 5 feet, which would generate about 220,000 pounds of force. Thus, it is seen that typical objects which the cask might encounter would generate substantially less force than the shipping cask because of the relatively weaker sections of their structures and the greater distance required to decelerate those bodies.

A second area of concern is the shipping cask colliding with stationary objects such as bridge abutments, etc. In this regard, it should be noted that even heavily loaded trucks contacting such stationary objects generally severely damage the object and displace it by some measurable amount. Therefore, these stationary objects generally cannot be considered as unyielding surfaces for the purposes of assessing the effects of a shipping cask impact. As demonstrated in Table E-1, the force developed by the shipping cask would be far greater than that developed by even a loaded truck, and thus the displacement of the "stationary objects" would be even greater than that encountered in a truck-type accident. Additionally, these impacts with the shipping cask assume that the shipping cask contacts the surface with the center of gravity directly behind the point of impact and in the line of travel such that the maximum force is exerted on the cask. In all likelihood, a shipping cask contacting such surfaces would strike a glancing blow in which case the energy required to be absorbed by the shipping cask would be greatly diminished over that which would result from a direct impact.

The required analysis of a 30-foot drop onto an essentially unyielding surface adequately provides for force to which a cask might be subjected as a result of a transportation accident. Therefore, as a result of these conditions and the ruggedness of the cask, the possibility of encountering a transportation accident of sufficient severity to result in rupture of the container has an extremely low, if not incredible, probability.

(2) <u>40-inch drop test</u> - The 40-inch puncture test requires that the cask be dropped from a height of 40 inches,

with the center of gravity directly above the point of impact, onto a 6-inch diameter pin of sufficient length to puncture the container but without allowing the puncture of even the outer shell of the vessel. The formula for analysis of this condition was developed at Oak Ridge National Laboratories[2] and other places based on extensive testing of steel and lead shipping containers.

In regard to the relationship of this test to the transportation environment, it was originally intended that the 6-inch diameter pin would approximate that of the end of a rail for rail transportation accidents. It should be noted that the puncture so specified would require that the cask hit the pin exactly perpendicular to the cask surface. Any deviation from this would result in a substantially reduced loading on the side of the cask and enhance changes of deflection. Further, the pin must be long enough to penetrate through the walls of the container, which would require damage to the contents. In most cases this would require that the pin be approximately 12 to 18 inches in length. However, if the pin is much longer than this, it becomes doubtful that the column strength of the pin is sufficient to rupture the container without buckling of the proposed pin.

It should be noted that the containers are required to pass the puncture test without rupture of even the outer shell. As generally there is a heavy outer shell backed up by several inches of shielding material followed by an inner steel shell, there is a wide margin between the damage that the container would sustain as a result of the required puncture test and that which would be required to rupture the inner vessel such that there could be dispersal of the radioactive contents. This test provides conditions at least as severe as those to which a container would be subjected as a result of a transportation accident.

(3) <u>30-minute fire test</u> - The 30-minute fire test was proposed as that to which a container would be subjected as a result of large open burning of petroleum such as diesel or jet fuel. In this regard it should be noted that the test conditions require that it be assumed that the cask is perfectly surrounded by a uniform heat flux corresponding to a thermal emissivity of 0.9 at a temperature of 1475°F. In actuality, the cask will most likely be lying on the ground near the cooler part of the flames such that it is not surrounded completely by the fire environment. Further, while there may be individual flame temperatures hotter than the proposed 1475°F, the average flame temperatures will not exceed these values. It is unlikely that a container the size of a large shipping cask would be completely engulfed in flames due lack the required quantities of combustible materials, winds which tend to blow the flames away from the container, and other factors which act to reduce the idealized conditions assumed for compliance with the 10 CFR Part 71 requirements. It is felt that the test conditions proposed in the regulations provide adequate, if not more severe, simulation of the fire conditions to which a container might be subjected during the course of transportation.

(4) <u>Conclusion</u> - In summary, the casks are designed to meet the requirements of applicable regulations, and it is unlikely that accident conditions more severe than those postulated in the regulations would be encountered.

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1. Excerpt from Applicant's Environmental Report, Supplement 1 - Midwest Fuel Recovery Plant, Morris, Illinois, General Electric Company.

2. Cask Designers Guide. Oak Ridge National Laboratory, ORNL-NSIC-68.

Table E-1

IMPACT ACCIDENT COMPARISON

Object	Weight (lb)	Initial Velocity (mi/h)	Stopping Distance (ft)	G's	Deceleration Force (lb)
Cask	45,000	30	0.5	60	2,700,000
Cask	130,000	30	0.5	60	7,800,000
Truck	75,000	60	10.0	12	900,000
Car	5,000	80	5.0	44	220,000

Appendix F

OZONE PRODUCTION AND ITS POTENTIAL EFFECTS

This appendix summarizes and references the literature on the characteristics of ozone and its potential effects on plants, animals, and man. Natural sources of ozone are compared with reference values of the quantities measured during tests on EHV transmission lines. Ozone quantities are also compared with the "Community Air Quality Guides"[1] and the "National Primary and Secondary Ambient Air Quality Standards"[2] for oxidants.

1. Ozone characteristics and potential effects on plants, animals, and man - The characteristic pungent odor of ozone can be detected at very low concentrations (0.02 to 0.05 ppm depending on individual acuity). At somewhat higher concentrations (0.05 to 0.10 ppm) the odor becomes more pronounced and disagreeable. Ozone is one of the most powerful oxidizing substances known and combines readily with many materials.

Ozone is not considered to be injurious to vegetation, animals, and humans unless concentrations exceed about 0.05 ppm over prolonged periods.[1] Extremely sensitive varieties of tobacco can be injured after about 8 hours of exposure to 0.05 ppm ozone or a 1-hour exposure of 0.07 ppm.[1,3] Most other vegetation, however, can withstand exposure exceeding 0.10 ppm for 8 hours without injury.[1,3] Mice exposed to ozone levels of 0.08 ppm in the laboratory for 3 hours which were then infected with streptococcus experienced a 23 percent increase in mortality rate.[4] TVA is not aware of any similar correlation studies of reduced tolerance to diseases versus ozone exposure which may have been made for humans. Most humans generally experience discomfort from ozone's unpleasant odor by the time concentrations approach 0.05 ppm.[4] Spectrograph operators who have experienced intermittent exposures of ozone concentrations in the range of 0.10 to 1.00 ppm over a 2-week period complained of shortness of breath and continuous headaches.[4] The visual acuity of humans can be reduced by prolonged exposures of 0.20 to 0.50 ppm.[3] Technical literature dealing with possible ozone-induced chromosome aberrations extrapolated from animal studies indicated that presently permitted ozone exposure would be expected to result in break frequencies that are orders of magnitude greater than those resulting from permitted radiation exposures.[5] The recent "Community Air Quality Guide,"[1] issued for ozone by the American Industrial Hygiene Association after consideration of the radiomimetic nature of ozone and the need for a realistic limit, recommended an upper concentration limit of 0.05 ppm for not more than 1 to 2 hours per day to protect very sensitive plants, and an exposure limit of 0.1 ppm/h/d on the average during any year if human health is not to be significantly impaired during a lifetime of exposure. By projecting observed impacts from experimental ozone exposures of Chinese hamsters, one observer estimates that even these levels could possibly produce about 1,270 times more lymphocyte chromosome breaks than the maximum permitted occupational radiation exposure.[5]

2. Natural ozone sources - Ozone is formed in nature by the dissociation action of solar ultraviolet radiation below 2,450A on the oxygen molecules present in the atmosphere. Peak

natural-formed concentrations of ozone as high as 11 ppm or more have been measured in the stratosphere; however, chemical, photochemical, and catalytic reactions tend to destroy the major portion of the ozone at ground levels where peak natural-formed concentrations would be expected to exceed 0.05 ppm only under rare circumstances, i.e., about 1 percent of the time.[1] Average ground-level concentrations of naturally formed ozone is estimated to be about 0.01 ppm in the United States.[4]

The actual instantaneous values for any specific location can vary from less than 0.01 ppm to over 0.05 ppm, depending on altitude, meteorological factors, geographical latitude, time of day, and time of year. Figure F-1 illustrates how ozone concentrations vary with altitude; however, vertical air currents constantly change the distribution, pattern, and magnitude of peak concentrations from those indicated. Similarly, figures F-2 and F-3 illustrate the magnitude of the diurnal variations which can occur between daytime ozone levels produced by the sun and nighttime levels when ozone tends to dissociate to its original oxygen form. The implications of figure F-2 will be discussed in greater detail later as it relates to the environmentally insignificant levels of ozone produced by transmission lines. Lightning is another natural phenomenon which produces large instantaneous quantities of extremely localized ozone; however, this accounts for very little of the total ozone existing in nature.

3. <u>Ozone generation by transmission facilities and other potential sources</u> - Ozone may be generated by any corona or electrical discharge in air or other oxygen medium. Quantities produced are dependent on the quantity of oxygen in the energy envelope. Ozone

may, therefore, be generated in undetermined quantities by motors, circuit breakers, electric welding torches, plasma sources, ultraviolet and fluorescent lamps, appliances, switches, transmission lines, or any other device which produces corona or electrical discharges.

Corona discharges can increase as a result of abrasions, foreign particles or sharp points on electrical conductors and electric equipment, or incorrect design which produces excessively high potential gradients. However, the design and construction of TVA transmission facilities minimize corona discharges and arcing. TVA specifications require that transmission line hardware and electrical equipment for operation at 500,000 volts be factory tested to assure as near corona-free performance as possible up to maximum operating voltage levels.

An extensive field-test program of detection of ozone in the vicinity of 765-kV lines has recently been completed, and full details and conclusions were incorporated in papers submitted for presentation at the 1972 IEEE Summer Power Meeting, San Francisco, July 1972.[6,7] Tests were conducted by Battelle Memorial Institute at 20 locations and under a variety of meteorological conditions, including several tests in which the instruments were placed as close as 6 meters downwind from the energized 765-kV conductors, at the conductor height. Ozone, NO_x, and corona-loss measurements were simulatneously conducted, under contract to AEP, at the Westinghouse EHV Laboratory at Trafford to measure the rates of ozone and NO_x production from full-scale conductor bundles which could be operated at 765 kV.[8] Diffusion models developed from these tests agreed closely with the actual transmission line measurements. No ozone contribution to the natural ozone levels was detected which could be attributed to the transmission lines.

Under these tests sponsored by the Electric Research Council and jointly financed by the Edison Electric Institute and the Bonneville Power Administration, the General Electric Company[9,10,11,12] is conducting transmission research in the 1,000-kV to 1,500-kV range. As a result of questions posed about the possible levels of ozone generation from the UHV configurations, ozone was monitored at the project. Figure F-2 shows ozone concentrations during the time the UHV test line was energized and deenergized over a 2-week period and graphically illustrates the following conclusions:

> From the results, it was evident that sunlight on a clear day is a more efficient producer of ozone than UHV lines, and any amounts created by the lines were so small that they were lost in the background produced by the sun's radiation.[13]

4. Conclusion - No significant adverse effects on vegetation, animals, or humans are expected to result from possible levels of ozone production attributable to transmission facilities for transmission voltages up to 765 kV. It is concluded that any level of ozone that can reasonably be expected to be generated by TVA's transmission facilities (500-kV maximum voltage), either resulting from normal transmission operation or following breaker or switching operations for the periods and the levels that they could be expected to persist, are environmentally inconsequential to humans, animals, or vegetation.

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6. Fryden, M., A. Levy. "Oxident Measurements in the Vicinity of Energized 765-kV lines," American Power and Batteile Memorial Institute submitted for presentation at the 1972 IEEE Summer Power Meeting, San Francisco, July 1972.

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8. Roach, J. F., Chartier. "An Estimate of Ozone and NO_x Concentrations Near Extra High Voltage Transmission Lines Based on Laboratory Measurements of Ozone and NO_x Production Rates for Four Conductor Bundles," Westinghouse Research Laboratories Research Report 71-7E8-COZOM-R1, December 31, 1971.

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10. Juette, G. W., "Corona-Caused Air Pollution - Preliminary Tests," Electrical Utility Engineering Technical Report T18-71-HY-13, March 18, 1971.

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13. "UHV Transmission Research Project Extended for Additional Two Years," Edison Electric Institute Bulletin, January-February 1972.

14. Ropperton, L. A., L. Kornreich, and J. Worth. "Nitrogen Dioxide and Nitric Oxide in Nonurban Air," Air Pollution Control Association Journal, Volume 20, No. 9 (September 1970), pp. 589-592.

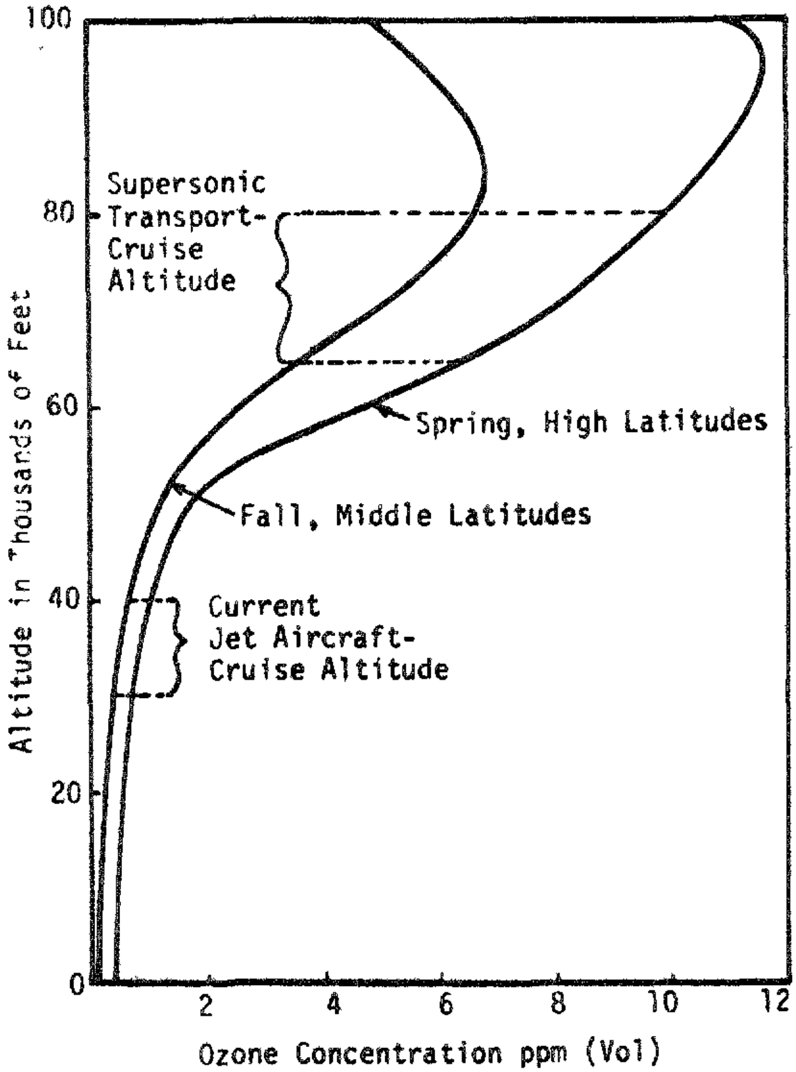


Figure F-1

Ozone Distribution
Northern Hemisphere

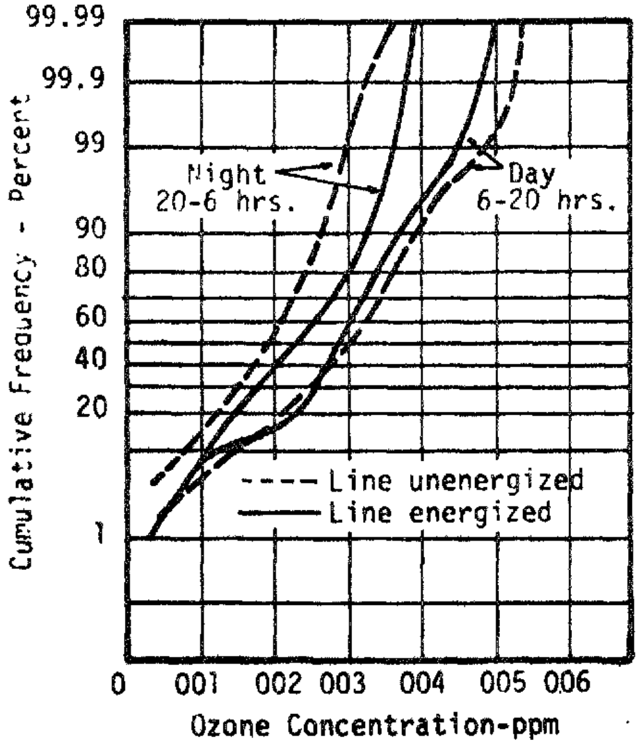


Figure F-2
Ozone Statistic obtained near UHV Test Line during 8 days of Energization and 10 days without Energization

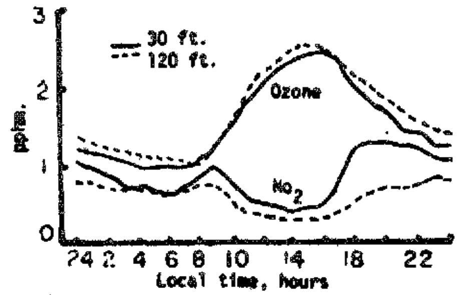
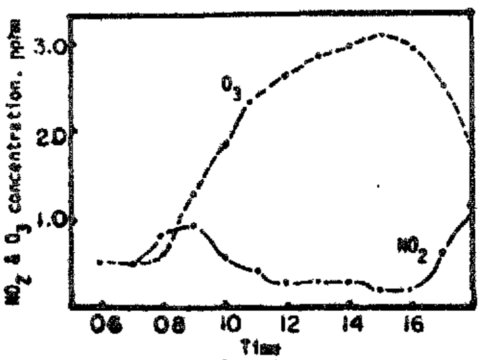
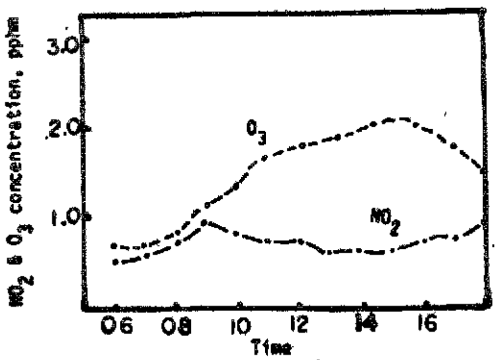


Figure 1. Averages of ozone and nitrogen dioxide for five months (Sept. 1966-Jan. 1967)



Clear Skies



Overcast skies

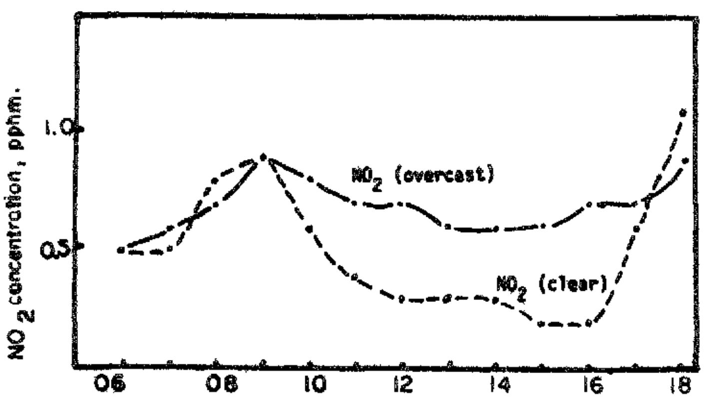


Figure 2. Nitrogen dioxide on clear and overcast days (Sept. 1966-Jan. 1967)

Figure F-3

FUNCTIONAL RELATIONSHIPS OF OZONE AND NITROGEN DIOXIDE[14]

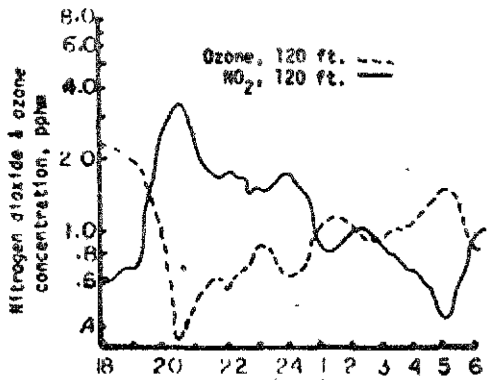


Figure 3. Nitrogen dioxide and ozone (1800-0600 hr on 11/24/66).

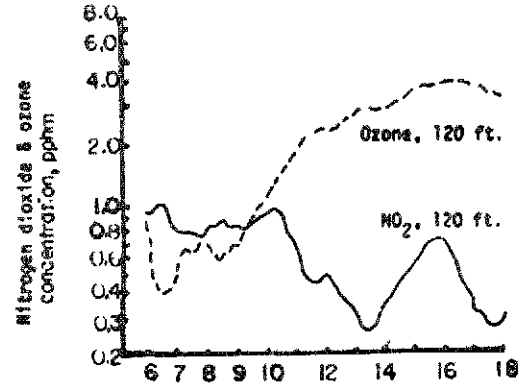


Figure 4. Nitrogen dioxide and ozone (0600-1800 hr on 11/25/66).

