TVA-OHES-EIS-72-6

TENNESSEE VALLEY AUTHORITY

ENVIRONMENTAL STATEMENT

BROWNS FERRY NUCLEAR PLANT UNITS 1, 2 and 3

VOLUME 1

TVA-OHES-EIS-72-6

Tennessee Valley Authority
Office of Health and Environmental Science

FINAL ENVIRONMENTAL STATEMENT
BROWNS FERRY NUCLEAR PLANT
UNITS 1, 2, AND 3
VOLUME 1

Chattanooga, Tennessee
September 1, 1972

SUMMARY SHEET

ENVIRONMENTAL STATEMENT

BROWNS FERRY NUCLEAR PLANT UNITS 1, 2, AND 3

( ) Draft (X) Final Environmental Statement Prepared by the Tennessee Valley Authority

1. (X) Administrative Action ( ) Legislative Action

2. This action is the construction and operation of a three-unit nuclear power generating station in Limestone County, Alabama.

3. Environmental impacts associated with the construction and operation of the Browns Ferry Nuclear Plant include:

   (1) Minute additions of radioactivity to the air and water.
   (2) Release of large quantities of heat to the environment.
   (3) Change in approximately 840 acres of land for the plant site from farming to industrial use and easements on 1,350 acres of land for transmission lines.
   (4) Release of small quantities of nonradioactive materials to the air and water.
   (5) Temporary stress on social infrastructure (schools, roads, housing, and similar services).
   (6) Stimulus to area economic development (jobs, attraction of visitors, etc.).
   (7) Some loss of aquatic organisms due to entrainment in condenser cooling water.

   No significant adverse environmental effects are expected to occur as a result of these impacts.

4. To meet projected peak loads, TVA considered the following alternatives: (1) base-loaded coal-fired units and (2) nuclear-fueled units. The second alternative provides the lowest cost of generating power and the least environmental impact. The purchase of power in the quantities needed is not a realistic alternative.

   Alternative systems were considered for waste heat dissipation and reduction of releases of radioactive products from the plant.

   Alternative heat dissipation systems considered included:

   (1) Mechanical draft cooling towers
   (2) Natural draft cooling towers
   (3) Spray canal system
   (4) Cooling lake

Considering feasibility, environmental impact, and cost, the mechanical draft cooling towers represent the best balance and has been adopted to meet proposed water temperature standards.

Alternatives considered for augmenting the original system to further reduce gaseous radioactive emissions included:

(1) Hydrogen recombiners
(2) Hydrogen recombiners in combination with charcoal adsorbers
(3) Solvent absorption system
(4) Cryogenic distillation system

Selection of hydrogen recombiners in combination with six charcoal beds per unit was made as a result of balancing feasibility, environmental benefit, and cost.

Demineralizers and evaporators were considered as alternate means to further reduce radioactive liquid discharges. Consideration of feasibility, environmental benefit, and cost shows that the use of evaporators for this purpose represents the best balance and TVA is proceeding with plans to install this alternative.

5. Comments have been received from the following agencies:

Environmental Protection Agency
Department of Transportation
Alabama Development Office, State of Alabama
  Alabama Department of Conservation
  Alabama Historical Commission
  State of Alabama, Department of Public Health
  Comprehensive Health Department
  Bureau of Environmental Health
  Alabama Water Improvement Commission
  North Central Alabama Regional Planning
    and Development Commission
  Top of Alabama Regional Council of Governments
  Alabama Development Office Coordinator
Department of Commerce
Department of Agriculture
Department of Health, Education, and Welfare
Department of the Interior
Atomic Energy Commission
Federal Power Commission
Department of Housing and Urban Development
Department of the Army

6. The draft statement was sent to the Council on Environmental Quality and made available to the public on July 14, 1971. Supplements and additions to the draft was sent to the Council and made available to the public on November 8, 1971. The final statement was sent to the Council and made available to the public on September 1, 1972.

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BROWNS FERRY ENVIRONMENTAL STATEMENT

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PREFACE

This detailed statement of environmental considerations, prepared by the Tennessee Valley Authority, evaluates the effects on the environment of construction and operation of the Browns Ferry Nuclear Plant (Docket Nos. 50-259, 50-260, and 50-296) and is made in accordance with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. §§ 4331 et seq).

TVA, a corporate agency of the Federal government, and the Atomic Energy Commission, a regulatory agency of the Federal government, have agreed that TVA is the lead agency for the preparation and circulation of detailed statements of environmental considerations for TVA nuclear plants. AEC has concluded that this statement is adequate to support the proposed license to operate the plant. AEC's letter to this effect follows the preface.

The Browns Ferry draft statement was circulated for review and comments by other government agencies and made available to the public on July 14, 1971. This was supplemented on November 8, 1971, with additional information responding to AEC's revisions to 10 CFR Part 50, made pursuant to the Calvert Cliffs decision (Calvert Cliffs' Coordinating Committee v. Atomic Energy Commission, 449 F.2d 1109 (D.C. Cir. 1971)). The draft and the supplement are included as part of the final environmental statement as Volume 2 and 3, respectively.

Comments have been received on both the draft and the supplement. In preparing the final statement TVA consulted with the Environmental Protection Agency and AEC.

On July 7, 1966, TVA filed an application for a construction permit for units 1 and 2. Construction Permit Nos. CPPR-29 and CPPR-30 were issued on May 10, 1967, and construction started on May 17, 1967. Construction Permit No. CPPR-48 was issued on July 31, 1968, for unit 3, and construction began on August 1, 1968. The final safety analysis report and a request for authorization to operate the three units were submitted to AEC on September 25, 1970.

The TVA Board of Directors has determined that it is not practicable to reassess the basic course of action in the design and construction of the plant. The environmental statement considers the ways in which the plant will interact with the environment by reevaluating environmental consequences considered at the outset of the project. This process minimizes adverse environmental consequences that would affect the overall balance of environmental costs and benefits by studying and adopting appropriate alternatives.

1.0 SUMMARY

TVA as a resource development agency generates electric power as part of its responsibility for the physical, social, and economic development of the Tennessee Valley region and as part of the national defense. An ample supply of low cost electrical energy together with a total resource development program has been a major factor in the progress achieved by the Tennessee Valley region since 1933. Employment, income, and productivity have all increased as the economy has shifted from primarily agricultural to industrial. The addition of the Browns Ferry Nuclear Plant to the TVA power system is a key element in continuing to provide an ample supply of electricity to the region.

In carrying out its responsibility, TVA has long used the type of interdisciplinary approach which the National Environmental Policy Act requires. In the case of Browns Ferry, Federal, state, and local agencies were consulted early in project development. The original design of the plant incorporated several features to lessen adverse environmental impacts. As part of TVA's continuing effort and through the environmental review process, further provisions have been made to maintain a quality environment. These are summarized below in the discussion of the principal ways in which the plant interacts with the environment. The three volumes of the environmental statement trace the environmental considerations and the manner in which they were incorporated into TVA's decision-making process.

1. Principal ways in which Browns Ferry interacts with the environment - The principal ways in which the plant will interact with the environment are:

1. Minute additions of radioactivity to the air and water.
2. Release of large quantities of heat to the environment.
3. Change in land use from farming to industrial.

(1) Radioactive releases - As a result of environmental considerations, the original plant design has been changed to incorporate provisions which will further reduce the release of radioactivity to the air and water. With regard to gaseous radioactive releases to the air, a system of hydrogen recombiners and charcoal beds will be added which will reduce the radiation dose to an individual at the site boundary by a factor of 100 below the dose with the system as originally designed. Radioactivity in releases to the water of Wheeler Reservoir will also be reduced by a factor of approximately 100 below that with the original system by adding an evaporator to treat the liquid releases. With this extended treatment of gaseous and liquid effluents, environmental concentrations of radioactivity from the Browns Ferry Nuclear Plant will be so low as to be indistinguishable from natural environmental radioactivity. For example, if a person were to stand at the site boundary continuously for a period of a year, he would receive a maximum dose of about two millirems from the operation of the plant. This is less than two percent of the dose from natural background radiation and is, in fact, less than the variations which occur in natural background radiation. In actuality this dose and percentage would, of course, be even smaller. The total dose from the operation of the plant to the population within 50 miles of the plant site is calculated to be about 0.01 percent of the dose from natural background radiation.

(2) Release of large quantities of heat to the environment - A diffuser system for releasing heat to Wheeler Reservoir was included in the original design for Browns Ferry. Use of this system to limit the temperature rise in the reservoir to 10°F and the maximum temperature

to 93°F was judged to be adequate to protect aquatic life. Reevaluation of these criteria through the environmental review process has reaffirmed this judgment. However, in order to meet proposed new thermal standards for Alabama which limit the temperature rise to 5°F and the maximum temperature to 86°F, a supplementary cooling system is required. After evaluation of the feasibility, environmental and economic considerations of alternative systems for supplementary cooling, TVA selected mechanical draft cooling towers as the best way to meet the new standards. The mechanical draft towers are estimated to have a capital cost of $36 million and a total cost, including operation and maintenance, of $44 million.

From the time the plant goes into operation until the construction of the cooling towers is completed, TVA will use the diffuser system to limit reservoir temperatures to the original thermal design criteria. The cooling waterflow through the plant amounts to about 10 percent of the mean annual flow of the Tennessee River at this point. When operating with the diffusers, water will be drawn from and returned to Wheeler Reservoir, and its temperature will be raised 25°F in passing through the plant's condensers. The diffuser system will cause the heated water discharge to be mixed quickly and will create no excessively warm surface strata. Under average flow conditions, the temperature of the reservoir will be increased not more than 2.5° to 3.5°F. TVA's environmental review concluded that this interim operation will adequately protect all water uses and aquatic life.

After its completion, the mechanical draft cooling tower system will supplement the diffuser system to the extent required to comply with the new standards. The natural heat dissipation

capacity of the reservoir will still be used as much as practicable. The cooling tower system can be operated in the open, helper, or closed modes. In the open mode the system will operate only on the diffusers and no water will be passed through the cooling towers. The helper mode will be used when reservoir conditions require cooling of the condenser water by passing it through the towers prior to discharge. When reservoir conditions require minimum heat releases, the plant will be operated in the closed mode which recirculates the cooling water through the towers. During the closed mode water will be withdrawn from Wheeler Reservoir only to replace evaporative losses and drift from the towers and the blowdown water which is removed to control the quality of water recirculating in the system. It is estimated that the cooling towers will have to be used in the helper and closed modes about 28 percent of the time to meet the new thermal standards.

(3) Change in land use - The construction and operation of Browns Ferry will result in changing the use of the 840-acre tract from agriculture to a power plant site. The environmental review has concluded that the presence of the plant will be compatible with the surrounding area and will have no significant adverse impact upon it. A recent TVA survey shows that the value of land adjacent to the Browns Ferry site has generally increased at the same rate as that of other land in Limestone County. The location of the plant at this site is compatible with the regional land use plan. Although the facility will occupy certain amounts of space, the range of beneficial uses of the environment will not be curtailed.

2. Other topics discussed - The statement also dicusses other impacts, including the transportation of nuclear fuel and radioactive

wastes and the radiological effects of accidents. The transportation of radioactive materials associated with the operation of the plant was evaluated during the environmental review. It was concluded that the transportation can be accomplished with no significant adverse impact. Doses of radiation exposure from this source to people living along the transportation routes are calculated to be less than 0.005 percent of the natural background radiation dose.

An assessment was also made of the radiological consequences of certain postulated accidents at the plant. It was found that the maximum radiation dose received by a person at the site boundary as a result of an accident would be within the limits established for normal plant operation.

The estimated total dose to the population within 50 miles of the plant from each of the postulated accidents would be orders of magnitude smaller than that from naturally occurring radioactivity. When the probability of occurrence is considered, the annual potential radiation exposure of the population from all the postulated accidents is even less and is well within naturally occurring variations in background radiation.

3. Conclusion - After weighing the environmental costs and the technical, economic, environmental, and other benefits of the project and adopting alternatives which affect the overall balance of costs and benefits by lessening environmental impacts, TVA has concluded that the overall benefits of the project far outweigh the monetary and environmental costs.

2.0 RESPONSES TO COMMENTS ON DRAFT AND SUPPLEMENT

This section of the final environmental statement for the Browns Ferry Nuclear Plant contains TVA's responses to agency review comments discussed on a topical basis. The topical discussions consider and are based on commercial operating dates of March 1973, December 1973, and July 1974 for units 1, 2, and 3, respectively. Section 3.0 provides a table which keys the responses to the comments. Information in Volumes 2 and 3 is still valid unless otherwise noted and is repeated in section 2.0 only as required to respond to the comments.

2.1 Transportation of Nuclear Fuel and Radioactive Waste - About one quarter of the 764 fuel assemblies in each of the three units' cores are expected to be replaced with new fuel assemblies on an annual cycle. As stated in Volume 3, this annual refueling cycle will involve about 200 tons of nuclear fuel shipped to and from the plant. Packaged low-level radioactive waste totaling about 300 tons annually will also be shipped from the plant to AEC-licensed disposal areas.

Packaging for the low-level compressible waste material is designed to remain leakproof under normal transport conditions of temperature, pressure, vibration, rough handling, exposure to rain, etc. This packaging may release its contents in an accident. However, since these materials normally fall under the classification of Low Specific Activity (LSA) as defined by AEC[1] and considering the solid form of the waste, the likelihood of significant exposure to people is extremely small.

As stated in Volume 3, the packaging for a large quantity of radioactive material must be capable of withstanding, without loss of contents or shielding, the damage which might result from a severe accident. Test conditions for this Type B packaging are specified in the regulations and include tests for high-speed impact, puncture, fire, and immersion in water.[2] Adequate shielding must also be provided to limit the exposure of transport workers and the general public. In addition, the package for irradiated fuel must have heat-dissipation capability to protect against overheating from radioactive decay heat. Nuclear criticality safety for both normal transport and accidental damage must also be provided for both new and irradiated fuel.

Truck accident statistics for 1969[3] show a rate of 2.46 accidents per million miles travelled. Based on these data and assuming that new fuel and radioactive waste material shipments are made by truck using the estimated annual shipment miles for the Browns Ferry plant, truck accidents may be expected to occur about once every 10 years.

Spent fuel shipments are to be transported about 7 miles by a multiwheeled vehicle from the plant to the nearest railhead at Tanner, Alabama, and by rail to Morris, Illinois, a distance of about 625 miles.

In case of a transportation accident, procedures[4] which carriers will be required to follow will reduce the consequences of an accident. The procedures include segregation of damaged and leaking packages from people and notification of TVA and the Department of Transportation. Radiological assistance teams are available through an intergovernmental program to provide equipped and trained personnel. These teams, dispatched in response to calls for emergency assistance, can mitigate the consequences of an accident. The effect of various other special precautions, such as routing, speed limitations, much lower speeds in heavily populated cities, and expert driving, are also factors that help to minimize the environmental risks.

Selection of shipping routes and shipping safeguards to be followed in the transport of nuclear fuel and radioactive waste are important considerations.

1. Shipping routes - New fuel will be shipped by truck; spent fuel will be transported by truck to Tanner, Alabama, and shipped by rail; and radioactive wastes will be shipped by truck. These

are the most probable modes of transportation for shipment of radioactive material from Browns Ferry. The population centers en route, the radionuclide inventory, and the environmental effects for these materials are discussed for the probable transportation modes. Shipping routes for spent fuel and radioactive waste will be selected to avoid population centers as much as possible. Escorts will be provided as required by regulations and, in addition, where TVA considers them necessary.

(1) New fuel - General Electric Company will ship new fuel assemblies by truck from its fabrication plant in Wilmington, North Carolina, to the plant. The major population centers encountered over the approximately 700-mile route include the following:

City	1970 Population	Density Persons/mile^2
1. Wilmington, NC--State 211, I-95	46,169	2,638
2. Columbia, SC--by way of I-20 to	113,542	1,069
3. Augusta, GA--by way of I-20 to	59,864	3,938
4. Atlanta, GA--by way of I-285 and I-20 to	496,973	3,779
5. Birmingham, AL--by way of I-65 to	300,910	3,785
6. Decatur, AL--by way of I-65 and U.S. 72 to	38,044	1,430
7. Browns Ferry plant site	-	-

As indicated, interstate highways will be used to the maximum extent possible for the shipment of nuclear fuel and radioactive wastes. Alternate parallel routes will be used whenever

necessary because of construction or temporary closure of interstate highway segments.

(2) Spent fuel - General Electric Company will ship the spent fuel from the plant approximately 625 miles to its Midwest Fuel Recovery Plant at Morris, Illinois. The major population centers through which the rail shipments will pass include the following:

City	1970 Population	Density Persons/mile^2
1. Browns Ferry plant site by land to rail siding at Tanner, Alabama, and thence to	-	-
2. Nashville, TN--by way of L&N to	448,003	882
3. Evansville, IN--by way of L&N to	138,764	3,855
4. Terre Haute, IN--by way of L&N to	70,335	2,695
5. Danville, IL--by way of C&EI to	42,570	3,300
6. Chicago Heights, IL--by way of EJ&E	40,900	5,382
7. Park Forrest, IL Joliet, IL --by way of EJ&E to	109,525	5,215
8. Morris, IL (MFRP site)	8,194	2,643

(3) Radwaste - TVA will either ship the low-level radioactive wastes to the Nuclear Engineering Company waste burial facility at Morehead, Kentucky, or to the Chem-Nuclear Services, Inc., waste burial facility at Barnwell, South Carolina. The proposed route to the former facility is approximately 400 miles and the following major population centers are encountered en route:

City	1970 Population	Density Persons/mile^2
1. Browns Ferry site--by way of U.S. 72 and I-65 to		
2. Nashville, TN--by way of I-65 to	448,003	882
3. Bowling Green, KY--by way of I-65 and Toll Highway to	36,253	2,238
4. Lexington, KY--by way of I-64 to	108,137	4,702
5. Morehead, KY (NECO facility)	7,191	4,494

The proposed route to the Chem-Nuclear Services facility is approximately 450 miles and the following major population centers are encountered en route:

City	1970 Population	Density Persons/mile^2
1. Browns Ferry site--by way of U.S. 72 and I-65 to		
2. Decatur, AL--by way of I-65 to	38,044	1,430
3. Birmingham, AL--by way of I-20 and I-285 to	300,910	3,785
4. Atlanta, GA--by way of I-20 to	496,973	3,779
5. Augusta, GA--by way of U.S. 278 to	59,864	3,938
6. Barnwell, SC (Chem-Nuclear facility)	4,439	562

2. Shipment activity -

(1) Spent fuel activity - Fuel elements are removed from the reactor after only a fraction of the available fuel has been used, since accumulation of fission products and possible cladding degradation prevents further usage of the element. This radioactive

"spent fuel" is subsequently shipped to a reprocessing plant for recovery of its unused fuel content (uranium and plutonium) for future use.

The inventory of fission product activity and the isotopic distribution of the Browns Ferry spent fuel at the time of shipment is given in Table 2.1-1. However, it should be noted that effectively all of this contained radioactivity, except for about 30 percent of the noble gases and about 3 percent of the iodines, is tightly bound within the insoluble, high-melting-point ceramic UO_2 pellets. Therefore, even if the shipping cask should be breached in an accident and the clad fuel were to be breached, there is still no ready mechanism for dispersing any substantial fraction of the total contained radioactivity.

(2) Waste activity - Radioactive liquid wastes are treated by filtration, demineralization, and evaporation to concentrate the wastes into low-volume higher-activity wet solid wastes. These wastes, consisting of spent powdered ion exchange resins, filter aid sludges, bead-type ion exchange resins, and evaporator bottoms, are stored in the radwaste building, solidified or dewatered, and packaged in accordance with applicable regulations for shipments to a licensed burial site for disposal. Miscellaneous low-level compressible and incompressible wastes and irradiated or contaminated equipment components are also packaged in accordance with applicable regulations for shipment to a disposal site for land burial.

The values shown in section 9.3 of the final safety analysis report[5] indicate that the normal and maximum

activities of the reactor water cleanup system sludge will be 16 Ci/ft^3 after a 60-day decay period. However, studies based on resin exposure to the reactor coolant of about 16 days, followed by intermittent backwashes over a period of 120 days, show that the activity of the reactor cleanup system sludge will be about 8.7 Ci/ft^3. The solid radwaste system is designed to handle about 70 ft^3 of sludge from the reactor water cleanup filter-demineralizers every 60 days. These sludges are accumulated and stored in three phase separator tanks. Each tank has a capacity of about 785 ft^3, of which 375 ft^3 is for settled sludge. Normal operating requirements can be met with two tanks with a 60-day decay period. The third tank provides operating flexibility and additional decay time. Since the container designed for this sludge will hold 150 ft^3 per load, this also permits additional decay time before shipment.

Evaporator bottoms will be solidified with cement or other solidification agent and will be packaged in 55-gallon drums or larger containers.

The estimated activity and quantities of the solid wastes to be shipped from Browns Ferry are summarized as follows:

Type Waste	Annual Amount-ft^3	Expected Activity @ Shipment
1. Reactor water cleanup system sludge	450	8.7 Ci/ft^3
2. Condensate system sludge	5,000	0.5 Ci/ft^3
3. Fuel pool demineralizer, waste, and floor drain filter sludge	2,500	
4. Waste demineralizer resins	1,250	
5. Waste evaporator bottoms	1,000	
6. Miscellaneous dry solids	4,500	$\ll$0.5 Ci/ft^3

The packaging system at Browns Ferry is designed to permit the use of several different types of containers. These include 55-gallon drums, disposable tanks in reusable shields, and disposable tanks with integral shields. One of the reusable shields has been fabricated for use in transporting radioactive wastes classified as reactor water cleanup system sludge from Browns Ferry to the waste disposal facility. The LL-60-150 (AEC License No. 41-08165-06) container for the higher level radioactive waste and the all-steel container for the lower level waste will be equipped with a disposable liner holding about 150 ft^3 and 183 ft^3 of waste respectively. The table shown below gives the dimensions of the two liners:

	I.D.	O.D.	IN.HT.	OUT.HT.
150 ft^3 liner	70"	70-1/2"	75"	78-1/2"
183 ft^3 liner	76"	76-1/2"	76"	79-1/2"

The liner walls are 1/4-inch carbon steel while the top and bottom are at least 1/2-inch carbon steel. The following criteria will be followed by the manufacturer in fabricating the liners:

1. All material to conform to ASTM-A36 or an approved equivalent.
2. All welds to be complete penetration, visually inspected for defects, and watertight.
3. Liner is to successfully pass a 2.0 lb/in^2 gauge hydro or pneumatic test lasting at least 10 minutes to check integrity.
4. All pipe fittings to conform with ASA-B36, 10-1950.

Upon the arrival at the waste disposal facility, the container cover is removed and slings permanently attached to the disposable liner are attached to a crane. The liner is then lifted from the container and lowered into a trench for burial. The disposable liners could eventually leak. However, a leak in the liner is not an overriding factor since neither NECO or Chem-Nuclear takes credit for containment of the low-level radioactive material in special liners in their license applications. In both cases each concluded in its analysis that contamination of ground water by this uncontained burial would be insignificant.[6,7,8] Extensive monitoring by each company, supported by monitoring from the state, is conducted to assure adjacent areas are not contaminated.

(3) <u>Environmental effects for spent fuel</u> - Following its removal from the reactor, spent fuel is stored for 3 to 4 months prior to shipment. During this time essentially all of the noble gases except krypton-85 decay to very low levels and the

decay heat will have decreased. Of the iodine isotopes, only iodine-131 is present in significant amounts (see Table 2.1-1). Fission products other than the noble gases and iodine are strongly held within the uranium dioxide fuel particles. Hence, only noble gases and iodine would escape through a penetration in fuel clad to the shipping cask cavity. Fuel known to have ruptured cladding prior to shipment is sealed in a container for ruptured fuel.

(a) Normal shipment - The principal normal environmental factor from spent fuel shipments would be the direct radiation dose as they move from the reactor to the reprocessing plant. The population exposure resulting from normal shipments of radioactive materials has been evaluated on the basis that there would be about 5,000 people living on both sides of the transport route along the estimated 625-mile route. It has also been assumed that the shipments are made at the maximum permitted level of 10 mrem/h at 6 feet from the nearest accessible surface. Figure 2.1-1 shows the location of the shipping container relative to people living adjacent to the railroad that was used to calculate the radiation exposures. The calculation does not include reductions of exposures due to shielding from structures, topographic features, or other radiation-attenuating materials.

The radiation dose as a function of distance from a stationary shipping container is shown in figure 2.1-2. As shown, the radiation exposure rate drops off quite rapidly and beyond 260 feet from the container can be considered insignificant.

The radiation exposure rate from a stationary container to a resident living within 260 feet of the container travel path is approximately equal to natural background. Because the container will normally be moving, the total exposure from the containers to such an individual will be an insignificant fraction of the exposure from natural background radiation. For the estimated 32 shipments per year, each moving at only 20 mi/h, the maximum exposure received by any individual along the route would be about 0.0042 mrem per year.

On the basis that there would be a total of about 5,000 people living on both sides of the transport route between Browns Ferry and the Midwest Fuel Recovery Plant at Morris, Illinois, these people would receive an annual dose of about 0.008 man-rem per year. Train brakemen or a member of the general public might spend a few minutes in the vicinity of the car, at an average distance of 6 feet, for an average exposure of about 0.5 mrem per shipment. With 10 different brakemen and 10 members of the general public so involved along the route, the total dose for 32 shipments during the year is estimated to be about 0.32 man-rem.

Since the exposure to the 5,000 people who reside along the route and to a person who might come within 6 feet of the railcar for a short period is only 0.001 and 0.4 percent respectively of the exposure these same people receive from natural background radiation, it is concluded that no adverse environmental effects will result from the normal transportation of spent fuel from Browns Ferry to the fuel reprocessing plant.

(b) Accident occurrences -

The principal potential environmental effects from an accident are those from direct radiation resulting from increased radiation levels, from gaseous release of noble gases and iodine, and from release of contaminated coolant.

Evaluation of exposure from direct radiation assumes that the radiation exposure rate is the maximum permitted by regulations, 1,000 mrem/h at 3 feet from the surface of the container, and that people have surrounded the container beginning at about 50 feet from the container. Figure 2.1-3 shows the exposure rate for accident conditions as a function of distance from the container. The exposure rate at 50 feet would be about 9 mrem/h. Assuming a tightly packed crowd, there would be 154 people in the front row and, as shown on figure 2.1-3, these people would provide shielding such that people in subsequent rows would receive greatly reduced radiation exposure. Even if a person remained in the front row for 2 hours, his exposure would be less than 20 mrem. Further, the increased radiation level would most likely be from only a localized areas on the continer, and thus only a small number of the people in even the front row of a crowd would be exposed to these low radiation levels.