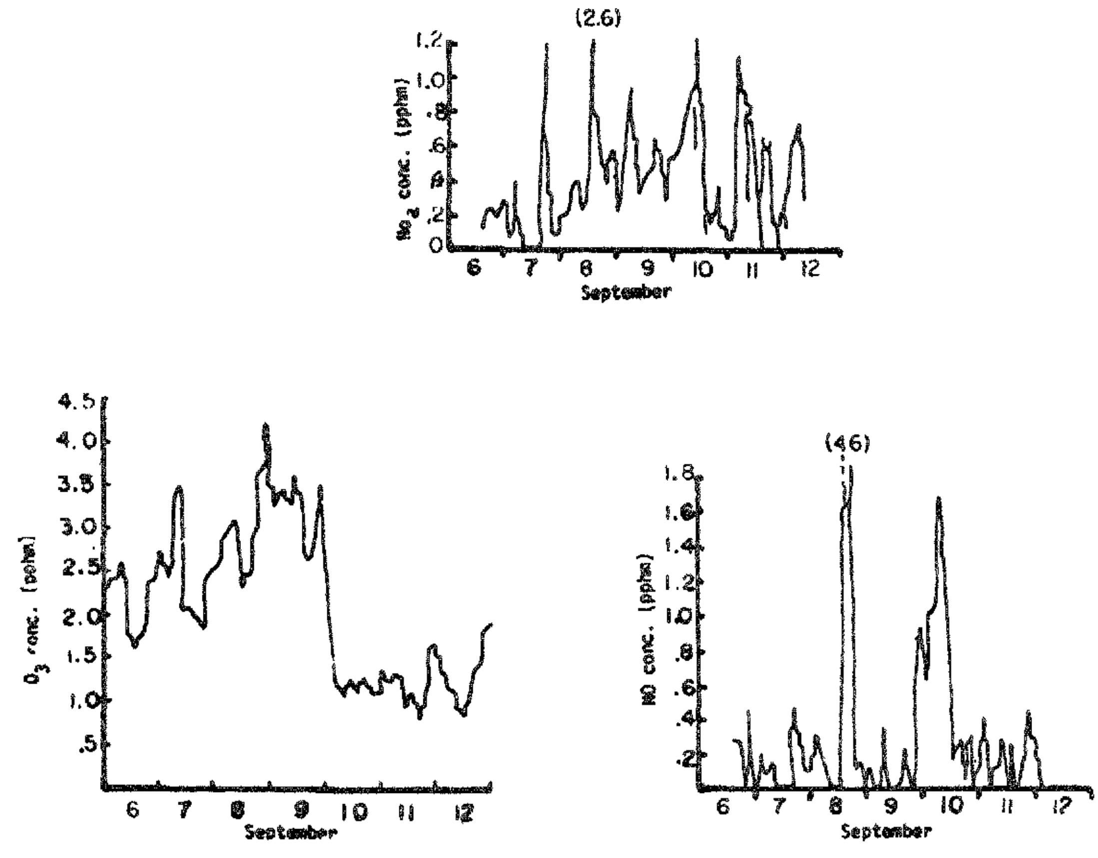


Figure 5. Diurnal averages for nitrogen dioxide and ozone at Green Knob. N. C. (Sept. 1965).

Figure F-3 (Cont'd)

FUNCTIONAL RELATIONSHIPS OF OZONE AND NITROGEN DIOXIDE[14]

Appendix G

OUTLINE OF ACCIDENT ANALYSES

1. Introduction - This appendix describes the evaluation of the environmental impact of postulated occurrences and accidents for the Bellefonte Nuclear Plant. This evaluation follows the guidelines given in the AEC document, "Scope of Applicants' Environmental Reports with Respect to Transportation, Transmission Lines, and Accidents," issued on September 1, 1971, and the guidance provided by AEC for the consideration of accidents in December 1971. As shown in Table G-1, the results of this evaluation demonstrate that the consequences of the postulated accidents and occurrences have no significant adverse environmental effects.

The postulated events are divided into the nine accident classes as shown in Table 2.3-1. The events analyzed in each class are those identified in Reference 1. Assumptions not specified in Reference 1 have been selected on the basis of using the most realistic values consistent with the present state of knowledge.

In the following pages, the individual events are described with emphasis on the routes of escape of activity to the environment, and the equipment and structures which contain the activity. Indications of the probable frequency or probability of occurrences of the postulated events are provided to the degree possible. Detailed descriptions of critical equipment and structures will be provided in the preliminary safety analysis report, which will also contain descriptions of very conservative analyses of many of these same events.

Table G-2 through G-8 give the fission product inventories in various plant components that were used in the analysis. Tables G-9a through G-9g tabulate the principal assumptions and parameters used in the analysis of each event. The dispersion of gaseous releases offsite was based on the assumptions discussed in section 10, below.

2. Evaluation of Class 1 and 2 events - Class 1 events are trivial incidents involving small releases due to normal operations. Class 2 events are small releases outside containment such as valve leakage, spills, etc. The releases from both Class 1 and Class 2 events are considered in the evaluation of routine releases.

3. Analysis of Class 3 events - Class 3 events include releases of radioactivity from the waste disposal systems as a result of equipment malfunction or a single operator error. The waste disposal system has been designed to collect, monitor, treat, and discharge or package for disposal liquid, solid, and gaseous wastes. Operations will be conducted in accordance with administrative procedures.

Waste releases and shipments are made on a batch basis which permits knowledge and control of anticipated releases before any action is undertaken to make the actual release. For the liquid and gaseous cases, the actual release is monitored by radiation detectors, and a permanent record of the activity release is recorded.

(1) Liquid radwaste - The bulk of the radioactive liquids discharged from the reactor coolant system are processed and retained inside the plant by the makeup and purification system recycle train. This minimizes liquid input to the waste disposal system which processes relatively small quantities of generally low

activity level wastes. The processed water from waste disposal, which contains relatively little radioactive material, is discharged through a monitored line into the waste discharge pipe.

At least two valves must be manually opened to permit discharge of liquid from the waste disposal system. One of these valves is normally locked closed and the other is interlocked with a flowmeter in the discharge pipe so that it can be opened only if the flow rate exceeds 15,000 gal/min. A control valve will trip closed on a high effluent radioactivity level signal.

The system is controlled from a central panel in the auxiliary building. Malfunction of the system actuates an alarm in the auxiliary building and annunciates in the control room. All system equipment is located in or near the auxiliary building except for the reactor coolant drain tank and drain tank pumps and flood and equipment drain sump and pumps which are located in the containment building.

Leakage of liquid radwaste from tanks is caught in sumps in the auxiliary building. Therefore, leakage or rupture of a radwaste tank does not lead to a significant release to the river. Gaseous activity from such a spill would be picked up by the auxiliary building ventilation system.

For illustrative purposes, an unplanned release of 0.93 curie of radioactive material (equal to the entire expected yearly liquid releases) was assumed to be released inadvertently to the river during conditions when the river dilution flow was 50 percent of the average flow.

(2) Solid radwaste - Because of the nature of solid radioactive wastes and specialized procedures and equipment provided for packaging and handling these wastes, significant accidental releases of radioactivity from solid wastes is considered extremely unlikely.

(3) Gaseous radwaste - Several postulated Class 3 accidents were analyzed, and a major leak in a gas waste holdup tank was found to yield the greatest potential for release to the environment. Operating experience indicates that the activity stored in the gas holdup tank consists of the noble gases released from the primary coolant and only negligible quantities of the less volatile isotopes. Any major leakage from these tanks would be processed through the filtration system in the auxiliary building ventilation systems to further reduce any potential release of particulates and iodines.

(4) Evaluation - The potential for environmental effects from Class 3 events is based on releases from a gaseous decay tank for gaseous releases and from a hypothetical liquid release. These releases are given in Tables G-10, G-11, and G-12.

The inventory in the gaseous radwaste tank is based on the accident occurring to the tank immediately after the coolant had been degassed during a reactor shutdown. The average inventory in each of the two gaseous decay tanks will be much less than this.

Leakage from the gaseous radwaste system might be expected to occur during the lifetime of the plant. Complete failure of a radwaste tank (gas or liquid) is not expected to occur during the lifetime of the plant.

4. Analysis of Class 4 events - Class 4 accidents are events that release radioactivity into the primary coolant, including anomalous fuel failures as well as fuel failures which might result in an increased primary coolant activity which increases the activity of the fluids processed by the waste disposal system.

The fuel rods consist of uranium dioxide ceramic pellets contained in slightly cold-worked Zircaloy-4 tubing which is plugged and seal-welded at the ends to encapsulate the fuel. The manufacturing process is subject to an extensive quality assurance program which provides assurance that the resulting fuel rods satisfy the manufacturing tolerances and design specifications. Excessive heating or pressurization of the fuel rods could possibly cause perforation of the fuel element cladding and subsequent fission product release. Consequently, very conservative design margins are used for the fuel to further reduce the possibility of fuel damage.

Operating experience with Zircaloy cladding has demonstrated that the extent of anomalous fuel rod failures during normal operation will be less than 0.5 percent failed fuel* with administrative controls. Therefore, 0.5 percent failed fuel is an upper bound basis for evaluation of accidental releases. A failed fuel level of 0.25 percent is used for routine releases since the releases occur over a long period of time.

Without protective systems, fuel failures are also possible as a result of certain abnormal operating transients. However, the plant design incorporates a reactor protection system which limits the postulated transients so that the design limits for the fuel will

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*0.5 percent failed fuel is defined as small clad defects (holes) in fuel pins which produce 0.5 percent of the total core power.

not be exceeded. As a result, the fuel will not be damaged, and no activity will be released to the primary coolant as a result of an abnormal operating transient.

5. Analysis of Class 5 accidents - Class 5 accidents are events which result in the release of radioactive material to the environment via any secondary plant system. Primary protection against Class 5 accidents is afforded by coolant chemistry control and good steam generator design. The plant fluid systems are designed with an intermediate water system between any radioactive fluid and any water that is continually discharged to the environment. For example, the component cooling water system cools all of the heat exchangers which contain primary coolant, and the component cooling water is in turn cooled by raw cooling water in a separate heat exchanger. Consequently, a highly unlikely simultaneous failure of two heat exchangers would be required in order for the primary coolant to reach the environment. As an added precaution, the component cooling water loop is continuously monitored for radioactivity, providing timely indication of a leak into the component cooling water system from the primary system.

The other source of possible radioactive release is a primary to secondary leak in a steam generator which transports the fission products, released by cladding failures, into the main steam system. Indication of the occurrence will be afforded by a radiation monitor in the effluent line of the vacuum pump which monitors the activity of the noncondensable gases leaving the main condenser. When a predetermined activity level is reached, the monitor actuates an alarm in the control room.

The most important environmental consequence of this event is the release of noble gases and iodines which are removed from the main condenser by the vacuum pump, and exhausted via a vent on the turbine building roof after passing through charcoal filters which remove most of the iodines. Releases due to steam generator tube leakage are included in the radioactive discharge section.

A hypothetical release due to an offdesign transient has been analyzed using the assumptions specified in Reference 1. The releases for this event are given in Table G-13.

The steam generator tube rupture accident is defined as a complete severence of one steam generator tube. The accident results in an increase in the contamination of the secondary (steam) system.

The plant design incorporates the following features to protect the reactor during and following the postulated accident:

1. The reactor will trip on a low pressurizer pressure signal,
2. The safety injection signal is actuated by coincident low pressurizer pressure and level signals, and
3. The safety injection signal actuates the emergency feedwater system.

Plant recovery can be achieved and normal shutdown initiated in 30 minutes.

The rupture of a steam generator tube would allow fission products that might be in the primary coolant to contaminate the secondary coolant, leading to releases of activity to the environment via the condenser offgas. The results of this postulated event are evaluated based on the release of 15 percent of the primary coolant to the secondary system. The secondary coolant activity before rupture of the tube is based on a primary to secondary leak rate of 20 gallons per day per unit.

All noble gases and 0.1 percent of the iodines in the secondary system are assumed to be released to the environment. The releases for this event are given in Table G-14.

The events analyzed in this class (offdesign transient and steam-generator tube rupture) are not expected to occur during the lifetime of the plant; however, steam-generator tube leakage may occur for short time periods during the plant lifetime, and therefore, it is included as part of the routine radioactive releases.

6. Analysis of Class 6 events - Included in this class of accidents are fuel failures (from any cause) that occur during refueling operations inside the primary containment.

The reactor is refueled with equipment specially designed to handle the spent fuel underwater from the time it leaves the reactor vessel until it is placed in a cask for shipment from the site. Underwater transfer of spent fuel provides an effective radiation shield and provides adequate cooling for the removal of decay heat. Boron added to the water as a neutron absorber ensures subcritical neutron multiplication during refueling.

The various components of the fuel-handling equipment are designed for failsafe operation utilizing interlocks and limit switches designed to preclude any occurrences which might damage a fuel assembly. Administrative procedures will ensure that the integrity of the equipment is maintained.

Detailed refueling instructions will be used to ensure a safe and orderly refueling. When fuel is being inserted, removed, or rearranged in the reactor core, licensed operators will be in the control room and on the refueling floor supervising the operations.

Detailed descriptions of fuel-handling equipment will be given in the Bellefonte Nuclear Plant PSAR.

Accidents involving spent fuel after it has left the transfer tube are discussed in the following section as part of the Class 7 accidents.

In the event of an accident the containment ventilation systems will be isolated on high containment activity. This effectively precludes the release of significant amounts of fission products to the environment since:

1. This accident is not accompanied by any containment pressure increase which could serve as a driving force for leakage.
2. Any leakage that does occur can be treated by the emergency gas treatment system.

Two events in this class are described by Reference 1. TVA has analyzed these events using the assumptions of Reference 1. It is assumed, however, that all activity released from the pool is exhausted to the purge exhaust filters where 99 percent of the iodines is removed. The releases for these events are given in Table G-15 and G-16.

Fuel-handling accidents have occurred in the past with both new and irradiated fuel. However, none has resulted in a substantial release of radioactivity to the environment. Therefore, while fuel element drops or other minor events may occur during the life of the plant, a fuel-handling accident leading to a significant release of activity from the fuel is not expected to occur during the lifetime of the plant or, in fact, during several plant lifetimes.

7. Analysis of Class 7 accidents - Class 7 accidents are events initiated during refueling operations outside the primary containment or storage of spent fuel which result in a release of radioactivity to the environment.

The movement of the spent fuel is accomplished in accordance with strict administrative procedures to reduce the possibility of an accident to a minimal level. Precautions taken include:

1. The fuel pool is designed to ensure that the stored fuel is submerged in water and placed in a subcritical array at all times.
2. The spent fuel pool water is cooled to remove decay heat and purified to remove metallic ions which could cause corrosion of the fuel assemblies, and fission products which may leak into the water.
3. Safety features incorporated into the fuel-handling crane which preclude dropping of the fuel shipping cask.
4. The spent fuel pool is normally ventilated with outside air at the rate of five volume changes per hour and maintained at a slight negative pressure. The exhaust is routed via the auxiliary building exhaust vent system which contains radioactivity monitors and filter trains which are automatically aligned in the event of an accident. These filters remove essentially all particulates and at least 99 percent of the iodines.

The three events analyzed in this class are (1) fuel element drop, (2) heavy object dropped on fuel storage rack, and (3) fuel cask drop accidents. The releases from the fuel element drop accident are based on the release of 1 percent of the fission product activity in 15 fuel pins (one row) after 7 days' decay time. The releases from the heavy object drop accident are based on the release of fuel pins (one fuel assembly) after 30 days' decay time. For both these events, 99.8 percent of the iodines is assumed to remain in the spent fuel pool water.

The results of the fuel cask drop accident have been estimated assuming one fuel assembly is damaged releasing 1 percent of the contained noble gas activity inside the auxiliary building. In all three events, it is assumed that 99 percent of the iodines in the exhaust from the building is removed by charcoal filters. Because of the design of the fuel cask and cask-handling equipment, no significant releases of radioactivity to the environment are expected, and no fuel damage is likely from hypothetical cask drop. However, the results for damage to one assembly are presented for illustrative purposes. The number of assemblies carried in a cask depends on the specific cask design as well as the mode of transportation. The releases for these events are given in Tables G-17, G-18, and G-19.

With the exception discussed above, events in this class are expected to have the same probability as those discussed for Class 6.

8. Class 8 accidents - Those accidents chosen as design basis accidents are included in Class 8. The postulated accidents

considered in this class are:

1. Loss-of-coolant accidents
2. Control rod ejection accident
3. Steamline rupture accidents

These accidents have a very low probability of occurring; however, several engineered safety features are incorporated in the plant design to minimize any significant radioactivity release associated, should any of the accidents occur. Each of the design basis accidents is discussed below.

(1) Loss-of-coolant accident - A loss-of-coolant accident may result from a rupture of a reactor coolant system (RCS) component or of any line connected to that system up to the first closed valve which results in loss of coolant at a rate which exceeds the capability of the makeup system.

The severity of the accident is a function of the primary coolant leakage rate and consequently the size of the pipe rupture. The most severe postulated accident is a result of the hypothetical "double-ended" rupture of the largest RCS pipe.

The design of the plant will include several safety features designed to minimize the effects of a loss-of-coolant accident. These features include:

1. A prestressed concrete primary containment structure surrounded by a secondary containment structure to prevent the leakage of fission products (double containment).
2. The emergency core cooling system which provides core cooling following the accident to minimize fuel element failure.

3. The emergency gas treatment system which filters the leakage from the primary containment before releasing it to the plant vent.

If a postulated loss-of-coolant accident should occur, the RCS will rapidly depressurize. The reactor trip will actuate when the pressurizer low-pressure set point is reached. The emergency core cooling system is actuated by the pressurizer low-pressure or by the high-containment pressure signal. These counter-measures will limit the consequences of the accident in two ways:

1. Reactor trip and borated water injection by the emergency core cooling system supplement void formation in causing rapid reduction of the nuclear power to a residual level corresponding to the fission product decay heat.
2. Injection of borated water ensures sufficient flooding of the core to prevent excessive temperatures.

For short-term core cooling, passive protection is provided by two core flooding tanks pressurized with nitrogen which rapidly discharge their borated water to the RCS when the RCS pressure decreases below the tank pressure. In addition, borated cooling water is injected by high-head charging pumps and low-head safety injection pumps.

For long-term core cooling, water spilled from the ruptured reactor coolant system and containment spray drainage are collected, cooled, and recirculated through the core. This recirculated water is delivered by low-head pumps when the reactor system pressure is low.

The decay heat generated in the core is removed for an indefinite period of time by this recirculation flow which is cooled by two residual heat exchangers.

Fission products which are released from failed fuel as a result of a loss of coolant are released to the primary coolant where some of the iodines and most of the particulate fission products are trapped. Of the iodine released to the primary containment, most is removed from the containment atmosphere by the containment sprays.

Fission products leaking from the primary containment to the annulus (region between primary containment and shield building) are held up for a long period of time. The release from this volume is through the charcoal filters of the emergency gas treatment system to atmosphere. The assumptions specified in Reference 1 were used to estimate releases. Fission products which leak to the auxiliary building are exhausted to atmosphere through charcoal filters. For this analysis, 10 percent of the primary containment leakage is assumed to bypass the annulus and go to the auxiliary building. It is expected that the final containment design will include provisions to preclude any such bypass leakage.

The releases estimated for the loss-of-coolant events specified in Reference 1 are given in Table G-20 and G-21.

(2) Control rod ejection accident - The design basis reactivity transient is the postulated ejection of a control rod. Such an ejection could result from a complete rupture of a control rod mechanism housing.

If the postulated accident should occur, a power transient would result, causing a reactor scram; fuel failures may occur as a result of this transient. The fission products in the coolant as a result of 0.5 percent failed fuel are assumed expelled from the reactor vessel through the broken control rod housing into the primary containment. The airborne and gaseous fission products may leak into the secondary containment (shield building) after which they are exhausted via the secondary containment cleanup system where filtration reduces the iodine concentration. As far as activity releases are concerned, this event is a small loss-of-coolant accident and is analyzed according to the guidance in Reference 1. The releases for this event are given in Table G-22.

(3) Main steamline rupture accident - A rupture of a steamline would result in an uncontrolled steam release from a steam generator. However, this only results in a significant radioactive material release when the reactor is being operated with primary to secondary leak in a steam generator in conjunction with fuel failures (cladding perforations).

The accident is initiated by a postulated failure in the main steamline system outside the containment which could cause depressurization of the steam generator in that loop. The following plant systems mitigate the consequences of a steam pipe rupture:

1. Emergency core cooling activation from one of several signals
2. The overpower reactor trips
3. Redundant isolation of the main feedwater lines
4. Trip of the fast-acting main steamline stop valves

The analysis of a steamline rupture does not yield any core damage so that the radioactivity release will be a function of the secondary system activity at the time of the accident.

The initial secondary system activity is based on a primary to secondary leak rate of 20 gallons per day per unit. The guidance given in Reference 1 is followed in the analysis. However, the halogen reduction factor for releases from the primary system is taken to be 0.1 for small breaks and 0.5 for large breaks. The releases for these events are given in Tables G-23 and G-24.

9. Evaluation of Class 9 accidents - Class 9 accidents are described as hypothetical sequences of successive failures which are more severe than those postulated as design-basis accidents whose results are summarized in safety analysis reports by applicants requesting construction permits and operating licenses from AEC for nuclear power plants. Although the consequences of Class 9 accidents could be severe, the probability of their occurrence is so small that their environmental risk is extremely low.

These accidents would require the occurrence of multiple failures of the plant's engineered safety features with each failure even more severe than the postulated design-basis accidents, which have extremely low probabilities of occurrence.

Conservative design; diverse and redundant physical barriers, protection systems, and engineered safety features; extensive quality assurance; and control of operations dictate such a probability of occurrence that the environmental risk associated with Class 9 accidents is negligible as compared to that of the other classes of accidents.

10. Atmospheric dispersion conditions - TVA has a site meteorological investigations program under way at the Bellefonte

site. However, the evaluation of the site atmospheric conditions has been based on data collected at the Widows Creek Steam Plant (about 20 miles north-northeast of the site), the Sequoyah Nuclear Plant (60 miles northeast of the site), and Watts Bar Nuclear Plant (85 miles northeast of the site). The evaluation predicts that the atmospheric dispersion conditions are similar to those at Sequoyah where there is a small but significant percentage of occurrence of low wind speeds concurrent with very stable atmospheric conditions. Although the small amount of onsite date analyzed indicates that the actual conditions may be more favorable than predicted, TVA has used accident relative dispersion factors which are 10 times higher than the values suggested by the proposed Annex to Appendix D, 10 CFR Part 50.[2]

Figure G-1 gives the dispersion values used as a function of distance for the time periods used in the analyses. For an explanation of these values see reference 1. Wind direction frequencies used in the analysis are given as baseline data in section 1.2.

11. Population densities - The population exposures from each postulated event have been estimated using projected population information for the year 2020. The population distribution used is shown in section 1.2. Population doses are based on doses to persons residing within 50 miles of the plant site.

12. Evaluation of environmental impact of postulated accidents - The principal effect of accidents on the environment is the increased exposure to man which might result from the release of radioactive material. This exposure is summarized in Table G-1 for the principal accidents analyzed. This analysis of this information shows that no accident or class of accidents is environmentally significant.

REFERENCES FOR APPENDIX G

1. "Safety Guide 4 - Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors," Safety Guides for Water-Cooled Nuclear Power Plants, November 2, 1970, United States Atomic Energy Commission.

2. Title 10, Code of Federal Regulations, Part 50, Appendix D Annex - "Discussion of Accidents in Applicants' Environmental Report: Assumptions," December 1, 1971.