Calculations indicate 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 fission gases carry any released fission gases to a height of 10 meters before they are dispersed in the environment. On this basis it is calculated that the maximum dose in the environs would occur at about 300 feet from the containers. Assuming a person stands in the plume during the entire accident, the resulting whole body exposure would be 2 mrem and the maximum thyroid dose would be about 5 rem. For the noble gas release, assuming an average population density of 130 people per square mile, the total whole-body population dose from the accident would be 0.09 man-rem. TVA considers the average population to be a more realistic number for analyzing transportation accidents because of the small fraction of the total distance travelled in high population density areas and because accidents in such areas generally occur at lower speeds and therefore would be less severe.

The contaminated coolant is basically low specific activity material. If it were drained from the container and accumulated in a pool on the ground, the exposure rate near the surface of the pool or collection would be less than 4 rem per hour and would be only about 16 mrem per hour at 50 feet, assuming no shielding. However, because the coolant would be absorbed in the ground, there would be significant shielding afforded by the soil and the actual exposure rate would be much less than the levels calculated.

The principal environmental risk resulting from an accident would be potential whole body radiation exposure due to the release of noble gases and from direct radiation and potential thyroid dose due to the release of iodine. Because of the dose reduction with distance and the mitigating effect of proposed emergency actions, it can be concluded that the whole body radiation exposure to the public will be negligible. Because of the unlikely combination of circumstances which must be present to result in a significant dose due to the release of iodine, the probability of significant doses due to this occurrence is considered extremely small.

(4) Environmental effects for radioactive waste - Materials which are in contact with the reactor fuel, its radioactive products, or neutron flux may become radioactive. Consequently, the operation of any nuclear power generating plant will produce radioactive materials in the normal functioning of the various water purification and treatment equipment, as well as routine maintenance operations. The environmental effects for these radioactive wastes for normal shipments and during accident occurrences are evaluated for the potential exposure to transport workers and the general public.

(a) Normal shipments - There will be approximately 53 shipments annually of the radioactive waste resulting from the operation of Browns Ferry. In order to assess the environmental effects of these shipments it is assumed that they are made at the regulatory radiation level limit of 10 mrem/h at 6 feet

from the nearest surface. It is also assumed that the exposure rate to transportation personnel is not greater than the regulatory radiation level limit of 2 mrem/h in occupied positions of vehicles.[9]

Under normal conditions, the truck driver might receive as much as 15 mrem per shipment. A total dose to all drivers for a given year, assuming two drivers per vehicle, would not exceed 1.6 man-rem.

Because of the low dose rates permitted at the time of shipment (10 mrem/h at 6 feet from the container), the only exposure to people from routine shipments is for the brief period such a shipment is in direct view. For example, a member of the general public who spends 3 minutes at an average distance of 6 feet from the container would receive a dose not exceeding 0.5 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 53 shipments of spent powdered ion exchange resins, filter aid sludge, and bead-type ion exchange resins would be about 0.3 man-rem.

Figure 2.1-1 shows the location of the shipping container relative to people living adjacent to the transport route that was used to calculate radiation exposures. The radiation dose as a function of distance from a stationary shipping container is shown in figure 2.1-2. On the basis that there would be a total of about 2,500 people living on both sides of the assumed 450-mile transport route between Browns Ferry and either the waste burial facility at Morehead, Kentucky, or at Barnwell, South Carolina, these 2,500 people would receive an annual dose of about 0.006 man-rem per year.

Since the exposure to the 2,500 people who reside along the route, to each truck driver per shipment, and to a person who might come within 6 feet of the container for a short period is only 0.002, 11, and 0.4 percent, respectively, of the exposure these same people receive from natural background radiation, it is concluded that no adverse environmental effects will result from the transportation of radioactive waste from Browns Ferry to either of the burial facilities.

(b) Accident occurrences - Although transportation accidents involving either new fuel or radioactive waste may be expected to occur about once every 10 years based on the national truck accident statistics for 1969, it is highly unlikely that a shipment of solid radioactive waste will be involved in a severe accident during the 40-year life of the plant. This is based on data on accidents involving TVA trucks during the past 10 years which show a rate of 4.06 accidents per million miles travelled. Based on these data and assuming that new fuel and radioactive waste shipments are by truck using the estimated annual shipment miles of radioactive material for the Browns Ferry plant, truck accidents may be expected to occur about once every 5 years. However, about 90 percent of the accidents included in the TVA data are of a minor nature and since radioactive shipments will be made in accordance with the stringent conditions imposed by AEC and DOT procedures and regulations, the probability of an accident of a severity which would result in release of significant quantities of radioactive materials to the environment would not be likely during the 40-year life of the plant.

If a shipment of compressible wastes in appropriate containers becomes involved in a severe accident, some release of waste might occur, but the specific activity of the waste will be so low that the exposure of personnel or the public would not be expected to be significant. Spent powdered ion exchange resins, evaporator bottoms, filter aid sludge, and bead-type ion exchange resins which have been solidified or dewatered will be shipped in Type B packages. The probability of release from a Type B package in a severe accident is sufficiently small that, considering the form of the waste and the very low probability of the severe accident occurrences, the likelihood of significant exposure would be extremely small.

3. Shipping safeguards - The protection of the public from radiation during shipment of nuclear fuel and radioactive waste is achieved by a combination of limitations on the contents of the package according to the quantities and types of radioactivity, the package design, and the external radiation levels. In addition to these shipping safeguards, the transportation emergency plans will provide for rapid and orderly use of personnel and equipment in the event an accident occurs in the shipment of radioactive materials by TVA.

The Department of Transportation (DOT) has regulatory responsibility for safety in the transport of radioactive materials by all modes of transport in interstate or foreign commerce (rail, road, air, and water), except postal shipments.[10] Those shipments not in interstate or foreign commerce are subject to control by

a state agency in most cases. The Atomic Energy Commission (AEC) also has responsibility for safety in the possession and use, including transport of radioactive materials.[11] Both Title 10 and Title 49 of the Code of Federal Regulations set forth the limitations and classifications of the contents, design, and external radiation levels of transport packages.

(1) Governing regulations - This section identifies and summarizes the governing regulations affecting the transport of nuclear fuel and radioactive material. The major aspects of package design and the technical bases of the regulations and the control of the radiation emitted from individual packages are also discussed. In addition, the external radiation levels permitted for low specific activity (LSA) are listed.

Package classification depends upon the type, form, and quantity of radioactive material being shipped in the individual container. Small quantities and certain materials of low specific activity are exempted from specification packaging, marking, and labeling when transported on a sole-use vehicle. All other types and quantities of radioactive materials are divided into two broad classes as either "special form" or "normal form." "Special form" radioactive materials means those which, if released from a package, might present some direct radiation exposure but would present little hazard due to radiotoxicity and little possibility of contamination. This may be the result of inherent properties of the material (such as metals or alloys) or acquired characteristics, as through encapsulation. "Normal form" materials which do not meet these criteria are

classified into one of seven transport groups and listed in a table of individual radionuclides.

Varying quantities of special form and normal form radioactive materials are specified for Type A packaging, larger quantities for Type B packaging, and in excess of Type B quantities for "large quantity" radioactive materials. The Type A packaging standards are for normal conditions of transport. Type B packaging standards are for accident conditions. The large quantity standards are for accident conditions. The large quantity standards, in addition to considering both normal and hypothetical accident test conditions, must take into account other factors such as radioactive decay heating of the contents. Fissile radioactive materials also require consideration of the potential for accidental criticality.

Low specific activity packages must not have any significant removable surface contamination, and the external radiation levels must not exceed the following dose rates:

(a) 1,000 millirem/h at 3 feet from the external surface of the package (closed transport vehicle only);

(b) 200 millirem/h at any point on the external surface of the car or vehicle (closed transport vehicle only);

(c) 10 millirem/h at 6 feet from the surface of the car or vehicle; and

(d) 2 millirem/h in any normally occupied position in the car or vehicle.

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 chances 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 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.

(c) <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. As evidenced from pictures of large fires, it is unlikely that a container the size of a large shipping cask would be completely engulfed in flames due to lack of 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.

(d) Conclusion - 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.

(3) Transportation procedures - Elements of the procedures to be followed by TVA for handling radioactive materials for transportation and while in shipment are given below. These procedures will cover the normal conditions of transport as well as accident occurrences which might be encountered.

(a) Onsite procedures - The administrative control of radioactive materials intended for offsite shipment will include the following elements:

a. Certify container contents.

b. Assure performance of all tests on loaded containers as required by 10 CFR Section 71.35(a)(4), 49 CFR Section 173.393(j), and 49 CFR Section 173.397(a).

c. Ensure that container and vehicle meet the requirements of applicable regulatory bodies for movement offsite.

d. Qualified manpower and appropriate equipment to be available to make routine determinations as required by (b) above.

e. Estimated time of arrival (ETA) at destination.

f. Driver of vehicle will be responsible for control of shipments en route and for following transportation procedures delivered to him before leaving site.

(b) Offsite procedures - Spent fuel is scheduled to be shipped intermodal which requires offsite handling at the rail siding at Tanner, Alabama. The roll-on-roll-off (RORO) procedure used for the intermodal transfer is shown on figure 2.1-4. The cask is mounted on a skid which becomes the trailer deck for highway transport. The multiwheeled front gooseneck and rear axle assemblies each have self-contained hydraulic lift units for raising and lowering the skid. To remove the cask from the railcar, the front and rear units are positioned and attached to the skid, and the skid is then lifted to provide about 1 foot clearance for the highway transport. On return the procedure is reversed to place the cask back on the railcar. As

the cask is never lifted more than 1 foot and as it is designed to withstand a 30-foot free fall onto a completely unyielding surface, there is effectively no possibility that a handling accident would result in the release of any radioactive materials from the cask.

(c) Normal conditions of transport - TVA presently has nine nuclear units under construction or planned for operation between 1972 and 1979. Because of these commitments to the use of nuclear power for substantial portions of its generating capacity and the necessity to ship radioactive materials associated with the operation of these and future nuclear plants, an interdisciplinary task force to evaluate the environmental implications, available technology, economics, and other factors related to the consequent shipment of radioactive material to and from these plants has been established.

The task force is investigating the various transportation modes, prevention of accidents, environmental risks and effects and is developing criteria for establishing TVA's policies and procedures relative to the applicable regulations. The findings and recommendations of the task force will be used in formulating the detailed plans for shipment of all radioactive material to and from all of TVA's nuclear plants currently under construction or planned for the future.

(d) Accident occurrences during transport - Each state through which these materials pass will have developed emergency plans for radioactive transportation accidents. These plans, in conjunction with TVA transportation emergency procedures,

will provide for rapid and orderly use of state facilities and personnel, augmented as necessary by TVA, carrier, and municipal emergency personnel and AEC radiological assistance teams in the event an accident occurs in the shipment of radioactive materials by TVA. In the event of an accident, emergency plans for containing the contaminated material and preventing a radiation hazard to the public and the environment will be initiated.

Emergency procedures regarding transportation of radioactive material are described in the TVA Radiological Emergency Plan. Elements of the emergency procedures for handling transportation accidents for which TVA has responsibility will include, but are not limited to, the following:

1. Vehicular Accidents - General
   a. In the event of a vehicular accident involving radioactive material, establish a restricted area [10 CFR Section 20.203(b) and (c)].
   b. Use radiation survey meter to establish the perimeter of the restricted area.
   c. If survey meter is inoperable, calculate from experience and training a very conservative perimeter.
   d. If survey meter is operable and no radiation hazard exists, and the vehicle is in safe operating condition, the driver may continue on way if not detained by other accident-related conditions.
   e. In any case, immediately after establishing a restricted area or before proceeding on way, TVA shall be notified.

2. Notification and Reports of Incident

   a. Appropriate TVA personnel receiving notice of a transportation accident shall notify the TVA load dispatcher who notifies the Central Emergency Control Center director.

   b. The CECC director notifies as appropriate the AEC Operations Office, the State Department of Public Health, the state police, and the AEC Division of Compliance.

TVA has consulted and will consult further with appropriate state agencies regarding the necessary emergency planning for shipments of radioactive material through the state and to seek the state's agreement with TVA's Radiological Emergency Plan.

4. Conclusion - Due to the integrity of the containers used for shipping new fuel elements, spent fuel elements, and low-level radioactive wastes; the emergency plans for vehicular accidents; the administrative control exercised over transportation; and coordination with appropriate state agencies; it is concluded that an insignificant environmental risk will result from the transportation of fuel elements from the fuel fabrication plant to the reactor, or spent fuel elements to the fuel reprocessing plant, and of low-level waste to offsite disposal grounds.

Table 2.1-1

SPENT FUEL FISSION PRODUCT ACTIVITY[a]

(Ci/MTU)[b]
Specific Power = 40 kW/kgU

Isotope	Half-Life	24,000 MWd/T 90D[c]	24,000 MWd/T 160D[c]	44,000 MWd/T 90D[c]	44,000 MWd/T 160D[c]
Noble Gases					
Kr-85	10.8y	7,385	7,294	11,540	11,390
Xe-131m	12d	108	2	113	2
Xe-133	5.3d	20	-	20	-
Total		7,513	7,296	11,673	11,392
Halogens					
I-129	1.6×10^{7}y	2.3×10^{-2}	2.3×10^{-2}	4.09×10^{-2}	4.09×10^{-2}
I-131	8.05d	507	~1	532	~1
Total		507	~1	532	~1
Tritium-H3[d]	12.26y	290	290	505	505
Transuranics[e]					
Am-241	458y				320
Am-243	7,650y				75
Cm-242	163d				65,000
Cm-244	18y				11,000
Total					76,395
All Remaining Fission Products (ARFP)					
Rb-86	18.7d	25	2	42	3
Sr-89	50.4d	316,700	121,400	249,100	95,480
Sr-90	28y	60,180	59,910	95,380	94,940
Y-89m	16s	32	12	25	10
Y-90	64.2h	60,200	59,920	95,400	94,970
Y-91	59d	502,300	220,700	413,600	181,700
Zr-93	9.5×10^{5}y	2	2	4	4
Zr-95	65d	736,400	349,100	707,600	335,400
Nb-95m	90h	15,630	7,409	15,020	7,119
Nb-95	35d	1,226,000	664,300	1,175,000	637,700
Tc-99	2.1×10^{5}y	11	11	19	19
Ru-103	40d	304,700	89,500	346,200	101,700
Rh-103m	57m	298,900	87,800	339,600	99,730
Ru-106	1.0y	366,900	321,400	684,900	600,100
Rh-106	30s	366,900	321,400	684,900	600,100

Table 2.1-1 (continued)

SPENT FUEL FISSION PRODUCT ACTIVITY[a]

(Ci/MTU)[b]
Specific Power = 40 kW/kgU

Isotope	Half-Life	24,000 MWd/T		44,000 MWd/T	
		90D[c]	160D[c]	90D[c]	160D[c]
Ag-110m	260d	320	265	1,104	916
Ag-110	24s	6	5	22	18
Ag-111	7.5d	12	-	16	-
Cd-115M	43d	133	43	168	54
Sn-119m	250d	35	29	50	41
Sn-121m	25y	1	1	2	2
Sn-123	125d	862	592	1,243	855
Sn-125	9.4d	22	-	28	-
Sb-124	60.2d	2,875	1,284	4,185	1,847
Sb-125	2.7y	5,164	4,916	10,430	9,932
Sb-126	12.5d	18	-	27	1
Te-125m	58d	1,069	1,061	2,253	2,184
Te-127m	105d	8,794	5,634	11,480	7,355
Te-127	9.3h	8,755	5,609	11,430	7,322
Te-129m	33d	8,280	1,987	8,346	2,003
Te-129	67m	5,307	1,274	5,349	1,284
Cs-134	2.1y	31,650	29,710	85,060	79,840
Cs-136	13d	207	5	313	7
Cs-137	30y	78,540	78,200	143,000	142,400
Ba-137m	2.6m	73,440	73,110	133,700	133,100
Ba-140	12.8d	14,870	336	14,350	324
La-140	40.2h	17,110	386	16,510	373
Ce-141	32.5d	291,700	65,250	288,300	64,490
Ce-144	285d	993,600	837,500	1,113,000	938,000
Pr-143	13.7d	19,690	556	18,620	525
Pr-144	17.3m	993,600	837,600	1,113,000	938,000
Nd-147	11.1d	2,499	32	2,427	31
Pm-147	2.7y	187,800	178,600	239,900	228,100
Pm-148m	41d	3,208	1,010	4,149	1,307
Pm-148	5.4d	222	70	287	90
Sm-151	90y	107	107	146	146
Eu-154	16y	1,073	1,065	3,135	3,109
Eu-155	1.8y	29,260	27,190	77,030	71,570
Eu-156	15.2d	305	13	396	16
Tb-160	72y	160	81	256	131
Total ARFP (10^6)		7.04	4.46	8.13	5.50

a. Fission product quantities are based on the RIBD code.
b. ~5 assemblies per MTU.
c. Cooling time before shipment.
d. Tritium yields are based on 10^{-4} atoms H3/fission.
e. Transuranic isotopic quantities are based on data extrapolation and calculation.

Table 2.1-2

RADIOACTIVE MATERIALS TRANSPORTATION - SUMMARY OF EFFECTS

(Normal Conditions)

Type Shipment	Transportation Mode	Transportation Frequency (Shipments/yr)	Stationary Cask Radiation Exposure (mrem/h) at 6 ft	Stationary Cask Radiation Exposure (mrem/h) at 100 ft	Cask Moving at 20 mi/h Individual Exposure (mrem) Maximum	Cask Moving at 20 mi/h Individual Exposure (mrem) Average	Population Exposure (man-rem/yr)
Spent Fuel	Rail (~3.5 MTU)	32	10	0.085	0.0042	0.0015	0.008
Waste							
Low Level	Truck	53[a]	10	0.085	0.0070	0.0025	0.006
						Total	0.014[b]

(10 CFR Part 71 Accident Conditions)

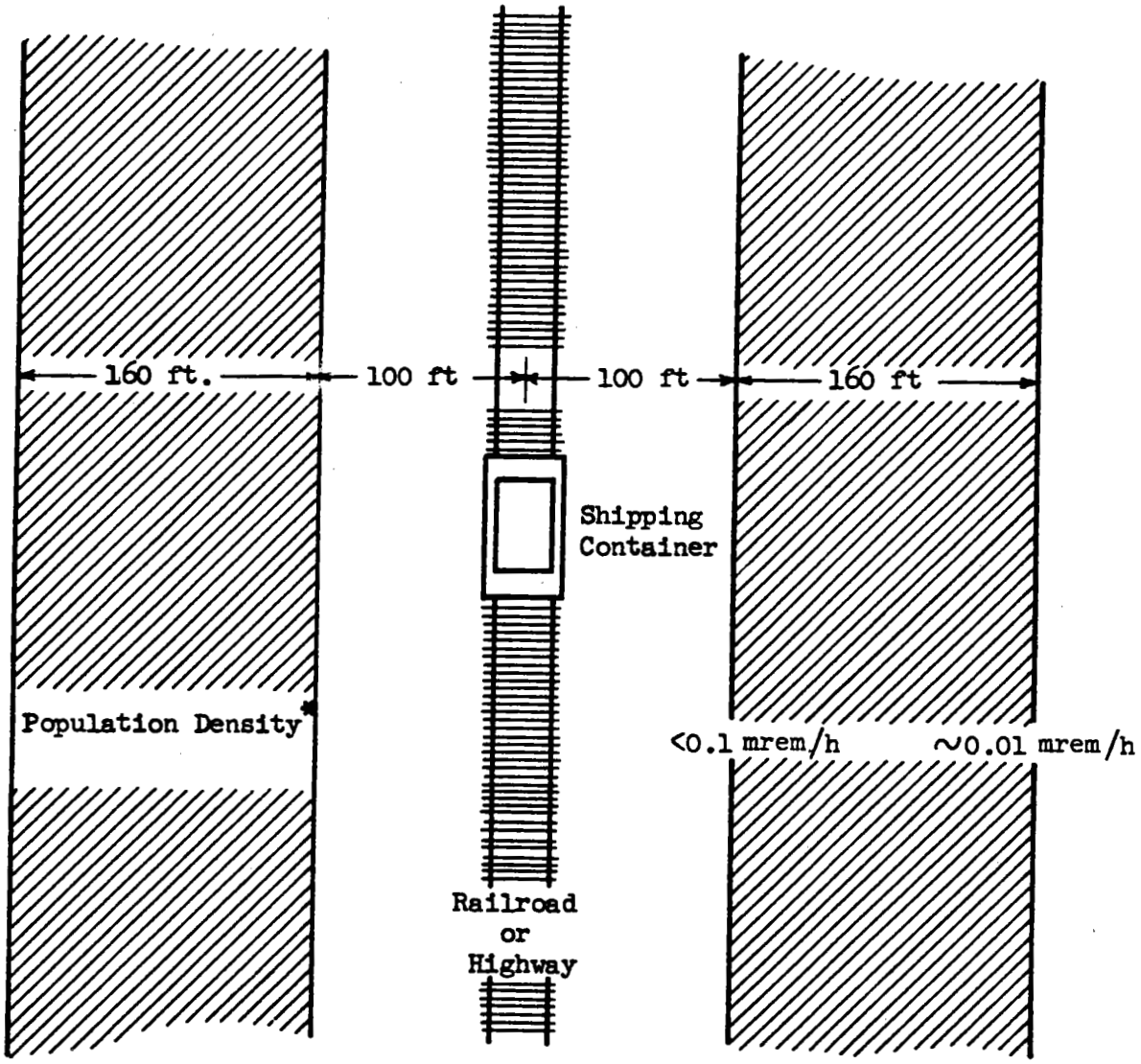
Type Shipment	Transportation Mode	Transportation (Shipments/yr)	Direct Radiation Dose Rate (mrem/h) at 3 ft	Direct Radiation Dose Rate (mrem/h) at 50 ft	Fission Gas Release External Dose (mrem) Whole Body	Fission Gas Release External Dose (mrem) Skin	Fission Gas Release Whole Body Population Dose (man-rem)	Thyroid Dose (rem)
Spent Fuel	Rail (~3.5 MTU)	32	1,000	9	2	80	0.09	5
Waste								
Low Level	Truck	53[a]	<500					

a. Design conditions.
b. This population group receives 1,100 man-rem/yr exposure from natural background radiation (~140 mrem/yr).

Table 2.1-3

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



When Container is moving at 20 mph:

Maximum Individual Exposure = 0.00013 mrem/trip
Average Individual Exposure = 0.000046 mrem/trip

* Assume 130 persons/mi^2 for spent fuel shipments and 85 persons/mi^2 for radioactive waste shipments.

Figure 2.1-1
Spent Fuel and Radioactive Waste Shipments Population Exposure Distribution

BROWNS FERRY NUCLEAR PLANT

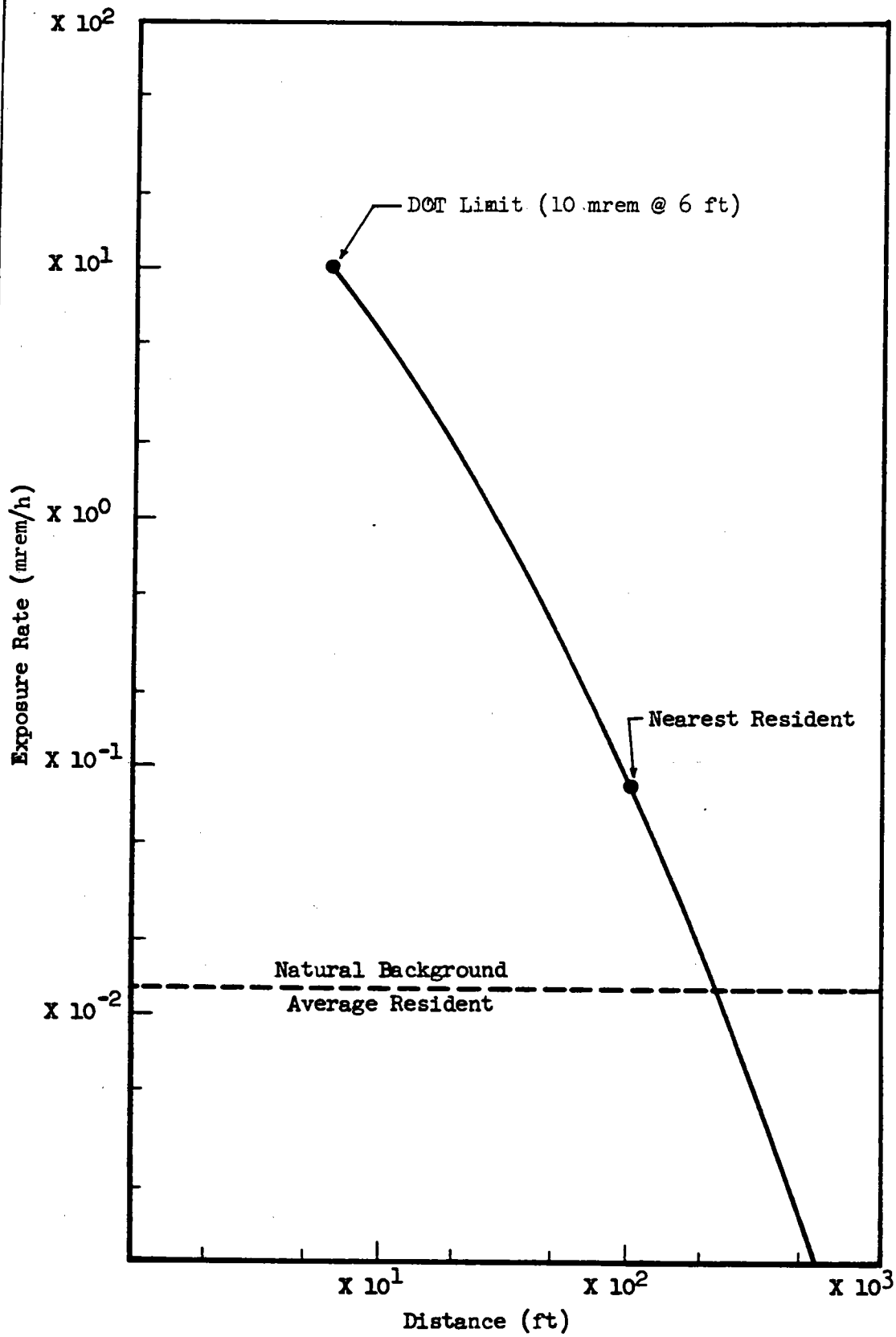


Figure 2.1-2
Direct Radiation Exposure Rate
From Stationary Shipping Container

BROWNS FERRY NUCLEAR PLANT

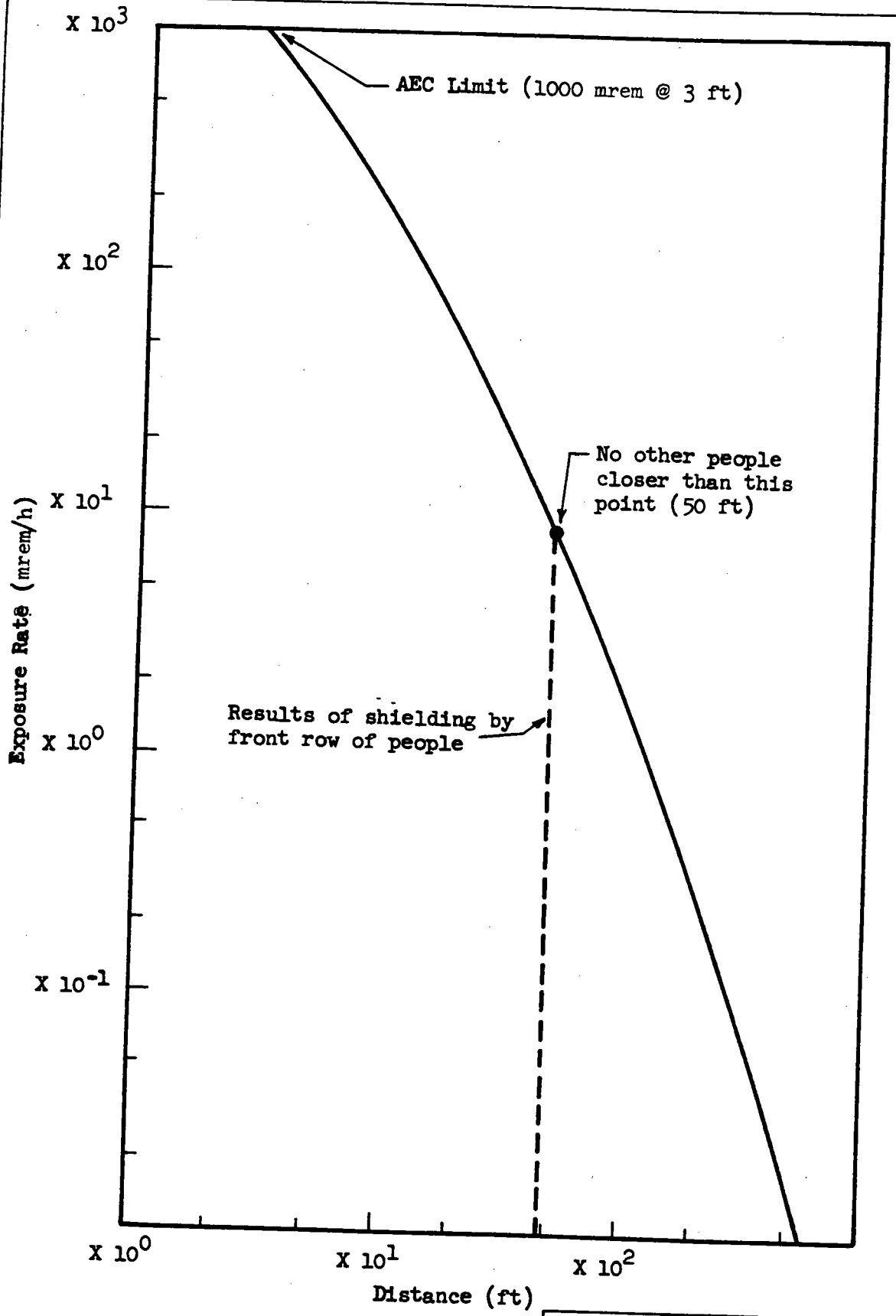


Figure 2.1-3
Direct Radiation Exposure
From Shipping Container
Accident Conditions
BROWNS FERRY NUCLEAR PLANT

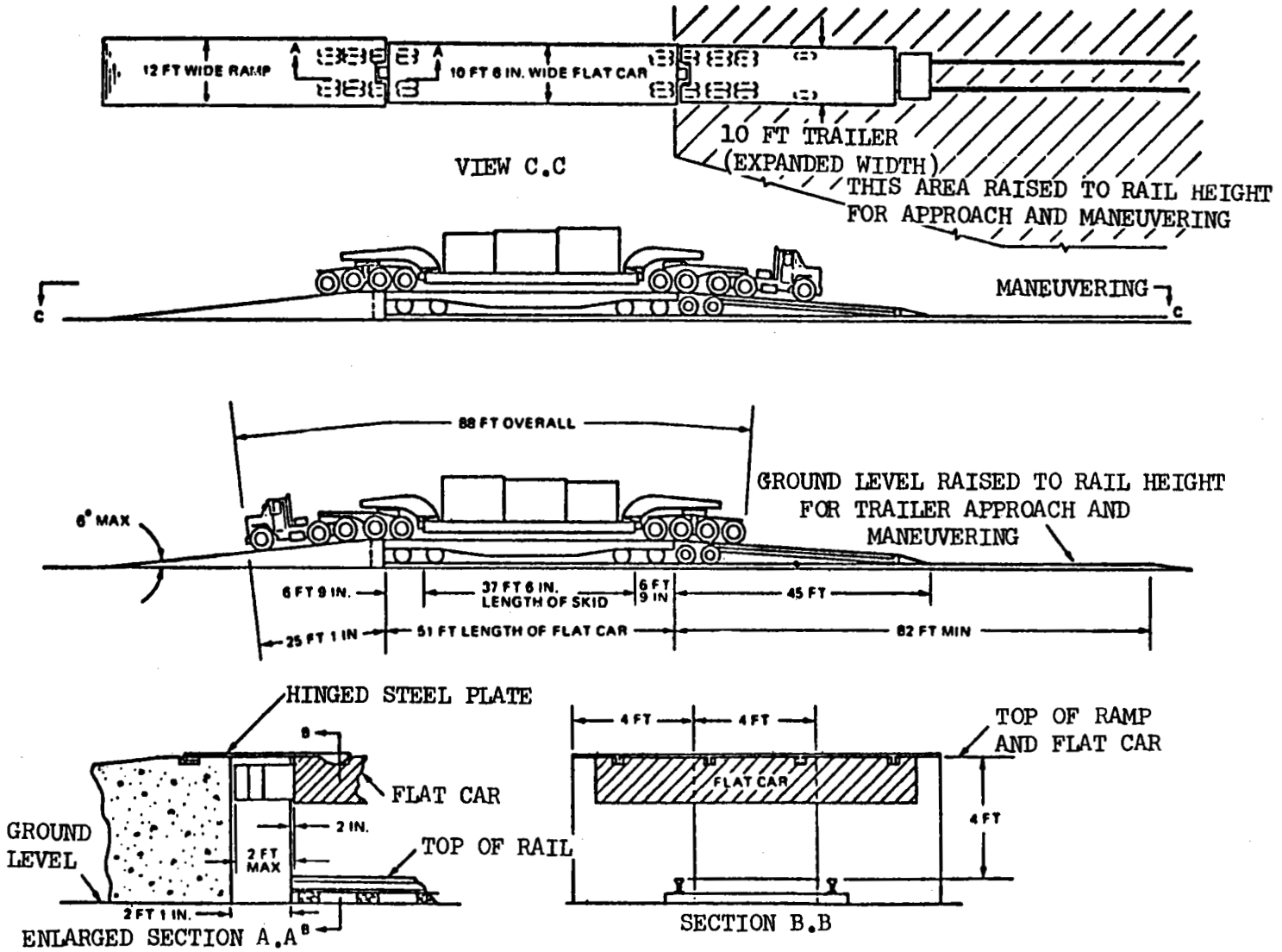


Figure 2.1-4
Intermodal Transfer Site
IF - 300 Shipping Package
Rail Siding - Tanner, Alabama
BROWNS FERRY NUCLEAR STEAM PLANT

2.2 Environmental Aspects of Transmission Lines - Construction of all transmission lines required for the Browns Ferry Nuclear Plant has been completed as stated in Volume 3. All new transmission line construction was within a 20-mile radius of the generating plant, as indicated schematically on figure 2.2-1 of Volume 3. Approximately 70 miles of new transmission construction was required to connect Browns Ferry to TVA's existing 500-kV transmission grid using six terminals. In addition, two 161-kV transmission lines totaling 25 miles were constructed to connect with the existing system.

Both economic and technical advantages dictate the development and operation of extra high voltage (EHV) power lines for the transport of electrical power over long distances. It is well known that ozone can be generated by conductor corona from EHV transmission lines if the conductors are operated at very high surface gradients. Ozone generation, its characteristics, its potential sources, and tests conducted by others are discussed below. The possibility of interference between transmission lines and communication lines is discussed relative to the potential for inductive coupling and direct faulting.

1. Ozone production and its potential effects - This report 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 of 0.05 ppm ozone or a 1-hour exposure of 0.07 ppm.[1,3] Most other vegetation, however, can withstand exposures exceeding 0.10 ppm/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/hr/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 2.2-1 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 2.2-2 and 2.2-3 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 2.2-2 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 phenomena which produces large instantaneous quantities of extremely localized ozone; however, this accounts for very little of the total ozone existing in nature.

(3) Ozone generation by transmission facilities and other potential sources - Ozone may be generated by any corona or electrical discharge in air or other oxygen medium. Quantities produced are dependent on the severity of the discharge and 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, applicances, 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 electrical 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 will be incorporated in papers being submitted for presentation at the 1972 IEEE Summer Power Meeting, San Francisco, California, 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 simultaneously 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 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 2.2-2 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 (including any significant increase in chromosome aberrations) 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 levels of ozone that can reasonably be expected to be generated by TVA's transmission facilities (500-kV maximum voltage), either resulting from normal transmission operations 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.

2. Inductive coupling - It is TVA's normal practice to send transmission line vicinity maps to railroad and telephone companies having tracks or communication lines in the general vicinity of proposed transmission lines for inductive coordination study. This was done in the case of transmission line connections for Browns Ferry Nuclear Plant, with proposed location maps being sent to the L&N and Southern Railroad Companies and the South Central Bell Telephone Company. No inductive coupling problems were anticipated by either TVA or the companies, and none has been experienced since the lines were energized and placed in service.

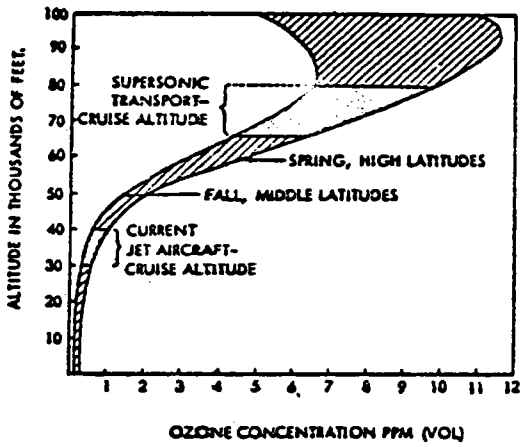


FIGURE 1. Ozone distribution—Northern Hemisphere.

Figure 2.2-1
(See Reference 5)

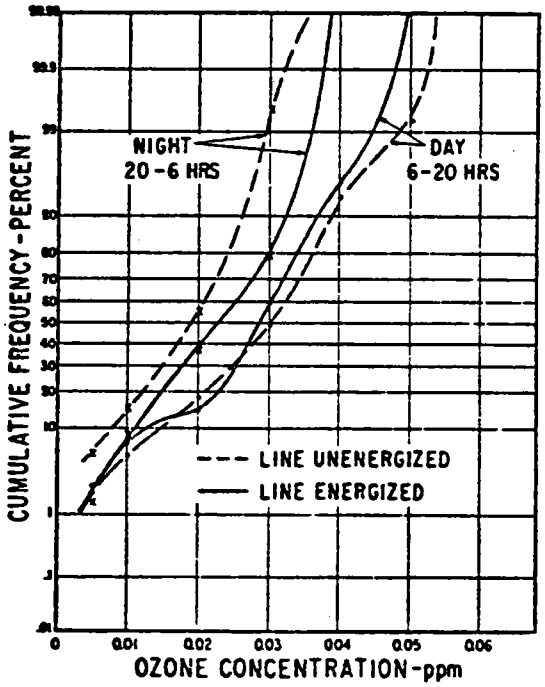


Fig. 2. Ozone statistic obtained near UHV test line during 8 days of energization and 10 days without energization.

NOTE: Test used single-phase UHV voltage of $1{,}260/\sqrt{3}$ kV.

Figure 2.2-2
(See Reference 10)

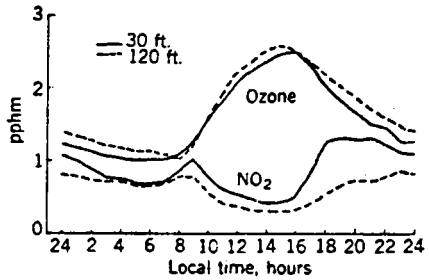
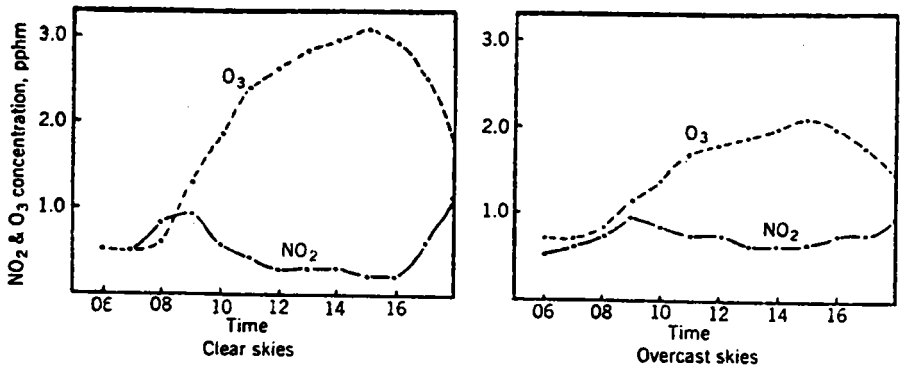


Figure 1. Averages of ozone and nitrogen dioxide for five months (Sept. 1966–Jan. 1967).



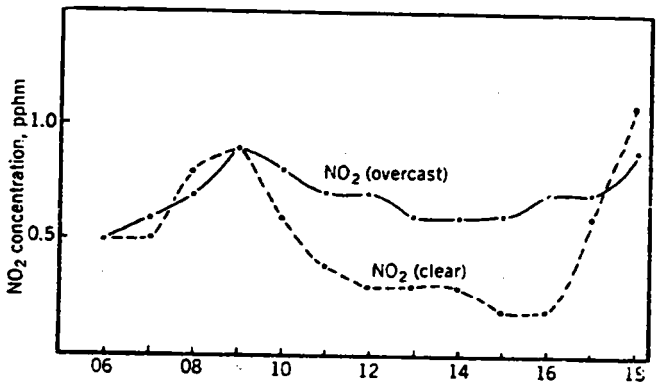


Figure 2. Nitrogen dioxide on clear and overcast days (Sept. 1966–Jan. 1967)

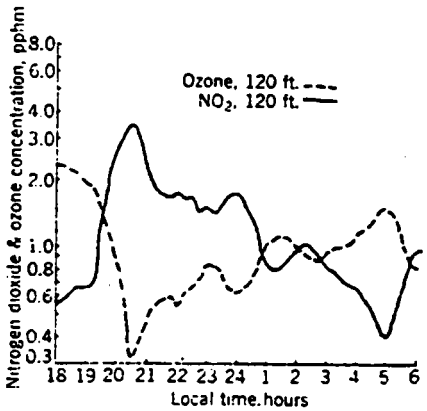


Figure 3. Nitrogen dioxide and ozone (1800–0600 hr on 11/24/66).

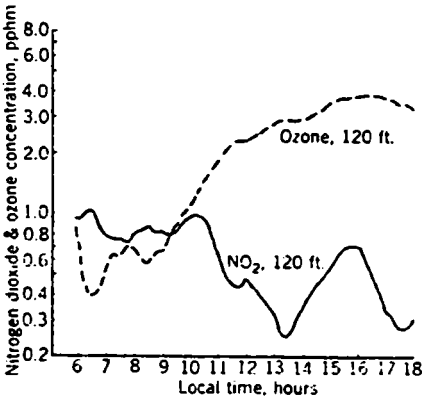


Figure 4. Nitrogen dioxide and ozone (0600–1800 hr on 11/25/66).

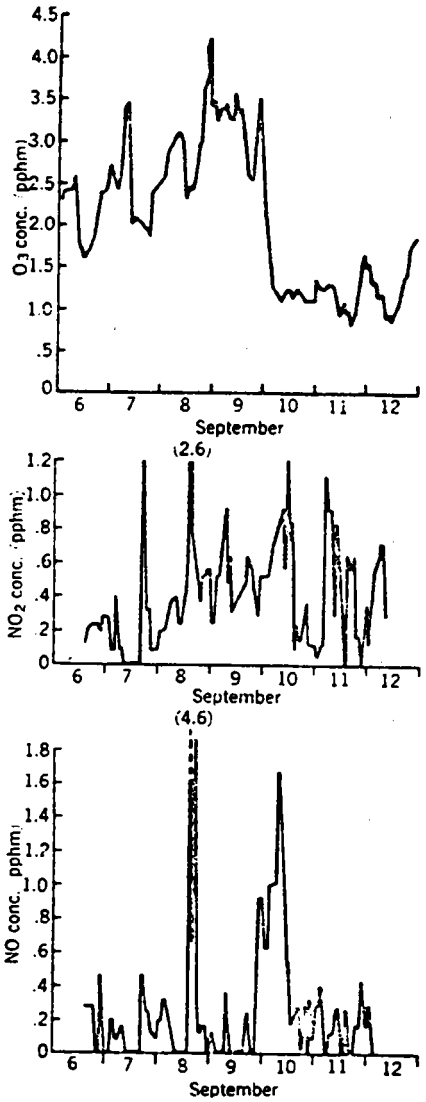


Figure 5. Diurnal averages for nitrogen dioxide and ozone at Green Knob, N. C. (Sept. 1965).

Figure 2.2-3
(See Reference 14)

2.3 Radiological Effects of Accidents - To aid in developing the overall balancing of environmental costs and benefits of the Browns Ferry Nuclear Plant, an assessment has been made of the consequences that could result from the occurrence of postulated accidents. Parameters, physical characteristics, and phenomena are used in the analyses to appraise realistically the environmental risks of postulated radiological accidents. Best estimates are used where experimental evidence is not sufficient to describe a situation. This approach to the analyses is therefore different from that used in safety analysis reports where conservatisms are supplied in order to place upper bounds on radioactive releases from postulated accidents.

Indications of the probable frequency or probability of occurrence of certain accidents are given; however, it is not possible at this time to quantify the probability or frequency of occurrence of any accident. This is principally due to the lack of statistically significant data available on which to base the probability determinations.

In accordance with AEC requirements, TVA has submitted with its application for permits to construct and operate units 1, 2, and 3 a final safety analysis report[1] which describes the technical features of the plant and the provisions for protecting the health and safety of the public. The analyses presented in this report demonstrate that even for postulated accidents of great severity, analyzed using conservative assumptions, the radiological consequences would be within the reference values of 10 CFR Part 100.

1. Minimizing the probability of occurrence - The probability of an accident occurrence is minimized in a number of ways:

(1) employment of conservative design criteria in selection and manufacture of system components; (2) incorporation of automatic protection systems; (3) quality assurance programs for design, construction, and operation; (4) administrative control of the conduct of operations; and (5) safety review. These matters are covered in greater detail in the context of the 10 CFR Part 50 licensing procedures.

2. Mitigating consequences of an accident - Several measures mitigate the consequences of an accident. These include: (1) multiple fission product barriers; (2) engineered safety features; and (3) emergency plans.

(1) Multiple fission product barriers - Fission product containment barriers are the basic features which minimize the release of radioactive materials. The design of Browns Ferry Nuclear Plant provides the following means of containing and/or minimizing the release of fission products: fuel barriers--high density ceramic UO_2 fuel sealed in zircaloy cladding; nuclear system process barrier--reactor vessel, pipes, pumps, valves, and similar process components; steel primary containment; and secondary containment building.

(2) Engineered safety features - The engineered safety features include those systems which are essential for the safe shutdown of the reactor and for maintaining it in a safe shutdown condition. They are designed to provide high reliability and ready testability. Even if an improbable maloperation or equipment failure, including a double-ended circumferential rupture of any primary coolant pipe, allowed variables to exceed their operating limits, the nuclear safety systems and engineered safeguards would limit the environmental effects from such an event.

(3) Emergency plans - The Browns Ferry Nuclear Plant emergency plans contain individual plans for coping with emergencies. They also include the radiological emergency plan which provides a description of action to be taken for events which could result in the release of signigicant amounts of radioactivity to the offsite environment. Procedures for operating the plant equipment under emergency or abnormal conditions are contained in emergency operating procedures. The Browns Ferry radiological emergency plan[2] is a part of the TVA radiological emergency plans.[3]

3. Accident analysis - Those postulated accidents having the potential for uncontrolled releases of radioactive material to the environment have been divided by the Atomic Energy Commission into nine classes based on the systems involved and the type and potential consequences of the release. The accident analyses presented here are based on the guidance given by AEC in Appendix D, 10 CFR Part 50.[4]

TVA has evaluated the fuel design as well as current BWR operating experience and have concluded that the design basis coolant activity and radioactive source term used for routine radioactive discharges provide a reasonable basis for evaluating the environmental impact of postulated accidents. Therefore, the results given in Table 2.3-1 are based on the design basis condition. TVA has also investigated the effect of a higher coolant activity on postulated accident releases. These analyses are based on TVA's estimate of the coolant activity due to 0.5 percent failed fuel and show that even with a higher

coolant activity there are no significant adverse environmental effects (Table 2.3-2).

Class one events are defined as trivial incidents including minor spills and pipe leaks that can release small quantities of radioactive material inside the containment. Class two events include miscellaneous small spills and leaks of radioactive material that may occur in structures other than containment. Both class one and class two events have been included in the routine radioactive discharges.

Class three accidents include uncontrolled releases of radioactivity from waste disposal systems as a result of an equipment malfunction or an operator error. The largest potential for release in this class is the hypothetical complete failure of the gas holdup pipe (subclasses 3.1 and 3.2). The postulated liquid radwaste accidents (subclass 3.3) lead to significantly smaller releases.

Class four accidents include postulated events which release radioactivity into the primary coolant system, including anomalous fuel failures (subclass 4.1) and fuel failure which might result from abnormal operating transients (subclass 4.2). Subclass 4.1 is included in the analysis of routine radioactive discharges. While no off design transient has been identified which can lead to fuel failures, subclass 4.2 has been analyzed using AEC guidance.

The off design transient (subclass 4.2) is assumed to result in release of 0.02 percent of the core inventory of noble gases and halogens to the coolant. One percent of the halogens and 100 percent of the noble gases in the reactor coolant are assumed to be released to the steam and transported to the condenser. This activity is assumed to

leak to the atmosphere at the rate of 0.5 percent of condenser volume per day for one day. A decontamination factor in the condenser of 10 is assumed for halogens.

The Atomic Energy Commission has not identified a class five accident which applies to BWR's. The refueling accident inside the primary containment is represented by two examples: Subclass 6.1 is based on failure of one row of fuel pins while the fuel is being handled one week after plant shutdown. One percent of the halogens and 1 percent of the noble gases in the failed fuel pins are assumed to be released to the water. One hundred percent of the noble gases are assumed to be released to the building atmosphere along with 0.2 percent of the halogens and are exhausted to the atmosphere through the stack after passing through charcoal filters (which are assumed to remove 99 percent of the halogens). No credit is taken for holdup in the secondary containment. Accident subclass 6.2 is similar to 6.1, except that all the pins in one element are assumed to fail after only 100 hours of decay time.

Accident subclasses 7.1 and 7.2 are fuel failure events in the fuel storage pool which is inside the secondary containment. The event in subclass 7.1 is identical to the event in subclass 6.1. The event in subclass 7.2 is identical to the event in subclass 6.2 except that the assumed decay time prior to failure is 30 days. The cask drop accident is based on the failure of all the pins in one element after 120 days of decay. The secondary containment integrity will be maintained during the handling process, therefore, the release path is identical to the rest of the fuel handling accidents except that no credit is taken for iodine removal in water.

The loss-of-coolant accidents, accident subclass 8.1, result in releases of fission products to the secondary containment due to leakage of the primary containment. No credit is taken for holdup in the secondary containment. The release from the secondary containment is via the standby gas treatment system (which is assumed to be 99 percent efficient for the removal of halogens) to the stack for release to the atmosphere. The source term for the "small" loss-of-coolant accident is the activity in the coolant due to routine operation with failed fuel. The "large" loss-of-coolant accident source term is the sum of the primary coolant inventory plus the release to the coolant of 0.2 percent of the core inventory of noble gases and halogens. For both events it is assumed that core spray, plateout, etc., remove 80 percent of the halogens. Accident subclass 8.1(a) is not applicable to the Browns Ferry plant.

The control rod drop accident, subclass 8.2(b), is similar to the off design transient except the source term is due to the primary coolant activity plus the release of 0.025 percent of the core inventory of noble gases and iodine. The steamline break accidents, subclass 8.3(b), are represented by a "small" and a "large" break size. The total amount of coolant released to the atmosphere for each is assumed to be 2,750 pounds and 52,000 pounds, respectively. The reduction factor for transfer of iodines to the atmosphere from the primary coolant is assumed to be 0.1 and 0.5, respectively.

In order to assess risk, some measure of probability is required. In general TVA believes that certain releases which have been classified as accidents may reasonably be expected to occur during the lifetime of the plant. These (accident subclasses, 1.0, 2.0, and 4.1)

are included in the estimates of routine radioactive discharges. The accidents in classes 3.0, 4.0, and 5.0 are considered improbable; that is, not likely during the 40-year life of the plant. Accidents in classes 6 and 7 are relatively less probable but still are possible. The probability of occurrence of class 8 accidents is very small. The postulated occurrences in class 9 involve sequences of successive failures more severe than those required to be considered in the design basis of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is so low that their environmental risk is extremely small. Defense in depth (multiple physical barriers); quality assurance for design, manufacture, and operation; continued surveillance and testing; and conservative design are all applied to provide and maintain the required high degree of assurance that potential accidents in this class are, and will remain, sufficiently low in probability that the environmental risk is extremely small.

Table 2.3-1 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary to concentrations of radioactive materials less than the maximum permissible concentrations (MPC) of Table II of Appendix B of 10 CFR Part 20. Figure 2.3-1 shows the minimum exclusion distance and site boundary. Table 2.3-1 also shows that the estimated integrated exposure of the population projected for the year 2010 within 50 miles of the plant from each postulated accident would be orders of magnitude smaller than that from naturally occurring radioactivity, which corresponds to approximately 174,000 man-rem/yr based on a natural background

level of 0.145 rem/yr. When the probability of occurrence is considered, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the background. It is concluded from the results of the analysis that the environmental risks due to postulated radiological accidents are exceedingly small.