Table G-1

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Individual Doses at the Site Boundary (rem)				Fraction of Limit[b]	Dose Commitment to Population[a] (man-rem)			
		Gamma Radiation	Beta Radiation	Gamma Plus Beta	Iodine Inhalation		Gamma Radiation	Beta Radiation	Iodine Inhalation	Total
1.0	Trivial incidents	*	*	*	*	*	*	*	*	*
2.0	Small releases outside containment	*	*	*	*	*	*	*	*	*
3.0	Radwaste system failures									
3.1	Equipment leakage or malfunction	8.5×10^{-2}	1.2×10^{-1}	2.1×10^{-1}	4.6×10^{-3}	4.2×10^{-1}	$1.7\times10^{+1}$	$2.3\times10^{+1}$	9.3×10^{-1}	$4.1\times10^{+1}$
3.2	Release of waste gas storage tank contents	3.4×10^{-1}	4.4×10^{-1}	7.8×10^{-1}	1.9×10^{-2}	1.6	$6.8\times10^{+1}$	$9.0\times10^{+1}$	3.8	1.6×10^{2}
3.3	Release of liquid waste storage tank contents	--	--	6.5×10^{-3}	4.2×10^{-2}**	4.1×10^{-2}	$\gamma + \beta$ =	1.2	6.1**	7.3
4.0	Fission products to primary system (BWR)	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.0	Fission products to primary and secondary systems (PWR)									
5.1	Fuel cladding defects and system generator leaks	*	*	*	*	*	*	*	*	*
5.2	Offdesign transient that induce fuel failure above the expected and steam generator leak	6.3×10^{-4}	4.5×10^{-4}	1.1×10^{-3}	9.7×10^{-5}	2.3×10^{-3}	1.5×10^{-1}	1.2×10^{-1}	2.6×10^{-2}	3.0×10^{-1}
5.3	Steam generator tube rupture	4.1×10^{-2}	6.6×10^{-2}	1.1×10^{-1}	2.0×10^{-2}	2.3×10^{-1}	8.5	$1.3\times10^{+1}$	4.1	2.6×10^{1}
6.0	Refueling accidents									
6.1	Fuel bundle drop	1.3×10^{-3}	2.9×10^{-3}	4.2×10^{-3}	6.5×10^{-4}	8.8×10^{-3}	2.6×10^{-1}	5.9×10^{-1}	1.3×10^{-1}	9.8×10^{-1}
6.2	Heavy object drop onto fuel in core	2.6×10^{-2}	5.8×10^{-2}	8.4×10^{-2}	1.2×10^{-2}	1.8×10^{-1}	5.3	$1.2\times10^{+1}$	2.4	$2.0\times10^{+1}$

Table G-1 (continued)

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Individual Doses at the Site Boundary (rem)				Fraction of Limit[b]	Dose Commitment to Population[a] (man-rem)			
		Gamma Radiation	Beta Radiation	Gamma Plus Beta	Iodine Inhalation		Gamma Radiation	Beta Radiation	Iodine Inhalation	Total
7.0	Spent fuel handling accident									
7.1	Fuel assembly drop in fuel storage pool	$1.3x10^{-3}$	$2.9x10^{-3}$	$4.2x10^{-3}$	$6.5x10^{-4}$	$8.8x10^{-3}$	$2.6x10^{-1}$	$5.9x10^{-1}$	$1.3x10^{-1}$	$9.8x10^{-1}$
7.2	Heavy object drop onto fuel rack	$8.9x10^{-4}$	$2.6x10^{-3}$	$3.5x10^{-3}$	$1.2x10^{-3}$	$7.8x10^{-3}$	$1.8x10^{-1}$	$5.3x10^{-1}$	$2.5x10^{-1}$	$9.6x10^{-1}$
7.3	Fuel cask drop[d]	$5.7x10^{-6}$	$6.0x10^{-4}$	$6.1x10^{-4}$	0.0	$1.2x10^{-3}$	$1.2x10^{-3}$	$1.2x10^{-1}$	0.0	$1.2x10^{-1}$
8.0	Accident initiation events considered in design basis evaluation in safety analysis report									
8.1	Small loss-of-coolant	$1.2x10^{-5}$	$2.5x10^{-5}$	$3.7x10^{-5}$	$1.9x10^{-6}$	$7.5x10^{-5}$	$3.5x10^{-3}$	$1.0x10^{-2}$	$7.5x10^{-4}$	$1.4x10^{-2}$
8.1	Large loss-of-coolant	$8.0x10^{-2}$	$8.1x10^{-2}$	$1.6x10^{-1}$	$7.7x10^{-3}$	$3.2x10^{-1}$	$2.3x10^{+1}$	$2.8x10^{+1}$	3.0	$5.4x10^{1}$
8.1 (a)	Instrument line break	NA	NA	NA	NA	NA	NA	NA	NA	NA
8.2 (a)	Rod ejection accident	$7.8x10^{-3}$	$7.9x10^{-3}$	$1.6x10^{-2}$	$1.4x10^{-3}$	$3.3x10^{-2}$	2.3	2.8	$5.8x10^{-1}$	5.7
8.3 (a)	Small MSLR	NIL	NIL	NIL	$9.8x10^{-7}$	$6.5x10^{-7}$	NIL	NIL	$2.0x10^{-4}$	$2.0x10^{-4}$
8.3 (a)	Large MSLR[c]	NIL	NIL	NIL	$5.1x10^{-6}$	$3.4x10^{-6}$	NIL	NIL	$1.0x10^{-3}$	$1.0x10^{-3}$

* Evaluated as routine releases in Section 2.4, Radioactive Discharges.

** Iodine ingestion.

NA Not applicable.

NIL Results in doses less than 10^{-4} rem and population doses less than 10^{-3} man-rem.

a. Based on estimated population within 50 miles of plant.

b. Estimated fraction of 10 CFR Part 20 limit at site boundary.

c. Main steamline rupture.

d. Represents the release from a single fuel element, since the number of elements in a cask varies with shipping method.

TABLE G-2

Primary Coolant Activity (Based on 0.50 Percent Failed Fuel, ρ = 42 lbm/ft3)

Isotope	Primary Coolant Activity (μCi/cc)
Kr-85m	0.664(+0)
Kr-85	0.620(+0)
Kr-87	0.364(+0)
Kr-88	0.117(+1)
Xe-131m	0.856(+0)
Xe-133m	0.192(+1)
Xe-133	0.109(+3)
Xe-135m	0.310(+0)
Xe-135	0.177(+1)
I-129	*NEG
I-131	0.143(+1)
I-132	0.998(+0)
I-133	0.174(+1)
I-134	0.199(+0)
I-135	0.848(+0)

*NEG = Negligible

TABLE G-3

Secondary Coolant Inventory (Based on 0.50 Percent Failed Fuel and 20 gpd/unit Hot Primary-to-Secondary Steam Generator Leak Rate)

Isotope	Primary Equilibrium Coolant Inventory (Ci)
Kr-85m	0.427(-9)
Kr-85	*NEG
Kr-87	*NEG
Kr-88	*NEG
Xe-131m	0.315(-9)
Xe-133m	0.521(-8)
Xe-133	0.923(-7)
Xe-135m	0.712(-5)
Xe-135	0.502(-6)
I-131	0.791(-3)
I-132	0.377(-3)
I-133	0.104(-2)
I-134	0.967(-4)
I-135	0.562(-3)

*NEG = Negligible

TABLE G-4

0.02 Percent* of Core Fission Product Inventory of Halogens and Noble Gases

Isotope	0.02 Percent Core Inventory (Ci)
Kr-83m	0.312(+4)
Kr-85m	0.976(+4)
Kr-85	0.259(+3)
Kr-87	0.176(+5)
Kr-88	0.241(+5)
Kr-89	0.299(+5)
Xe-131m	0.195(+3)
Xe-133	0.423(+5)
Xe-133m	0.104(+4)
Xe-135m	0.117(+5)
Xe-135	0.403(+5)
Xe-137	0.384(+5)
Xe-138	0.358(+5)
I-131	0.188(+5)
I-132	0.285(+5)
I-133	0.422(+5)
I-134	0.495(+5)
I-135	0.383(+5)

*0.02 percent of core inventory is utilized in off-design transient accident analysis.

2 percent of core inventory is utilized in large loss-of-coolant accident analysis.

TABLE G-5

Fission Product Gap Inventory of Halogens and Noble Gases Contained in One Fuel Assembly

Isotope	1 Fuel Assy (Ci) (100 Hrs Decay)	1 Fuel Assy (Ci) (30 Days Decay)
Kr-83m	*NEG	*NEG
Kr-85m	0.302(-3)	*NEG
Kr-85	0.327(+2)	0.325(+2)
Kr-87	*NEG	*NEG
Kr-88	0.833(-7)	*NEG
Kr-89	*NEG	*NEG
Ke-131m	0.382(+2)	0.857(+1)
Xe-133	0.609(+4)	0.205(+3)
Xe-133m	0.735(=2)	0.298(-1)
Xe-135m	*NEG	*NEG
Xe-135	0.503(+1)	*NEG
Xe-137	*NEG	*NEG
Xe-138	*NEG	*NEG
I-131	0.328(+4)	0.356(+3)
I-132	0.900(-9)	*NEG
I-133	0.385(+3)	0.470(-6)
I-134	*NEG	*NEG
I-135	0.322(+0)	*NEG

Gap activity is defined for environmental statement accident analysis as 1 percent of total pin activity.

*NEG = Negligible

TABLE G-6

Noble Gas Gap Inventory of One Assembly

Isotope	Noble Gas Inventory - 1 Assy (Ci) (120 Days Decay)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	0.319(+2)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Ke-131m	0.471(-1)
Xe-133	0.152(-2)
Xe-133m	*NEG
Xe-135m	*NEG
Xe-135	*NEG
Xe-137	*NEG
Xe-138	*NEG

*NEG - Negligible

TABLE G-7

Fission Product Gap Inventory of Halogens and Noble Gases Contained In One Row of Fuel Pins

Isotope	Inventory of One Row of Pins (Ci) (1 Week Decay)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	0.234(+1)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	0.233(+1)
Xe-133	0.302(+3)
Xe-133m	0.224(+1)
Xe-135m	*NEG
Xe-135	0.206(-2)
Xe-137	*NEG
Xe-138	*NEG
I-131	0.185(+3)
I-132	*NEG
I-133	0.291(+1)
I-134	*NEG
I-135	0.210(-4)

*NEG = Negligible

TABLE G-8

Gas Decay Tank Inventory (Based on 0.50 Percent Failed Fuel)

Isotope	Gas Decay Tank Inventory (Ci)
Kr-83m	0.847(+2)
Kr-85m	0.413(+3)
Kr-85	0.777(+2)
Kr-87	0.234(+3)
Kr-88	0.743(+3)
Kr-89	*NEG
Xe-131m	0.212(+3)
Xe-133	0.377(+5)
Xe-133m	0.560(+3)
Xe-135m	0.222(+3)
Xe-135	0.111(+3)
Xe-137	*NEG
Xe-138	*NEG
I-131	0.747(-1)
I-132	0.115(+0)
I-133	0.966(-1)
I-134	0.124(-1)
I-135	0.298(-1)

*NEG = Negligible

*TABLE G-9a

Accident Assumptions Used in Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 1.0 Trivial Incidents

These incidents are included and evaluated under routine releases in accordance with proposed Appendix I of 10 CFR Part 50.

ACCIDENT 2.0 Small Release Outside Containment

These releases include such things as releases through steamline relief valves and small spills and leaks of radioactive materials outside containment. These releases are included and evaluated under routine releases in accordance with proposed Appendix I of 10 CFR Part 50.

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*The classification of accidents in this and the following tables of assumptions is that of 10 CFR 50, Appendix D Annex. Note, however, that classifications 4.0, 8.2(b), and 8.3(b) were not considered as they pertain only to boiling water reactors. Classification 5.1 is also considered under routine release calculations. Meteorology assumptions common to all accidents are discussed in section 10 of this appendix.

TABLE G-9b

Accident Assumptions Used In
Bellefonte Environmental Statement Accident Analysis

ACCIDENT 3.0 Radwaste System Failure

3.1 Equipment leakage or malfunction
(Includes operator error)

(a) Release of 25 percent of the average inventory of gases in a waste gas decay tank assuming operation with 0.5 percent failed fuel.

(b) The waste gas decay tank inventory given in Table G-8.

3.2 Release of waste gas storage tank contents

(a) 100 percent of the average waste gas decay tank inventory (Table G-8) is assumed to be released.

3.3 Release of liquid waste storage tank contents

(a) Hypothetical instantaneous release to the river of the expected routine liquid radwaste releases for an entire year.

(b) Low river flow.

TABLE G-9c

Accident Assumptions Used In Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 5.0 Fission Products to Primary and Secondary Systems (Pressurized Water Reactor)

5.1 Fuel cladding defects and steam generator leaks

Releases from these events are included and evaluated under routine releases in accordance with proposed Appendix I of 10 CFR Part 50.

5.2 Off-design transients that induce fuel failure above those expected and steam generator leak (such as flow blockage and flux maldistributions)

(a) 0.02 percent of the core inventory of noble gases and 0.02 percent of the core inventory of halogens is assumed to be released into the reactor coolant (see Table G-4).

(b) Average inventory in the primary system before the transient is based on operation with 0.5 percent failed fuel (see Table G-2).

(c) Secondary system equilibrium radioactivity before the transient is based on a 20 gal/day steam generator leak (see Table G-3).

(d) All noble gases and 0.01 percent of the halogens in the steam reaching the condenser are assumed to be released by the condenser air ejector. (Assumes air ejector charcoal filters remove 90 percent of the iodines.)

(e) The release is terminated after one day.

5.3 Steam generator tube rupture

(a) 15 percent of the average inventory of noble gases and halogens in the primary coolant is assumed to be released into the secondary coolant. The average primary coolant activity is based on 0.5 percent failed fuel (see Table G-2).

(b) Equilibrium radioactivity before rupture is based on a 20 gallon per day steam generator leak (see Table G-3).

(c) All noble gases and 0.1 percent of the halogens in the steam reaching the condenser is assumed to be released by the condenser air ejector.

TABLE G-9d

Accident Assumptions Used In Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 6.0 Refueling Accidents

6.1 Fuel bundle drop

(a) The gap activity (noble gases and halogens) in one row of fuel pins is assumed to be released into the water. (Gap activity is 1 percent of total activity in a pin--see Table G-7).

(b) One week decay time before the accident occurs is assumed.

(c) Iodine decontamination factor in water is 500.

(d) Charcoal filter efficiency for iodines shall be 99 percent.

(e) 100 percent of the containment volume is assumed to leak to the atmosphere.

6.2 Heavy object drop onto fuel in core

(a) The gap activity (noble gases and halogens) in one average fuel assembly is assumed to be released into the water. (Gap activity shall be 1 percent of total activity in a pin).

(b) 100 hours of decay time before object is dropped is assumed.

(c) Iodine decontamination factor in water is 500.

(d) Charcoal filter efficiency for iodines is 99 percent.

TABLE G-9e

Accident Assumptions Used In Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 7.0 Spent Fuel Handling Accident

7.1 Fuel assembly drop in fuel storage pool

(a) The gap activity (noble gases and halogens) in one row of fuel pins is assumed to be released into the water. (Gap activity is 1 percent of total activity in a pin).

(b) One week decay time before accident occurs is assumed.

(c) Iodine decontamination factor in water is assumed to be 500.

(d) Charcoal filter efficiency for iodines is assumed to be 99 percent.

7.2 Heavy object drop onto fuel rack

(a) The gap activity (noble gases and halogens) in one average fuel assembly is assumed to be released into the water. (Gap activity is 1 percent of total activity in a pin.)

(b) 30 days decay time before the accident occurs is assumed.

(c) Iodine decontamination factor in water is 500.

(d) Charcoal filter efficiency for iodines is 99 percent.

7.3 Fuel cask drop

(a) Noble gas gap activity from one fuel assembly (120 day cooling) is assumed to be released. (Gap activity is 1 percent of total activity in the pins.)

TABLE G-9f

Accident Assumptions Used In Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 8.0 Accident Initiation Events Considered in Design Basis Evaluation in the Safety Analysis Report

8.1 Loss-of-coolant accidents
Small Pipe Break (6-in. or less)

(a) Source term: the average radioactivity inventory in the primary coolant is used. (This inventory is based on operation with 0.5 percent failed fuel.)

(b) Charcoal filter efficiency is assumed to be 99 percent.

(c) For the effects of plateout, sprays, decontamination factor in pool, and core sprays a 0.2 reduction factor is assumed.

(d) The primary containment leak rate is assumed to be 0.2 percent/day for the first day and 0.1 percent thereafter.

(e) The exhaust rate from the secondary containment is assumed to be 50 percent/day.

Large Pipe Break

(a) Source term: The average radioactivity inventory in the primary coolant is used. (This inventory is based on operation with 0.5 percent failed fuel.) In addition a release into the coolant of 2 percent of the core inventory of halogens and noble gases is assumed.

(b) Charcoal filter efficiencies (two filters in series) is assumed to be 99 percent for elemental iodine and 95 percent for organic iodines.

(c) For the effects of plateout, containment spray, core sprays a 0.2 reduction factor is assumed.

(d) Consequences are calculated by weighting the effects in different directions by the frequency the wind blows in each direction.

8.1(a) Break in instrument line from primary system that penetrates the containment.

Not applicable to Bellefonte.

8.2(a) Rod ejection accident (pressurized water reactor)

Table G-9g

Accident Assumptions Used in Bellefonte Environmental Statement Accident Analysis

(a) 0.2 percent of the core inventory of noble gases and halogens are assumed to be released into the primary coolant plus the average inventory in the primary coolant based on operation with 0.5 percent failed fuel.

(b) The containment assumptions are the same as those used in Class 8.1.

8.3(a) Steamline breaks (pressurized water reactors - outside containment)

Small break

(a) Primary coolant activity is based on operation with 0.5 percent failed fuel. The primary system contribution during the course of the accident is based on a 20 gal/day tube leak.

(b) During the course of the accident, a halogen reduction factor of 0.1 is used.

(c) Secondary coolant system radioactivity before the accident is based on 20 gallons per day primary-to-secondary leak.

(d) Volume of one steam generator is released to the atmosphere with an iodine partition factor of 10.

Large break

(a) Primary coolant activity is based on operation with 0.5 percent failed fuel. The primary system contribution during the course of the accident is based on a 20 gal/day tube leak.

(b) A halogen reduction factor of 0.5 is applied to the primary coolant source during the course of the accident.

(c) Secondary coolant system radioactivity before the accident is based on 20 gallons per day primary-to-secondary leak.

(d) Volume of one steam generator is assumed to be released to the atmosphere with an iodine partition factor of 10.

TABLE G-10

ACCIDENT 3.1
Radwaste System Equipment Leakage

Isotope	0-8 Hr. Release (Curies)
I-131	1.87(-2)
I-132	2.88(-2)
I-133	2.41(-2)
I-134	3.09(-3)
I-135	7.46(-3)
Kr-83m	2.12(+1)
Kr-85m	1.03(+2)
Kr-85	1.94(+1)
Kr-87	5.80(+1)
Kr-88	1.86(+2)
Kr-89	*NEG
Xe-131m	5.30(+1)
Xe-133m	1.40(+2)
Xe-133	9.42(+3)
Xe-135m	5.56(+1)
Xe-135	2.79(+2)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-11

ACCIDENT 3.2

RELEASE OF WASTE GAS STORAGE TANK CONTENTS

Isotope	0-8 Hr. Release (Curies)
I-131	7.47(-2)
I-132	1.15(-1)
I-133	9.66(-2)
I-134	1.24(-2)
I-135	2.98(-2)
Kr-83m	8.47(+1)
Kr-85m	4.13(+2)
Kr-85	7.77(+1)
Kr-87	2.34(+2)
Kr-88	7.43(+2)
Kr-89	*NEG
Xe-131m	2.12(+2)
Xe-133m	5.60(+2)
Xe-133	3.77(+4)
Xe-135m	2.22(+2)
Xe-135	1.11(+3)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-12

ACCIDENT 3.3

RELEASE OF LIQUID WASTE STORAGE TANK CONTENTS

Isotope	Release (Curies)
I-129	3.1(-8)
I-131	1.1(-1)
I-132	6.8(-7)
I-133	3.0(-2)
I-134	1.9(-7)
I-135	3.2(-5)
H-3	2.8(+2)
Cr-51	5.8(-4)
Mn-54	9.7(-5)
Fe-59	7.8(-5)
Co-58	4.5(-3)
Co-60	2.9(-3)
Br-84	1.2(-8)
Rb-88	7.9(-7)
Sr-89	8.8(-4)
Sr-90	9.2(-5)
Sr-91	2.7(-7)
Sr-92	4.6(-9)
Y-90	8.2(-6)
Y-91	5.8(-4)
Zr-95	5.9(-3)
Mo-99	3.1(-2)
Ru-106	1.0(-1)
Cs-134	1.1(-1)
Cs-136	4.9(-3)
Cs-137	2.8(-1)
Cs-138	2.3(-7)
Ba-140	9.1(-5)
La-140	2.0(-4)
Cs-144	2.5(-4)

TABLE G-13

ACCIDENT 5.2

OFF-DESIGN TRANSIENTS THAT INDUCE FUEL FAILURE ABOVE EXPECTED AND STEAM GENERATOR LEAKS

Isotope	Release (Curies) 0-8 Hrs.	8-24 Hrs.
I-131	2.72(-4)	3.26(-4)
I-132	1.66(-4)	1.18(-5)
I-133	5.41(-4)	4.67(-4)
I-134	1.24(-4)	1.56(-7)
I-135	3.83(-4)	1.59(-4)
Kr-83m	1.61(-1)	7.61(-3)
Kr-85m	9.15(-1)	2.95(-1)
Kr-85	7.85(-2)	1.39(-1)
Kr-87	6.70(-1)	8.62(-3)
Kr-88	1.72(+0)	0.24(+0)
Kr-89	3.17(-2)	*NEG
Xe-131m	3.60(-2)	6.20(-2)
Xe-133m	2.26(-1)	3.45(-1)
Xe-133	6.70(+0)	1.11(+1)
Xe-135m	9.00(-2)	*NEG
Xe-135	4.92(+0)	3.69(+0)
Xe-137	7.45(-2)	NEG
Xe-138	3.03(-1)	*NEG

*NEG = Negligible

TABLE G-14

ACCIDENT 5.3
STEAM GENERATOR TUBE RUPTURE

Isotope	0-8 Hrs. Release (Curies)
I-131	8.05(-2)
I-132	5.63(-2)
I-133	9.76(-2)
I-134	1.12(-1)
I-135	4.70(-2)
Kr-83m	*NEG
Kr-85m	3.72(+1)
Kr-85	3.48(+1)
Kr-87	2.05(+1)
Kr-88	6.58(+1)
Kr-89	*NEG
Xe-131m	4.82(+0)
Xe-133m	6.70(+1)
Xe-133	6.13(+3)
Xe-135m	1.74(+1)
Xe-135	9.98(+1)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-15

ACCIDENT 6.1
REFUELING ACCIDENT - FUEL BUNDLE DROP

Isotope	0-8 Hrs. Release (Curies)
I-131	3.70(-3)
I-132	*NEG
I-133	5.82(-5)
I-134	*NEG
I-135	4.20(-10)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	2.34(+0)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	2.33(+0)
Xe-133m	2.24(+0)
Xe-133	3.02(+2)
Xe-135m	*NEG
Xe-135	2.06(-3)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-16