Table 2.3-1

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	INDIVIDUAL DOSES AT THE SITE BOUNDARY (rem)					DOSE TO POPULATION[a] (man-rem)			
		Gamma Radiation	Beta Radiation	Gamma Plus Beta	Iodine Inhalation	Fraction of Limit[b]	Gamma Radiation	Beta Radiation	Iodine Inhalation	Total
1.0	Trivial incidents	*	*	*	*	*	*	*	*	*
2.0	Small releas outside containment	*	*	*	*	*	*	*	*	*
3.0	Radwaste system failures									
3.1	Equipment leakage or malfunction	1.7 (-3)[c]	8.8 (-4)	2.6 (-3)	**	5.2 (-3)	3.5 (-1)	1.9 (-1)	**	5.4 (-1)
3.2	Release of waste gas storage tank contents	6.7 (-3)	3.5 (-3)	1.0 (-2)	**	2.0 (-2)	1.4 (0)	7.7 (-1)	**	2.2 (0)
3.3	Release of liquid waste storage tank contents	**	**	**	**	**	**	**	**	**
4.0	Fission products to primary system (BWR)									
4.1	Fuel cladding defects	*	*	*	*	*	*	*	*	*
4.2	Off-design transient	1.7 (-4)	1.3 (-4)	3.0 (-4)	7.7 (-4)	1.1 (-3)	4.5 (-2)	4.4 (-2)	2.4 (-1)	3.3 (-1)
5.0	Fission products to primary system (PWR)	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 2.3-1 (continued)

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	INDIVIDUAL DOSES AT THE SITE BOUNDARY (rem)					DOSE TO POPULATION[a] (man-rem)			
		Gamma Radiation	Beta Radiation	Gamma Plus Beta	Iodine Inhalation	Fraction of Limit[b]	Gamma Radiation	Beta Radiation	Iodine Inhalation	Total
6.0	Refueling accidents									
6.1	Fuel bundle drop	1.3 (-6)	3.1 (-6)	4.4 (-6)	7.7 (-7)	9.3 (-6)	4.4 (-3)	1.0 (-2)	2.5 (-3)	1.7 (-2)
6.2	Heavy object drop onto fuel in core	1.4 (-5)	3.1 (-5)	4.5 (-5)	7.0 (-6)	1.0 (-4)	4.5 (-2)	1.0 (-1)	2.3 (-2)	1.7 (-1)
7.0	Spent fuel handling accident									
7.1	Fuel assembly drop in fuel storage pool	1.3 (-6)	3.1 (-6)	4.4 (-6)	7.7 (-7)	9.3 (-6)	4.4 (-3)	1.0 (-2)	2.5 (-3)	(-2)
7.2	Heavy object drop onto fuel rack	4.7 (-7)	1.8 (-6)	2.3 (-6)	7.4 (-7)	5.1 (-6)	1.5 (-3)	6.0 (-3)	2.4 (-3)	9.9 (-3)
7.3	Fuel cask drop[d]	7.2 (-9)	7.7 (-7)	7.8 (-7)	3.2 (-10)	1.6 (-6)	2.4 (-5)	2.5 (-3)	1.0 (-6)	2.5 (-3)
8.0	Accident initiation events considered in design basis evaluation in safety analysis report									
8.1	Small loss-of-coolant	4.3 (-6)	2.6 (-6)	6.9 (-6)	1.1 (-7)	1.4 (-5)	1.5 (-2)	9.0 (-3)	4.0 (-4)	2.4 (-2)
8.1	Large loss-of-coolant	2.1 (-4)	2.1 (-4)	4.2 (-4)	2.7 (-3)	2.6 (-3)	7.6 (-1)	8.0 (-1)	1.0 (+1)	1.2 (+1)
8.1(a)	Instrument line break	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 2.3-1 (continued)

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

		INDIVIDUAL DOSES AT THE SITE BOUNDARY (rem)					DOSE TO POPULATION[a] (man-rem)			
Class	Event	Gamma Radiation	Beta Radiation	Gamma Plus Beta	Iodine Inhalation	Fraction of Limit[b]	Gamma Radiation	Beta Radiation	Iodine Inhalation	Total
8.2(b)	Rod drop accident (BWR)	2.1 (-4)	1.6 (-4)	3.7 (-4)	9.6 (-4)	1.4 (-3)	5.6 (-2)	5.5 (-2)	3.0 (-1)	4.1 (-1)
8.3(b)	Small main steam line rupture	1.5 (-6)	3.2 (-7)	1.8 (-6)	1.5 (-4)	1.0 (-4)	3.2 (-4)	6.8 (-5)	3.2 (-2)	3.2 (-2)
8.3(b)	Large main steam line rupture	1.4 (-4)	3.0 (-5)	1.7 (-4)	1.4 (-2)	9.4 (-3)	3.0 (-2)	6.5 (-3)	3.0 (0)	3.0 (0)

* Evaluated as routine releases in Section 2.4, Radioactive Discharges
NA Not Applicable
** Results in doses less than 10^{-4} rem and population doses less than 10^{-3} man-rem
a. Based on projected population for the year 2010 within 50 miles of the plant
b. Estimated fraction of 10 CFR Part 20 limit at site boundary
c. 1.7×10^{-3}
d. Represents the release from a single fuel element, since the number of elements in a cask varies with shipping method

Table 2.3-2

ACCIDENT RESULTS BASED ON A CONSERVATIVE COOLANT ACTIVITY[a]

Class	Site Boundary Dose Fraction of Limit[b]	Population Dose Man-Rem
1.0 Trivial incidents	*	*
2.0 Small release outside containment	*	*
3.0 Radwaste system failures		
3.1 Equipment leakage or malfunction	1.1 (-2)	1.2 (0)
3.2 Release of waste gas storage tank contents	4.3 (-2)	4.7 (0)
3.3 Release of liquid waste storage tank contents	**	**
4.0 Fission products to primary system (BWR)		
4.1 Fuel cladding defects	*	*
4.2 Off-design transient	1.1 (-3)	3.3 (-1)
5.0 Fission products to primary system (PWR)	NA	NA
6.0 Refueling accidents		
6.1 Fuel bundle drop	9.3 (-6)	1.7 (-2)
6.2 Heavy object drop onto fuel in core	1.0 (-4)	1.7 (-1)
7.0 Spent fuel handling accident		
7.1 Fuel assembly drop in fuel storage pool	9.3 (-6)	1.7 (-2)

Table 2.3-2 (Continued)

ACCIDENT RESULTS BASED ON A CONSERVATIVE COOLANT ACTIVITY[a]

Class	Site Boundary Dose Fraction of Limit[b]	Population Dose Man-Rem
7.2 Heavy object drop onto fuel rack	5.1 (-6)	9.9 (-3)
7.3 Fuel cask drop	1.6 (-6)	2.5 (-3)
8.0 Accident initiation events considered in design basis evaluation in safety analysis report		
8.1s Small loss-of-coolant	3.0 (-5)	5.2 (-2)
8.1l Large loss-of-coolant	2.6 (-3)	1.2 (+1)
8.1a Instrument line break	NA	NA
8.2b	1.4 (-3)	4.1 (-1)
8.3(b)s Small MSLR	2.2 (-4)	6.9 (-2)
8.3(b)l Large MSLR	2.0 (-2)	6.5 (0)

Notes

a. Coolant activity consistent with a noble gas release rate after 30-minute decay of 215,000 μCi/s per unit.

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

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

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

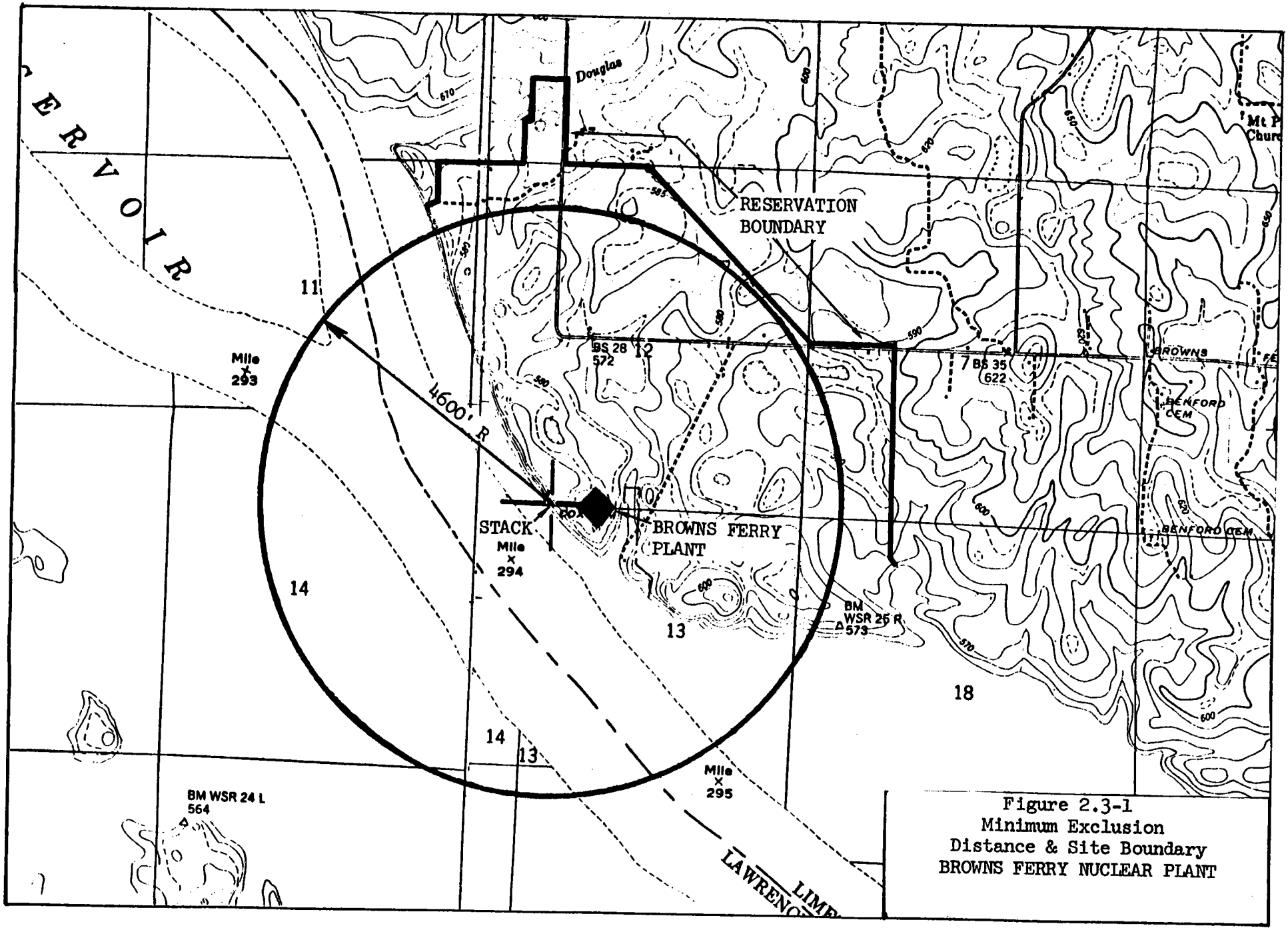


Figure 2.3-1
Minimum Exclusion
Distance & Site Boundary
BROWNS FERRY NUCLEAR PLANT

2.4 Radioactive Discharges - TVA's waste management policy has been implemented at Browns Ferry by improving plant design to include extended treatment for both gaseous and liquid radwaste. Alternatives available for keeping the radioactivity in effluents released to unrestricted areas as low as practicable were investigated by TVA and are discussed in section 5.7 of Volume 2 and section 3.1 of Volume 3. Hydrogen recombiners and six charcoal beds will be added to each unit to reduce radioactive gaseous wastes to very low levels. An evaporator along with its associated equipment will be added to treat liquid radwaste.

All equipment installed by TVA to reduce radioactive effluents to the minimum practicable level will be maintained in good operating order and will be operated to the maximum extent practicable. The technical specifications[1] for the Browns Ferry Nuclear Plant will set forth limits beyond which a reduction in load or a change in operating procedures is required. Operating procedures will be provided and maintained in an up-to-date condition to assure that this equipment is operated as designed to reduce radioactive effluents to the maximum extent practicable. Preventive maintenance will be performed to assure the equipment is in good operating order.

1. Gaseous radwaste system -

(1) Description of system - The gaseous radwaste system for the Browns Ferry Nuclear Plant is described in section 5.7 of Volume 2 and section 3.1 of Volume 3. This system will include hydrogen recombiners and six charcoal beds for each unit (18 charcoal beds for the three units) to reduce radioactive gaseous wastes

to very low levels. Studies have been made on aging characteristics and degradation of the charcoal beds and on the buildup of radionuclides on the charcoal beds.

(a) Aging characteristics of charcoal beds - Operation of the charcoal adsorption system on the German KRB reactor over a period of 5 years indicates that the charcoal will last for the life of the plant. In the 5-year period, there was no evidence that the effectiveness of the charcoal was decreasing. There was no increase in the pressure drop through the beds. Such an increase would be expected if degradation of the charcoal were occurring. Moreover, the dynamic nature of the process results in no continuing buildup of noble gas, which enhances the ability of the charcoal to function for the life of the plant.

During operation of the charcoal adsorber systems, the radioactivity concentrations of the inlet and outlet gas, the gas flow rate, and pertinent temperatures will be continuously monitored for each system. Hence, data needed to evaluate the retention characteristics of the charcoal will be obtained continuously.

The charcoal adsorber is a passive system and it is expected to last for the life of the plant. If it were to be necessary to replace the charcoal, the radioactivity of the charcoal at the time of disposal would be as given below.

(b) Buildup of radionuclides on charcoal beds - A study has been made of the buildup of radionuclides on the charcoal beds. Two cases were considered. In one case the high

efficiency particulate absolute (HEPA) filter was assumed 99.99 percent efficient, and in the second case it was assumed 90 percent efficient. In both cases the HEPA filter was assumed to remove only the nonnoble isotopes. Noble gases will pass through the (HEPA) prefilter and enter the charcoal bed. The charcoal bed is then assumed to retain 100 percent of the nonnoble isotopes entering or generated by noble gas precursors. Since the charcoal beds are designed to remain in place for the life of the plant, the buildup for 40 years has been computed for the two assumed HEPA efficiencies. Decay of each isotope was then computed for 1 week, 1 month, and 6 months. It is assumed that all of the activity is concentrated in the first 3 feet of the first charcoal bed. The concentrates resulting with the indicated decay after 40 years of use would be:

Assuming 99.99 percent efficient HEPA filter:

6-month decay	0.00040 Ci/ft^3
1-month decay	0.00047 Ci/ft^3
1-week decay	0.00051 Ci/ft^3

Assuming 90 percent efficient HEPA filter:

6-month decay	0.207 Ci/ft^3
1-month decay	0.272 Ci/ft^3
1-week decay	0.315 Ci/ft^3

Assuming a HEPA filter efficiency of only 90 percent and assuming that all of the activity is concentrated in the first 3 feet of the first charcoal bed, the activity after 40 years of use and 1-week decay is 0.315 Ci/ft^3. Since the cask built to transport condensate system sludge is designed for an activity of 0.5 Ci/ft^3, this cask could be used to transport the charcoal to a

suitable disposal site. These assumptions are on the extremely conservative side. Using a realistic HEPA filter efficiency for two series filters of about 99.99 percent and distribution of the activity throughout the first charcoal bed, the actual concentration experienced after 6 months' decay would be close to 0.000060 Ci/ft^3. Charcoal with this low level of activity could then be loaded in 55-gallon drums for disposal.

(2) Release of radioactivity - TVA recognizes that actual operating experience of nuclear power plants with failed fuel is limited. As experience accumulates, it will be possible to predict more accurately the amount of fission products that are released by defective fuel. The design of the Browns Ferry Nuclear Plant and calculations given in section 9.4 of the FSAR are based on an average annual offgas release rate (after 30 minutes' decay) of 100,000 μCi/s per unit. This release rate is also used for dose calculations for this final environmental statement and replaces that used in Volumes 2 and 3. The distribution of radionuclides expected to be released is shown in Table 2.4-1.

AEC's Division of Compliance[2] published the following information on noble and activation gas releases from operating BWR's:

Facility	Total Annual Curies Released			
	1970	1969	1968	1967
Oyster Creek	110,000	7,000	-	-
Dresden 1	900,000	800,000	240,000	260,000
Nine Mile Point	9,500	55	-	-

(Continued)

Facility	Total Annual Curies Released 1970	1969	1968	1967
Humboldt Bay	540,000	490,000	897,000	900,000
Dresden 2	250,000	-	-	-
Big Rock Point	280,000	200,000	232,000	264,000

The highest value in this tabulation, 900,000 Ci/yr, corresponds to a release rate of 28,500 μCi/s. This is substantially below the release rate of 100,000 μCi/s per unit used by TVA for estimating doses in the FSAR and this environmental statement.

2. Liquid radwaste system -

(1) Description of system - The liquid radwaste system for the Browns Ferry Nuclear Plant is described in section 5.7 of Volume 2. This system will include demineralizers and an evaporator to reduce radioactive liquid waste to very low levels. Table 2.4-2 gives expected releases of radioactive materials on the basis that floor drain and chemical wastes will be treated and discharged. Actually, a large portion of these liquids will be recycled after the evaporator is placed in service which will minimize radioactive releases. Prior to installation of the evaporator, floor drain waste will be processed with the waste demineralizer as required to meet the proposed Appendix I limits. This flexibility will be retained after installation of the evaporator.

The liquid radwaste system has the capability to treat the water contained within the pressure suppression torus. Water inputs to the suppression chambers result primarily from tests of the emergency core coolant pumps, which are driven by steam turbines utilizing

reactor steam. The exhaust from these turbines is discharged below the water surface in the suppression chambers. Inputs from these tests will amount to about 50,000 gal/unit/yr. Inputs from other possible sources cannot be predicted, but TVA is designing for an additional 50,000 gal/unit/yr. The radioactivity content of the added liquid will be approximately that of the condensate in the hotwell.

Treatment is needed to remove excess water and radioactive material. Prior to installation of the radwaste evaporator, one of the auxiliary boilers will be used to remove excess water, but not radioactivity. Thereafter, the radioactivity content and the water level will be maintained within acceptable limits by a feed-and-bleed procedure whereby a portion of the chamber contents is drawn off to radwaste periodically and is replaced as needed with fresh solution. In the liquid radwaste system, the liquid will be processed through the evaporator. If necessary, the condensate will be passed through the waste demineralizer to make it suitable for reuse or discharge. These operations do not have to be performed at specific times but can be carried out at the convenience of the radwaste system operation.

(2) Releases of radioactivity -

AEC's Division of Compliance[2] published the following information on radioactivity contained in the liquid releases from operating BWR's:

Facility	Total Annual Curies Released			
	1970	1969	1968	1967
Oyster Creek	18.5	0.48	-	-
Dresden 1	8.2	9.5	6.0	4.3

(Continued)

Facility	Total Annual Curies Released 1970	1969	1968	1967
Nine Mile Point	28.0	0.9	-	-
Humboldt Bay	2.4	1.5	3.2	3.1
Dresden 2	13.0	-	-	-
Big Rock Point	4.7	12.0	7.9	10.0

It should be noted that these units employ condensate demineralizers which are chemically regenerated. The amount of radioactivity in liquid releases from these units depends to a significant extent on the degree to which the spent regenerant solutions are processed by evaporation. Browns Ferry, on the other hand, uses Powdex-type condensate demineralizers. With this type of demineralizer, none of the radioactivity removed from the condensate enters the plant liquid effluent. Therefore, releases of radioactivity are reduced.

The distribution of radionuclides in Browns Ferry liquid wastes will be different from that in the wastes from plants with regenerable deep bed demineralizers. The estimated composition of radionuclides expected to be released based upon the particular processes to be employed at Browns Ferry is shown in Table 2.4-2. Isotopic analyses of the effluent will be made to determine the actual composition.

3. <u>Estimated increase in annual environmental radioactivity levels and potential annual radiation doses from principal radionuclides</u> - With extended treatment of gaseous and liquid effluents, environmental concentrations of radioactivity due to releases to unrestricted areas from the Browns Ferry Nuclear Plant will be so low as to

be unmeasurable with present techniques. However, TVA has calculated the expected increase in radioactivity levels and potential radiation doses as a result of these low-level releases.

(1) Radionuclides in gaseous effluents - The following doses to humans living in the vicinity of the Browns Ferry Nuclear Plant are calculated for routine releases of radioactive gases:

1. External beta doses
2. External gamma doses
3. Thyroid doses due to inhalation of radioactive iodine
4. Thyroid doses due to reconcentration of radioactive iodine in milk produced near the site

The external beta and gamma doses to terrestrial plants and animals are considered to be the same magnitude as the doses estimated for humans.[3]

The gaseous effluents are released either from vents located near the top of the plant buildings or from the 600-foot plant stack. Dilution of the gaseous effluents will take place due to diffusion and turbulent mixing as the gases travel downwind from the point of release. The downwind, ground-level air concentrations of radioactive gases are determined using sector-averaged diffusion equations.

External beta doses are computed using a semi-infinite cloud, immersion dose model. In computing external gamma doses, a technique employing both an immersion dose model and a finite-volume-element integration model is used. Iodine inhalation doses are calculated by assuming that these doses are proportional to the ground-level air concentration and the receptor breathing rate. Iodine ingestion

doses are calculated by assuming that these doses are proportional to the rate of iodine deposition on pasturage, the concentration of iodine in milk due to uptake by cows, and the milk consumption rate of the receptor.

Iodine releases are estimated using reasonable assumptions of coolant activities, leakage rates, and release mechanisms. Table 2.4-3 shows that with these assumptions, iodine releases from the Browns Ferry Nuclear Plant should be less than the design objectives of proposed Appendix I.

The extended gaseous radwaste system virtually eliminates iodine releases from the condenser offgas. Therefore, the principle potential for iodine release is the plant ventilation systems. The primary containment is purged periodically, thereby providing significant decay time prior to release. TVA has concluded that it is not practical to treat iodine releases from other structures because of the large flow rates and small iodine concentrations involved.

Should the operating conditions significantly exceed those used in the analysis and result in iodine releases exceeding proposed Appendix I guidelines, the offsite concentrations would still be only a small fraction of one percent of the 10 CFR Part 20 limits.

A more detailed description of the analytical methods used in calculating these doses and a detailed listing of results are given in Appendix I.

(2) Radionuclides in liquid effluents - The following doses to biota including man are calculated for exposures to radionuclides routinely released in liquid effluents:

1. Doses to man
   a. from the ingestion of water
   b. from the consumption of fish
   c. from water sports
2. Doses to terrestrial vertebrates from the consumption of aquatic plants
3. Doses to aquatic plants, aquatic invertebrates, and fish

The organisms and pathways that are considered in this report are those that are thought to be the most significant because of species, habitat, diet, or patterns of living. Conservative assumptions are applied in these analyses which should result in overestimation of the doses.

Internal doses are calculated using methods outlined by the ICRP[4] which describe internal retention of radionuclides with a single-exponential model. This model is used for estimating the doses to man from ingestion of water and consumption of fish and for estimating the doses to terrestrial vertebrates from the consumption of green algae. For calculating the internal doses to aquatic organisms it is assumed that an equilibrium exists between the activity concentrations in the water and those inside the organisms.

Internal doses to man are calculated for the bone, G.I. tract, thyroid, and total body. The internal dose given in Volumes 2 and 3 is the maximum organ dose. The total body dose is much lower (Table 2.4-3).

External doses are estimated using either an infinite or a semi-infinite, homogeneous-medium approximation depend- on whether the organism is considered to be immersed in or floating on the water.

A more detailed discussion of the analytical methods used in calculating these doses and a detailed listing of the results are given in Appendix II.

(3) Summary of radiological impact - Table 2.4-3 summarizes the radiation doses calculated for release of radionuclides in gaseous and liquid effluents during normal operation of the Browns Ferry Nuclear Plant. External radiation exposure from sources inside the reactor and turbine buildings is treated in Appendix III. TVA has also calculated potential doses resulting from releases during the 12-month interim operating period prior to the installation of extended radwaste treatment systems. Table 2.4-4 summarizes the doses for this interim period.

A comparison of doses resulting from the operation of Browns Ferry Nuclear Plant to those occurring from natural radioactivity assists in placing the doses from Browns Ferry in perspective. Near the plant site the average annual dose from naturally occurring external sources of radiation is 125 mrem (Table 2.4-5). An individual receives an additional dose of approximately 20 mrem per year from naturally occurring internal sources. Therefore, the average total dose from natural radioactivity in the vicinity of the Browns Ferry plant is approximately 145 mrem per year. Individual doses vary widely around this average value because of local differences in the concentrations of terrestrial radioactivity and because of variances in dose rates within different types of buildings. Large variations are also observed between different areas within the United States because of the correlation of cosmicray dose rates with altitude and geomagnetic latitude. Due

to these variations, the annual total-body doses to individuals in the United States from natural radioactivity range from less than 110 mrem to greater than 240 mrem.

A hypothetical individual at the site boundary would receive a maximum dose of 2.2 mrem from the normal operation of the Browns Ferry Nuclear Plant. For this individual to receive the maximum dose he would have to stand in the open at the highest dose point on the site boundary for 24 hours a day, 365 days per year. The maximum dose to the hypothetical individual is 1.5 percent of the dose from natural background radiation. The maximum dose to an actual individual should be significantly less than the calculated dose to the hypothetical individual.

The population dose within 50 miles of Browns Ferry from naturally occurring radioactivity is estimated to be approximately 174,000 man-rems in the year 2010 (Table 2.4-5). The population dose in the year 2010 due to normal operation of the Browns Ferry Nuclear Plant is calculated to be 23 man-rems (Table 2.4-3), which is 0.013 percent of the dose from natural background radiation.

TVA has evaluated the potential radiation dose from a broad spectrum of possible pathways of exposure. It should be emphasized that it is possible to theoretically calculate an environmental radioactivity level or potential radiation dose that is minutely small. The dose calculated in this evaluation is only a small fraction of the dose from the natural background radiation and is, in fact, much less than the variations in natural background radiation doses. It is concluded that the Browns Ferry Nuclear Plant will operate with no significant risk to the health and safety of the public.