ACCIDENT 6.2
HEAVY OBJECT DROP ONTO FUEL IN CORE

Isotope	0-8 Hrs. Release (Curies)
I-131	6.56(-2)
I-132	*NEG
I-133	7.69(-3)
I-134	*NEG
I-135	6.43(-6)
Kr-83m	*NEG
Kr-85m	3.02(-4)
Kr-85	3.27(+1)
Kr-87	*NEG
Kr-88	8.33(-8)
Kr-89	*NEG
Xe-131m	3.82(+1)
Xe-133m	7.36(+1)
Xe-133	6.10(+3)
Xe-135m	*NEG
Xe-135	5.03(+0)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-17

ACCIDENT 7.1
FUEL ASSEMBLY DROP IN FUEL STORAGE POOL

Isotope	0-8 Hrs. Release (Curies)
I-131	3.70(-3)
I-132	*NEG
I-133	5.82(-5)
I-134	*NEG
I-135	4.20(-10)
Kr-83m	*NEG
Kr-85m	4.38(-10)
Kr-85	2.35(+0)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	2.33(+0)
Xe-133m	2.24(+0)
Xe-133	3.02(+2)
Xe-135m	*NEG
Xe-135	2.06(-3)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-18

ACCIDENT 7.2
HEAVY OBJECT DROP ONTO FUEL RACK

Isotope	0-8 Hrs. Release (Curies)
I-131	7.12(-3)
I-132	*NEG
I-133	9.41(-9)
I-134	*NEG
I-135	*NEG
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	3.25(+1)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	8.58(+0)
Xe-133m	2.98(-2)
Xe-133	2.05(+2)
Xe-135m	*NEG
Xe-135	*NEG
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-19

ACCIDENT 7.3
Fuel Cask Drop

Isotope	0-8 Hrs. Release (Curies)
I-131	*NEG
I-132	*NEG
I-133	*NEG
I-134	*NEG
I-135	*NEG
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	3.20(+1)
Kr-87	*NEG
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	4.70(-2)
Xe-133m	*NEG
Xe-133	1.52(-3)
Xe-135m	*NEG
Xe-135	*NEG
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-20

ACCIDENT 8.1 Small LOCA
Loss of Coolant Accident

Isotope	0-8 Hrs.	Release (Curies) 8-24 Hrs.	1-30 Days
I-131	2.45(-6)	1.23(-5)	7.29(-5)
I-132	4.04(-6)	2.00(-7)	6.32(-10)
I-133	2.96(-6)	9.23(-6)	5.24(-6)
I-134	5.18(-7)	3.07(-10)	*NEG
I-135	1.43(-6)	1.73(-6)	1.55(-7)
Kr-83m	*NEG	*NEG	*NEG
Kr-85m	2.37(-2)	1.31(-2)	1.20(-6)
Kr-85	4.11(-2)	1.31(-1)	6.50(+0)
Kr-87	4.85(-3)	1.04(-4)	1.70(-8)
Kr-88	3.12(-2)	7.24(-3)	1.51(-4)
Kr-89	*NEG	*NEG	*NEG
Xe-131m	5.62(-3)	1.75(-2)	4.14(-1)
Xe-133m	7.51(-2)	2.06(-1)	1.01(+0)
Xe-133	7.06(-2)	2.11(-1)	2.54(+0)
Xe-135m	7.42(-4)	*NEG	*NEG
Xe-135	8.43(-2)	1.14(-1)	5.03(-2)
Xe-137	*NEG	*NEG	*NEG
Xe-138	*NEG	*NEG	*NEG

*NEG = Negligible

TABLE G-21

ACCIDENT 8.1 Large LOCA
Loss of Coolant Accident

Isotope	Release (Curies) 0-8 Hrs.	8-24 Hrs.	1-30 Days
I-131	8.61(-3)	4.30(-2)	2.55(-1)
I-132	3.07(-2)	1.53(-3)	4.82(-6)
I-133	1.92(-2)	5.99(-2)	3.40(-2)
I-134	3.43(-2)	2.03(-5)	*NEG
I-135	1.74(-2)	1.10(-2)	1.90(-3)
Kr-83m	1.57(+1)	1.23(-1)	3.59(-3)
Kr-85m	9.31(+1)	5.12(+1)	4.70(+0)
Kr-85	4.58(+0)	1.47(+1)	7.25(+2)
Kr-87	6.28(+1)	1.34(+0)	2.20(-4)
Kr-88	1.71(+2)	3.98(+1)	8.31(-1)
Kr-89	3.92(+0)	*NEG	*NEG
Xe-131m	3.41(+0)	1.06(+1)	2.52(+2)
Xe-133m	1.74(+1)	4.78(+1)	2.36(+2)
Xe-133	8.16(+2)	2.19(+3)	2.64(+4)
Xe-135m	7.49(+0)	*NEG	*NEG
Xe-135	5.97(+2)	7.92(+2)	3.51(+2)
Xe-137	6.11(+0)	*NEG	*NEG
Xe-138	2.55(+1)	*NEG	*NEG

*NEG = Negligible

TABLE G-22

ACCIDENT 8.2a
Rod Ejection Accident

Isotope	Release (Curies) 0-8 Hrs.	8-24 Hrs.	1-30 Days
I-131	8.66(-4)	4.33(-3)	8.39(-2)
I-132	3.09(-3)	1.53(-4)	4.82(-7)
I-133	1.93(-3)	6.01(-3)	3.41(-3)
I-134	3.43(-3)	2.03(-6)	*NEG
I-135	1.74(-3)	2.11(-3)	1.90(-4)
Kr-83m	1.57(-1)	1.23(-1)	3.59(-4)
Kr-85m	9.50(+0)	5.23(+0)	4.81(-1)
Kr-85	4.94(-1)	1.58(+0)	7.81(+1)
Kr-87	6.28(+0)	1.34(-1)	2.20(-5)
Kr-88	1.71(+1)	3.98(+0)	8.31(-2)
Kr-89	3.92(-1)	*NEG	*NEG
Xe-131m	3.94(-1)	1.22(+0)	2.90(+1)
Xe-133m	1.08(+0)	4.97(+0)	2.45(+1)
Xe-133	8.03(+1)	2.40(+2)	2.66(+3)
Xe-135m	7.49(-1)	*NEG	*NEG
Xe-135	5.20(+1)	7.35(+1)	3.05(+1)
Xe-137	6.11(-1)	*NEG	*NEG
Xe-138	2.55(+0)	*NEG	*NEG

*NEG = Negligible

TABLE G-23

ACCIDENT 8.3a
Steamline Break - Small Break

Isotope	0-8 Hrs. Release (Curies)
I-131	3.92(-6)
I-132	1.86(-6)
I-133	5.16(-6)
I-134	4.78(-7)
I-135	2.77(-6)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	*NEG
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	*NEG
Xe-133m	1.94(-9)
Xe-133	3.44(-8)
Xe-135m	2.65(-6)
Xe-135	1.88(-7)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

Table G-24

ACCIDENT 8.3a
Large Steamline Break

Isotope	0-8 Hrs. Release (Curies)
I-131	1.96(-5)
I-132	9.30(-6)
I-133	2.58(-5)
I-134	2.39(-6)
I-135	2.77(-5)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	*NEG
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	*NEG
Xe-133m	1.94(-9)
Xe-133	3.44(-8)
Xe-135m	2.65(-6)
Xe-135	1.88(-7)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

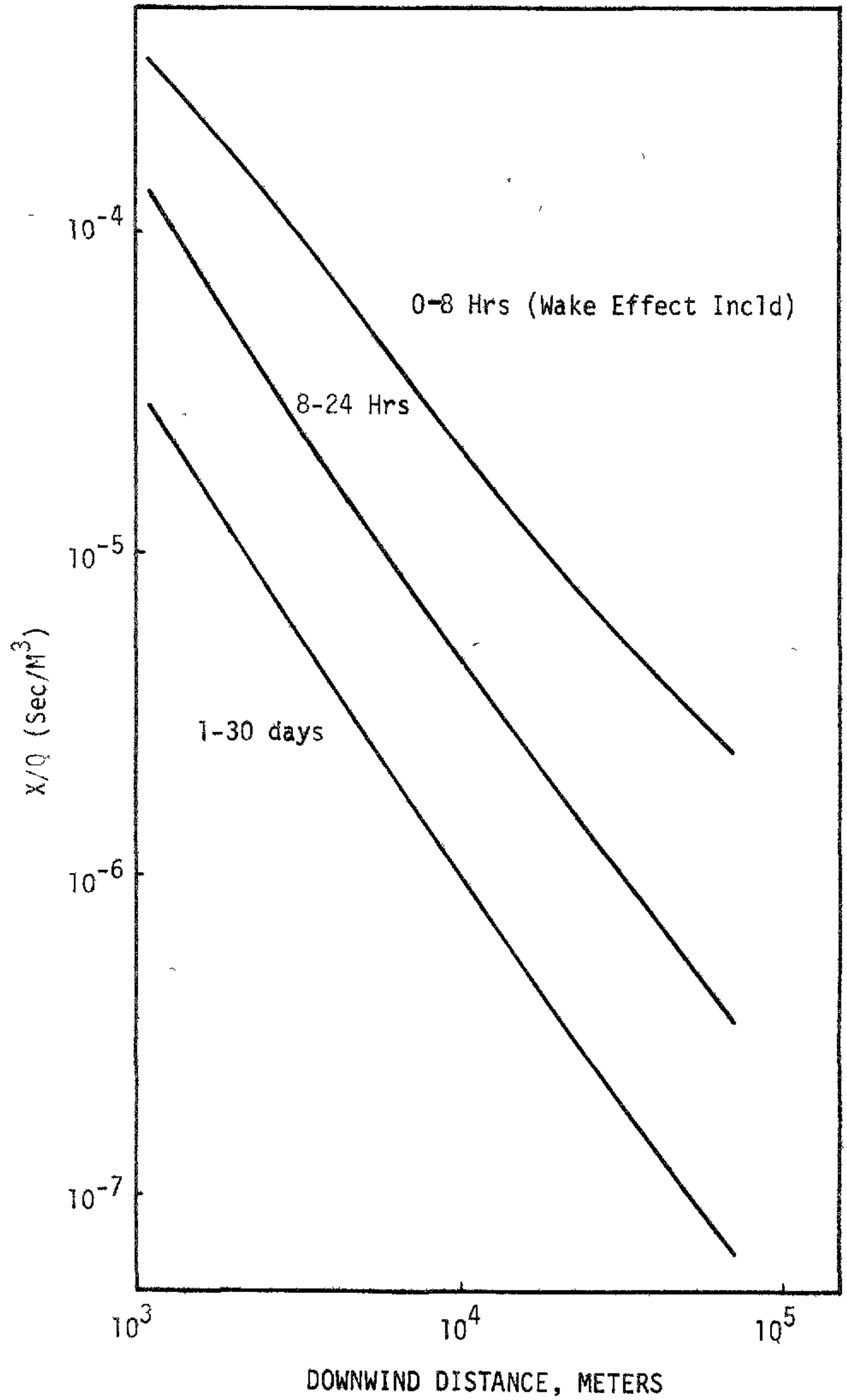

Figure G-1

X/Q VERSUS DISTANCE

Appendix H

RADIOLOGICAL IMPACT OF LIQUID EFFLUENTS

The calculation of radiation doses to organisms that are exposed in their normal environment is a difficult task. Because of the complexity of biological functions and the interrelationship between organisms and their environment, it is necessary to develop simplified dose models that can predict doses resulting from the more significant exposure pathways. While these models cannot predict the detailed variances of a system and while the results of an analysis cannot be applied equally to all members of a population, assumptions are chosen so that the radiation doses are conservative, i.e., over-estimated. Only the basic assumptions are given in this appendix along with a brief outline of the models and methods of calculation. Doses listed in Table H-2 are calculated for the radionuclides which are expected to be released during normal operation of the Bellefonte Nuclear Plant.

Tritium doses are considered separately and are based on a normalized release of 1 Ci per year. The tritium dose can be computed by multiplying this normalized value by the annual tritium release in curies.

Calculations of doses to humans include doses to bone, G.I. tract, thyroid, skin tissues, and the total body. Total body doses are calculated for organisms other than man. Population doses are estimated for the year 2020 based on the current populations multiplied by 1.95. The factor 1.95 is the increase projected for a 125-county area in the Tennessee River basin.

1. Doses to man from the ingestion of water - Data listed on Table H-1 for public and industrial water systems is used to calculate dose commitments from the consumption of Tennessee River water. It is assumed that the plant effluent is mixed with one-half of the river flow in the 6-mile reach between the nuclear plant site and the first water supply intake. Although natural water turbulence will continue to increase the dispersion downstream, it is assumed that half-dilution is maintained as far as Guntersville Dam past which full-dilution is assumed.

Dilution is calculated using average annual flow data for the Tennessee River as measured during 1899-1968. The average flow ranges from approximately 39,000 ft^3/s at the nuclear plant site to 65,000 ft^3/s at the mouth of the river near Paducah, Kentucky.

Radioactive decay and the buildup of daughter activity are based on estimates of the transport time using data for water velocities which vary between 0.1 and 3.5 ft/s. No radioactive decay is considered between the time of intake in a water system and the time of consumption. It is assumed that each individual consumes 2,200 ml of water per day (the average daily adult ingestion from all sources including drinking water, food, bottled drinks, etc.).

Due to a lack of definitive data, no credit is taken for removal of activity from the water through absorption on solids and sedimentation, by deposition in the biomass, or by processing within water treatment systems.

Internal doses, D_{ij}, for the j^{th} organ from the i^{th} radionuclide are calculated using the relation

$$D_{ij} = (DCF)_{ij} \times I_i, \qquad (1)$$

where

$(DCF)_{ij}$ = the dose commitment factor for the j^{th} organ from the i^{th} radionuclides for an average adult assuming that the dose can be accumulated over a 50-year interval, (mrem/μCi),

I_i = the activity of the i^{th} radionuclide taken into the body annually via ingestion, (μCi).

The dose commitment factors are derived from data given in the references listed[1,2,3,4] and are defined in units of (mrem/μCi) by the equation:

$$(DCF)_{ij} = \frac{51.2 \times 10^3 \, f_{wij} \, \varepsilon_{ij} \left(1-\exp(-\lambda_{ij}T)\right)}{m_j \, \lambda_{ij}}, \qquad (2)$$

where

$$51.2 \times 10^3 = \left(1.60 \times 10^{-8} \; \frac{\text{g-rad}}{\text{MeV}}\right) \left(3.20 \times 10^9 \; \frac{\text{dis}}{\mu\text{Ci-day}}\right) \left(10^3 \; \frac{\text{mrem}}{\text{rem}}\right)$$

f_{wij} = fraction of the i^{th} radionuclide taken into the body by ingestion that is retained in the j^{th} organ, (dimensionless),

ε_{ij} = effective energy absorbed in the j^{th} organ per disintegration of the i^{th} radionuclide including daughter products, (MeV-rem/dis-rad),

λ_{ij} = the effective decay constant of the i^{th} radionuclide in the j^{th} organ, (day^{-1}),

T = integration time, (18,250 days),

m_j = mass of the j^{th} organ, (g).

In the absence of a detailed knowledge regarding solubility characteristics of the radionuclides, the dose for the G.I. tract is overestimated using the assumption that none of the radionuclides is removed from the G.I. tract by absorption. Estimates of the doses to bone, thyroid, and total body are based on fractional uptakes given by the International Commission on Radiological Protection.[2] A detailed breakdown of the dose commitments at each public water supply intake is shown in Tables H-2 and H-3.

For comparison, dose commitments are also calculated for a hypothetical individual whose entire yearly water supply is obtained from the plant discharge conduit prior to dilution in the Tennessee River. These estimates are upper limits based on a continuous discharge flow rate of 30,000 GPM which corresponds to the minimum effluent flow rate. Average-annual concentrations of radionuclides in the liquid effluent can be estimated by dividing the releases by the annual discharge flow.

Dose commitments for the annual intake of ground water are derived from the estimates of the doses at Tennessee River water supplies. It is assumed that the radioactivity concentration in ground water within 0.5 mile of the Tennessee River is 100 percent of that present in the river. A conservative estimate of the human population drinking ground water within 0.5 mile of the river is 22,000 persons between Bellefonte and Paducah, Kentucky. The maximum population dose commitment (thyroid) for an annual release of 0.93 Ci in the liquid effluent is 0.11 man-rem. This dose commitment, DC_p, is obtained as follows:

$$DC_p = \sum_{i=1}^{24} \frac{P_i}{A_i} \times A_i^* \times DC_i$$

where

P_i = population of county i,

A_i = county area, (sq.mi.),

A_i^* = county area within 0.5 mile of the Tennessee River, (sq.mi.),

DC_i = individual thyroid dose commitment calculated for a public water supply in or near county i, (rem).

Doses to humans from ingestion of Tennessee River water affected by slug releases can be estimated using the data in section A of Tables H-2 and H-3 provided: (1) the distribution of activity is essentially the same as that given in Table 2.4-6 (2) the total activity of the slug release is known, and (3) the river velocities and dilution factors are not grossly different from the average values on which the routine dose estimates are based. A conservative estimate of the doses to humans from a slug of radioactivity released during low-flow conditions can be obtained by multiplying the doses in Table H-2 by: (1) the ratio of activity released to 0.93 Ci, and (2) by the ratio of the average flow rate to the acutal flow rate. For example, a slug of 1.0 Ci activity released during a 5 percent* flow condition could result in doses that are higher than those in Table H-2 by the factor

$$F = \frac{1.0\ \text{Ci}}{0.93\ \text{Ci}} \times \frac{(\text{Average Flow Rate})}{0.37 \times (\text{Average Flow Rate})} = 2.9$$

2. Doses to man from the consumption of fish - Current estimates of Tennessee River annual fish harvests are 15.2 lb/acre sport fish[5] and 13.7 lb/acre edible commercial fish.[6] It is assumed that these rates will increase with the population expansion, so that the dose calculations are based on harvests of 30-lb/acre sport fish and 27-lb/acre commercial fish in the year 2020. The Tennessee River is segmented into 10 reaches in order to facilitate the calculations of fish harvests and radioactivity concentrations. For convenience, the limits defining the reaches correspond to the locations of Guntersville, Wheeler, Wilson, Pickwick Landing, and Kentucky Dams, and the Browns Ferry Nuclear Plant site. Additional points were selected to subdivide Guntersville and Kentucky reservoirs into shorter reaches. The radioactivity levels in the fish from each reach are estimated by the product of an average activity concentration in the reach and a concentration factor for each radionuclide.[7,8] Concentration factors derived from references 7 and 8 are listed in Table H-4. It is assumed that the maximum annual consumption of fish by an individual is 45 lbs. The population dose is calculated using the assumption that all of the edible

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*A 5 percent flow rate is that which is equaled or exceeded 95 percent of the time. This flow rate is approximately 37 percent of the annual-average flow rate based on daily discharge data during 1960-1970 for Nickajack, Guntersville, Wheeler, Pickwick Landing, and Kentucky Dams.

fish harvested are consumed by humans. Radioactive decay is not considered between the time the fish is removed from the water and the time of consumption, and the entire mass of the fish is assumed to be eaten.

Dose commitments are calculated with equations 1 and 2 which are discussed for water ingestion in the previous section, and the results are shown in Tables H-2 and H-3.

Calculations indicate that there would be no significant radiological impact from human utilization of shellfish. Shellfish are not currently being harvested commercially in the Tennessee River, and consumption of shellfish by humans is assumed to be negligible.

3. <u>Doses to man due to water sports</u> - Estimates of the doses from immersion in the Tennessee River are calculated for each radionuclide using the following relations. For the dose rate to the skin,

$$R_i = 51.2 \times 10^3 \, C_{wi} \left(\bar{E}_\beta/2 + E_\gamma\right)_i \ \frac{\text{mrem}}{\text{day}} \qquad (3)$$

For the dose rate to the total body,

$$R_i = 51.2 \times 10^3 \, C_{wi} \, E_{\gamma i} \ \frac{\text{mrem}}{\text{day}} \qquad (4)$$

where 51.2×10^3 = (see equation 1),

C_{wi} = water concentration for the i^{th} radionuclide, (μCi/g),

$E_{\gamma i}$ or $(\bar{E}_\beta/2 + E_\gamma)i$ = average effective energy emitted by the i^{th} radionuclide per disintegration (MeV-rem/dis-rad).

Dose rates for above-water activities such as boating are assumed to be given by equations 3 and 4 divided by 2.

The maximum individual doses for above-water use of the river are estimated for a commercial fisherman who is not a water sport enthusiast but who might be exposed for 300 days per year at 5 hours per day. The maximum individual doses for in-water activities are estimated for a person who swims 918 hours per year (6 hours per day for the 5 warm months) at a location just below the Bellefonte site. In order to estimate the maximum possible tritium dose to a swimmer, continuous immersion for 5 months in the Tennessee River just below the Bellefonte site is assumed.

In order to estimate the doses from shoreline activities, the buildup of radioactivity in sediments is considered. Because of the complexity of the dynamics associated with radionuclide transport and deposition, a simplified dose model[9] is used to estimate the accumulation of radionuclides in sediment. The dose contribution from all of the radionuclides contained within the top 2.5 cm of sediment is considered. Assuming a mass of 40 kg/m^2 of surface, an effective surface contamination can be estimated using the relation

$$S_i = 100\ T_i\ C_{wi}\ W_f\ (1 - \exp(-\lambda_i t)) \tag{5}$$

where

S_i = "effective" surface contamination, (pCi/m^2),

100 = constant, ($1/m^2$-day),

T_i = radiological half-life of nuclide i, (days),

C_{wi} = concentration of nuclide i in water adjacent to the sediment, (pCi/l),

W_f = shore width factor, equaling 1 for maximum individual dose calculations and 0.3 for population dose calculations,

λ_i = radiological decay constant of nuclide i, (years^{-1}),

t = length of time the sediment is exposed to the contaminated water = 40 years.

The dose rates to the skin and total body are calculated using the dose factors listed in reference 9. An individual adult is assumed to be involved in shoreline activities for 500 hours per year. In calculating the population dose, an average shoreline visit is assumed to last 5 hours.

Water concentrations are calculated for 10 reaches between the nuclear plant site and Kentucky Dam (TRM 22.4). Doses to the population are calculated using estimates for above-water, in-water, and shoreline visits for the respective reaches based on current information given in reference 10 multiplied by the predicted population growth factor of 1.95.

4. Doses to organisms other than man - A comprehensive analysis of the radiation doses to species other than humans would require many man-years of effort that could be justified only if a significant radiological impact on a particular species were anticipated. After consultation with professionals in the health physics and radioecology fields, a decision was made by TVA to restrict the analyses to those organisms living on or near the Bellefonte site that would most likely receive the greatest doses. These include terrestrial vertebrates, aquatic plants, aquatic invertebrates, and fish.

(1) Terrestrial vertebrates - Radioactivity contained in nuclear plant liquid effluents is concentrated in fish, invertebrates, and plants by factors that range from less than 1 to greater than 10^5 depending on interrelated physical, chemical,

and biological factors. Terrestrial vertebrates will receive a radiation dose from liquid effluents if their food chain includes aquatic organisms that have concentrated radionuclides. In general, aquatic plants such as green algae concentrate trace elements to a greater extent than do fish and invertebrates.[7] Therefore, internal dose estimates have been made for ducks and muskrats with the conservative assumption that their diet consists entirely of green algae from algal masses growing near the Bellefonte discharge. Equations 1 and 2 from section 1 are used for estimating the annual internal total body dose. It is assumed that the duck or muskrat has a mass m of 1,000 g, and effective radius of 10 cm, and consumes 333 g of green algae per day. Long-lived radionuclides such as Sr-90 can deliver significant portions of the total dose commitment long after the time of ingestion. Therefore, a period of 5 years was chosen for the integration interval T. In the absence of data specifically applicable to ducks or muskrats, ICRP data[2] are used for the fractional uptake in the total body and for the biological half-life of parent radionuclides. The use of human data for the biological half-lives is considered to be conservative because, in general, warm-blooded vertebrates that are smaller than man exhibit more rapid elimination rates.[8] Equation 5 is a combination of the above assumptions with equations 1 and 2.

$$D_i = 51.2 \times 10^3 \, I_i \, f_{wi} \, \varepsilon_i \, (1-\exp(-\lambda_i T))/\lambda_i m \text{ mrad} \qquad (5)$$

where

$I_i = 333 \frac{g}{d} \times C_{wi} \times 365 \, F_{pi} \frac{d}{y}$, ($\mu$Ci/y),

C_{wi} = water concentration, (μCi/g),

F_{pi} = concentration factor[7,8] for aquatic plants, (dimensionless).

T = 1,825 days

m = 1,000 g

External doses are estimated with equation 4 using the conservative assumption that the duck and muskrat are exposed continuously by full immersion in the water.

Estimates of the doses to ducks and muskrats living near the Bellefonte Nuclear Plant are shown in Table H-5.

(2) <u>Aquatic plants, invertebrates, and fish</u> - Radionuclide activity internally deposited in these organisms is estimated from the concentration in the water in the Tennessee River just below the liquid effluent discharge, assuming mixing with one-half the average river flow, multiplied by the applicable concentration factors.[7,8] Doses are estimated for organisms having effective radii of 3 cm and 30 cm. Although estimates for both geometries are reported, an effective radius of 30 cm could represent organisms weighing up to 250 pounds. This geometry probably results in overestimates of the doses. In the absence of a detailed knowledge of the dynamic behavior of daughter products that are produced from internally-deposited parents, the conservative assumption is made that all daughter products are permanently bound in the organisms and every daughter in a decay chain contributes energy at an equilibrium disintegration rate for each disintegration of the parent. The annual doses from the i^{th} radionuclide are calculated using the relation:

$$D_i = 51.2 \times 10^3 \; C_{fi} \; \varepsilon_i \times 365 \text{ mrad} \qquad (6)$$

where

C_{fi} = radioactivity concentration in the organism

= $C_{wi} \times F_i$, (μCi/g),

C_{wi} = water concentration, (μCi/g),

F_i = concentration factor, (dimensionless)

External doses for organisms surrounded by water are calculated using equation 4. Benthic organisms such as mussels, worms, and fish eggs may receive higher external doses if significant radioactivity is associated with bottom sediments. Accurate prediction of the accumulation of activity in sediment requires a detailed knowledge of a number of physiochemical factors including mineralogy, particle size, exchangeable calcium in the sediment, channel geometry, water-flow patterns, and the chemical forms of the radio-compounds. Many of these factors must be obtained from extensive field experiments. In the absence of detailed knowledge, the doses are calculated using the following assumptions:

a. Two-tenths of the activity in the liquid effluent is deposited uniformly in a sediment bed having dimensions of 10 cm x 100 m x 10 km.

b. The radioactivity concentration in the sediment is calculated assuming a buildup over the plant life of 35 years at a constant rate of deposition.

c. Beta doses are based on a 4-π geometry and gamma doses assuming a 2-π geometry.

The doses calculated using these assumptions are probably overestimated. Periodic surveillance of the sediment downstream from the nuclear plant will detect a buildup of radionuclides in the sediment, should it occur. If a gradual buildup of radionuclides in the sediment does occur, corrective action will be taken prior to its becoming a significant environmental hazard.

Estimates of the doses to aquatic plants, invertebrates, and fish living near the Bellefonte Nuclear Plant are shown in Table H-6.

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4. Eve, I. S., "A Review of the Physiology of the Gastrointestinal Tract in Relation to Radiation Doses from Radioactive Materials," Health Physics 12, p. 131 (1966).

5. Tennessee Game and Fish Commission, Tennessee Valley Authority, and Kentucky Department of Fish and Wildlife Resources, "Kentucky Lake Fishing."

6. U.S. Department of the Interior, "Estimated Commercial Fish Harvést, Tennessee Valley, 1969," Bureau of Commercial Fisheries.

7. Chapman, W. H., et al, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," Lawrence Radiation Laboratory Report, UCRL-50564, 1968.

8. Reichle, D. E., et al, "Turnover and Concentration of Radionuclides in Food Chains," Nuclear Safety, 11, No. 1 (January-February 1970).

9. U.S. Atomic Energy Commission, Final Environmental Statement Concerning Proposed Rule Making Action: Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents, WASH-1258, Appendix F, July 1973.

10. Tennessee Department of Conservation, "Statistical Summary--State Demand, Supply, and Comparisons," Tennessee Statewide Comprehensive Outdoor Recreation Plan - 1969, Final Report, Appendix IV, Table 27, 1969, p. 31.

Table H-1

TENNESSEE RIVER DRINKING WATER SUPPLY INTAKES

DOWNSTREAM FROM THE BELLEFONTE NUCLEAR PLANT

System	Location (TRM)	Distance (Miles)	Populations Served 1970	2020
Bellefonte Nuclear Plant	392.0	0.0	0	0
Scottsboro	385.8	6.2	11,000	21,000
Sand Mountain Water Authority	382.1	9.9	8,200	16,000
Christian Youth Camp	368.2	23.8	130	240
Guntersville	358.0	34.0	6,600	13,000
N. E. Morgan Co. Water and Fire	334.4	57.6	3,600	7,000
Huntsville	334.2	57.8	150,000	290,000
Decatur	306.0	86.0	41,000	80,000
U.S. Plywood - Champion Papers	283.0	109.0	500	1,000
Wheeler Dam	274.9	117.1	50	100
Reynolds Metals	260.0	132.0	5,000	10,000
Muscle Shoals	259.6	132.4	7,500	15,000
Wilson Dam	259.5	132.5	2,500	4,900
Sheffield	254.3	137.7	14,000	27,000
Colbert Steam Plant	245.0	147.0	350	680
Cherokee	239.3	152.7	2,700	5,300
Tri-County Utility District	193.5	198.5	1,700	3,200
Clifton	158.0	234.0	1,000	2,000
New Johnsonville	100.5	291.5	950	1,900
Camden	100.4	291.6	3,100	6,000
Foote Mineral	100.0	292.0	170	320
Johnsonville Steam Plant	100.0	292.0	380	730
Bass Bay Resort	79.5	312.5	120	230
Paris Landing State Park	66.3	325.7	100	200
Grand Rivers	24.0	368.0	640	1,200
Paducah	0.1	391.9	63,000	120,000

Table H-2

DOSES[a] TO HUMANS FROM WATER CONTAINING A MIXTURE[b] OF RADIONUCLIDES

A. Ingestion of Tennessee River Water[c]

Location	Bone	G.I. Tract	Thyroid	Total Body
Bellefonte Site (for comparison)	1.7 (-3)[d]	2.1 (-3)	1.5 (-2)	9.8 (-4) mrem
Scottsboro	1.7 (-3)	2.1 (-3)	1.4 (-2)	9.8 (-4) mrem
	3.6 (-2)	4.4 (-2)	3.0 (-1)	2.1 (-2) man-rem
Sand Mountain Water Authority	1.7 (-3)	2.0 (-3)	1.3 (-2)	9.7 (-4) mrem
	2.7 (-2)	3.3 (-2)	2.1 (-1)	1.6 (-2) man-rem
Christian Youth Camp	1.6 (-3)	2.0 (-3)	1.2 (-2)	9.6 (-4) mrem
	4.0 (-4)	4.8 (-4)	2.8 (-3)	2.3 (-4) man-rem
Guntersville	1.6 (-3)	1.9 (-3)	1.1 (-2)	9.3 (-4) mrem
	2.1 (-2)	2.4 (-2)	1.4 (-1)	1.2 (-2) man-rem
N. E. Morgan Co., Water and Fire	7.6 (-4)	8.8 (-4)	4.5 (-3)	4.4 (-4) mrem
	5.3 (-3)	6.2 (-3)	3.2 (-2)	3.1 (-3) man-rem
Huntsville	7.6 (-4)	8.8 (-4)	4.5 (-3)	4.4 (-4) mrem
	2.2 (-1)	2.5 (-1)	1.3 (0)	1.3 (-1) man-rem
Decatur	7.3 (-4)	8.5 (-4)	4.0 (-3)	4.3 (-4) mrem
	5.9 (-2)	6.8 (-2)	3.2 (-1)	3.4 (-2) man-rem
U.S. Plywood - Champion Papers	6.6 (-4)	7.5 (-4)	3.0 (-3)	3.8 (-4) mrem
	6.4 (-4)	7.3 (-4)	2.9 (-3)	3.7 (-4) man-rem
Wheeler Dam	6.5 (-4)	7.3 (-4)	2.5 (-3)	3.8 (-4) mrem
	6.3 (-5)	7.1 (-5)	2.4 (-4)	3.7 (-5) man-rem
Reynolds Metals	6.3 (-4)	7.0 (-4)	1.9 (-3)	3.7 (-4) mrem
	6.1 (-3)	6.8 (-3)	1.8 (-2)	3.6 (-3) man-rem
Muscle Shoals	6.3 (-4)	7.0 (-4)	1.8 (-3)	3.7 (-4) mrem
	9.2 (-3)	1.0 (-2)	2.7 (-2)	5.3 (-3) man-rem
Wilson Dam	6.3 (-4)	7.0 (-4)	1.8 (-3)	3.7 (-4) mrem
	3.1 (-3)	3.4 (-3)	9.0 (-3)	1.8 (-3) man-rem
Sheffield	6.3 (-4)	6.9 (-4)	1.8 (-3)	3.6 (-4) mrem
	1.7 (-2)	1.9 (-2)	4.9 (-2)	9.9 (-3) man-rem
Colbert Steam Plant	6.2 (-4)	6.9 (-4)	1.8 (-3)	3.6 (-4) mrem
	4.3 (-4)	4.7 (-4)	1.2 (-3)	2.5 (-4) man-rem
Cherokee	6.2 (-4)	6.9 (-4)	1.7 (-3)	3.6 (-4) mrem
	3.3 (-3)	3.6 (-3)	9.1 (-3)	1.9 (-3) man-rem
Tri-County Utility District	5.9 (-4)	6.5 (-4)	1.3 (-3)	3.4 (-4) mrem
	1.9 (-3)	2.1 (-3)	4.2 (-3)	1.1 (-3) man-rem
Clifton	5.8 (-4)	6.4 (-4)	1.2 (-3)	3.4 (-4) mrem
	1.1 (-3)	1.2 (-3)	2.4 (-3)	6.6 (-4) man-rem

a. Estimates for parts A, B, and C are internal dose commitments for each annual intake of radioactivity. Estimates for part D are external doses for each annual exposure.
b. Excluding tritium.
c. Based on the estimated population in the year 2020.
d. 1.7×10^{-3}.

Table H-2 (Continued)

	Bone	G.I. Tract	Thyroid	Total Body	
New Johnsonville	5.2 (-4)	5.6 (-4)	9.5 (-4)	3.0 (-4)	mrem
	9.6 (-4)	1.0 (-3)	1.8 (-3)	5.5 (-4)	man-rem
Camden	5.2 (-4)	5.6 (-4)	9.5 (-4)	3.0 (-4)	mrem
	3.1 (-3)	3.3 (-3)	5.7 (-3)	1.8 (-3)	man-rem
Foote Mineral	5.2 (-4)	5.6 (-4)	9.5 (-4)	3.0 (-4)	mrem
	1.7 (-4)	1.8 (-4)	3.1 (-4)	9.6 (-5)	man-rem
Johnsonville Steam Plant	5.2 (-4)	5.6 (-4)	9.5 (-4)	3.0 (-4)	mrem
	3.8 (-4)	4.1 (-4)	7.0 (-4)	2.2 (-4)	man-rem
Bass Bay Resort	5.1 (-4)	5.5 (-4)	8.6 (-4)	3.0 (-4)	mrem
	1.2 (-4)	1.3 (-4)	2.0 (-4)	6.9 (-5)	man-rem
Paris Landing State Park	5.0 (-4)	5.4 (-4)	7.9 (-4)	2.9 (-4)	mrem
	9.8 (-5)	1.1 (-4)	1.5 (-4)	5.7 (-5)	man-rem
Grand Rivers	5.0 (-4)	5.3 (-4)	5.4 (-4)	2.9 (-4)	mrem
	6.2 (-4)	6.6 (-4)	6.8 (-4)	3.6 (-4)	man-rem
Paducah	4.9 (-4)	5.2 (-4)	5.1 (-4)	2.8 (-4)	mrem
	6.0 (-2)	6.4 (-2)	6.2 (-2)	3.5 (-2)	man-rem
Total Population Dose Commitments	4.7 (-1)	5.5 (-1)	2.5	2.8 (-1)	man-rem

B. Ingestion of Nuclear Plant Effluent[e] Prior to Dilution in the Tennessee River

	Bone	G.I. Tract	Thyroid	Total Body	
Individual Dose Commitments	4.9 (-1)	6.2 (-1)	4.2	2.9 (-1)	mrem

C. Eating Fish Taken from the Tennessee River

	Bone	G.I. Tract	Thyroid	Total Body	
Maximum Individual Dose Commitment	1.9 (-2)	1.2 (-2)	1.9 (-2)	1.2 (-2)	mrem
Population Dose Commitment	6.1	4.1	4.9	3.9	man-rem

D. Use of the Tennessee River for Water Sports

	Above Water[f]		In Water[g]		Shoreline[h]		
	Skin	Total Body	Skin	Total Body	Skin	Total Body	
Maximum Individual Dose	2.6 (-5)	2.0 (-5)	6.6 (-5)	5.0 (-5)	3.0 (-2)	2.6 (-2)	mrem
Population Dose	1.5 (-3)	1.1 (-3)	5.6 (-4)	4.3 (-4)	9.9 (-1)	8.4 (-1)	man-rem

e. Assuming a continuous discharge of 30,000 GPM.
f. Boating and fishing, for example.
g. Swimming and water skiing, for example.
h. Picnicking and bank fishing, for example.

Table H-3

DOSES[a] TO HUMANS FROM WATER CONTAINING TRITIUM[b]

A. Ingestion of Tennessee River Water[c]

	Individual (mrem)	Population (man-rem)
Bellefonte Nuclear Plant (for comparison)	5.2 (-6)[d]	-
Scottsboro	5.2 (-6)	1.1 (-4)
Sand Mountain Water Authority	5.2 (-6)	8.3 (-5)
Christian Youth Camp	5.1 (-6)	1.2 (-6)
Guntersville	5.0 (-6)	6.4 (-5)
N. E. Morgan Co. Water and Fire	2.4 (-6)	1.7 (-5)
Huntsville	2.4 (-6)	6.8 (-4)
Decatur	2.3 (-6)	1.8 (-4)
U.S. Plywood - Champion Papers	2.1 (-6)	2.0 (-6)
Wheeler Dam	2.0 (-6)	2.0 (-7)
Reynolds Metals	2.0 (-6)	1.9 (-5)
Muscle Shoals	2.0 (-6)	2.9 (-5)
Wilson Dam	2.0 (-6)	9.6 (-6)
Sheffield	2.0 (-6)	5.4 (-5)
Colbert Steam Plant	2.0 (-6)	1.3 (-6)
Cherokee	1.9 (-6)	1.0 (-5)
Tri-County Utility District	1.9 (-6)	6.0 (-6)
Clifton	1.8 (-6)	3.6 (-6)
New Johnsonville	1.6 (-6)	3.0 (-6)
Camden	1.6 (-6)	9.6 (-6)
Foote Mineral	1.6 (-6)	5.2 (-7)
Johnsonville Steam Plant	1.6 (-6)	1.2 (-6)
Bass Bay Resort	1.6 (-6)	3.8 (-7)
Paris Landing State Park	1.6 (-6)	3.1 (-7)
Grand Rivers	1.6 (-6)	2.0 (-6)
Paducah	1.6 (-6)	1.9 (-4)
Population Total		1.5 (-3) man-rem

B. Ingestion of Nuclear Plant Effluent[e] Prior to Dilution in the Tennessee River

Individual Dose Commitment 1.5 (-3) mrem

C. Eating Fish Taken from the Tennessee River

Maximum Individual Dose Commitment 6.1 (-8) mrem

Population Dose Commitment 2.1 (-5) man-rem

a. Estimates are internal dose commitments for each annual intake of tritium
b. Normalized to 1.0 Ci total annual release
c. Based on the estimated population in the year 2020
d. 5.2×10^{-6}
e. Assuming a continuous discharge of 30,000 GPM

Table H-3 (Continued)

D. Use of the Tennessee River for Water Sports

	Individual (mrem)
Maximum Individual Dose[f]	4.7 (-6) mrem
Population Dose	7.3 (-4) man-rem

f. Assuming continuous immersion for 5 months

Table H-4

CONCENTRATION FACTORS FOR AQUATIC ORGANISMS

Nuclide	Half-Life	Concentration Factors: Fish	Invertebrates	Plants
H-3	4.5 (+3)	1.0 [a]	1.0 [a]	1.0 [a]
Cr-51	2.8 (+1)	2.0 (+2)[a]	2.0 (+3)[a]	4.0 (+3)[a]
Mn-54	3.0 (+2)	2.5 (+1)[a]	1.4 (+5)[b]	3.5 (+4)[b]
Fe-59	4.6 (+1)	3.0 (+2)[a]	3.2 (+3)[a]	5.0 (+3)[a]
Co-58	7.1 (+1)	2.1 (+1)[b]	1.3 (+3)[a]	6.2 (+3)[b]
Co-60	1.9 (+3)	4.8 (+1)[b]	1.5 (+3)[a]	6.2 (+3)[b]
Br-84	2.2 (-2)	1.3 (+2)[a]	1.0 (+2)[a]	7.5 (+2)[a]
Rb-88	1.2 (-2)	2.0 (+3)[a]	2.0 (+3)[a]	1.0 (+3)[a]
Sr-89	5.3 (+1)	3.5 [c]	4.0 (+3)[b]	3.0 (+3)[b]
Sr-90	1.0 (+4)	9.9 [c]	4.0 (+3)[b]	3.0 (+3)[b]
Sr-91	4.0 (-1)	4.0 (-2)[c]	3.2 (+3)[b]	3.0 (+3)[b]
Sr-92	1.1 (-1)	1.1 (-2)[c]	2.1 (+3)[b]	3.0 (+3)[b]
Y-90	2.7	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Y-91	5.9 (+1)	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Zr-95	6.6 (+1)	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Nb-95	3.5 (+1)	3.0 (+4)[a]	1.0 (+2)[a]	1.0 (+3)[a]
Mo-99	2.8	1.0 (+2)[a]	1.0 (+2)[a]	1.0 (+2)[a]
Ru-106	3.7 (+2)	1.0 (+2)[a]	2.0 (+3)[a]	2.0 (+3)[b]
I-129	6.2 (+9)	5.0 (+1)[b]	1.0 (+3)[b]	2.0 (+2)[b]
I-131	8.1	4.5 (+1)[b]	1.0 (+3)[b]	2.0 (+2)[b]
I-132	9.4 (-2)	4.3 [b]	1.0 (+3)[b]	2.0 (+2)[b]
I-133	8.5 (-1)	2.3 (+1)[b]	1.0 (+3)[b]	2.0 (+2)[b]
I-134	3.6 (-2)	1.7 [b]	1.0 (+3)[b]	2.0 (+2)[b]
I-135	2.8 (-1)	1.1 (+1)[b]	1.0 (+3)[b]	2.0 (+2)[b]
Cs-134	7.5 (+2)	1.0 (+3)[a]	9.9 (+3)[b]	2.5 (+4)[b]
Cs-136	1.4 (+1)	9.3 (+2)[a]	5.8 (+3)[b]	2.5 (+4)[b]
Cs-137	1.1 (+4)	1.0 (+3)[a]	1.0 (+4)[b]	2.5 (+4)[b]
Cs-138	2.2 (-2)	2.2 (+1)[a]	2.2 (+1)[b]	2.5 (+4)[b]
Ba-140	1.3 (+1)	1.0 (+1)[a]	2.0 (+2)[a]	5.0 (+2)[a]
La-140	1.7	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Ce-144	2.8 (+2)	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Pr-144	1.2 (-2)	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]

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Table H-5

DOSES[a] TO DUCKS AND MUSKRATS LIVING NEAR THE BELLEFONTE NUCLEAR PLANT

	0.93 Ci Mixture	1.0 Ci Tritium
Internal	1.6 (2) mrad	5.1 (-5)[b] mrad
External	2.4 (-4) mrad	0
Total	1.6 (2) mrad	5.1 (-5) mrad

a. Internal dose commitments for each annual intake and external doses from each annual exposure.
b. 5.1×10^{-5}

Table H-6

DOSES TO AQUATIC ORGANISMS LIVING IN THE TENNESSEE RIVER

NEAR THE BELLEFONTE NUCLEAR PLANT

A. Doses from an Annual Release of a 0.93 Ci Radionuclide Mixture[a]

	Internal (mrad)		External (mrad)
	3-cm	30-cm	
Plants	3.6	8.5	6.3 (-4)[b]
Invertebrates	1.6	3.5	6.3 (-4) suspended 120 benthic
Fish	0.1	0.3	6.3 (-4)

B. Doses from an Annual Release of 1.0 Ci Tritium

Plants, invertebrates, and fish	1.1 (-5) mrad (internal)

a. Excluding tritium
b. 6.3×10^{-4}

Appendix I

RADIOLOGICAL IMPACT OF GASEOUS EFFLUENTS

Estimation of doses due to gaseous effluents from the Bellefonte Nuclear Plant is an important consideration in assessing the environmental impact of the plant. The methods of calculation and the results presented in this appendix should provide a realistic estimate of the impact from radionuclides released in gaseous effluents during normal operation. Where assumptions are necessary in developing these methods of calculation, they are chosen to yield conservative results. The following doses to humans are calculated for the routine releases of radionuclides listed in Table I-1.