Table 2.4-1

EXPECTED RELEASES OF PRINCIPAL RADIONUCLIDES IN GASEOUS EFFLUENTS

Isotope	Sources of Release: Original Offgas System[a] Ci/yr	Extended Offgas System[b] Ci/yr	Gland Seal Ci/yr	Containment Purge[c] Ci/yr	Mechanical Vaccum Pump[c] Ci/yr	Turbine Building[d] Ci/yr
Kr-83m	2.7 (5)[e]	6.1 (2)	3.2 (2)			
85m	5.3 (5)	4.2 (4)	5.8 (2)			
85	1.9 (3)	1.9 (3)	1.9 (0)			
87	1.4 (6)	2.4 (2)	1.9 (3)			
88	1.7 (6)	3.0 (4)	1.9 (3)			
Xe-131m	1.4 (3)	9.2 (2)	1.4 (0)	2.0 (0)		
133m	2.6 (4)	2.8 (3)	2.7 (1)	4.0 (0)		
133	7.8 (5)	2.9 (5)	7.7 (2)	1.6 (2)	5.8 (3)	
135m	6.5 (5)		2.5 (3)	2.0 (1)		
135	2.1 (6)		2.1 (3)	6.5 (1)	8.6 (2)	
137	6.3 (4)		1.4 (4)			
138	2.0 (6)		8.4 (3)			
I-131	6.5 (-3)[f]			1.8 (-2)		1.1 (-2)
132	6.0 (-2)[f]			2.1 (-3)		1.0 (-1)
133	4.5 (-2)[f]			1.4 (-2)		7.5 (-2)
134	1.2 (-1)[f]					2.1 (-1)
135	6.5 (-2)[f]					1.1 (-1)

a. Based on an air ejector flow rate of 18.5 scfm and 30-minute holdup system.
b. Based on an air ejector flow rate of 18.5 scfm and extended offgas system including recombiners and six charcoal beds per unit.
c. Taken from FSAR.
d. Based on 100 gal/day/unit leakage, a total DF of $2x10^3$, and no decay.
e. $2.7x10^5$
f. Based on a DF of 100 due to washout.

Table 2.4-2

EXPECTED RELEASES OF PRINCIPAL LIQUID RADIONUCLIDES EXCLUDING TRITIUM [a]

Isotope[b]	Half-Life	Release Rate (Ci/yr)[c] Original System Design	Original System With Added Demineralization	Original System With Evaporator
Sr-89	52.7d	3.2 (-1)[e]	4.0 (-2)	3.2 (-3)
Sr-90[d]	28y	2.4 (-2)	3.0 (-3)	2.4 (-4)
Sr-91[d]	9.7h	3.0 (0)	3.7 (-1)	3.0 (-2)
Mo-99[d]	66h	2.1 (0)	2.6 (-1)	2.1 (-2)
I-131	8.05d	1.3 (0)	1.6 (-1)	1.3 (-2)
I-133	20.8h	6.2 (0)	7.7 (-1)	6.2 (-2)
I-135	6.7h	3.9 (0)	4.9 (-1)	3.9 (-2)
Cs-134	2.1y	1.7 (-2)	2.1 (-3)	1.7 (-4)
Cs-137	30y	2.5 (-2)	3.1 (-3)	2.5 (-4)
Ba-140[c]	12.8d	9.0 (-1)	1.1 (-1)	9.0 (-3)
Ce-144[c]	284d	3.6 (-3)	4.5 (-4)	3.6 (-5)
Np-239	2.35d	2.2 (+1)	2.8 (0)	2.2 (-1)
Co-58	70d	5.2 (-1)	6.5 (-2)	5.2 (-3)
Co-60	5y	5.2 (-2)	6.5 (-3)	5.2 (-4)
	TOTAL	40 Ci/yr	5 Ci/yr	0.4 Ci/yr

a. Tritium releases from the plant are expected to approach 51 Ci/yr. The distribution between gaseous and liquid wastes will depend upon the actual amount of water leaving by each route.

b. Isotopes having a half-life less than 2.3 hours were excluded because the holdup in the plant would generally be sufficient to result in negligible concentrations in released wastes. Other isotopes of the elements listed were considered. The radionuclides Zr-95, Nb-95, Ru-103, Ru-106, Te-219m, Te-132, Nd-147, Na-24, S-35, P-32, Cr-51, Mn-54, Mn-56, Fe-55, Fe-59, Cu-64, Ni-65, Zn-65, Zn-69m, Ag-110m, Ta-182, and W-187 were also considered. These radionuclides may be present, but if present will be of negligible radiological significance relative to those isotopes listed.

c. Although two significant numbers are used in expressing the release rates as a convenience for making further calculations, only one significant figure is warranted by the source data.

d. Daughter isotopes, Yttrium, Technetium, Lanthanum, and Praseodynium, may be observed in waste samples in equilibrium with or approaching equilibrium with their parent depending upon sample and analysis timing and procedure.

e. 3.2×10^{-1}

f. The relative isotopic abundance is based on recent analyses of reactor coolant composition in operating boiling water reactors. The relative abundance of the isotopes in the primary coolant was determined and was modified to reflect 12 hours of decay prior to release. This information updates that used in Vol. 3.

Table 2.4-3

SUMMARY OF RADIOLOGICAL IMPACT

ON ANNUAL BASIS

WITH EXTENDED WASTE TREATMENT SYSTEMS

	Normal Operation[a]	Proposed 10 CFR 50 Appendix I Limits
A. Gaseous Effluents		
I-131 concentration at site boundary	2.4 (-16)[b] $\frac{\mu Ci}{cc}$	1.0 (-15) $\frac{\mu Ci}{cc}$
Maximum individual doses		
1. inhalation at site boundary (thyroid)	0.04 mrem	
2. consumption of milk from nearest dairy farm (thyroid)	0.18 mrem	
3. external exposure at site boundary (β&γ)	1.6 mrem	10 mrem
Population doses within a 50-mile radius		
1. inhalation (thyroid)	0.11 man-rem	
2. consumption of milk (thyroid)	0.73 man-rem	
3. external exposure (β&γ)	23 man-rem	
B. Liquid Effluents[c]		
Activity released	0.43 Ci	15 Ci
Average concentration before dilution in the Tennessee River	1.5 (-10) $\frac{\mu Ci}{ml}$	2.0 (-8) $\frac{\mu Ci}{ml}$

a. Releases consistant with a noble gas release rate of 100,000 μCi/sec/unit (after 30 minutes decay)
b. 2.4×10^{-16}
c. Excluding tritium

Table 2.4-3 (Continued)

	Normal Operation	Proposed 10 CFR 50 Appendix I Limits
Maximum human organ doses		
1. bone	3.5 (-4) mrem	5 mrem
2. G.I. tract	9.7 (-3) mrem	5 mrem
3. thyroid	1.4 (-3) mrem	5 mrem
4. skin	5.7 (-5) mrem	5 mrem
5. total body	5.2 (-5) mrem	5 mrem
Human population doses within a 50-mile radius		
1. bone	1.2 (-2) man-rem	
2. G.I. tract	7.8 (-1) man-rem	
3. thyroid	6.8 (-2) man-rem	
4. skin	1.9 (-3) man-rem	
5. total body	1.9 (-3) man-rem	
Maximum dose to terrestrial vertebrates	0.21 mrad	
Maximum doses to aquatic organisms		
1. plants	0.21 mrad	
2. invertebrates	2.1 mrad	
3. fish	0.52 mrad	
C. Scattered Radiation from Turbine Building[d]	0.6 mrem	
D. Maximum Annual Dose[e] to Any Individual	2.2 mrem	
E. Maximum Population Dose[e] Within a 50-mile Radius	23 man-rem	

d. Upper bound as calculated in Appendix III
e. Skin

Table 2.4-4

SUMMARY OF RADIOLOGICAL IMPACT

ON ANNUAL BASIS

DURING INTERIM OPERATION

	Interim[a] Operation
A. Gaseous Effluents	
I-131 concentration at site boundary	1.0 (-16)[b] μCi/cc
Maximum individual doses	
1. inhalation at site boundary (thyroid)	1.7 (-2) mrem
2. consumption of milk from nearest dairy farm (thyroid)	8.0 (-2) mrem
3. external exposure at site boundary (β&γ)	2.9 (1) mrem
Population doses within a 50-mile radius	
1. inhalation (thyroid)	4.7 (-2) man-rem
2. consumption of milk (thyroid)	3.1 (-1) man-rem
3. external exposure (β&γ)	1.5 (2) man-rem
B. Liquid Effluents[c]	
Activity released	6.3 Ci
Average concentration before dilution in the Tennessee River	4.5 (-9) μCi/ml

a. Releases consistant with a noble gas release rate of 100,000 μCi/sec/unit (after 30 minutes decay)
b. 1.0×10^{-16}
c. Excluding tritium

Table 2.4-4 (Continued)

	Interim Operation
Maximum human organ doses	
1. bone	4.8 (-3) mrem
2. G.I. tract	1.3 (-1) mrem
3. thyroid	2.0 (-2) mrem
4. skin	9.0 (-4) mrem
5. total body	7.2 (-4) mrem
Human population doses within a 50-mile radius	
1. bone	1.6 (-1) man-rem
2. G.I. tract	11 man-rem
3. thyroid	0.93 man-rem
4. skin	2.6 (-2) man-rem
5. total body	2.6 (-2) man-rem
Maximum dose to terrestrial vertebrates	2.9 mrad
Maximum doses to aquatic organisms	
1. plants	2.9 mrad
2. invertebrates	28 mrad
3. fish	7.2 mrad
C. Scattered Radiation from Turbine Building[d]	0.3 mrem
D. Maximum Annual Dose[e] to Any Individual	2.9 (1) mrem
E. Maximum Population Dose[e] Within a 50-mile Radius	1.5 (2) man-rem

d. Upper bound as calculated in Appendix III.
e. Skin

Table 2.4-5

DOSES FROM NATURALLY-OCCURRING BACKGROUND RADIATION

Individual Doses (mrem)

External[a]	125
Internal[b]	20
Total	145 mrem

Population Dose (man-rem)

0.145 rem x 1,200,000[c] people = 174,000 man-rem

a. Measured by TVA personnel
b. See Reference 5 for this section
c. Estimated population within a 50-mile radius of the Browns Ferry Nuclear Plant in the year 2010

2.5 Nonradioactive Wastes - It is TVA's policy to keep the discharge of all wastes from its facilities, including nuclear plants, at the lowest practicable level by using the best and highest degree of waste treatment available under existing technology, within reasonable economic limits. TVA has incorporated extensive control and treatment facilities into the Browns Ferry design for handling nonradioactive plant wastes. This section describes the types and sources of these wastes and discusses the control and treatment to be provided to minimize their impact on the environment.

1. Chemical discharges - Chemicals, which are added from plant processes, will result in only very low concentrations of these chemicals in the Tennessee River near the plant site. The major increase of mineral concentrations, in the form of total dissolved solids, occurs during closed-cycle operation of the cooling towers when these substances drawn into the condenser cooling water system from the reservoir are concentrated to approximately twice their reservoir concentrations prior to release in the cooling tower blowdown. The sources of these chemicals and the expected maximum quantity of chemical end products that could be discharged are summared in Table 2.5-1. The average and maximum expected total chemical concentrations in the discharge and in the reservoir for each mode of cooling tower operation are shown in Table 2.5-2. These data show that the operation of the Browns Ferry plant will result in only minimal increases in the chemical and mineral concentrations of the discharge water and after mixing with the reservoir water. During periods of closed-cycle cooling tower operation

the largest increase in the reservoir will be a 3 mg/l increase in total dissolved solids as compared to an average concentration of about 104 mg/l. The allowable dissolved solids concentration to meet the Alabama Water Improvement Commission's standards[1] is 500 mg/l. During extended periods of closed-cycle operation of the cooling towers, the maximum total dissolved solids discharge concentration in the blowdown would not be expected to exceed 260 mg/l. No significant adverse environmental impact on the water quality of Wheeler Reservoir due to chemical discharges is expected to occur and no alteration of the production of living natural resources including fish and wildlife is anticipated.

The sources of chemical wastes and a description of the waste treatment to be provided are discussed in the following paragraphs.

(1) Makeup water filter plant - Operation of the filter plant will require the addition of the following thermal water treatment chemicals: alum, soda ash, coagulation aid,* and sodium hypochlorite. Use of these chemicals in the treatment process will result in increased concentrations of soluble SO_4^{--} and Na^+ in the treated water that will ultimately be discharged to Wheeler Reservoir. The filter plant influent will be chlorinated to prevent slime growths in the filter plant clearwell. A residual of 0.1 mg/l will be maintained in the filter plant effluent. Residual chlorine will be removed in the demineralizers.

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*Referred to in Volume 2 as "polymer."

The filter backwash and water treatment plant sludge will be diverted to a settling pond from which the supernatant water will be decanted and discharged to the condenser circulating water intake channel. The sludge, consisting of the alum floc, most of the coagulation aid, and sediment removed from the water during treatment, will be removed from the lagoon as necessary and, along with other normal solid waste, disposed of by burial. This method of sludge disposal results in only a minimal environmental impact.

Although the discharge of the sludge added by normal plant operation would not result in any significant adverse environmental impact, the settling pond estimated to cost in excess of $100,000 is provided to comply with proposed regulations for the State of Alabama.

All coagulation aids to be used at Browns Ferry will be selected from EPA's approved list[1] of coagulation aids and will be used in accordance with manufacturer's recommendations. The coagulation aid being used is a high molecular weight polyacrylamide containing a soluble toxic ingredient (acrylamide monomer) which is less than 0.05 percent of the product. Most of the coagulation aid is contained in the sludge. The monomer is dissolved in the treated water and eventually released. Its release will result in a maximum discharge concentration of the monomer of less than 2×10^{-6} mg/l. The Dow Chemical Company has conducted tests[3] on a product of this formulation which show that lake emerald shiners and yellow perch showed no ill effects after prolonged exposures to this product in concentrations

several orders of magnitude larger than that shown above. Therefore, considering the small release of the monomer and the low concentrations which will occur when released, no significant environmental risk can be associated with its use.

(2) Water treatment plant demineralizer - Regeneration of makeup water treatment plant demineralizers requires the use of sulfuric acid and sodium hydroxide, which results in releases of SO_4^{--} and Na^+. Treatment of these wastes will consist of holding the acid and caustic wastes in a sump for monitoring and adjusting pH prior to discharging to the condenser circulating water intake. Regeneration cycles will be set so that the pH of the mixed water in the waste sump will be near neutral, thereby minimizing the need for further adjustment.

Operating experience with the makeup water treatment facilities during construction of the Browns Ferry plant indicates that the quality of raw water to be treated for reactor makeup will be such that the amounts of chemicals used in the water treatment process shown in Table 2.5-1 represent the maximum usage if the water treatment facilities are operated at full capacity. After plant cleanup and startup it is anticipated that the actual treated water needs will be about 10 percent of the rated capacity of the treatment facilities. The quantity of water treatment chemicals required will be reduced correspondingly. However, as shown in Table 2.5-2, if the equipment were operated at full capacity, the discharge concentrations would be such that they would cause no significant impact on the environment.

(3) Auxiliary steam generator blowdown - Treatment of the feedwater for the auxiliary steam generators will require the use of ammonia for pH control and hydrazine for control of dissolved oxygen. One steam generator will be in daily operation throughout the year. A second will be in service for heating about five months of the year. Hydrazine concentration will be maintained at about 15 ppb in the feedwater, and ammonia will be fed to maintain a pH of about 9.0. This normally requires an ammonia concentration of about 0.25 ppm. To maintain acceptable dissolved solids concentrations when operating at full capacity, provision has been made for about 3 gal/min of blowdown for each steam generator. Continuous release of this amount of blowdown with all steam generators operating at maximum capacity would result in daily release of about 0.002 pounds of decomposed hydrazine as either nitrogen gas or ammonia and about 0.029 pounds of residual ammonia. Annual releases of hydrazine and ammonia shown in Table 2.5-1 are based on full capacity operation of all of the steam generators 12 months per year. These releases would result in insignificant increases in concentrations of ammonia in plant discharges as shown in Table 2.5-2. These releases will not cause any signfiicant adverse environmental impacts.

(4) Raw cooling water system - For the control of Asiatic clams, tentative plans are to chlorinate the 90,000 gal/min raw cooling waterflow which cools the plant auxiliaries to maintain 1.0 mg/l maximum chlorine residual in the raw cooling water system. It is not expected that the use of chlorine will be required more than

three weeks per year and will not be used during closed-cycle operation of the cooling towers. The raw cooling water will be discharged to the condenser cooling water system. Operating experience has shown that the reservoir water has a chlorine demand of about 0.5 mg/l. Based on the relative flow rates of the condenser cooling water and raw cooling water systems (about 20:1), the chlorine demand of the condenser cooling water will be sufficient to react with all of the chlorine residual and result in only chlorides being discharged.

The use of acrolein for this purpose is also being considered. If used, it would have a maximum concentration in the raw cooling water system of 0.3 mg/l. Its use would not be required more than 120 days per year and when used it will be fed into the system one-half hour each day. When the cooling towers are in operation, any acrolein which does not react with the condenser cooling water due to the acrolein demand of the water will essentially all be scrubbed out as the cooling water passes over the cooling tower fill. Additional studies will be required to determine whether the acrolein demand of the condenser cooling water is sufficient to react with all of the acrolein and prevent its discharge during open-cycle operation.

The release of these diluted or decomposed biocides to the reservoir will not significantly affect the reservoir.

(5) Closed cooling water system - Sodium chromate is used as a corrosion inhibitor in components of the closed cooling water system. On rare occasions, when necessary for maintenance purposes, the chromate-containing water will be drained from portions of the closed system. If possible, the water will be returned to the system.

If not, it will be routed to the radwaste system and processed through the nonregenerable mixed bed demineralizers where it will be recycled until the chromate concentration is 1.0 ppm or less. It will then be routed to the condensate storage tank. No chromate will be released to the reservoir.

(6) Cooling tower blowdown and drift - As described in section 2.6, the cooling towers will be operated in the closed-cycle mode about 7 percent of the time. The need for chemical treatment of the condenser circulating water can be eliminated by limiting the concentration of total dissolved solids in the cooling system to about twice the normal reservoir concentration when operating in the closed mode. About 110 ft^3/s of blowdown from the towers would be required to maintain this concentration. The discharge of this blowdown through the diffuser system is described in section 2.6 of this volume. The diffuser should provide thorough mixing of the blowdown with the reservoir flow. In addition to the dissolved solids from the cooling water system, the blowdown will contain the other liquid chemicals discharged from the plant.

Chemical effluent concentrations in the reservoir have been conservatively calculated assuming 5,000 ft^3/s reservoir flow (exceeded 99 percent of the time) for all modes of operation (Table 2.5-2). The cooling tower blowdown could be withheld for relatively short periods of time when reservoir conditions warrant without reaching prohibitive chemical concentrations in the condenser circulating water system. During periods of closed-cycle cooling

tower operation the largest increase in the reservoir resulting from the combined effect of tower operation and chemical discharges will be a 3 mg/l increase in total dissolved solids. The allowable dissolved solids concentration to meet the Alabama Water Improvement Commission s standards[1] is 500 mg/l. During extended periods of closed-cycle cooling tower operation, the maximum total dissolved solids concentration in the blowdown would not be expected to exceed 260 mg/l. The dissolved chemical and mineral concentrations of the plant discharge to the diffuser system would be well below the permissible concentrations of the USPH Drinking Water Standards[4] prior to mixing with the reservoir water. Increases in the existing levels of chemicals concentrations in the reservoir during any operating mode are insignificant.

Tower drift, which is expected to be no more than 0.1 percent of the total condenser cooling waterflow or about 3.7 ft^3/s will carry both suspended and dissolved solids from the condenser circulating water system to the atmosphere. Most of these solids will be deposited in the immediate vicinity of the cooling towers and will eventually be returned to the reservoir. No area outside the immediate vicinity of the towers will receive significant concentrations of deposited solids.

Assuming that maximum observed solids concentrations exist in the reservoir and that drift amounts to 3.7 ft^3/s during periods of closed-cycle operation of the cooling towers, about 5,000 pounds per day of solids (both suspended and dissolved) will be released from the towers in the drift. If the towers operate 7 percent

of the time in the closed-cycle mode, this will result in a total annual release of solids from the towers of about 66 tons.

When the cooling towers are operating on the helper mode the same maximum amount of drift will occur. The fraction of time on the helper mode is expected to be about 22 percent. However, total solids concentration in the condenser circulating water system and the drift during these periods will be approximately the same as exists in the reservoir, and the solids carried from the towers via drift will amount to about 2,600 pounds per day and about 100 tons annually.

(7) Miscellaneous - As stated in Volume 2, some decontamination operations will involve the use of chemicals such as sodium phosphate, sodium permanganate, ammonium citrate, nitric acid, and hydrofluoric acid. If chemical concentrations in the cleaning solutions are too high to allow treatment in the radwaste system, they will be drummed for offsite disposal at a suitable disposal site. Otherwise, they will be treated in the radwaste system to meet applicable water quality standards prior to release.

Some small quantities of miscellaneous chemicals will be used in the plant laboratory for tests, analyses, etc. This source of chemicals will result in only trace increases in discharge concentrations and will probably be well below detectable levels in the discharge stream. Since these chemicals may contain some radioactivity they will be routed to a chemical drain tank for treatment similar to that provided for the decontamination solutions described above.

The small quantity of detergent wastes which must be handled will be diverted to the radwaste facilities for treatment prior to release. Biological treatment of such small quantities of these wastes is not considered practicable.

2. Sanitary wastes - Two 15,000-gallons-per-day extended aeration sewage treatment plants were initially installed at Browns Ferry to handle construction and operating personnel loads with the intention of ultimately putting one unit in reserve as the construction load diminishes. These plants have timers to regulate aeration times and will be operated in accordance with Federal and state requirements. It is anticipated that the ultimate operating force will number between 175 and 200 persons. In addition, personnel in training will number about 40-45 persons, and it is anticipated there may always be a small maintenance crew on hand in addition to the regular plant maintenance personnel. Browns Ferry will be attractive to many visitors, and considering them in addition to the persons above, a sewage load during normal operating periods from about 300 persons may be anticipated. Based on a flow of 35 gallons per person per day the normal expected load will be about 10,500 gallons per day. With allowances for peak loading, underloading of the plant which could result in inadequate treatment of the wastes would not be expected. It is anticipated that at times of unit outage and during any major overhaul periods both plants may have to be put into operation to handle the increased loads.

3. Gaseous emissions - Three oil-fired auxiliary steam generators supply steam for building heating and other uses. The total annual fuel consumption for these steam generators will not

exceed 5.3 million gallons of No. 2 fuel oil, and it is expected that average annual consumption will be less than half this value. The fuel oil will have a sulfur content of not more than 0.5 percent.

Annual combustion of the maximum amount of the fuel would result in gaseous and particulate releases from the plant in the following quantities:

particulates	20.9 tons/year
sulfur oxides	205.0
carbon monoxide	0.1
hydrocarbons	13.1
nitrogen oxides	274.0

These products of combustion will be released from the plant through a stack which is approximately 175 feet above ground level.

In addition, the four diesel-powered auxiliary generators are estimated to consume about 82,000 gallons of fuel per year. This fuel will be the same type as used for the auxiliary steam generators. The exhaust will be via stacks about 55 feet above ground level and will release the following constituents:

particulates	0.33 tons/year
sulfur oxides	3.2
carbon monoxide	0.002
hydrocarbons	0.21
nitrogen oxides	4.3

Calculated maximum ambient concentrations resulting from these emissions, together with the applicable standards, are given below:

Pollutant	Averaging Time	Calculated Concentrations	Secondary Ambient Standard
Particulates	24 hour	0.29 ug	150.0 ug/m^3
Sulfur oxides	3 hour	0.0034 ppm	0.5 ppm
Carbon monoxide	1 hour	0.000005 ppm	35.0 ppm
Hydrocarbons	3 hour	0.0011 ppm	0.25 ppm
Nitrogen oxides	1 year	0.000097 ppm	0.05 ppm

An evaluation of the emissions from the auxiliary boilers and diesel generators indicates that the emissions will have a negligible environmental impact. For this reason it is not considered necessary to conduct an ambient monitoring program to determine the effect of these emissions.

4. Solid waste disposal - Normal solid wastes will be disposed of by burial either on the plant site or on other TVA grounds. This method of disposal is considered to minimize environmental impacts from solid waste.

5. Storage and transportation of materials - Oils, chemicals, and other potentially harmful materials will be shipped to Browns Ferry by tank trucks under applicable ICC and state highway regulations.

Oil will be used in various equipment and stored in storage tanks both inside and outside the powerhouse. Oil for various uses stored outside the powerhouse includes a total of 21 miscellaneous insulating oil storage tanks with a combined capacity of 366,000 gallons. These tanks range in capacity from 4,000 gallons to 35,000 gallons. In addition, there are two diesel oil tanks with a capacity of 71,000 gallons each and two lubricating oil tanks at 30,000 gallons each.

Outside storage is also provided for the sulfuric acid which is used in the makeup water treatment plant. The storage tank provided for this purpose has a capacity of 3,400 gallons. This capacity closely corresponds to the minimum shipment quantity of bulk sulfuric acid of 3,000 gallons. Shipment of acid for this use is expected to amount to a maximum of six shipments per year. Chemicals stored in tanks onsite are provided with retention basins and/or crushed limestone beds to either contain or neutralize these chemicals if they should be released from their storage tanks.

In the event of a tank or equipment rupture resulting from plant malfunction, human error, or natural disasters such as tornadoes, earthquakes, etc., oil in any of the outside equipment or storage tanks will be contained in retention basins unless the occurrence were of a severity to destroy the basins. The probability of an occurrence of this severity is very low. Consequently, the environmental risk associated with the storage of these materials is very small.

Oil storage inside the powerhouse includes six 5,700-gallon tanks of turbine lube oil and nine 1,000-gallon tanks of reactor feed pump lube oil. Oils spilled in the powerhouse will flow to appropriate sumps where they are retained until they can be reclaimed. If not suitable for reuse they will be drummed for proper disposal. One method of disposal is to transport the oil to one of TVA's fossil-fired plants and blend it with the fossil fuel used there.

Indoor storage is provided for the sodium hydroxide which is used in the makeup water treatment plant consisting of one

3,200-gallon tank. Should this chemical be released from the storage tank, it will be retained in a sump where it can be reclaimed for reuse.

Chemicals spilled in the powerhouse will flow to sumps where they will be retained until pumped either to appropriate containers for disposal or to the radwaste building where facilities for filtering, settling, and other types of treatment are installed to assure that no harmful substance is released to surface watercourses.

It is concluded that the use of multiple storage tanks and collection sumps and the use of retention basins and limestone beds reduces the risks to the environment associated with storage of potentially hazardous materials to the minimum practicable level. Liquid nitrogen for use in inerting the primary containment vessels is stored in an outdoor insulated tank. Rupture of the tank would result in spilling the liquid nitrogen onto a limestone bed. The liquid would soon vaporize, producing no adverse effect on the environment.

Table 2.5-1

Sources of Added Chemicals and Resulting End Product Chemicals

System	Chemical Added Source Chemical	Maximum[a] Annual Use lbs	Waste End Product Chemical	Maximum Resulting[a] End Product Annual LBS	Mean Daily LBS
Makeup Water Treatment Plant	Alum $Al_2(SO_4)_3 \cdot 18\ H_2O$	15,800	$Al(OH)_3$[b]	3,700	~10
			SO_4^{--}	6,800	~21
			Suspended solids[b,c]	13,500	~37
	Soda Ash Na_2CO_3 (100%)	7,900	Na^+	3,400	~10
	Sodium Hypochlorite NaOCl (21% Solution)	3,950	Na^+	260	~ 1
			OCl^-	570	~ 2
	Coagulation Aid (see text)	590	Coag. Aid[b]	590	~ 2
Makeup water Treatment Plant Demineralizer Regneration	Sulfuric Acid 98%	270,000	SO_4^{--}	259,000	~710
	Sodium Hydroxide (50%)	205,000	Na^+	59,000	~160
Auxiliary Steam Generator Blowdown	Ammonia	Variable[d]	NH_3	6	~0.02
	Hydrazine	Variable[e]	NH_3	0.4	~0.001
Raw cooling water[f] System	Chlorine	34,000	OCl^- and Cl^-	34,000	1,620[f]

a. Based on 24-hour operation 365 days/year at demonstrated maximum capacity of equipment.
b. Suspended materials that will make up the water treatment plant sludge, on a dry weight basis.
c. Estimates from suspended solids data observed at TRM 300.3
d. Ammonia will be added as needed to keep pH of system at 9.0.
e. Hydrazine will be added as needed as a DO scavenger.
f. Chlorination will be required a maximum of 21 days/yr.

Table 2.5-2

SUMMARY OF CHEMICAL DISCHARGES

Waste Product Chemical	Maximum[a] Annual Discharge of Product Chemical lbs	Operating[b] Mode Open (O) Helper (H) Closed (C)	Waste[b] Product Chemical Contribution to Discharge Concentrations mg/l	Observed Concentrations in Reservoir Water at TRM 300.3 mg/l Average	Observed Concentrations in Reservoir Water at TRM 300.3 mg/l Maximum	Total Discharge[b] Concentrations CF=2 for Closed Mode mg/l Average	Total Discharge[b] Concentrations CF=2 for Closed Mode mg/l Maximum	Total Concentrations[c] in River After Mixing mg/l Average	Total Concentrations[c] in River After Mixing mg/l Maximum	Maximum Allowable Concentrations[1] in River mg/l
Sulfates (SO_4^{--})	265,800	O	0.031	15.0	23.0	15.031	23.031	15.027	23.027	250
		H	0.037			15.037	23.037	15.028	23.028	
		C	1.235			31.235	47.235	15.366	23.546	
Sodium (Na^+)	62,700	O	0.007	5.92	9.18	5.927	9.187	5.9263	9.1863	d
		H	0.009			5.929	9.189	5.9264	9.1864	
		C	0.287			12.127	18.647	6.060	9.393	
Chlorides[e]	34,600	O	0.068	14.0	21.0	14.068	21.068	14.060	21.060	250
		H	0.081			14.081	21.081	14.061	21.061	
		C	0.0026			28.0026	42.0026	14.3154	21.4731	
Ammonia[f] NH_3	6.4	O	nil	0.02	0.07	0.02	0.07	0.02	0.07	d
		H	nil			0.02	0.07	0.02	0.07	
		C	nil			0.04	0.14	0.02	0.07	
Total Dissolved Solids	363,106	O	0.106	104.0	129.0	104.106	129.106	104.093	129.093	500
		H	0.127			104.127	129.127	104.095	129.095	
		C	1.528			209.528	259.528	106.38	131.94	

a. Based on 24-hour operation 365 days per year at demonstrated maximum capacity of equipment and chemical requirements.
b. Discharge flows based on 3-unit operation for all modes.
c. Concentrations based on downstream riverflow of 5,000 ft^3/s, less evaporation of 114 ft^3/s for closed and helper modes of operation; 5,000 ft^3/s for open mode. However, heat dissipation considerations will require minimum of 23,000 ft^3/s for open mode.
d. No specific standard has been identified but contribution to dissolved solids has been included.
e. Computation is for chlorides since the chlorine demand of the cooling water is such that no residual chlorine will be discharged. Chlorides and total dissolved solids reflect maximum daily use of chlorine in raw cooling water.
f. Ammonia and hydrazine added to auxiliary steam generator for pH and dissolved oxygen control. Hydrazine conservatively assumed to decompose to ammonia.

2.6 Heat Dissipation

1. Water temperature standards - As discussed in Volume 3 beginning on page 3-18, the diffuser system was designed to meet a temperature criteria of 10°F thermal rise above ambient water temperature with a maximum temperature not to exceed 93°F after reasonable mixing. These criteria, 10°F rise with a 93°F maximum temperature, were the temperature standards proposed by the State of Alabama in compliance with the requirements of the Water Quality Act of 1965.

Since Volume 3 was issued for review, TVA received a letter from the Region IV Administrator, Environmental Protection Agency, dated December 17, 1971, stating that EPA was intensely pursuing the immediate adoption of proposed thermal standards for the State of Alabama. The Region IV Office informed TVA that EPA will not accept any maximums for the water of the Tennessee River Basin in Alabama other than the following: "Temperature shall not be increased more than 5°F above the natural prevailing background temperatures, nor exceed a maximum of 86°F." TVA's interpretation of the EPA-recommended standards is that the 86°F maximum temperature, within the constraints of the 5°F allowable thermal rise, applies for all months. These temperature standards proposed by EPA for the State of Alabama were published by EPA in the March 11, 1972, Federal Register.

In light of these developments and TVA's policy to take appropriate action on a timely basis to meet any future applicable standards, TVA has determined that the diffuser system is not adequate to ensure acceptable conformance with the 5°F rise and 86°F maximum temperature. The alternatives for heat dissipation which are described

in Volume 3 beginning on page 3-55 have been reevaluated, and it has been decided that the best long-term solution to meet the more stringent standards is the installation of mechanical draft cooling towers. The towers will supplement the diffuser system in order to comply with the new standards.

The towers will require about 2 to 2-1/2 years to design and construct, which will necessitate operating with diffusers only until the towers are ready. During this interim period when diffusers only are to be used, the 10°F rise and 93°F maximum standard will be observed. However, it is possible that only two units will operate in this manner provided the first set of towers is ready before unit 3 begins commercial operation.

On March 16, 1972, TVA discussed with representatives of EPA the plans for auxiliary cooling facilities and interim operation of the Browns Ferry Nuclear Plant.

2. Required modifications to intake channel - The original design for the intake channel has been modified to include a multigate structure to permit combined-cycle operation. The structure will consist of three bays each 40 feet wide by 24 feet high. During closed-mode operation, a 20-foot high gate will be lowered into each bay leaving an opening of 4 feet x 40 feet for passage of makeup water. Velocity through these openings in this mode will be 2/3 ft/s. During the open and helper modes the gates will be lifted leaving a 40- x 24-foot opening for each bay. The maximum velocity through these openings will occur during the open mode and will be about 1.6

ft/s for 3-unit operation, 1.0 ft/s for 2-unit operation, and 0.5 ft/s for 1-unit operation. The velocity will be independent of the reservoir elevation.

The intake pump structure will consist of 18 bays, each having a traveling screen. Each bay will have a net opening of 8 feet 8 inches by 20 feet. The maximum average velocity through each bay will be about 1.4 ft/s and will be independent of the reservoir elevation. The maximum average velocity through a clean screen which will have net openings 3/8-inch by 3/8-inch will be about 1.8 ft/s during the April through September period when biotic entrainment is of most interest. Velocities through the intake pump structure bays and the traveling screen will be independent of the number of units in operation.

3. Present thermal regime of the Wheeler Reservoir - The hydraulic regime in the reservoir is controlled by the operation of Guntersville and Wheeler Dams. In the past these projects have been operated primarily for power production, navigation, and flood control.

Wheeler Reservoir is one of TVA's main stream reservoirs on the Tennessee River and is not a deep reservoir like the headwater reservoirs. The maximum depth in the main channel just upstream from Wheeler Dam is about 66 feet at normal summer pool elevation.

The reservoir exhibits weak thermal stratification during the summer months due primarily to the relatively short

detention time within the reservoir and the fact that the power intakes withdraw water from the entire vertical depth of the reservoir. The dissolved oxygen and temperature profiles of Wheeler Reservoir observed between May 1964 and April 1965 are shown in figure 2.6-1.

Water temperatures in Wheeler Reservoir have been monitored by permanent recording stations for 3 to 4 years. The recorded temperatures range from about 40°F in the winter to a typical maximum of 85-90°F at the surface in the summer. The maximum top to bottom vertical temperature difference is about 5-8°F. Natural water temperatures above the proposed maximum temperature standard of 86°F have been recorded over much of the reservoir depth. The dissolved oxygen and temperatures observed in the tailrace of Wheeler and Guntersville Dams for calendar years 1964 and 1965 are shown in figure 2.6-2. The temperatures of the releases from Guntersville and Wheeler Dams for the period 1960 to 1971 are summarized in Table 2.6-1. Based on these data there is no significant change in the temperature of the inflow and outflow of Wheeler Reservoir. Thus, with the exception of the surface waters which are subject to diurnal temperature fluctuation resulting from meteorological conditions, the temperatures of the Wheeler Dam releases are reasonable estimates of the average water temperatures at the Browns Ferry site. Comparison of the water temperature data collected at the Browns Ferry Nuclear Plant monitoring station located at Tennessee River mile (TRM) 293.6 with the Wheeler Dam tailrace temperature for the years 1969, 1970, and 1971 further verified this conclusion.

The Whitesburg gage is located at Tennessee River mile 333.3, or about 39 miles upstream from the plant. The average annual discharge of the Tennessee River at this gage for 46 years of record is about 42,500 ft^3/s. At the Browns Ferry site the average annual discharge is estimated to be about 45,000 ft^3/s. Based on the Whitesburg gage data for the period 1951 to 1970, the following table lists the percentage of days the mean daily flows at the Browns Ferry site would be below the indicated discharge.

Tennessee River Mean Daily Discharge at Browns Ferry	Percent of Days Mean Daily Discharge Is Lower
50,000 ft^3/s	76
45,000	67
40,000	56
33,000	35
30,000	27
25,000	17
20,000	10
15,000	6
10,000	3
5,000	1
1,000	0.3

It is recognized that the operation of Wheeler and Guntersville Dams results in wide fluctuations within the daily period represented by the mean daily streamflows. The hourly releases from Guntersville and Wheeler Dams for 10 years of record (1959-68) are illustrated by the flow duration curves of figures 2.6-3 and 2.6-4. An examination of the hourly records showed that the periods of no flow are restricted to the offpeak periods of below average flow days and are generally of from about 1 to 6 hours in duration. By comparing the daily duration and hourly duration curves,

it is apparent that the periods of low or no flow are only a matter of hours in duration. Therefore, the majority of the no or low flow occurrences can be eliminated by making adjustments in the daily operation of these plants.

4. Reservoir thermohydrodynamics and the diffuser system - At the time Volume 3 was issued TVA had completed extensive 2-dimensional model studies and had begun 3-dimensional thermal model studies of Wheeler Reservoir in the vicinity of Browns Ferry. Since that time TVA has made additional 3-dimensional studies to further assess the performance of the diffuser system and to determine the relationship between reservoir flow and temperature distribution. A detailed discussion and the results of TVA studies are contained in TVA report 63-38, Prediction and Control of Water Temperatures in Wheeler Reservoir During Operation of the Browns Ferry Nuclear Plant, April 1972. Appendix IV contains major excerpts from this report, including discussions of the hydraulic design of the diffusers, the 2-dimensional and 3-dimensional model testing, the predicted temperature and flow distributions, and the downstream water temperature predictions.

The 3-dimensional model studies which have been performed since Volume 3 was written have revealed that the diffuser system will achieve much more thorough mixing with the reservoir flows than had been indicated earlier. Figure 8 of Appendix IV illustrates the high level of mixing which will be achieved by the diffuser system. It is emphasized that the mixed temperature rises between 5°F and 10°F

will only occur during the interim operation. After cooling towers are operational the towers will be used during low flows (about 22,000 ft^3/s for 3-unit operation) to prevent mixed temperature increases greater than 5°F.

5. Thermal discharges during interim operation - Until construction of all the cooling towers is completed, TVA will operate the existing heat dispersal system as it was designed; that is, to meet the originally proposed temperature standards of 10°F rise and 93°F maximum. However, as soon as any sets of towers are operable, TVA will use the auxiliary cooling facilities to the extent practicable to meet any lower temperature standards which may be in effect at the time.

Under the current schedule, commercial operation is expected to be March 1973 for unit 1, December 1973 for unit 2, and July 1974 for unit 3. The predicted operating dates for the cooling towers are July 1974 for the first set of towers, October 1974 for the second set of towers, and by January 1975 all the towers are expected to be in operation. Each generating unit requires a set of two towers, so there will be a total of six towers at Browns Ferry. Based on this schedule, Browns Ferry units will be in operation for 16 months during which only the diffuser system and no towers will be available for heat dispersal. The total time period during which one or more units are scheduled to be operating before the installation of all the towers is 22 months. This period includes 12 months of one unit, 10 months of two units, and no months of three units in operation without towers.

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releases from upstream storage, (3) operation of any available cooling towers, (4) reduction in the generation at Browns Ferry Nuclear Plant, or (5) a combination of these operations.

A daily analysis of these data was also made for the interim period when generating units at Browns Ferry would be in operation but the construction of cooling towers would not be completed. This analysis revealed for low-flow conditions that the 10°F rise above natural temperatures or the 93°F maximum temperature would not be met on only 3 days during the interim period. Under average-flow conditions the 10°F rise and 93°F maximum thermal criteria would not have been exceeded. Another analysis of the 22-month interim period was made assuming that each month was the worst such month that occurred in the 5-year period, i.e., the worst April during the period was followed by the worst May, etc. Under these extreme conditions, the criteria would not be met on only 15 days, or about 2 percent of the days. The 1966-70 streamflow years were about 10 percent below the long-term normal flows. These studies were based on full load output for the Browns Ferry units and the mean daily releases from Guntersville and Wheeler Dams exclusive of modification of the operating schedule for other upstream hydro projects. These studies reveal that only minor amounts of supplemental flows from upstream storage reservoirs or reductions in the output of Browns Ferry would be required to meet the 10°F rise and 93°F maximum standards and that most of the time the thermal rise would be considerable less than 10°F. TVA anticipates that the peaking operation of Wheeler and Guntersville Dams will have to be modified to reduce the periods of low or no flow at the project

An analysis was made to determine if under normal operating conditions a sufficient volume of water is available within a 24-hour period to provide the streamflow required to meet the 10°F-93°F standard. The computed increases in water temperature for the 5-year period 1966 through 1970 are shown in figures 2.6-5, 2.6-6, and 2.6-7. These figures are based on the use of the diffuser system for heat dispersion and do not reflect the use of cooling towers. The streamflow estimates for Browns Ferry site are based on the releases from both Guntersville and Wheeler Dams. These figures have been revised from figures 3.2-27, 3.2-28, and 3.2-29 of Volume 3 to reflect the results of the latest model tests and the estimates of the streamflows at the Browns Ferry site. While average daily releases were used in the computations, it is recognized that operation of the dams for peaking power results in wide fluctuations within the daily period represented by the mean daily streamflows. The computations do show, however, what the corresponding temperatures of the reservoir waters would have been if the releases had been uniform during the 24-hour period.

The number of days during the period 1966 to 1970 in which the originally proposed temperature standards (10°F rise - 93°F maximum) would not have been met are summarized in Table 2.6-2. During daily periods when the evaluations indicate that the standards would not have been met, at least one of the following modifications of the actual operating schedule would have been required: (1) revision of the operation of Wheeler or Guntersville Dam, (2) an increase in the

As presented in Section 3.4, Alternative Heat Dissipation Methods, of Volume 3, the combined-cycle system using the heat dissipation capacity of the reservoir has a considerable economic advantage over a closed-cycle system. The combined-cycle system can be operated in the open, helper, or closed modes.

In the helper mode the temperature of the heated water after leaving the condensers will be reduced by passing it through the cooling tower system before it is discharged through the diffusers. In both the helper and closed modes the condenser flow and temperature rise will be about 1,223 ft^3/s and 31.7°F for each unit; however, the temperature of the water leaving the towers will depend on the wet bulb temperature, which is highly variable, and the tower design, which is not complete.

Based upon an analysis of the natural water temperatures and flow data for 1966 to 1971, the mixing capability of the diffusers (see figure 8 of Appendix IV) and an allowable 5°F rise with a maximum temperature of 86°F, it is estimated that Browns Ferry will be operated about 72 percent in the open, 21 percent in the helper, and 7 percent in the closed mode. This is also based on 3-unit operation with each unit in the same mode at the same time.

(1) Location - Figure 2.6-8 shows the presently anticipated location and arrangements of the six mechanical draft towers on the plant site. Originally TVA planned to build a 5,000-foot long permanent dike about 200 feet from the present shoreline to provide the elevated support surfaces necessary for towers and

site. The extent of the changes in operation of Guntersville and Wheeler will have to be determined by actual operating experience at Browns Ferry as controlled by the temperature monitoring network.

In summary, TVA will operate during this interim period to meet the 10°F rise and 93°F maximum temperature for which Browns Ferry was originally designed, and as the cooling towers become available TVA will utilize them to the maximum extent practicable to meet any lower temperature standards which are in effect.

6. Mechanical draft cooling towers - TVA has reexamined the alternative heat dissipation facilities which were outlined in Volume 3 beginning on page 3-55 and has again concluded that the installation of mechanical draft cooling towers is the best alternative to meet the more stringent thermal standards. Except as discussed in this volume, the engineering and environmental characteristics of the mechanical draft cooling towers are as presented in Volume 3. The principal advantages for mechanical towers over other auxiliary cooling facilities are lower capital expenditures and the nearly 2-year shorter lead time for construction. The disadvantages include higher noise levels, possible higher potential for fogging and icing, and higher operation and maintenance costs. Of these considerations the principal one which determined the use of mechanical draft towers was the shorter time required to complete the plan and thereby reduce the time the plant would be in operation without having auxiliary cooling facilities available.

monitoring activities during this relocation it may be necessary to construct temporary facilities prior to dismantling and reassembling the present structures. The main telephone trunk lines for both construction and permanent plant usage also cross the cooling tower area. New lines will be installed and placed in service before the existing lines are abandoned. The principal access road must be abandoned from a point near the meteorological tower to the permanent parking lot, and a new road must be constructed around the cooling tower area. The sewage treatment plant and possibly the boat harbor will have to be relocated.

While it will be necessary to relocate or change the planned location of numerous facilities, the purchase of additional land beyond that presently owned will not be required.

(3) Environmental considerations -

(a) Physical and chemical characteristics of tower effluent - The water required for continuous operation of the plant will be obtained from the Tennessee River at the plant site. The quantity of water required (makeup) will be dependent on the following items: (1) amount of blowdown necessary to maintain desirable levels for dissolved solids within the system, (2) the amount of evaporation from the tower, and (3) drift losses. With a blowdown dissolved solids concentration factor of 2, the total makeup required would be approximately 6 percent of the circulating flow, or 220 ft^3/s.

flumes. The towers were to be located in a single row in this area. Since making these preliminary plans TVA has discussed with tower manufacturers the most desirable arrangement of towers to attain maximum cooling effect and to minimize the environmental effects of cooling tower operation. As a result of these discussions and the desirability of reducing the length of shoreline which would be disturbed, the towers as now planned will be located inland as shown. This arrangement will reduce the length of the required dike from 5,000 feet to 1,500 feet and thereby reduce the length of shoreline disturbed by about 3,500 feet. The exact spacing and the final dimensions of the towers cannot be determined until the contract has been awarded.

(2) Land requirements - The return channel from the cooling towers to the intake channel will be generally located immediately south of the reactor building. Construction of the return channel will require an earth dike located approximately 375 feet offshore in the reservoir. This dike will run approximately 1,500 feet in an east-west direction from the west bank of the present intake channel to a tie-in point at the previously placed offshore fill originally planned for the biothermal research facility.

The cooling towers will require the relocation of the construction administrative and engineering complex. Project plans were to relocate this complex as the project was nearer to completion, but the timing of the cooling tower construction requires that this be done promptly. The meteorological building and tower facility must also be relocated. To avoid extensive interruption of

Only under extreme conditions can blowdown not be held up at least 12 hours. This capability can be used to restrict blowdown, when natural water temperatures are above 86°F, to the periods of the day when the wet bulb temperature is most favorable. This will result in discharges of blowdown at the lowest possible temperatures.

Nevertheless, there will be very limited times when the natural water temperature is 86°F or more and blowdown will have to be discharged. The quantity of heat to be added to the reservoir will be small and will be dispersed within the receiving waters by whatever mixing device is used. For example, based on historical wet bulb and river temperatures, the maximum temperature rise of the blowdown above the ambient river temperature is expected to be about 10°F. The blowdown diffuser on which studies have been made would result in a mixed temperature rise of about 0.5°F.

(b) Local fogging and icing - These environmental effects of cooling tower operation were discussed in detail beginning on page 3-59 of Volume 3. To minimize the plume drift the mechanical draft cooling towers will have drift eliminators designed to limit drift to a maximum of 0.1 percent of the condenser cooling water flow. The effects of plume drift are discussed in section 2.5 of this volume.

(c) Construction effects - The 1,500-foot long dike will be constructed in an area that has been previously disturbed as described in Volume 3. Maintenance of a navigable channel and installation of the diffuser pipes has already

disturbed this area. The construction of the dike will disturb approximately 13 acres of reservoir habitat adjacent to the plant. This is about 5 to 10 acres less than would have been disturbed by the original tower location. Because of previous construction activity this area has not returned to its previous condition.

Riprap will be placed on the reservoir side as the dike is completed to avoid wave action erosion and resultant siltation. The channel section will be shaped with rolled fill, and the inside slopes will be protected by riprap. Any muck removed from the ponded area will be deposited in upland spoil areas. After drying the area will be covered with a light cover of earth-fill, if needed, and will be seeded and mulched.

Some localized siltation is expected in the immediate area of dike construction. Because of the shallow water in this location, the relatively low velocity of the currents, and the use of riprapping, siltation of the reservoir is expected to be localized, minimal, and of short duration.

Some additional trees near the south bank must be cleared for the cooling tower construction. These trees and shrubs will be disposed of by open burning. The burning will be accomplished in accordance with applicable state and local regulations.

About 3.6 million cubic yards of earthwork will be required to grade the cooling tower area. This includes 3 million cubic yards of excavation for the cooling towers, 0.3 million cubic yards of excavation to relocate a drainage diversion ditch, and 0.3 million cubic yards of fill for the present diversion

ditch. The excavated material will be disposed of in an area to the northeast of the cooling towers. This material will be shaped to provide a pleasing aesthetic appearance and will be seeded and mulched.

Approximately 130 acres of land must be graded for the cooling tower installation. Special precautions will be employed to avoid excessive runoff from this graded area and the resultant excessive siltation in the Wheeler Reservoir. Erosion control methods will include, but will not be limited to, special sloped grading, drainage ditches, check dams, benches, and seeding and mulching as areas are completed; and if necessary for proper control, settling ponds or other control techniques will be used.

(d) Aesthetics - The general location of the cooling towers as related to the main plant access road, shoreline, offgas stack, parking areas, gatehouse, and visitors' facilities places special emphasis on the aesthetics of the cooling towers. The relatively low profile (60 feet high) of the mechanical draft towers will not present a very large vertical barrier. Without changing the basic functional criteria of the towers, TVA will design and construct the towers to make them an aesthetically integral part of the project. Since the standard materials of construction for mechanical draft towers may not be compatible with the architecture of the powerhouse, design features will be incorporated to achieve architectural compatibility with the main plant. This will be accomplished by selection of materials and colors compatible with overall plant design or by special treatment and modifications of features to achieve compatibility with the total composition. Special site

treatment will be provided to relate the towers to the main plant area. Landscaping along the main plant access road and in the tower area will be used to reduce the impact of the plume and towers. Nevertheless, as is apparent in figure 2.6-8, the towers by their very size will present a large horizontal barrier which is an unavoidable consequence.

(e) Noise - The use of mechanical draft cooling towers will increase noise levels outside the plant site by a small increment. The predicted operational noise levels at a distance of 1,000 feet along the two centerlines of the tower complex were calculated. In addition, predicted operational noise levels at greater distances outside the plant boundary were calculated along the centerline in the direction of the highest noise levels and compared to measured background noise data. These values ranged from 33 to 38 dB(A) (1 to 5 dB(A) above background) which is within the normally acceptable range according to the noise criteria developed by the U.S. Department of Housing and Urban Development. The details of this study are presented in Appendix V.

Since the noise levels associated with mechanical draft cooling towers are within the normally acceptable range, no adverse effects are expected.

7. Operating procedure following tower installation - The cooling towers will be designed and sized assuming that the 5°F temperature rise and 86°F maximum temperature standards will be finally adopted. TVA expects that after the installation of the towers is complete all generating units will usually be operated in the same

mode at the same time. During the time when only limited supplemental cooling is required, one or two units may be operated in the helper mode. With the units operating in the open mode (river cooling only) the normal procedure would be to change to the helper mode and then to the closed mode as required to meet the thermal standards. As the temperature standards permit, the units would be changed to the helper mode and then to the open mode.

TVA estimates the cooling tower operation will be required about 28 percent of the time to supplement the diffuser system in meeting the 5°F and 86°F thermal standards. As shown by figure 8 of Appendix IV, a minimum riverflow of about 22,000 ft^3/s is required to meet a 5°F rise criterion for 3-unit operation when utilizing the diffuser system only. There have been periods of several days during which the flow at the Browns Ferry site has been below 22,000 ft^3/s. The five longest periods since 1951 were:

October 3-14, 1954	12 days
December 19-29, 1958	11 days
April 9-26, 1966	18 days
April 1-17, 1967	17 days
September 7-October 1, 1968	24 of 25 days

Table 2.6-3 shows the number of days and the percent of days during the period 1966-71 that the 5°F rise and 86°F maximum temperature criteria would not have been met utilizing the diffuser system only. The two sections of this table are based on the upper and lower limits of the temperature rise as indicated by figure 8 of Appendix IV. The data in this table are indicative of the amount of

time that operation of the cooling towers will be required to meet the 5°F rise and 86°F maximum standards.