1. External beta doses
2. External gamma doses
3. Thyroid doses due to inhalation of radioactive iodine
4. Thyroid doses due to concentration of radioactive iodine in milk

The doses and radioiodine concentrations which appear in Tables I-3, I-4, and I-5 are calculated assuming operation of two units for one year at full power with 0.25 percent failed fuel. Doses are calculated for routine releases with a waste treatment system with 60-day holdup and for an alternate system with cryogenic removal.

Radionuclides will be released from the Bellefonte Nuclear Plant through vents located near the top of various plant buildings. To calculate downwind, ground-level air concentrations of these radionuclides, a ground-level, volume-source dispersion equation as described by Davidson[1,2] is used (equation 1). It is assumed that the gaseous effluents are initially diluted in the turbulent wake downwind of the building.

$$\chi_{km} = \sum_i \sum_j \frac{\sqrt{2}\, Q f_{ijk}}{\sqrt{\pi}\, \Sigma_{zim} u_j \, \theta x_m} \exp\left(\frac{-\lambda x_m}{u_j}\right) \qquad (1)$$

and

$$\Sigma_{zim} = \left(\sigma_{zim}{}^2 + \frac{cA}{\pi}\right)^{1/2}$$

where

χ_{km} = average annual, ground-level concentration of a radionuclide in sector k at distance x_m, (Ci/m^3),

Q = release rate of a particular radionuclide, (Ci/s),

f_{ijk} = fraction of the release period during which the wind blows in direction k, with speed j, and atmospheric stability condition i,

σ_{zim} = vertical standard deviation of the plume for stability condition i at distance x_m, (m),

Σ_{zim} = vertical standard deviation of the plume (modified for the effect of building wake dilution) for stability condition i at distance x_m, (m),

c = a parameter which relates the cross-sectional area of the building to the size of a turbulent wake caused by the building,

A = cross-sectional area of the reactor building, (m^2),

x_m = downwind distance at which the radionuclide concentration is calculated, (m),

u_j = wind speed j, (m/s),

θ = sector width, (radians),

λ = radioactive decay constant for a particular nuclide, (s^{-1}).

Equation 1 is used to predict the average annual, ground-level concentration of the radionuclides across a 22.5° (θ = 22.5° = 0.39 radian). In equation 1, c is assumed to be 0.5 and A is assumed to be 2,450 m^2 which is the minimum cross-sectional area of the reactor building.

For these calculations Pasquill vertical plume standard deviations[1] are used. Values for the joint meteorological frequencies, f_{ijk}, in equation 1 are determined by methods discussed in Section 1.2.5, Climatology, meteorology, and air quality. In this section, the joint meteorological frequencies for the seven Pasquill stability conditions A through G are presented as a function of wind direction and wind speed in Table 1.2-6 through 1.2-12. The data are grouped for five wind speed ranges (0-0.5, 0.6-3.4, 3.5-7.4, 7.5-12.4, 12.5 mi/h) and for 16 standard wind directions, (N, NNE, NE, . . ., NW, NNW).

The concentration of a radionuclide in sector k at distance x_m for a release rate of 1 Ci/s is expressed as a dispersion factor (χ_{km}/Q). The maximum value for the average annual dispersion factor at the site boundary is 1.1×10^{-5} s/m^3. The maximum value occurs in the NNE sector where the distance to the site boundary is 950 meters.

1. External beta doses - Beta doses to individuals are computed using an immersion dose model described by the equation:

$$D_B = 4.64 \times 10^9 \bar{E}_B \chi \, , \qquad (2)$$

where

D_B = external beta dose due to immersion in a cloud, (mrem/yr),

4.64×10^9 = a constant used in calculating external beta dose,

$$\left(\frac{\text{mrem/yr}}{\text{Ci-MeV/dis-m}^3}\right)$$

$\overline{E}_B$ = average beta energy of nuclide being considered, (MeV/dis)

X = average-annual, ground-level radionuclide concentration as calculated by equation 1, $\frac{Ci}{m^3}$.

In this equation, a correction factor of 0.64 is included to account for cloud geometry, and a correction factor of 0.5 is included to account for self-shielding by the human body.

The χ in equation 2 is the same as χ_{km} in equation 1. To compute the total beta dose from a mixture of radionuclides, equation 2 is applied for each nuclide and the resulting doses are summed. The average beta energies for the nuclides are calculated from information contained in reference 3 and are listed in Table I-1.

In computing the beta dose to the population within 50 miles of the Bellefonte Nuclear Plant, the area is divided into 16 directional sectors and 10 concentric rings, i.e., 160 small area elements. A beta dose computed at the center of each element is multiplied by the number of people residing in that element. A summation of these products over all elements gives the total population dose within 50 miles of the plant. The projected population for the year 2020, as listed in Table I-2, is used in calculating population dose.

The individual and population external beta doses for gaseous effluents are reported in Table I-3.

2. External gamma doses - Gamma doses to individuals are computed using an immersion dose model described by the equation:

$$D_\gamma = 7.21 \times 10^9 \, \bar{E}_\gamma \chi, \qquad (3)$$

where

D_γ = external gamma dose due to immersion in a cloud, (mrem/yr),

7.21×10^9 = a constant used in calculating external gamma dose, $\left(\frac{\text{mrem/yr}}{\text{Ci-MeV/dis-m}^3}\right)$

$\bar{E}_\gamma$ = average gamma energy of nuclide being considered, (MeV/dis),

χ = average-annual, ground-level radionuclide concentration as calculated by equation 1, (Ci/m^3).

In this equation, a correction factor of 0.5 is included to account for cloud geometry.

The χ in equation 3 is the same as χ_{km} in equation 1. When several nuclides are released, the dose due to each nuclide is computed and a summation is executed to obtain the total external gamma dose. The average gamma energies used in calculating external gamma doses are computed from data contained in reference 3 and are listed in Table I-1.

The total population gamma dose within 50 miles of the Bellefonte Nuclear Plant is calculated using the method described for the population beta dose. The annual individual and population external gamma doses for gaseous effluents are reported in Table I-3.

3. Thyroid doses due to iodine inhalation - The equation used in calculating inhalation doses for routine releases of radioiodine from the Bellefonte Nuclear Plant is:

$$D = 8.76 \times 10^3 \chi(BR)(DCF), \quad (4)$$

where

D = thyroid dose committed, (mrem committed/yr),

8.76×10^3 = hours per year,

χ = average-annual, ground-level radionuclide concentration as calculated by equation 1, (Ci/m^3),

BR = breathing rate, (m^3/h),

DCF = dose commitment factor for iodine inhalation (mrem/Ci inhaled).

Maximum individual thyroid doses due to intake of radioiodine are calculated for a 1-year-old child in accordance with the recommendations of the Federal Radiation Council.[4] Population doses are calculated using adult parameters and the same method described for calculating population beta doses.

The breathing rate assumed for a 1-year-old child[5] is 0.29 m^3/h and for an adult[6] is 0.83 m^3/h. The iodine inhalation dose commitment factors for the 1-year-old child and for the adult are obtained from reference 7.

The calculated annual individual and population iodine inhalation doses for gaseous effluents are reported in Table I-4.

4. Thyroid doses due to iodine ingestion - The equation used in calculating the thyroid doses due to iodine ingestion through the milk food chain is:

$$D = 3.15 \times 10^7 (\chi)(v_g)(M)(CR)(DCF) \quad (5)$$

where

D = thyroid dose committed, (mrem committed/yr),

3.15×10^7 = seconds per year,

χ = average-annual, ground-level radionuclide concentration as calculated by equation 1, (Ci/m^3),

v_g = radioiodine deposition velocity, (m/s),

$\dot{M}$ = empirically determined value for concentration of radioiodine in milk per unit deposition rate, $\left(\frac{Ci/liter}{Ci/m^2\text{-}day}\right)$,

CR = milk consumption rate, (liter/day),

DCF = dose commitment factor for iodine ingestion (mrem/Ci ingested).

Only Iodine-131 and 133 are considered in calculating milk ingestion doses due to routine releases of radioiodine. Iodine-132, 134, and 135 have short half-lives (<7 hours) and will have essentially disappeared due to decay before significant concentration in the milk occurs.

The 1-year-old child is assumed to be the critical receptor in calculating the maximum dose to an individual drinking milk produced at the nearest dairy farm (11 miles SSW of the plant). Population doses to persons within 50 miles of the plant are calculated using adult parameters. The assumption is made that all milk produced within 50 miles of the Bellefonte Nuclear Plant is consumed within this area, and cows are assumed to graze the pastures during the entire year. County milk production data[8,9,10,11] are used in computing milk ingestion assuming that the population dose increases in direct proportion to the increase in the population.

The numerical values used for the parameters, v_g, M, CR, and DCF are taken from references 7, 12, 13, 14, and 15.

The individual and population milk ingestion doses are reported in Table I-4.

5. <u>Maximum average-annual radioiodine concentration</u> - The maximum average-annual radioiodine concentrations occur in the NNE sector at the site boundary (950 m). The maximum iodine concentrations for routine gaseous releases are calculated using equation 1 and are reported in Table I-5.

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Table I-1

AVERAGE GAMMA AND BETA ENERGIES USED TO ESTIMATE EXTERNAL DOSES FROM NUCLIDES RELEASED IN GASEOUS EFFLUENTS

Isotope	Average Gamma Energy (MeV/dis)	Average Beta Energy (MeV/dis)
I-131	3.8 (-1)	2.0 (-1)
I-132	2.5	5.0 (-1)
I-133	6.7 (-1)	4.4 (-1)
I-134	2.4	5.2 (-1)
I-135	1.7	3.3 (-1)
Kr-83m	9.0 (-3)	0
Kr-85m	1.5 (-1)	2.5 (-1)
Kr-85	2.0 (-3)	2.4 (-1)
Kr-87	1.5	1.3
Kr-88	1.7	3.9 (-1)
Kr-89	3.9	1.7
Xe-131m	2.5 (-2)	1.2 (-1)
Xe-133m	5.3 (-2)	1.6 (-1)
Xe-133	4.9 (-2)	1.2 (-1)
Xe-135m	4.3 (-1)	9.9 (-2)
Xe-135	2.3 (-1)	3.3 (-1)
Xe-137	3.2 (-1)	1.7
Xe-138	2.9	9.4 (-1)

Table I-2

PROJECTED 2020 POPULATION DISTRIBUTION WITHIN 50 MILES OF THE BELLEFONTE NUCLEAR PLANT

Direction from Plant	Distance from Plant (miles)									
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
	Population within Segment									
N	-	15	100	10	-	200	350	450	6,915	3,795
NNE	-	-	30	115	45	640	5,030	13,735	2,910	4,295
NE	-	-	-	-	30	100	3,035	13,525	25,015	148,535
ENE	-	-	5	10	30	50	2,755	10,700	80,960	308,365
E	-	-	40	50	105	705	3,080	2,550	17,480	5,195
ESE	-	-	35	40	305	680	2,015	1,570	19,565	6,645
SE	-	5	25	-	40	540	2,335	12,275	4,370	13,705
SSE	-	-	-	10	10	495	11,020	17,515	4,820	16,880
S	-	-	-	5	30	840	4,530	3,345	2,495	86,775
SSW	-	-	-	5	15	795	1,750	4,010	62,230	12,245
SW	-	55	610	305	1,355	18,385	6,970	4,625	20,565	24,475
WSW	5	50	600	1,610	5,835	22,800	1,150	4,490	4,680	7,465
W	-	-	2,150	2,225	1,475	2,875	1,500	3,090	365,865	74,145
WNW	-	1,320	2,810	1,385	35	210	1,030	785	8,985	12,550
NW	5	25	70	10	25	185	555	485	5,755	18,365
NNW	5	30	20	10	15	225	155	170	26,360	34,995

Table I-3

ESTIMATED ANNUAL EXTERNAL GAMMA AND BETA DOSES

FROM NUCLIDES RELEASED IN GASEOUS EFFLUENTS[a]

	Total Routine Releases Including 60-day Holdup	Total Routine Releases Including Cryogenic or Absorption Removal System
Maximum Individual Gamma Dose at Site Boundary (mrem)	5.6 (-1)[b]	5.5 (-1)
Maximum Individual Beta Dose at Site Boundary (mrem)	1.1	4.7 (-1)
Total Population Gamma Dose Within 50 miles (man-rem)	1.8	1.7
Total Population Beta Dose Within 50 miles (man-rem)	6.1	2.2

a. For operation of two units at full power with 0.25 percent failed fuel.
b. 5.6×10^{-1}.

Table I-4

ESTIMATED ANNUAL THYROID DOSE COMMITMENTS FROM RADIOIODINE RELEASED IN GASEOUS EFFLUENTS[a]

	Total Routine Releases Including 60-day Holdup	Total Routine Releases Including Cryogenic or Absorption Removal System
Iodine Inhalation		
Maximum Individual Thyroid Dose at Site Boundary (mrem)	1.7 (-2)[b]	1.3 (-2)
Total Population Thyroid Dose Within 50 miles (man-rem)	4.2 (-2)	3.0 (-2)
Iodine Ingestion via Milk		
Maximum Individual Thyroid Dose at Nearest Dairy Farm (mrem)	4.5 (-2)	3.1 (-2)
Total Population Thyroid Dose Within 50 miles (man-rem)	3.3 (-1)	2.2 (-1)

a. For operation of two units at full power with 0.25 percent failed fuel.
b. 1.7×10^{-2}

Table I-5

ESTIMATED MAXIMUM ANNUAL IODINE CONCENTRATIONS FROM RELEASES IN GASEOUS EFFLUENTS[a]

	Total Routine Releases Including 60-day Holdup	Total Routine Releases Including Cryogenic or Absorption Removal System
Maximum Annual Concentration of I-131, μCi/cc	4.4 (-16)[b]	3.0 (-16)
Maximum Annual Concentration of I-132, μCi/cc	1.3 (-16)	1.3 (-16)
Maximum Annual Concentration of I-133, μCi/cc	4.0 (-16)	4.0 (-16)
Maximum Annual Concentration of I-134, μCi/cc	3.8 (-17)	3.8 (-17)
Maximum Annual Concentration of I-135, μCi/cc	2.0 (-16)	2.0 (-16)

a. For operation of two units at full power with 0.25 percent failed fuel.
b. 4.4×10^{-16}

Appendix J

CUMULATIVE RADIOLOGICAL IMPACT ON THE TENNESSEE RIVER FROM THE OPERATION OF TVA NUCLEAR PLANTS AND OAK RIDGE NATIONAL LABORATORY

Assessments of the cumulative radiological impact from the operation of TVA nuclear plants and Oak Ridge National Laboratory are based on estimated releases from Watts Bar, Sequoyah, and Bellefonte Nuclear Plants and the measured releases from Oak Ridge National Laboratory during 1969 through 1972. The analyses were made using the analytical models and assumptions described in Appendix H, and the results are shown in Table J-1. An assumption was made that the Tennessee and Clinch Rivers behave as pipelines transporting the radionuclides with no losses due to accumulations in the biomass and bottom sediments. Mass balance analyses conducted by Oak Ridge National Laboratory[1] indicated that this assumption is realistic for Sr-90, Ru-106, and Co-60 which contribute the greater portion of the doses to humans due to Oak Ridge releases.

REFERENCES FOR APPENDIX J

1. Comprehensive Report of the Clinch River Study, USAEC Report ORNL-4035, 1967.

Table J-1

CUMULATIVE RADIOLOGICAL IMPACT ON THE TENNESSEE RIVER IN 2020[a] AT BELLEFONTE NUCLEAR PLANT

	TVA Nuclear Plants					
	Watts Bar	Sequoyah	Bellefonte	ORNL[i]	Total	
Average Annual Radioactivity[b] Released	0.92	2.0	0.93	8.76	1.3(+1)	Ci/yr
Tritium Average Annual Radioactivity Released	2.8(+2)[h]	3.5(+2)	2.8(+2)	1.0(+4)	1.1(+4)	Ci/yr
I. Average Annual Doses to Humans						
A. Ingestion of Tennessee River Water						
1. Water Supplies						
Scottsboro						
a. individual	6.7(-3)	1.8(-2)	1.4(-2)	1.1	1.1	mrem[c]
b. population	1.4(-1)	2.2(-1)	2.9(-1)	2.5(+1)	2.5(+1)	man-rem[c]
Sand Mountain Water Authority	1.1(-1)	2.8(-1)	2.1(-1)	1.8(+1)	1.8(+1)	man-rem[c]
Christian Youth Camp	1.4(-3)	3.8(-3)	2.9(-3)	2.7(-1)	2.8(-1)	man-rem[c]
Guntersville	6.9(-2)	1.9(-1)	1.4(-1)	1.4(+1)	1.4(+1)	man-rem[c]
N.E. Morgan Co., Water and Fire	3.3(-2)	8.6(-2)	3.1(-2)	7.2	7.4	man-rem[c]
Huntsville	1.3	3.4	1.3	3.0(+2)	3.0(+2)	man-rem[c]
2. Tennessee Valley[d] Population Dose	8.8	2.4(+1)	2.4	1.3(+3)	1.3(+3)	man-rem
B. Eating Fish Taken from the Tennessee River						
1. Guntersville Lake Downstream from the Bellefonte Nuclear Plant Site						
a. maximum individual	2.0(-2)[e]	3.7(-2)[c]	1.9(-2)[e]	1.0	1.1	mrem
b. population	5.2(-1)[e]	2.1[c]	1.1[e]	2.6(+1)	3.0(+1)	man-rem
2. Tennessee Valley Population Dose	8.6	1.3(+1)	6.2	4.7(+2)	5.0(+2)	man-rem[e]

Table J-1 (Continued)

	TVA Nuclear Plants					
	Watts Bar	Sequoyah	Bellefonte	ORNL[i]	Total	
C. Use of the Tennessee River for Water Sports						
1. Guntersville Lake Below the Bellefonte Nuclear Plant Site						
a. above-water	4.1(-4)	7.4(-4)	1.4(-1)	5.9(-1)	7.3(-1)	man rem[g]
b. in-water	1.6(-4)	2.8(-4)	2.3(-2)	4.3(-1)	4.5(-1)	man rem[g]
2. Tennessee Valley[d] Population Dose						
a. above-water	1.6(-3)	2.9(-3)	9.9(-1)	7.4	8.4	man-rem[g]
b. in-water	5.8(-4)	1.1(-3)	1.6(-1)	5.4	5.6	man-rem[g]
II. Average Radionuclide Concentration at Bellefonte Nuclear Plant μCi/cc						
^{3}H	8.7(-9)	1.0(-8)	1.6(-8)	3.0(-7)	3.4(-7)	
^{60}Co	2.4(-14)	3.3(-14)	1.7(-13)	2.6(-11)	2.6(-11)	
^{90}Sr	9.9(-16)	1.5(-15)	5.3(-15)	1.2(-10)	1.2(-10)	
^{90}Y	8.9(-16)	1.5(-15)	4.7(-16)	1.2(-10)	1.2(-10)	
^{95}Zr	5.0(-15)	8.4(-15)	3.4(-13)	1.4(-12)	1.7(-12)	
^{95}Nb	6.1(-15)	9.5(-15)	-	1.7(-12)	1.7(-12)	
^{106}Ru	-	-	-	2.8(-11)	2.8(-11)	
^{137}Cs	9.6(-12)	1.5(-11)	1.6(-11)	4.3(-11)	8.4(-11)	
^{144}Ce	4.0(-15)	2.1(-15)	1.4(-14)	1.1(-12)	1.1(-12)	
^{144}Pr	4.0(-15)	2.1(-15)	-	1.1(-12)	1.1(-12)	

a. Assuming normal operation full time
b. Excluding tritium
c. Doses to thyroid tissue for TVA nuclear plants and doses to bone for ORNL
d. Between Watts Bar Dam and Paducah, Kentucky
e. Dose to bone tissue
f. Doses to G.I. tract tissue
g. Doses to skin tissue
h. 2.8×10^2
i. 1969-1972 average-annual release

Appendix K

RADIOLOGICAL IMPACT OF EXTERNAL DOSE FROM BORATED WATER AND CONDENSATE STORAGE TANKS

The direct gamma radiation dose rate at the site boundary from three borated water storage tanks and two condensate storage tanks has been calculated. The assumptions used in performing these analyses are given below:

1. The dose rate model considers the tanks to be cylindrical, "self-absorbing" volume sources surrounded by a thin steel slab.
2. The physical dimensions and volume of the tanks are: Borated water storage tank: 55'0" dia. x 40'0" high, 650,000 gallons/tank; Condensate storage tank: 51'3" dia. x 40'0" high, 600,000 gallons/tank.
3. Each tank is completely filled with water, with an assumed density of 1.0 g/cm^3.
4. The isotopic distribution of the radioactivity in each tank is shown in Table K-1. The specific activity in the borated water storage tanks is 0.0012 μCi/ml and in the condensate storage tanks is 0.0034 μCi/ml. The total activity, exclusive of tritium, in each borated water storage tank is 2.82 Ci and in each condensate storage tank is 7.67 Ci.
5. The isotopic mixture is considered uniformly distributed in the tank.
6. Decay of the isotopes is not considered in the calculation.

7. Only those gamma rays of significant energy (MeV) and intensity (number per disintegration) are included in the calculations.
8. The average gamma energy for the mixture of isotopes given in Table K-1 is calculated to be 0.70 MeV for the borated water storage tank and 0.68 MeV for the condensate storage tank.
9. The contribution from each nuclide to the total dose rate is weighted according to its fraction of the total activity.
10. The distance from the tanks to the nearest point on the site boundary is used for these calculations (991 meters for the borated water storage tanks and 610 meters for the condensate storage tanks).
11. Attenuation and buildup for air and for the 1/4" steel tank wall are considered in the calculations. Self-absorption and buildup due to the water in the tanks is also considered.
12. No credit for the air-earth interface absorption and scattering effect is taken in the calculations.

Using these assumptions, the direct gamma dose rate at the site boundary from activity contained in each borated water storage tank is calculated to be 0.0001 mrem/yr. For each condensate water storage tank, the direct gamma dose rate is 0.014 mrem/yr. The total direct gamma dose rate at the restricted area boundary from the three borated water storage tanks and the two condensate storage tanks is calculated to be 0.028 mrem/yr.