TVA will, as far as practicable, make maximum use of the heat dissipation capacity of the river. The extensive thermal monitoring network installed for the Browns Ferry plant will be utilized to assure that thermal standards are met. This system will be used to verify the preliminary operating procedures which are based upon the results of model studies and will serve to develop the operating procedures for unsteady-state flow conditions. The monitor network will permit a rapid determination of impending violations of thermal standards and enable TVA to make operational changes on a timely basis to meet the standards. These operational changes could include: (1) adjustments to the scheduled releases at Wheeler and Guntersville Dams; (2) use of the auxiliary cooling facilities at Browns Ferry; and (3) reductions in the generation from Browns Ferry should auxiliary cooling facilities be unavailable. Any reductions in generation which result from these changes will require either increased generation from alternative power sources or system load reductions.

The Browns Ferry Nuclear Plant is expected to be operated as a base load plant for the first 15 years of the plant life after which, as lower cost generation becomes available, the capacity factor on Browns Ferry will be reduced. Peak power requirements on the TVA system occur during the winter and summer seasons, and it is expected that generation from Browns Ferry will be needed during these periods for the life of the plant.

At this time TVA has no definitive plans for installing additional capacity at the Browns Ferry site or on Wheeler Reservoir. The closest existing TVA facility above Browns Ferry which rejects large amounts of heat to the river is the Widows Creek Steam Plant consisting of eight units. This 1,977,985-kW plant is located on the Guntersville Reservoir at about Tennessee River mile 407, or some 113 miles above the Browns Ferry plant. Because of the distance separating the plants, there are no identifiable temperature effects at Browns Ferry as a result of the heat rejected to Guntersville Lake by the Widows Creek plant.

TVA's Colbert Steam Plant is located on the Pickwick Reservoir at about Tennessee River mile 245, or some 49 miles below the Browns Ferry plant. The prediction of water surface temperatures downstream from Browns Ferry are discussed and illustrated in Appendix IV. Based on these predictions, the mixing of the surface and bottom waters by the Wheeler and Wilson turbines and the distance separating the two plants, Browns Ferry is not expected to cause any identifiable thermal effects at the Colbert plant.

Table 2.6-1

SUMMARY OF WEEKLY OBSERVED WATER TEMPERATURES IN THE RELEASES

FROM GUNTERSVILLE AND WHEELER DAMS

1960 to 1971

Year	Maximum Temperature °F		Minimum Temperature °F		Number of Days Natural Temperature Equalled or Exceeded 86°F	
	Guntersville	Wheeler	Guntersville	Wheeler	Guntersville	Wheeler
1960	82.4	86.0	41.0	42.8	0	16
1961	82.4	82.4	39.2	41.0	0	0
1962	84.2	86.0	39.2	41.0	0	8
1963	82.4	84.2	39.2	39.2	0	0
1964	84.2	86.0	41.0	41.0	0	1
1965	84.2	86.0	42.8	44.6	0	1
1966	86.0	86.0	37.4	37.4	1	36
1967	80.6	80.6	42.8	44.6	0	0
1968	86.0	87.8	41.0	42.8	1	22
1969	88.7	87.8	41.0	41.0	15	30
1970	84.2	87.8	39.2	37.4	0	17
1971	84.2	86.0	41.0	41.0	0	2
					17	133

Table 2.6-2

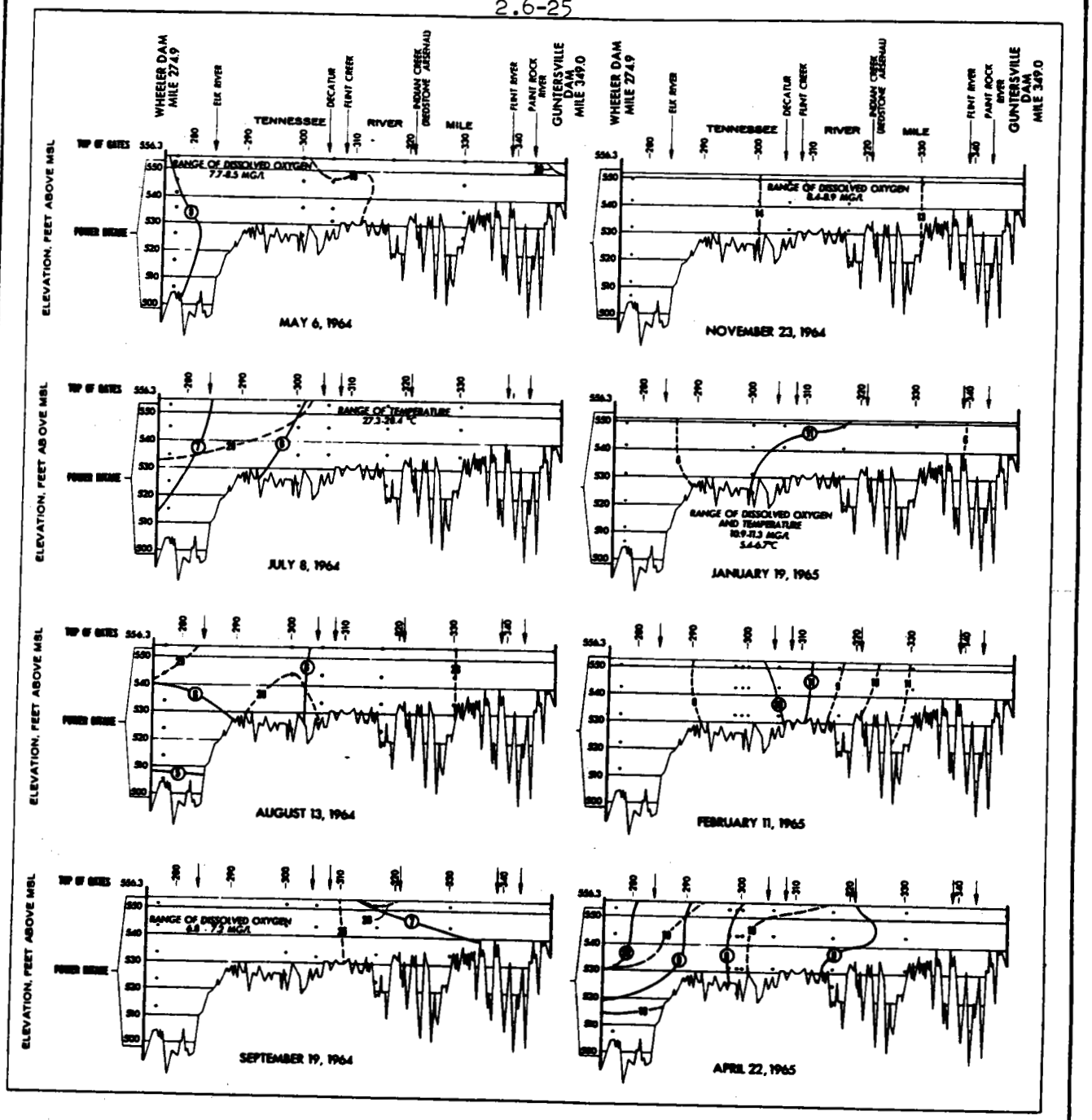
NUMBER AND PERCENT OF THE DAYS DURING THE 5-YEAR PERIOD 1966-70 THAT THE 10°F RISE AND 93°F MAXIMUM STANDARDS WOULD NOT HAVE BEEN MET FOR OPERATION OF BROWNS FERRY ON THE DIFFUSER SYSTEM ONLY

	10°F Rise With 93°F Maximum Days Equaled or Exceeded					
	10°F Rise		93°F Max.		10°F Rise or 93°F Max.	
Operation	Number	%	Number	%	Number	%
One Unit - Full Load						
1966	0	0	0	0	0	0
1967	2	0.5	0	0	2	0.5
1968	0	0	0	0	0	0
1969	0	0	0	0	0	0
1970	0	0	0	0	0	0
TOTALS	2	0.1	0	0	2	0.1
Two Units - Full Load						
1966	7	1.9	2	0.5	8	2.2
1967	6	1.6	0	0	6	1.6
1968	4	1.1	0	0	4	1.1
1969	2	0.5	4	1.1	4	1.1
1970	0	0	0	0	0	0
TOTALS	19	1.0	6	0.3	22	1.2
Three Units - Full Load						
1966	21	5.8	5	1.4	23	6.3
1967	13	3.6	2	0.5	13	3.6
1968	18	4.9	5	1.4	19	5.2
1969	7	1.9	9	2.5	11	3.0
1970	3	0.8	3	0.8	4	1.1
TOTALS	62	3.4	24	1.3	70	3.8

Table 2.6-3

DAYS DURING THE SIX-YEAR PERIOD, 1966-71, THAT THE 5°F RISE AND 86°F MAXIMUM STANDARDS WOULD NOT HAVE BEEN MET FOR 1-, 2-, AND 3-UNIT OPERATION AT BROWNS FERRY IN THE OPEN MODE

Operation	Upper Limit (3.5°F Rise for Intermediate Flows)						Lower Limit (2.5°F Rise for Intermediate Flows)					
	5°F Rise		86°F Max.		5°F Rise or 86°F Max.		5°F Rise		86°F Max.		5°F Rise or 86°F Max.	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
One Unit - Full Load												
1966	7	1.9	48	13.2	54	14.8	7	1.9	45	12.3	51	14.0
1967	6	1.6	0	0	6	1.6	6	1.6	0	0	6	1.6
1968	4	1.1	50	13.7	53	14.5	4	1.1	42	11.5	45	12.3
1969	2	0.5	74	20.3	74	20.3	2	0.5	62	17.0	62	17.0
1970	0	0	80	21.9	80	21.9	0	0	71	19.5	71	19.5
1971	0	0	76	20.8	76	20.8	0	0	59	16.2	59	16.2
TOTALS	19	0.9	328	15.0	343	15.7	19	0.9	279	12.7	294	13.4
Two Units - Full Load												
1966	32	8.8	53	14.5	77	21.1	32	8.8	50	13.7	74	20.3
1967	28	7.7	2	0.5	28	7.7	28	7.7	2	0.5	28	7.7
1968	39	10.7	61	16.7	86	23.5	39	10.7	55	15.0	80	21.9
1969	13	3.6	78	21.4	82	22.5	13	3.6	69	18.9	73	20.0
1970	12	3.3	83	22.7	90	24.7	12	3.3	76	20.8	83	22.7
1971	7	1.9	76	20.8	79	21.6	7	1.9	60	16.4	63	17.3
TOTALS	131	6.0	353	16.1	442	20.2	131	6.0	312	14.2	401	18.3
Three Units - Full Load												
1966	74	20.3	65	17.8	119	32.6	74	20.3	64	17.5	118	32.3
1967	40	11.0	2	0.5	40	11.0	40	11.0	2	0.5	40	11.0
1968	89	24.3	73	19.9	135	36.9	89	24.3	72	19.7	134	36.6
1969	47	12.9	85	23.3	111	30.4	47	12.9	83	22.7	109	29.9
1970	51	14.0	91	24.9	122	33.4	51	14.0	90	24.7	121	33.2
1971	30	8.2	82	22.5	103	28.2	30	8.2	74	20.3	95	26.0
TOTALS	331	15.1	398	18.2	630	28.8	331	15.1	385	17.6	617	28.1



LEGEND

- - - 24 - - - TEMPERATURE, °C

——(6)—— DISSOLVED OXYGEN, MG/L

Figure 2.6-1
Dissolved Oxygen
and Temperature Profiles
Wheeler Reservoir
1964-1965

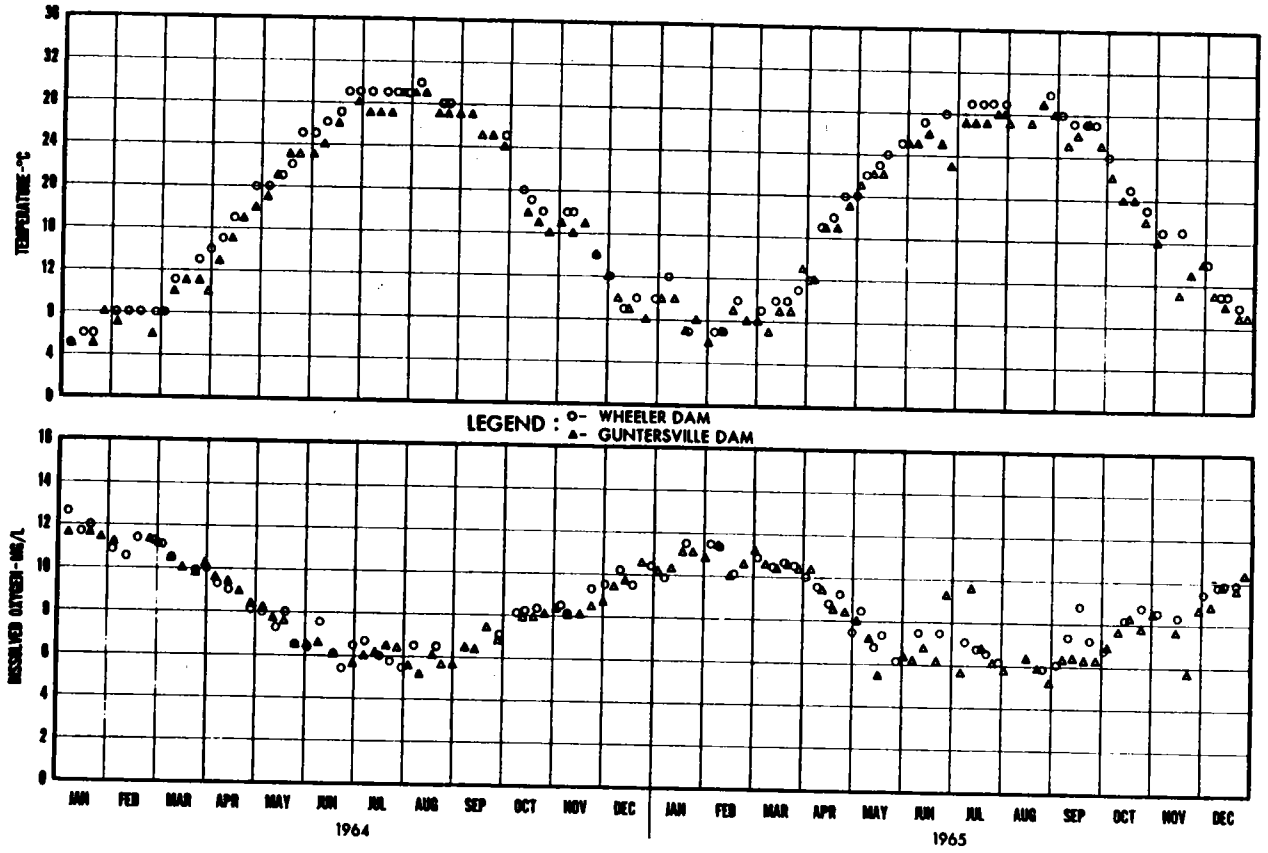


Figure 2.6-2
Dissolved Oxygen and
Temperature at
Wheeler and Guntersville Dams

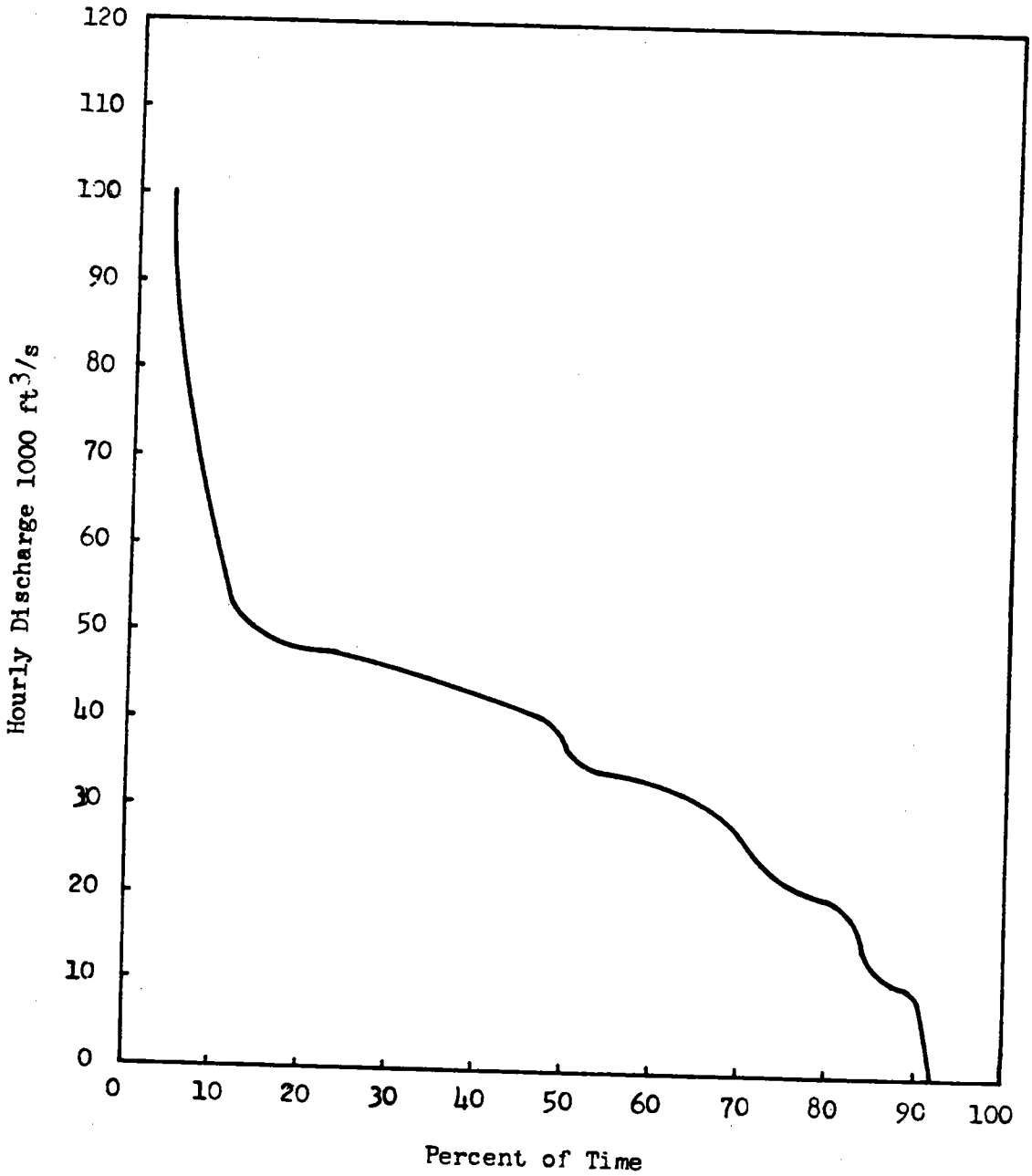


Figure 2.6-3
Guntersville Dam
Hourly Flow
10 Years of Record
1959 - 1968

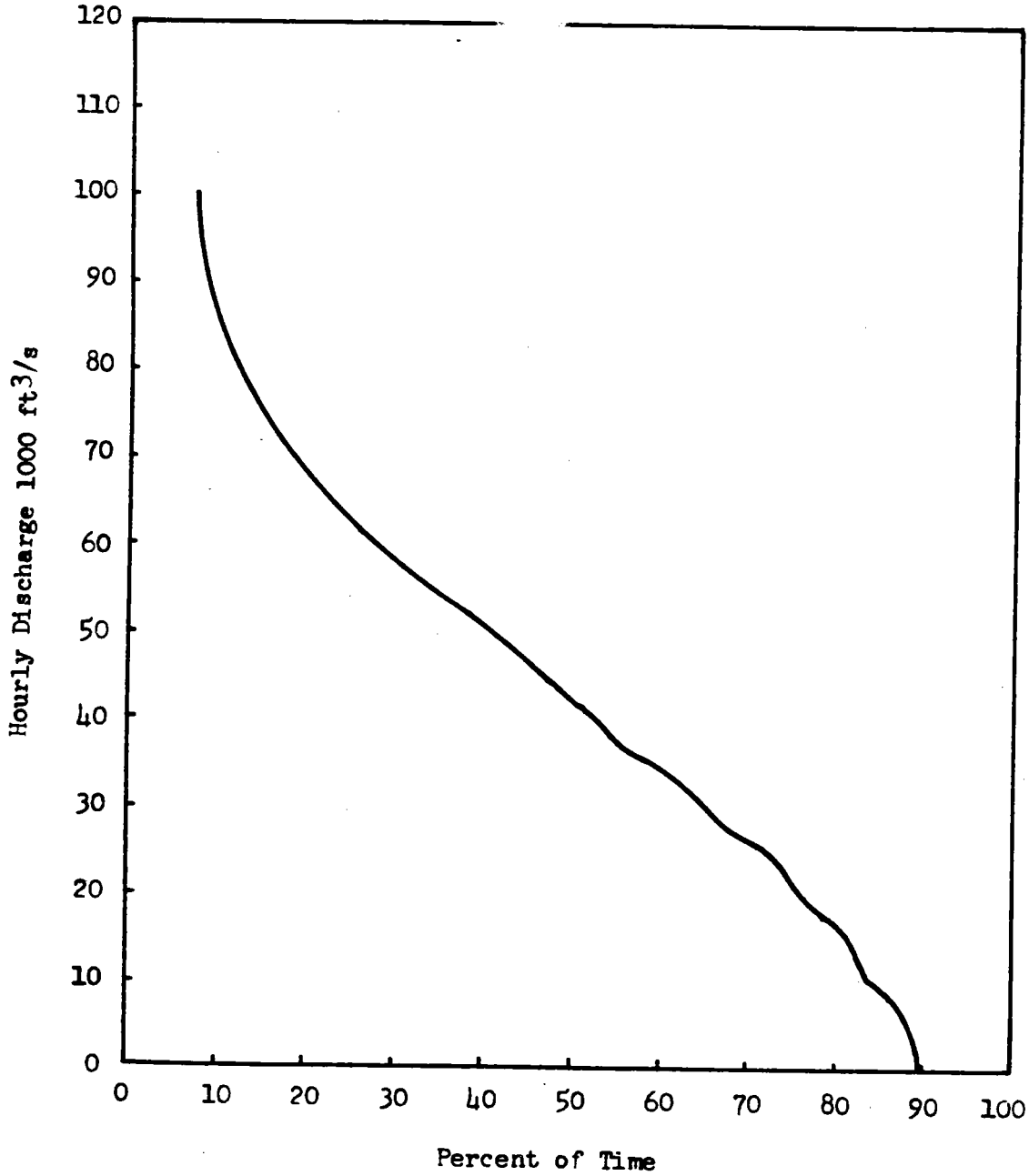
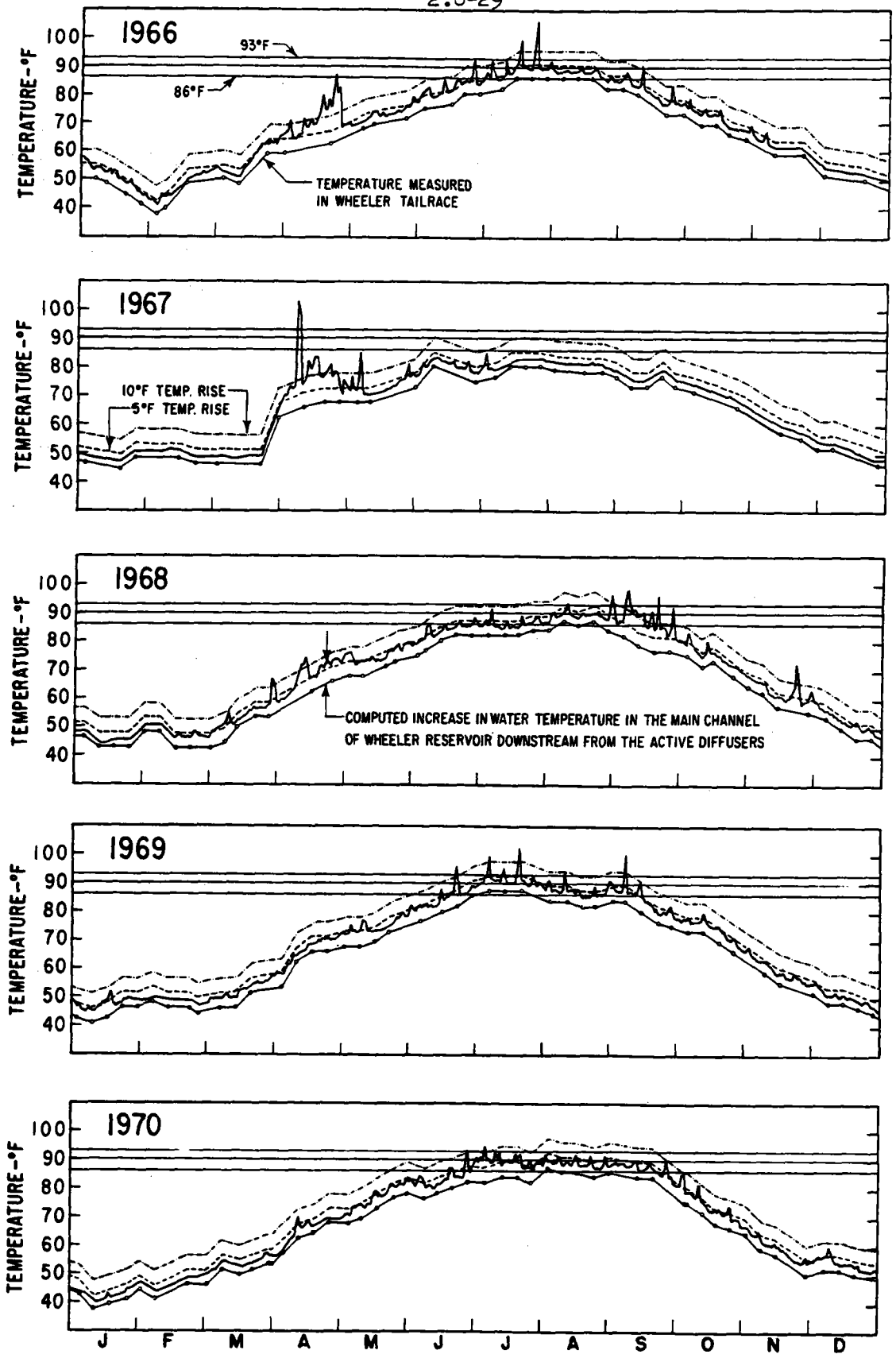