Table K-1

ISOTOPIC DISTRIBUTION OF ACTIVITY IN BORATED WATER AND CONDENSATE STORAGE TANKS[a]

Isotope	Borated Water Storage Tank Contents, Curie/tank	Condensate Storage Tank Contents, Curie/tank
Sr-89	4.03 (-3)	2.81 (-2)
Y-91		2.78 (-2)
Zr-95	8.80 (-4)	8.14 (-3)
Nb-95	7.22 (-4)	9.55 (-3)
Nb-95m		1.72 (-4)
Mo-99	1.10 (-1)	3.17 (-3)
Tc-99m		3.03 (-4)
I-131	8.25 (-1)	7.13 (-2)
Cs-134	2.93 (-1)	5.29 (-1)
Cs-136	7.21 (-2)	1.66 (-2)
Cs-137	1.49	6.25
Ba-137m		5.75 (-1)
Ba-140	7.20 (-4)	4.68 (-3)
La-140		5.39 (-3)
Ce-144	3.90 (-4)	5.77 (-3)
Pr-144		5.77 (-3)
Mn-54	9.20 (-4)	3.71 (-4)
Co-58	2.64 (-2)	6.81 (-3)
Co-60	9.10 (-4)	1.50 (-2)
Fe-59	1.02 (-3)	7.57 (-5)
Cr-51		3.38 (-4)
Sr-90	1.62 (-4)	9.50 (-3)
Y-90		9.50 (-2)
Total	2.82	7.67

a. Exclusive of tritium.

Appendix L

NONRADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM FOR THE BELLEFONTE NUCLEAR PLANT

This appendix is an integrated nonradiological environmental monitoring program for the assessment of terrestrial and aquatic impacts due to the construction and operation of the Bellefonte Nuclear Plant. It is a cooperative effort of the Division of Environmental Planning; the Division of Forestry, Fisheries, and Wildlife Development; and the Division of Water Control Planning.

Basis for Monitoring Program - As part of the assessment of environmental impact, monitoring programs are necessary to confirm hypothesized impacts and to provide continuing surveillance of the environment so that previously unknown impacts may be assessed. This appendix outlines the nonradiological monitoring program TVA proposes to implement as part of the program for assessing the environmental impacts of the Bellefonte Nuclear Plant. Included in this discussion are rationale, sampling designs and procedures, the parameters that will be measured, and a general identification of the impacts that might be expected.

Although further study may reveal that different or additional impacts may need to be considered, a number of hypothetical environmental impacts, which might be expected to result from construction and operation of nuclear power generating facilities, were identified as a basis upon which the nonradiological environmental monitoring program could be designed. The monitoring program will periodically be reviewed, and various elements may then be added to the program or deleted. Certain parameters cannot be measured because of imprecise analytical techniques or because of large inherent variation in samples obtained by conventional sampling techniques. In both cases, development of the proper procedures would involve large expenditures of effort and funds with no assurances of useful results. These decisions are documented in the text.

The monitoring program is divided into three time periods: preconstruction, construction, and operation. Monitoring before construction begins will provide baseline information for the entire program, although in certain cases baseline data may be collected during the construction period.

1. Detailed Rationale -

(1) Terrestrial Impacts - The nonradiological terrestrial monitoring program for the Bellefonte Nuclear Plant is designed to evaluate the following hypotheses:

1. Land use changes associated with construction and operation will result in changes or losses of wildlife, wildlife habitat, forested areas, hunting opportunity, and nonconsumptive recreational activities.
2. Transmission line construction, operation, and maintenance will result in changes or losses of wildlife, wildlife habitat, forested areas, hunting opportunity, and nonconsumptive recreational activities.
3. Operation of the facility may result in accumulations of toxic materials in plant and animal tissues or soil.
4. Operation of the facility may alter moisture regimes of natural ecosystems.

(a) Construction Monitoring - Portions of hypothesis 1 pertaining to construction impacts will be tested by collecting and analyzing data from permanent plots located both on and adjacent to the 1,500-acre project site. Measurements will begin in the winter of 1973-74 before construction is started and will continue through construction until the plant begins operation. After the plant begins operation, monitoring will follow the same experimental design and sampling procedures subject to alterations that monitoring experience may indicate are necessary.

Baseline studies were conducted on the site in August 1972. Fifty-two permanent vegetation plots were located in 8 different types of habitat, and the ecological parameters that describe the plant ecology of each site were evaluated. Data gathered from these plots along with information gathered from vertebrate census techniques will allow analysis before, during, and after construction. The nature of the plant and animal communities that may be disturbed, displaced, or destroyed will be identified as will the nature of the new communities that may be created by the construction impacts.

Construction impacts will be treated as primary and secondary. Examples of primary impacts would be modification and alteration of habitat by blasting, drilling, excavating, and clearing. At Bellefonte, specific examples of direct impacts will be development of access corridors (roads, railroads, and transmission lines), clearing and excavation for all construction (intake and discharge areas, holding ponds, causeway, cooling towers, visitor center, and other buildings), noise and vibrations from construction equipment, exhaust emissions, atmospheric particulates, fuel leaks and spills, mud, and activity of men and machines. Associated with these direct impacts are secondary impacts such as increases in housing developments, trailer courts, resource commitments, recreation and use of recreation facilities (camping, hunting, boating, hiking, etc.), and transportation of all types (automobile, truck, railroad, barge, air).

Monitoring for direct construction impacts on the site will concentrate on vegetation and vertebrate parameters. Direct and secondary construction impacts that will occur regionally (other than on site) will be related to construction of power lines and other changes in land use. When power line corridors are developed, habitats will be altered and land cover will change. The major impacts associated with the power lines will be to deciduous and coniferous forest communities. Land area changes related to plant construction will involve the development of roads, trailer parks, houses, and recreation facilities and increased land use by the new work force coming into the area. Aerial photography will be used to document significant changes in land use on the site and in the vicinity. (Refer to page L-17).

(b) Operational Monitoring - To evaluate each of the hypotheses two types of impacts must be considered: (1) possible moisture, chemical, and structural impacts associated with the cooling towers, and (2) changes in regional land use and land cover not related to possible impacts of cooling towers.

Cooling towers may have an adverse impact on migratory birds. An ongoing monitoring program will be conducted once the cooling towers are constructed to determine if birds fly into the structures.

Natural draft cooling towers release moist air with suspended water droplets that may appear as a visible white plume. Possible effects of cooling tower plume releases are (1) changes in air and soil moisture, (2) changes in plant growth, (3) damage to plants because of icing, (4) changes in incidence of disease or insect infestation, and (5) changes in the structure (diversity) of plant or vertebrate communities.

Along with moisture, suspended and dissolved particulate material will also be emitted over the landscape within spray droplets (drift). Some believe dispersion of chemical materials by this means to be of little consequence. Although impacts related to drift on the soil as well as plant and animal communities may not be adverse and may in fact not be measurable, an attempt should be made to assess the possible impact. Preliminary studies have been proposed and some are under way to evaluate the impact of these effluents at operating facilities. Monitoring of moisture and chemical constituents will depend on the results of recent studies at Paradise Steam Plant, planned studies at Browns Ferry Nuclear Plant, and possible future studies at new cooling towers that may be constructed before Bellefonte Nuclear Plant begins operation. A general study plan for chemical constituents is provided that indicates the types and quantities of measurements that would be included if preliminary studies show impacts.

(2) Aquatic Impacts -

(a) Construction Monitoring - Construction activities may potentially present two main types of aquatic impacts: the long-term commitments of acreages of water and substrate, particularly embayments and overbank areas, and the short-term effects of turbidity and localized siltation.

A third category of possible impacts include accidental releases or spills of materials, but no routine monitoring for these impacts is planned. If pesticides are applied in the reservoir for control of Eurasian watermilfoil and mosquitoes during the construction period, a sampling program for monitoring those pesticides will be instituted. Designated areas on Guntersville Reservoir will be excluded from herbicidal treatment as indicated in figure 1. In this way, the impacts on aquatic macrophytes that might be caused by herbicides used during construction of the nuclear facility can be separated from those that might be caused by the program of pest control in the reservoir and their relative significance assessed. A National Pollutant Discharge Elimination System (NPDES) permit which will be obtained from the Environmental Protection Agency (EPA) will dictate limits and monitoring requirements for sanitary waste effluent.

Acreages of aquatic habitat lost owing to construction of intake and discharge structures and channels, causeways, and other earthfills will be documented. Short-term effects of turbidity are expected to cause changes in rates of phytoplankton and macrophyte productivity. Localized siltation is potentially a long-term phenomenon that may affect benthos.

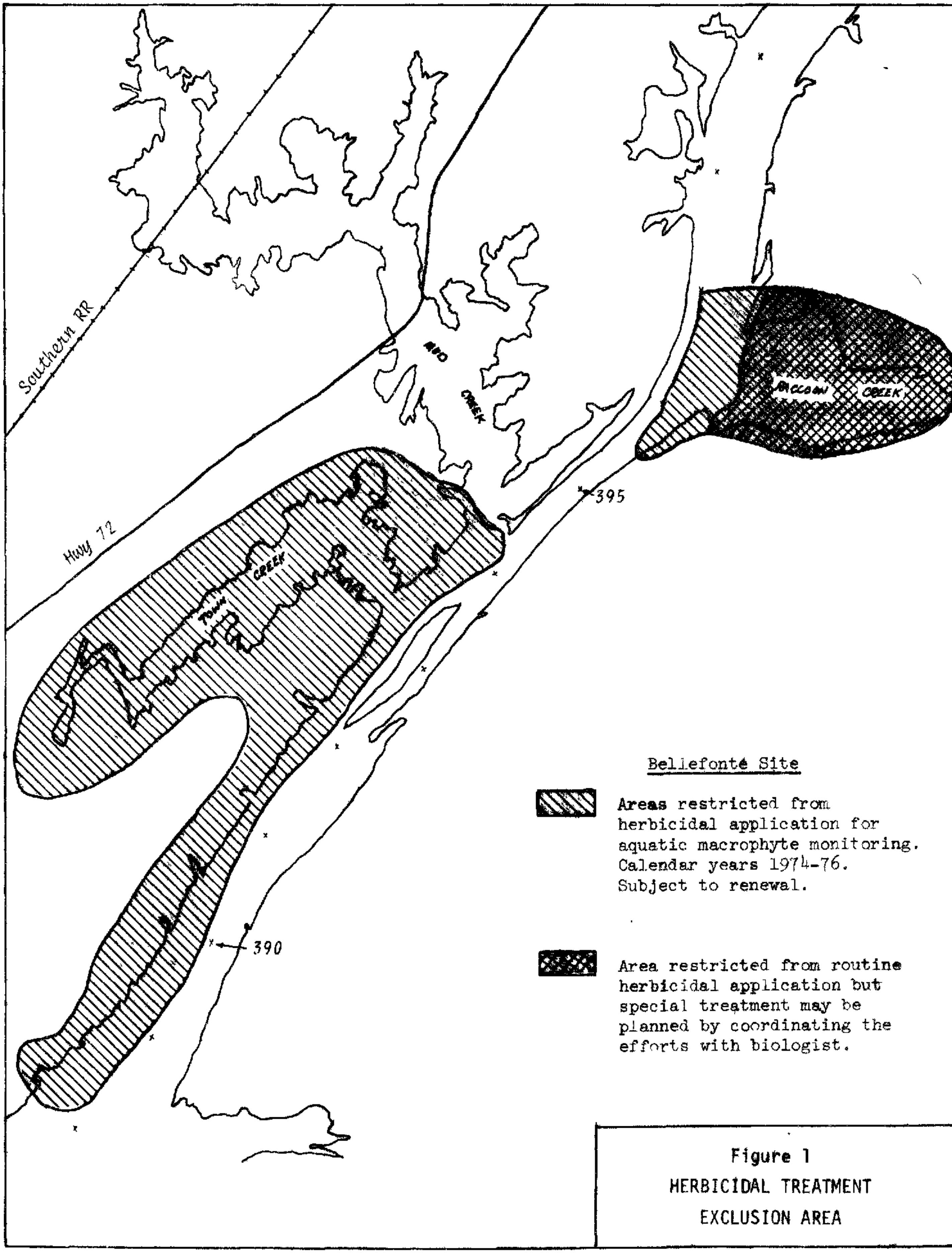


Figure 1
HERBICIDAL TREATMENT
EXCLUSION AREA

No fish monitoring is planned for the construction phase because of the dynamic nature of fish distributions and the difficulties of separating construction effects from natural variation in populations.

(b) Operational Monitoring - Operation of the plant will result in four main categories of impact: heated water discharges, impingement of organisms on trash-collecting screens, entrainment of biota, and discharge of chemicals. Most of the monitoring will be done in the area very near the plant, where any impacts should be most pronounced. No reservoir-wide monitoring is contemplated.

A monitoring program will show the changes in the distributions of biota in response to heated water. Certain species of fish may be attracted to heated water during winter or repelled during summer. Changes in numerical abundances of periphyton, macrophytes, and benthic organisms are also expected. Sampling will be concentrated in the overbank areas influenced by the heated discharge.

While other effects of heated water can be hypothesized, these effects would be less obvious than changes in the distribution of biota. Monitoring of these more subtle effects is not planned.

While the number of fish impinged on screens can be determined, the significance of this impact to total fish populations in the reservoir is poorly known. It is evident that the impact of impingement losses is related to both the total number of fish in the reservoir and the relative abundance of each species. The total number of fish impinged will be compared to the estimated figures on standing crop obtained from rotenone samples to estimate the impact.

Numbers of larval fish entrained will be compared to the estimated total population in the vicinity of the site. Of particular importance are comparisons by species of entrainment losses versus the abundance of adults of the same species in the reservoir. In addition, localized impacts on the species living near the plant will be studied.

Chemical discharges can be categorized as substances added to water during various processes in the nuclear plant and as substances that were present in the water as it was drawn from the reservoir but that are concentrated during use of the water in the plant, particularly in the cooling towers. Chemicals might also be added to water from decomposition of entrained organisms.

Since EPA will probably require a NPDES permit, effluent monitoring will be conducted by plant personnel. Should inplant monitoring of the chemicals indicate potential problems, reservoir monitoring will be initiated.

2. Sampling Design and Procedures -

(1) Terrestrial Monitoring -

(a) Construction -

Vegetation - Baseline information describing the flora of the Bellefonte site was gathered in September 1972. Fifty-two permanent plots were established on the 1,500-acre plant site area. A vegetation type map was prepared and types were located on aerial photographs. Eight vegetation types were identified. The purpose of the baseline study which began the monitoring program was to: (1) provide information on species frequency, distribution, density, percent cover, and vigor of higher plants in the area, (2) determine the presence of any rare or endangered plant species; and (3) provide baseline data.

A square grid was laid over the study area to establish circular 1/5-acre plots at 1,035-foot intervals. Plots falling in forest or abandoned fields were used. Forested plots were permanently located so that the exact spot could be resurveyed at later dates during the monitoring program. Old field plots were not permanently marked; however, their locations were noted by the intersection of the transect lines. Pole, sawtimber, and reproduction data were collected. Four 1/100-acre subplots were located at cardinal points around the periphery of each 1/5-acre plot. In each subplot, all tree stems between 1 and 5 inches diameter breast height (DBH) were recorded and classified as "shrub stratum." Percent cover was recorded for each shrub stratum species according to the following code:

1 - less than 5 percent
2 - 5 to 25 percent
3 - 26 to 50 percent
4 - 51 to 75 percent
5 - 76 to 95 percent
6 - over 95 percent

In addition, the general condition of dominant species was noted collectively, with a description given of any unusual or unhealthy patterns developing.

Beginning at the 4 cardinal points and moving toward the center of each plot, quadrats 10.75 feet long by 1 foot wide were established. In these quadrats the ground cover (including all tree and shrub species less than 18 inches high) was recorded by species and percent cover, and the general condition of dominant species was noted (as was done for shrubs and small trees). A vegetation type was subjectively determined for each plot in the field.

Plots were grouped according to vegetation types established in the field. Within each type, frequencies were established for all species to estimate the importance of their occurrence. Data from all plots in all types were then combined, and an importance value index was established for each species within each of the 4 vegetation strata (i.e., trees, understory, shrub stratum, and ground cover).

Over one-half of the permanent plots established in 1972 will be directly impacted by construction activities. Plots located in direct impact zones will be measured once again prior to construction activity, then remeasured during and after construction of the plant. As mentioned in a previous section, construction impacts on vegetation outside of the direct impact zone will be insignificant.

Birds - Breeding bird surveys will be conducted beginning in late May 1974 in each vegetative type on and adjacent to the direct impact zone areas. Permanent fixed-dimension transects 200 yards by 50 yards will be laid out and run each spring until the plant becomes operational. Species composition, diversity, and relative density expressed in birds per 100 acres will be the parameters measured.

The surveys will be continued each spring until the landscape becomes stabilized. A before and after comparison of bird response to nuclear plant construction is the objective of the bird survey work. Bird life on areas outside the direct impact zone area will not be significantly affected.

In addition to terrestrial surveys, riparian surveys conducted by boat are scheduled each spring. In spring 1973, wood duck and prothonotary warbler censusing was begun along a route encompassing the entire Bellefonte peninsula. These counts will be expanded in spring of 1974 to include great blue herons. The parameters measured are relative density of breeding birds expressed in pairs or individuals per unit area of specific sections of shoreline. Particular emphasis will be given to the areas near the proposed causeway and points of cooling water intake and discharge. Spring bird counts will be conducted until after the plant becomes operational and disturbed habitats become stabilized.

Mammals - The monitoring program to be used to assess construction impacts on mammals will be initiated in late fall and winter 1973-74. Changes in mammal abundance and distribution as well as species composition and species diversity will be the parameters measured in the direct impact zones.

A grid of small mammal live traps will be utilized in each of the habitat types within and adjacent to the direct impact area. Permanent trapping stations will be established and 3 trap periods, beginning in September and ending in November, will be utilized. Each period will run 4-5 days with 3 men running 200 to 300 live traps per day. The trapping will be continued each winter as described above and will cease after the plant becomes operational and the new habitats become stabilized.

Estimations of presence and relative abundance of white-tailed deer and other larger mammals in the area of direct impact will be made based on incidence of tracks, browse sign, scat, dens, and direct observation. Before and after comparisons will result from the mammal monitoring.

Transmission Lines - Prior to construction of the transmission line connections discussed under step II, an inventory of vegetation on specific test tracts along the right of way will be evaluated. The specific tracts to be used in this evaluation program will be determined at a later date. Following construction, during subsequent maintenance periods, regrowth rates will be recorded to determine the effectiveness of various right of way clearing methods including shear clearing treatment as it relates to line maintenance and environmental impacts. Concurrent studies will be performed also on other transmission line projects in the TVA area to determine specific impacts to wildlife, understory development, and ecotonal influences. Results of these studies will be used to determine the specific right of way clearing methods to be utilized by TVA for the remainder of the Bellefonte Transmission Line connections (Steps III and IV).

Other - Quarterly inspection visits on and around the site by ecologists will serve to document the seriousness of secondary impacts. We do not anticipate that secondary impacts will become a serious problem. If a major impact occurs, e.g., a large oil or chemical spill, specific followup evaluation will be immediately undertaken. The basic sampling methods and sampling periodicity are given in Table 1 and figure 2. Definition of parameters is given in Table 2.

(b) Operation -

Drift - During operation chemical constituents in cooling water will be discharged as drift along with water vapor. Normal constituents of water will be concentrated because of evaporation losses and other chemical constituents may be present because they are used during the plant operation. Accumulation of chemical constituents on leaves and in soil may increase the uptake and may, in extreme cases, cause necrosis of leaf tissue. Chemical constituents may be retained in the soil or may be cycled by plants and animals on the site.

Soil and litter samples will be obtained on each plot once each year in August for determination of chemical constituents. Litter samples will be a composite of the O1 and O2 horizon. Surface soil samples 1 cm thick will be composited for the plot. Subsoil samples from 10 cm depth (2 cm thick) will also be obtained and composited.

Vegetation samples will be obtained on each plot during August of each year to determine chemical constituents. At each plot location individuals will be selected and marked for sampling. Species to be selected include loblolly pine, broom sedge, ragweed, elm seedling, and Virginia creeper. Leaves obtained will be composited by plots and by species.

TABLE 1

CONSTRUCTION IMPACT ASSESSMENT SAMPLING SCHEME

Group	Parameters	Sample Technique	Schedule	Evaluation
Vegetation[a]	Relative density Relative basal area Relative frequency Importance value	Permanent Fixed 1/5 acre Plots, 1/100 acre Plots, square Meter plots	Once during pre-operational phase, once during post-operational phase.	Evaluate before and after results of nuclear plant construction
Breeding Birds[b]	Species composition Relative density Species diversity	Permanent Fixed 200 yd. x 50 yd. transects	Once per year every year until communities stabilize after plant becomes operational.	As above.
Small Mammals[c]	As for breeding birds	Permanent fixed grid live trapping	As above.	As above.

a. Vegetation parameters and their derivation are discussed in Quantitative Plant Ecology by Greig-Smith (1964).

b. Parameters for breeding birds have been discussed by Bond (1957) and techniques used are discussed in Effect of Urbanization and Type of Development on Bird Populations by Geis (1973).

c. Mammal censusing techniques are discussed in Wildlife Investigational Techniques by Giles (1969).

Table 2

DEFINITION OF PARAMETERS USED TO ASSESS CONSTRUCTION IMPACTS

Vegetation--Importance Value (IV) was measured in three ways:

For the trees;

$$IV = (\text{Relative Density} + \text{Relative Frequency} + \text{Relative Basal Area}) \div 3$$

Where

$$\text{Relative Density} = \frac{\text{Number of trees of a single species}}{\text{Total number of all trees}} \times 100,$$

$$\text{Relative Frequency} = \frac{\text{Number of occurrences of a single species}}{\text{Total number of occurrences of all species}} \times 100,$$

$$\text{Relative Basal Area} = \frac{\text{Basal area of a single species}}{\text{Total basal area of all species}} \times 100.$$

For the understory;

$$IV = \frac{\text{Relative Density} + \text{Relative Frequency}}{2}$$

For shrub stratum and ground cover;

$$IV = \frac{\text{Relative Frequency} + \text{Relative Cover}}{2}$$

Where

$$\text{Relative Cover} = \frac{\text{Percent cover of a single species summed over all subplots or quadrats}}{\text{Sum of the percent covers of all species in all subplots or quadrats}} \times 100.$$

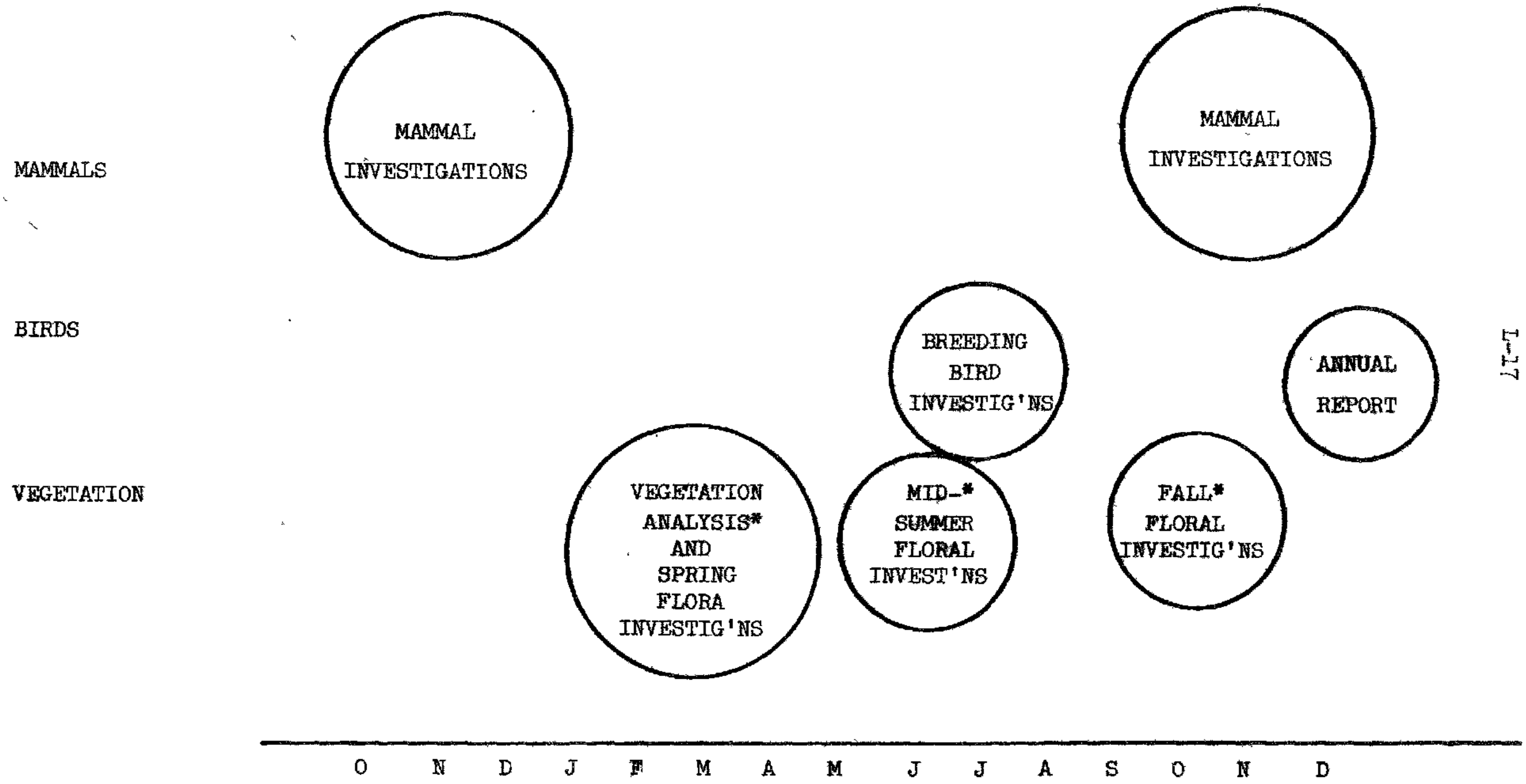
By dividing by the appropriate denominator, Importance Values are assigned to a linear scale ranging from 0 to 100. Since the sum of IV's of all species within a particular stratum totals 100, each Value can be viewed as a measure of the relative percentage of importance of that species in the stratum.

Breeding Birds and Small Mammals;

Species Composition - Simply a listing of all birds found per habitat type.
Relative Density - Expressed as number of birds per 100 acres of each habitat type.
Species Diversity - Ratio between number of species and numbers of individuals.

FIGURE 2

SAMPLING SCHEME - PRECONSTRUCTION AND CONSTRUCTION MONITORING



*Vegetation information not collected each year. (See Table 1)

Individuals of (1) seed-eating resident mammals; (2) insect-eating resident mammals; and (3) forage-eating resident mammals will be collected for determination of chemical constituents. Samples will be obtained once each year in autumn and will be obtained in the vicinity of the cooling towers, on Poorhouse Mountain, Sand Mountain, and two locations in the NE and SW windrose.

Materials to be sampled and number of samples to be obtained annually are given in Table 3. Soil and vegetation sampling will be attempted during relatively dry periods.

Elevated Structures - Preliminary studies to assess the impact of cooling towers and tall stacks on migrating birds will be implemented at TVA's Paradise and Bull Run plants. Results of these studies and those conducted at other steam plants, such as Davis-Besse on Lake Erie, will dictate whether future TVA plants, such as Bellefonte, will be monitored for this impact.

Land Use Changes - As a direct and indirect result of construction and operation, some land cover changes are likely to occur in the general vicinity of the site. While an extensive survey program could document all land cover changes, no feasible method is available for relating these changes to the project, either directly or indirectly. This is due to the dynamic economic and population growth the area is experiencing which would obscure the relatively small changes likely to occur due to the project. However, the access railroad, the two access roads, and the possible use of the peninsula tip for recreation alter the development potential of nearby lands to

Table 3

NUMBER OF SAMPLES/YEAR FOR CHEMICAL CONSTITUTENTS[a]

Material	Composite or Replicated Sample	Sample
Litter	Composite x 20 locations	20
Surface soil	Composite x 20 locations	20
Subsoil	Composite x 20 locations	20
Hardwood leaves	Composite x 10 locations	10
Conifer needles	Composite x 10 locations	10
Broom sedge	Composite x 10 locations	10
Ragweed	Composite x 10 locations	10
Kentucky 31 fescue	Composite x 10 locations	10
Virginia creeper	Composite x 10 locations	10
Lawn grass	3 replications x 40 locations	120
Insectivorous small mammal	3 replications x 5 locations	15
Seed-eating small mammal	3 replications x 5 locations	15
Forage-eating small mammal	3 replications x 5 locations	15
		285

a. Tentative sampling schedules subject to modification depending upon variation.

such an extent that changes around these developments could reasonably be attributed to the project. These land use and cover changes will be evaluated using aerial photography and/or ground checks in conjunction with assessment of onsite cover changes.

(2) Aquatic Monitoring - The monitoring program for the Bellefonte Nuclear Plant will begin one year prior to the initiation of construction. Sampling will continue through construction and operational phases. The monitoring program will be subjected to periodic review.

(a) Construction - The acreages of aquatic habitat added or removed from the reservoir will be documented. This will include silted areas and other areas such as discharge canals which no longer can be used by aquatic biota. Those reservoir areas removed from public use will also be included.

Siltation effects will be assessed by measuring the composition and areal extent of siltation and the changes in the standing crops and species composition of benthic fauna. Following cessation of construction activities, repopulation of affected areas will also be monitored.

Water Quality - During construction, water quality parameters to be sampled quarterly at the stations on the Tennessee River are: pH, temperature, dissolved oxygen, conductivity, coliforms, solids (dissolved, suspended, and total), turbidity, nutrients (nitrogens and Phosphates), and BOD. All samples will be analyzed in accordance with "Recommended Methods for Water Data Acquisition," Federal Interagency Work Group on Designation of Standards for Water Data Acquisition.

Station locations will include one upstream control, one near the intake/discharge structure site, and one downstream station. All stations will be in the overbank area of the right descending bank for maximum effectiveness. It is possible that a shoreline station (control) will be established on Bellefonte Island should an upstream overbank control be adversely affected by run-off from Mud Creek.

Periodic monitoring for direct construction effects will be conducted in creeks and sloughs that drain the construction area. These samples will be collected to coincide with surveys for biotic impact assessment, periods of heavy rainfall, and major changes in construction phases. Aerial color photographs will be taken as an aid to further assess the potential impact.

Plankton - The impact of turbidity on phytoplankton will be assessed by measuring the reduction on photosynthetic activity due to shading and by measuring the areal extent of construction-induced turbidity. Samples will be taken in January or February and monthly from March through October. It is expected that turbidity effects will be reduced after the onset of plant operation.

Macrophytes - The impact of turbidity on aquatic macrophyte standing crop will be monitored by alternate-month sampling at sites along the main river, in the overbank areas near the construction site, and in Town Creek (Table 4). Sampling will be done at these locations before construction and at locations away from expected impact. Alternate-month sampling is necessary because of the known occurrence of two seasons of growth of Eurasian watermilfoil. Comparable samples will be taken at different depths at 1/2-m contour intervals. Aquatic macrophyte distribution changes will be monitored by aerial photography and will be interpreted by comparison with the turbidity plume (Table 4).

<u>Benthos</u> - Ten ponar grab samples of zoobenthos and replicate samples of sediment will be taken randomly from one station above the designated water intake area, from one station approximately halfway between the water intake and the designated discharge area, and from one station 200 to 300 yards below the discharge construction area and the Town Creek area (Table 5). Zoobenthos population composition and distribution is usually correlated with substrate type. Changes in sediment composition resulting from construction will induce changes in zoobenthos diversity.

(b) <u>Operation</u> -

<u>Thermal Monitoring</u> - A detailed thermal monitoring program for the Bellefonte Nuclear Plant will be available at the operating license stage.

<u>Heated Water Impacts</u> - Monitoring programs will be provided for the major categories of aquatic life.

TABLE 4

AQUATIC MACROPHYTE IMPACT ASSESSMENT SAMPLING SCHEME

Parameter	Items Sampled	Methodology	Location	Position	Frequency	Purpose
Standing Crop	Aquatic macrophytes	$0.1m^2$ harvest, determine ash-free dry weight[a]	Riverbank, overbank, Town Creek	1/2m depth intervals	Alternate months	Turbidity
Standing Crop	Aquatic macrophytes	$0.1m^2$ harvest, determine ash-free dry weight[a]	Riverbank, overbank	1 depth only	Alternate months	Temperature
Distribution	Aquatic macrophytes	Aerial Photography	All	Surface view	Annual	Habitat loss, turbidity, temperature
None[b]	Aquatic macrophytes	Chemical analysis comparison with known responses	Discharge channel			Herbicides, nutrients

a. R. A. Stanley, E. Shackelford, D. Wade, and C. Warren. 1973. Effects of Season and Water Depth on Standing Crop of Eurasian Watermilfoil. (Manuscript prepared by TVA for publication.)

b. No direct sampling of biota planned due to extensive knowledge of interrelationships and because of improbability of environmental impact.

Table 5

TYPES AND LOCATIONS OF BIOLOGICAL SAMPLES COLLECTED TO MONITOR NONRADIOLOGICAL PREOPERATIONAL AND OPERATIONAL CONDITIONS IN GUNTERSVILLE RESERVOIR IN RELATION TO THE BELLEFONTE NUCLEAR PLANT

(January or February and monthly from March through October)

Sample Location	Depths for Zooplankton, Chlorophyll a and Phytoplankton (random, replicate samples), m	Depths for Productivity,[b] m	Benthic Fauna-Grabs[c,e]	Benthic Fauna - Artificial Substrates[d]	Periphyton Substrates[d]	Sediment
Upstream[a]	0, 1, 3, 5	0, 1, 3, 5	10	3	2	2
Plant below outfall[a]	0, 1, 3, 5	0, 1, 3, 5	10	3	2	2
Downstream[a]	0, 1, 3, 5	0, 1, 3, 5,	10	3	2	2
Town Creek	0, 1	0, 1	10			2

a. Channel (and right overbank, if necessary)
b. Location of lower depths depends on depth of the photic zone and water depth
c. Number per stratum
d. Number per station
e. Number subject to adjustment

Benthic Fauna (Zoobenthos)

The main or old river channel in the vicinity of the Bellefonte site is bedrock for the most part and affords only one substrate type. From 50 to 60 percent of the substrate on the right overbank is composed of very fine sand (1/8 to 1/16 mm) while 0.4 to 12 percent is composed of coarse silt (1/32 mm). Fine sand is the only overbank benthic sediment with particle size percentage in excess of 10 in all test samples. Therefore, for all practical purposes, there is only one substrate type on the overbank. Zoobenthos samples will be taken with a ponar sampler from random locations in the two principal substrate types, overbank and main channel. Duncan's New Multiple-Range Test will be used to detect significant differences between stations at the 5-percent level.

Artificial substrates

Three artificial substrates will be placed at each sampling location selected at random for each sampling date. Substrates will be placed on sampling dates and removed after approximately 30 days' colonization.

Phytoplankton

Duplicate samples of phytoplankton will be taken at the surface, 1-m, 3-m, and 5-m as shown in Table 5. Samples will be collected with an 8-liter Van Dorn sampler. Phytoplankton data will be analyzed with emphasis on determination of any signficant shifts in diatoms or green algal dominance to bluegreen algal dominance as a result of plant operation. Such a shift in dominance would be considered undesirable. Appropriate statistical tests will be applied to the data for detecting significant differences if they occur. Phytoplankton productivity (C^{14}) studies will be conducted by replicate sampling (Table 5).

Zooplankton

Identification of species common to this section of the Tennessee River and general quantitative results, such as abundance, will be used. Biomass determinations will also be used as a parameter. Species common to Guntersville Reservoir will also be selected for intensive study.

Periphyton

Two sets of five plexiglass plates, each 6 mm thick and having an exposed area of 1.5 dm^2, will be used as artificial substrata at each station. These plates will be exposed for about 2 weeks (14 to 17 days), since previous studies showed this to be an optimum accrual time for periphyton in this area.

The ratio of phytopigment absorbency to total organic matter is the autotrophic index; for example,

$$\frac{0.212 \text{ (phytopigment absorbency)}}{0.053 \text{ (grams of ash-free dry weight)}} = 4.0 \text{ (autotrophic index)}$$

Shift of the autotrophic index toward heterotrophic production may be undesirable. This will be determined by analysis of variance and Duncan's New Multiple-Range Test to evaluate differences in the mean autotrophic indices between stations and between positions on the sampling rack attached. Algal groups will also be identified.

Slides from each rack will be used for taxonomic purposes. Data will be used to identify shifts in the periphyton community from a diatom or green predominance to a bluegreen dominance. Such a shift would be considered undesirable.

Macrophytes

Alternate-month sampling of aquatic macrophytes will be used to evaluate interaction of season with temperature. Since maximum thermal impact is expected at or near the surface, only a single contour elevation will be selected for sampling. Monitoring locations will include the area of maximum expected thermal impact and areas of no expected impact.

Fish

The changes in distribution of post-larval fish caused by heated water will be assessed by gill net sampling and rotenone samples. Two areas, sited as close to the discharge as possible, will be sampled annually in August or September. The choice of these months is to show relative abundance of young-of-the-year fish. The experimental design is a before and after comparison of the individual species and size classes within each area.

Gill net samples will be collected at three stations located in shoreline areas of the reservoir. One station will be located in an uninfluenced area of the reservoir immediately above the plant; the other two in areas immediately below the plant. Each sample will consist of ten, 100 x 8 ft., 1-1/2 inch bar mesh sinking gill nets fished for four consecutive nights. Nets at each station will be set perpendicular to shore and in similar habitats, i.e., similar depths, bottom contours, etc., so that the nets can be treated as replicates. Each net will be fished four consecutive nights which will provide further replication. However, avoidance of the nets by some species is expected, resulting in decreasing catch per day through the four-day period.

During a calendar year gill net sampling will be conducted during four quarters where the quarters are defined on the basis of water temperatures (°C.), as measured upstream from the plant. The quarters are: winter, less than 10° C.; spring, 15-18° C.; summer, at or above 25° C.; and fall, 15-18° C.

Gill net analyses will be both upstream-downstream and pre- and post-operational. After initiation of plant operation, the sample sites may be **changed**. In this case, analytical procedures will become upstream-downstream comparisons entirely. The dependent variable will be the number of each species caught, although numbers of certain super-populational groups (e.g., game fish, shad, or sunfish) may be utilized.

Impingement - The numbers of fish impinged will be counted periodically. Periodically fisheries biologists will identify all fish and obtain length frequencies.

Entrainment -

Plankton

Zooplankton will be sampled hourly for 24 hours at least twice during periods of maximum abundance and/or maximum ambient temperature. Kinds, numbers, and biomass standing crop of zooplankton will be determined. Phytoplankton kinds, numbers, and chlorophyll a estimates of biomass standing crop will be sampled concurrently with zooplankton.

Larval Fish

The entrainment will be assessed by weekly sampling during the time period March 15 to August 1. Larval fish will be sampled from three positions in a cross-section of the reservoir; shoreline, channel-surface, and channel-deep, where channel refers to water flowing over the former Tennessee River streambed and deep refers to samples taken at depths of about 5 m. These three positions will be sampled at each of two stations: one above the intake and one below the diffusers. A sample at a particular position and station will consist of two replicate meter-net tows of 5-minute duration. It is anticipated that aquatic vegetation may hamper sampling in shoreline areas and require different sampling methods.

Larval fish sampling will also be conducted in the intake after plant operations begin. These samples will be taken with stationary nets.

Several entrainment experiments are being conducted at TVA's Browns Ferry and Sequoyah plants. These experiments are designed to:

1. Evaluate the densities of larval fish at the intake versus those in the reservoir proper.
2. Establish the numbers and densities of larval fish passing through the plant versus those noted in the reservoir.
3. Evaluate the efficacy of "skimmer walls" in reducing entrainment of larval fish.
4. Document localized decreases in densities of larval fish downstream from the intake.

The results of these studies will exert a major influence on the planning of future sampling and experimentation.

Water Quality - Reservoir Monitoring - Parameters will include, but not be limited to: temperature, pH, conductivity, alkalinity, solids, dissolved oxygen, 5-day 20° C. BOD, COD, nitrogen series (nitrate, nitrite, organic), and ammonia, phosphorus (soluble and total), copper, nickel, zinc, chromium, and coliforms (total and fecal).

Operational water quality monitoring will be conducted on a quarterly basis at at least three reservoir stations.

FIGURE A-4

Aerial Photography Showing The Cultural Features Of The Bellefonte Nuclear Plant Site And Vicinity

Date Prepared: Jan., 1973

Notes:

1. Mosaic of black and white aerial photography taken by TVA in April, 1972.

2. Circles and numbers refer to photographs as identified in Figures A-5, A-6, & A-7.

No. 1
Aerial View
Community of Bellefonte

No. 2
Old Bellefonte Hotel
and New Mobile Home

No. 3
Old Bellefonte Hotel

No. 4
Old Bellefonte Stable

No. 5
Old Bellefonte Store

FIGURE A-5

Photographs of Structures in the Old Bellefonte Community

No. 6
Structures on Plant Site

No. 8
Old Shipp Chapel

No. 10
Structure on Plant Site

No. 12
Finnell Cemetery

No. 7
Structure on Plant Site

No. 9
Structure on Plant Site

No. 11
Structures on Plant Site

No. 13
Shipp Cemetery

FIGURE A-6

Photographs of Cemeteries and Typical Structures on the Bellefonte Nuclear Plant Site

No. 14
U.S. Highway 72
Bellefonte Road Intersection

No. 15
Jackson County
Technical School

No. 17
Farm House and Out Buildings

No. 19
Entrance to
Town Creek Subdivision

No. 16
Sand and Gravel
Operation

No. 18
Town Creek Subdivision

No. 20
Town Creek Subdivision

FIGURE A-7

Photographs of Structures and Developments in the Vicinity of the Bellefonte Nuclear Plant Site

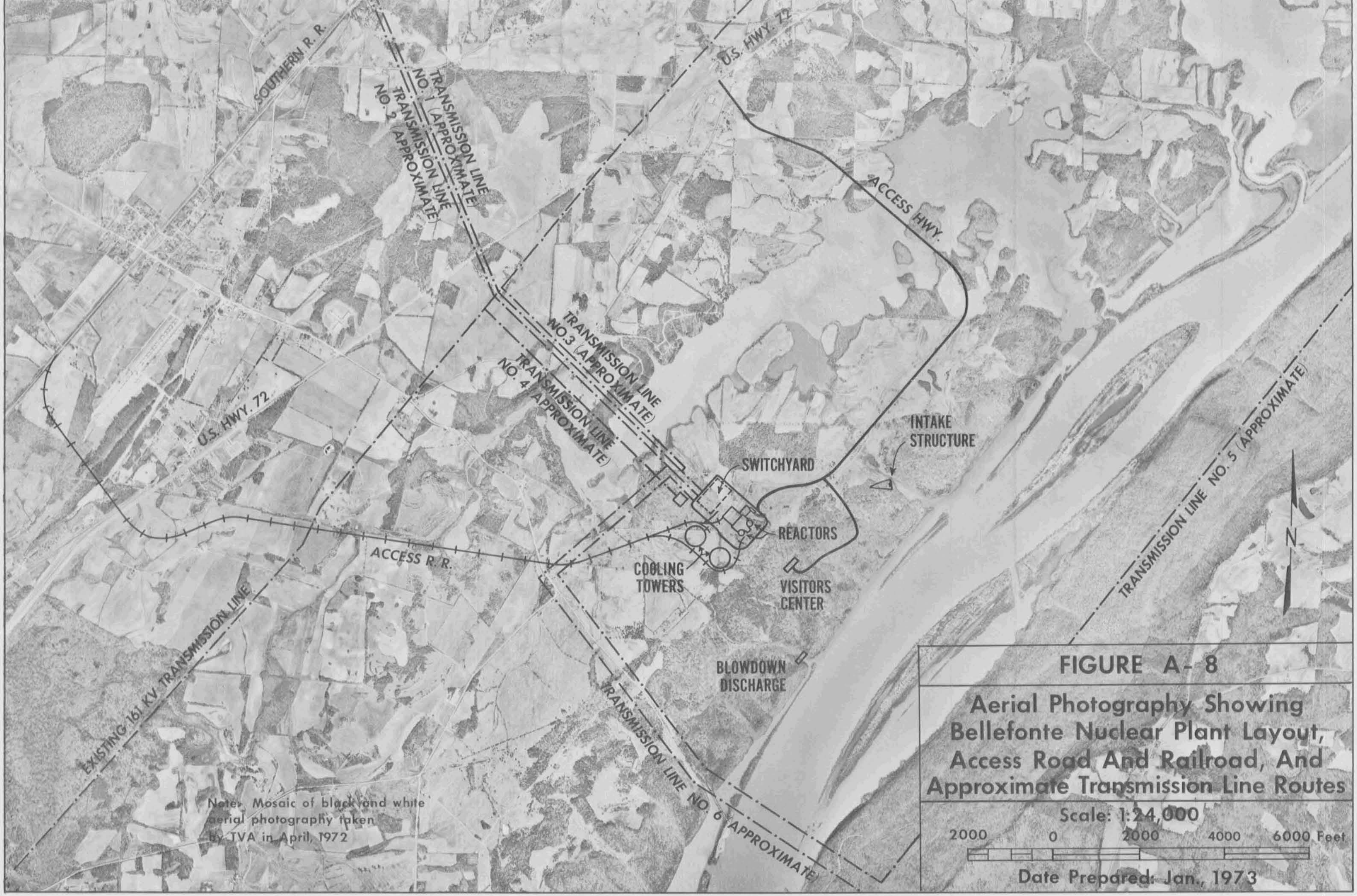


FIGURE A- 8

Aerial Photography Showing Bellefonte Nuclear Plant Layout, Access Road And Railroad, And Approximate Transmission Line Routes