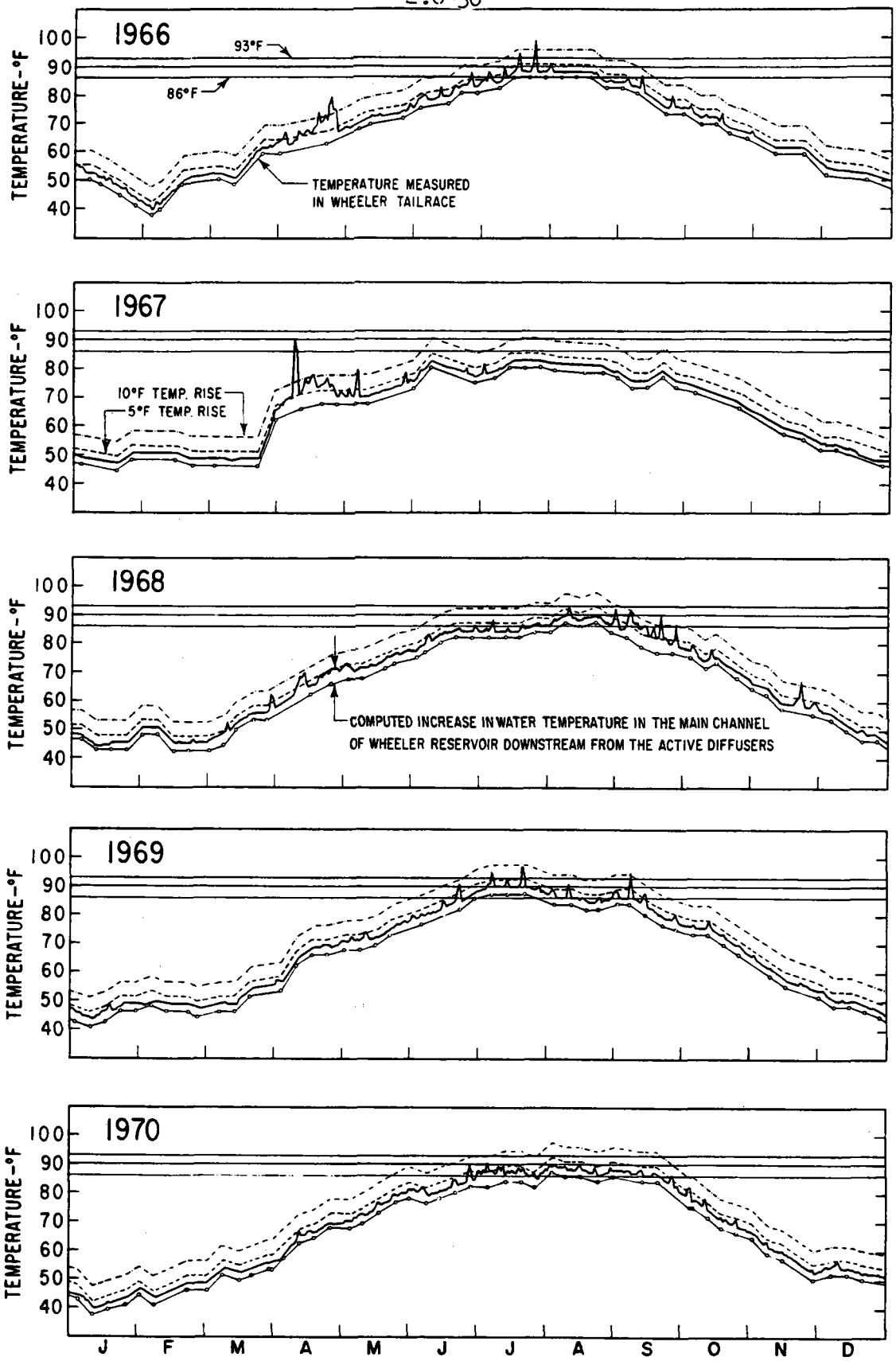
Figure 2.6-4
Wheeler Dam
Hourly Flow
10 Years of Record
1959 - 1968



COMPUTED INCREASE IN WATER TEMPERATURE IN THE MAIN CHANNEL OF WHEELER RESERVOIR DOWNSTREAM FROM THE ACTIVE DIFFUSERS

ASSUMING THREE UNITS IN FULL OPERATION AND STEADY STREAMFLOW CONDITIONS AT BROWNS FERRY NUCLEAR PLANT SITE

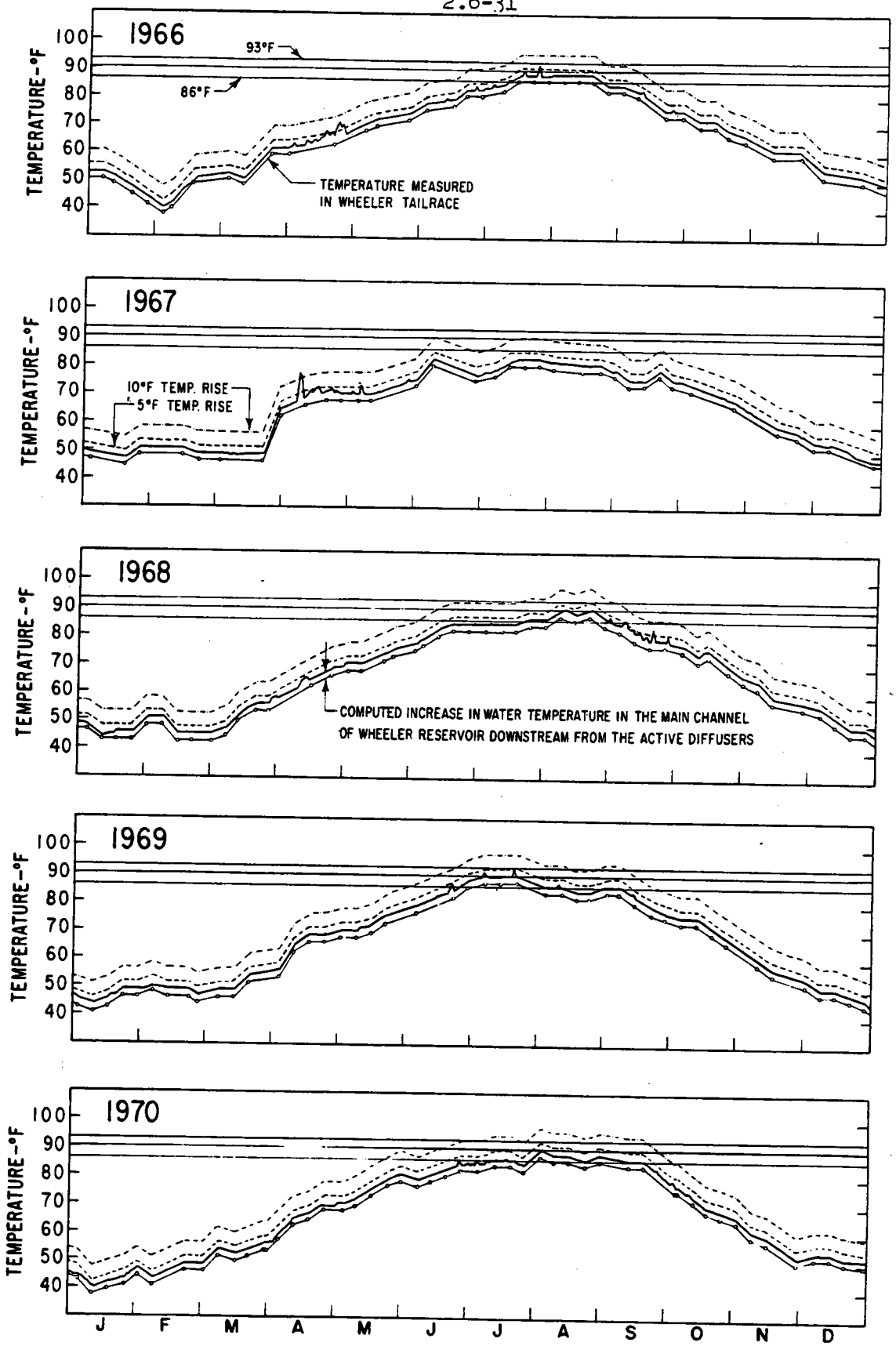
Figure 2.6-5



COMPUTED INCREASE IN WATER TEMPERATURE IN THE MAIN CHANNEL OF WHEELER RESERVOIR DOWNSTREAM FROM THE ACTIVE DIFFUSERS

ASSUMING TWO UNITS IN FULL OPERATION AND STEADY STREAMFLOW CONDITIONS AT BROWNS FERRY NUCLEAR PLANT SITE

Figure 2.6-6



COMPUTED INCREASE IN WATER TEMPERATURE IN THE MAIN CHANNEL OF WHEELER RESERVOIR DOWNSTREAM FROM THE ACTIVE DIFFUSERS

ASSUMING ONE UNIT IN FULL OPERATION AND STEADY STREAMFLOW CONDITIONS AT BROWNS FERRY NUCLEAR PLANT SITE

Figure 2.6-7

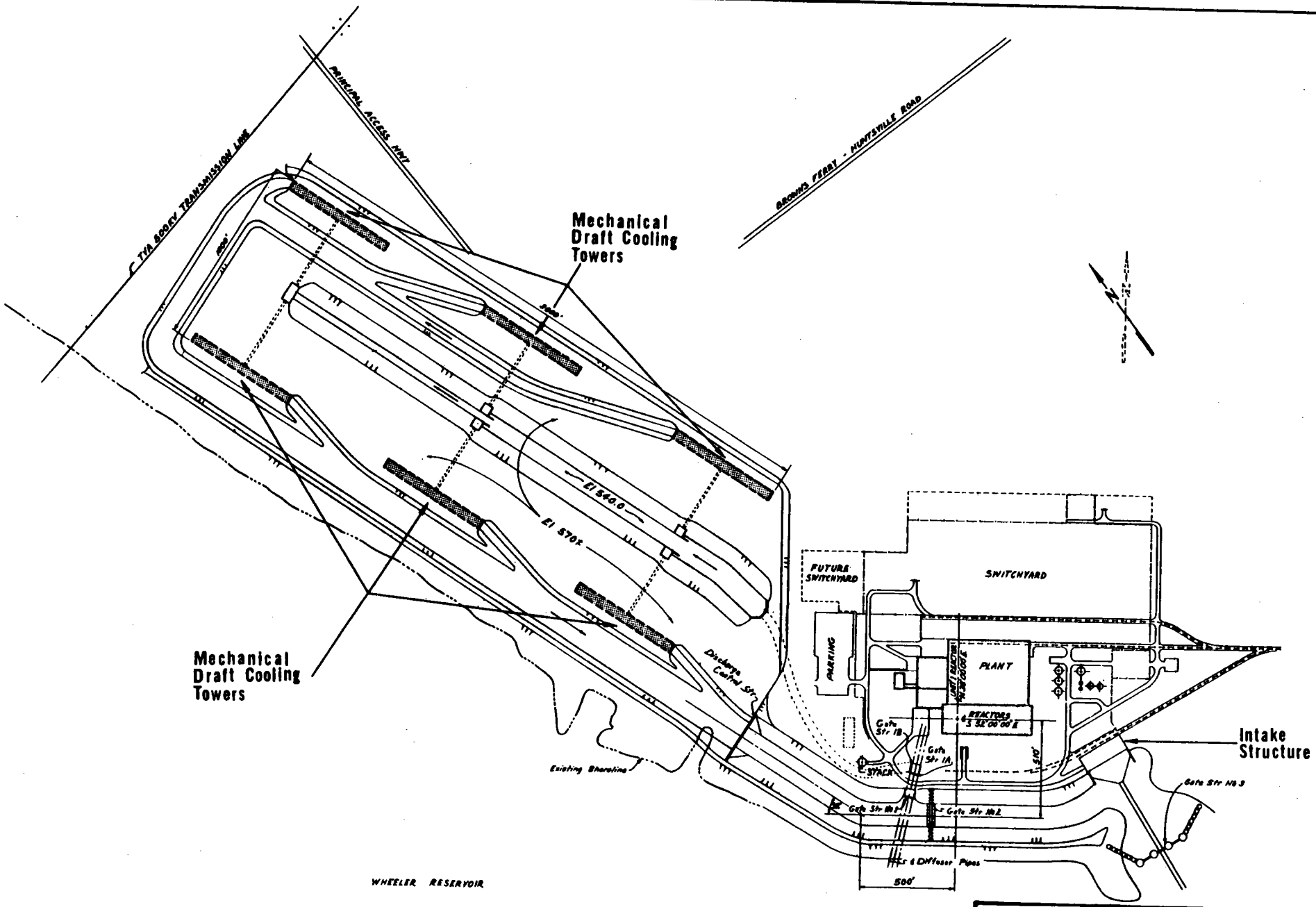


Figure 2.6-8
Mechanical Draft
Cooling Tower Arrangement
BROWNS FERRY NUCLEAR PLANT

2.7 Biological Impacts

1. Thermal effects following cooling tower installation - The impact of thermal discharges from Browns Ferry Nuclear Plant on aquatic life in Wheeler Reservoir based on TVA's design criteria for reservoir temperatures, a 10°F rise and a 93°F maximum, has been discussed in Volume 2, section 5.6, and Volume 3, section 3.3. In these volumes the bottom fauna and fish habitat in Wheeler Reservoir have been described, fish species of interest to sport and commercial fishermen have been identified, and effects of the warmwater discharge on the life history of fish and bottom fauna have been considered.

TVA concluded in these discussions that limiting the Wheeler Reservoir temperatures to the design criteria maximum would not result in significant detrimental impacts to the reservoir ecosystem. This evaluation is still considered valid. However, after Volume 3 was issued for review, TVA made the decision to install mechanical draft cooling towers to meet the more stringent temperature standards of 86°F maximum and 5°F above natural prevailing background temperature proposed by EPA for the State of Alabama.

2. Thermal effects during the interim period - Thermal discharges during the interim period until cooling towers are completed are discussed in section 2.6.5 of this volume. The plant commercial operation schedule and the tower completion schedule discussed in that section indicate that the total time period during which one or more units are scheduled to be operating before installation of all towers is 22 months. This period includes 12 months of

1-unit, 10 months of 2-unit, and no period of 3-unit operation without towers.

In addition to the limited time span when the plant units will be operating without available auxiliary cooling facilities, evaluation of past flow records (see Table 2.6-3) indicates that only about 16 percent of this time will the more stringent 86°F and 5°F rise standard not be met during the period of 1-unit operation, and only about 20 percent of the time will these limits be exceeded during 2-unit operation. This analysis is based on mean daily flows. However, reference to figure 2.6-3 and figure 2.6-4 shows that the minimum flow required to limit the temperature rise in the reservoir to the proposed standard of 5°F, approximately 7,250 ft^3/s for 1-unit operation, is exceeded about 90 percent of time based on hourly flow records. The minimum flow required to meet this standard for two units is about 14,500 ft^3/s and is equalled or exceeded more than 80 percent of the time. Thus, the following discussion of interim operation thermal effects must be evaluated relative to those periods when the proposed standards are exceeded.

As described in section 2.6 of this volume, thermal patterns in Wheeler Reservoir can be separated into three categories. These three categories, which are described below, will be termed Condition I, Condition II, and Condition III.

<u>Condition I</u> - At streamflows greater than ten times the diffuser discharge, warm water will extend in a surface layer across the width of the reservoir at some point downstream from the diffusers, leaving cooler water at "ambient" temperature

in a subsurface layer. The temperature of the warm surface water outside the jet-mixing zone will be approximately 1.4 to 2.0 deg C (2.5 to 3.5 deg F)* above ambient for approximately 2 miles downstream from the plant site, at which point the temperature will begin to decrease because of surface heat losses. The warm layer will impinge on shallow overbank and littoral areas on both sides of the river, including the Mallard Creek embayment, and on the submerged island downstream from the plant.

Condition II - At flows less than ten times the diffuser discharge, the entire flow of the river will mix with the condenser effluent. No subsurface zones at ambient temperature will occur immediately downstream from the diffuser. Temperature increments above ambient in the mixed flow will range from 1.4 deg C (2.5 deg F) to 5.6 deg C (10 deg F) depending on reservoir flow-diffuser discharge relationships. It should be noted that after cooling towers are available the rise will not exceed 2.8°C (5°F). Water elevated in temperature by these increments will impinge on the entire reservoir substrate for approximately 2 miles downstream from the diffusers before significant surface heat loss occurs; warm water will also move upstream, the distance depending on reservoir and diffuser flows; and warm water will invade to an unknown

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*This discussion will follow the convention: deg C (or deg F) refers to a change in temperature; °C (or °F) refers to actual temperature.[1,2]

extent the Mallard Creek embayment located across the reservoir from the plant site.

Condition III - Occasionally there will be very high streamflows for which the thermal regime will be essentially the same as in Condition I except that additional mixing will result in mixed upper layer temperatures lower than 2.5 to 3.5 deg F.

3. Effects on fish -

(1) Reproduction -

(a) Spawning - Under Condition I the expected mixed temperatures on the order of 1.4 to 2.0 deg C above ambient probably will not have a measurable effect on prespawning migrations. In addition, the bottom area in the overbank areas will be at ambient temperatures, thus affording subsurface passage routes.

Under Condition II warm water at the mixed temperature will occupy the entire water column. The extent to which this will serve as a barrier to migrating fish will depend on (1) the magnitude of the temperature elevation in the mixed area and (2) the steepness of the thermal gradients within the mixed zone. Temperatures of from 1.4 to 5.6 deg C above ambient will be experienced by migrating fish. It is important to note that a complex 3-dimensional distribution of thermal gradients within the range noted above will exist in the region of mixed temperature. The literature available on thermal preferences and reactions to thermal gradients is extensive.[2,3] Laboratory investigations have shown that fish can be trained to discern temperature differentials of 0.05 deg C or less;

in natural situations, however, discrimination of thermal differentials of less than 4 to 5 deg C has seldom been demonstrated except where these differentials occur near lethal limits.[4] Certain species may avoid localized areas or "pockets" of highest temperature but should successfully negotiate the mixed region.

Where warm water extends both upstream and downstream from the diffusers, the gradients encountered by migrating fish will vary. Fish moving upstream from below the plant will traverse a gradually increasing gradient, experience the highest temperatures in a localized region in the vicinity of the diffusers, and then traverse a decreasing gradient as they move upstream. The gradient from warm to cooler water upstream from the diffusers will be somewhat steeper than the gradient from cooler to warmer water downstream from the diffusers, but it will not be sufficiently steep to produce cold shock. It is therefore judged that a barrier, in the strict sense of preventing or significantly decreasing or retarding migration, will not result under the proposed interim operating regime.

A recent review of environmental factors which may control teleost reproductive cycles[5] indicates that for most teleost orders rates of gametogenesis are controlled by a combination of temperature and photoperiod and that photoperiodism is partly temperature controlled. The same argument can be extended to spawning <u>per se</u> provided other factors, e.g., availability of suitable substrate, are included. Generalizations regarding the role of increased temperatures on the spawning cycles of fish resulting from plant operation are therefore difficult to make. Depending on the degree to which

temperature can override photoperiodic control, those species which reside more or less permanently, expecially during late autumn and winter, in the vicinity of the plant may experience acceleration of gametogenesis and hence spawning. As discussed in Volume 2, results of preoperational monitoring indicate considerable seasonal variation in catch; there are no available data to ascertain the presence or absence of resident subpopulations of any species. It is possible that members of relatively sedentary species such as minnows, bluegills, largemouth bass, and perhaps flathead catfish will remain in the area long enough to be affected. Early spawning by clupeids and largemouth bass and late spawning of bluegill were noted in the discharge cove of a steam plant on Lake Norman, North Carolina.[1] The consequences of earlier maturation and spawning are discussed below in the consideration of thermal effects on egg development.

Under Condition II warm water may encroach upon overbank areas above the plant and across the reservoir. Fish spawning in these areas would experience changes in temperature which may affect normal spawning. Spawning is most likely to be disrupted by a downward shift in temperature early in the spawning season, i.e., when the threshold temperature for spawning has first been passed. During this period a shift from one condition to the other could interrupt spawning in these areas; the significance of this in terms of the fishery resource of the reservoir is unknown.

(b) Egg development - Increased temperatures in the vicinity of the plant under both Condition I and Condition II may accelerate development of both demersal eggs deposited

in the area and pelagic eggs which drift past the plant and become entrained in the jet mixing zone.

Under Condition I rates of development of demersal eggs deposited in the vicinity of the plant will be accelerated somewhat, but increased mortality of eggs is not expected to be a significant factor. Increased developmental rates owing to elevated temperatures may result in a higher frequency of anatomical anomalies (changes in numbers of vertebrae, pug-headedness, etc.). These anomalies seldom are direct factors in mortality, but they may decrease swimming and feeding efficiency and render the affected fish more susceptible to predation. Anomalies may be under genetic control as well, and adult individuals exhibiting anomalies have been reported in the literature for several species. Increased developmental rates may also result in young hatching at an earlier stage of development than is normal; mortality rates of prematurely hatched young are higher than for normal young. Considering the area involved, approximately 5 percent of the reservoir surface area, it is judged that such effects will have an insignificant impact on fishery resources.

Under Condition II a greater, but undefinable, degree of acceleration of developmental rates can be expected. Egg mortalities may result if the combination of ambient temperature conditions near the upper lethal threshold, low riverflow, and high diffuser discharge occurs. Such occurrences will be infrequent and of short duration; mortalities which may occur are judged to be insignificant in terms of the entire reservoir.

Pelagic eggs which become entrained in the diffuser discharge stream will be subject to rapid thermal shock as they pass through the jet mixing zone. The degree to which mortality is caused by the thermal shock will depend on the magnitude of the shock, the maximum temperature experienced by the eggs, the developmental stage of the eggs, and the duration of exposure to elevated temperature. Data on these effects are scanty, and no quantitative estimates of adverse effects can be made, but some increase in egg mortality may occur. Incomplete analysis of meter-net samples indicates that egg concentrations in the river channel near Browns Ferry (TRM 293) varied from 0 to $0.5/m^3$ in May 1971; from 0.004 to $2.5/m^3$ in June 1971; and from 0.003 to $0.4/m^3$ in July 1971. Presumably, the eggs taken were pelagic, buoyant eggs, most probably of the drum, Aplodinotus grunniens, and some fraction of these would have been exposed to the conditions noted above. Available information indicates that only two species common to the reservoir produce buoyant eggs: drum and mooneye (Hiodon tergisus); one other species, the skipjack herring (Alosa chrysochloris) may also have bouyant eggs. It is not anticipated that egg mortalities owing to entrainment will have a significant impact on populations of these species in Wheeler Reservoir.

(2) Early life stages - Preliminary results of the first year of sampling for young fish* in the vicinity of the plant are shown in figure 2.7-1. The methods and stations established for sampling for young fish are shown in figure 19 of Volume 2. While a complete analysis of the species composition and

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*For convenience, larval and young-of-the-year fish not exceeding the 1" to 2" size class are combined and referred to as young fish, unless further specified in the text.

relative species abundance is not yet available, some general observations can be made. Throughout the period in which young fish are vulnerable to the sampling gear, shad (Dorsoma spp.) dominate the catch, and gizzard shad appear to be more abundant than threadfin shad. The percentage of nonshad species, which never exceeds 10 percent of the total, increases somewhat in July. The downward trends of the curves in late June and July are the result of several processes--mortality, migration from inshore to pelagic areas, and gear avoidance due to a larger size and increased swimming ability. For these reasons the curves underestimate the abundance of fish and may overestimate the proportion of species other than shad. A list of species identified thus far is given in Table 2.7-1.

The data in figure 2.7-1 represent inshore samples only; population densities of young fish in the pelagic area (channel) at the same location are approximately one-tenth as great, and population densities at the 5m depth in the channel are somewhat lower than at the surface. The extent to which population densities noted at TRM 293 are typical of the entire reservoir is not known, but examination of a limited number of samples taken approximately 4 miles upstream from the plant has yielded equal or somewhat higher numbers, although the peak observed at TRM 293 on June 17 may not be reached.

The dynamics of populations of young fish are not clearly understood. The effects of adverse impacts on young fish as ultimately reflected in adult stocks and the reservoir ecosystem are unknown. The magnitude of the projected losses of larval

fish as discussed in subsequent pages does, however, suggest the possibility of a significant adverse impact. To provide assurance that the operation of the Browns Ferry plant is not adversely affecting fish populations in Wheeler Reservoir, larval fish monitoring will continue following plant startup. Should there be significant adverse effects due to plant operation, corrective action will be taken.

(a) Thermal discharges - The effects of thermal discharges on young fish are largely unknown at present. Increased temperatures which remain below incipient lethal thresholds will accelerate metabolism, thereby accelerating growth if other factors, e.g., dissolved oxygen and food concentrations, are not limiting. Evidence has been presented of faster growth of young fish in a discharge embayment as compared to other areas of Lake Norman.[1] However, the extent to which this is a result of accelerated growth rates as opposed to increased growth due to earlier hatching has not been resolved. Since increased temperatures increase maintenance level food requirements, the effects of temperature are likely to operate in conjunction with available food supplies.[6]

Young fish subject to Condition I will experience slight increases in temperature; however, the effects on growth of a 1.4 deg C increase in water temperature may not be measurable. Increased predation may occur if significant numbers of predators are attracted to the warmer areas. Under Condition II temperatures of up to 5.6 deg C may be experienced. Increased growth may occur if food is not limiting; increased predation may also result,

but it will be offset somewhat by the shorter period of vulnerability due to increased growth.

It is judged that the effects of thermal discharges on larval fish, whether adverse or beneficial, will not be of a measurable level. However, mortality of young fish resulting from plant operations may be caused by three distinct but related factors: (1) entrainment in the jet mixing zone; (2) impingement on intake screens; and (3) passage through the condenser cooling system.

(b) Entrainment - The number of larval fish entrained in the jet mixing zone will vary considerably over time. Based on (1) the volume of the jet mixing zone of 203.6 x 10^3 cubic meters (165 acre-feet) under 3-unit open-mode operation and (2) mean concentration of larval fish obtained from surface tows in the channel, the ranges of the numbers of larval fish in the zone under normal flow conditions are: April (1 date only), 653 x 10^3; May, 179 x 10^3 to 383 x 10^3; June, 20.2 x 10^3 to 1.88 x 10^6; July, 2.2 x 10^3 to 12.8 x 10^3. Assuming a turnover rate for the volume in the mixing zone of 20 times per hour, an estimated 11.99 x 10^9 larval fish would have passed through the jet mixing zone in the 91-day period from April 27 through July 27 in 1971.

Fish thus entrained will be subjected to a gradient of increased temperature from approximately 13.9 deg C at the diffuser ports to 1.4 deg C at the downstream edge of the mixing zone. Temperature data from 1971 indicate that, of the 11.99 x 10^9 fish noted above, 5.8 x 10^9 would have been subjected to temperatures

in excess of 40°C (104°F) for short durations. No data are available to enable assessment of the effects of short-term exposures of larval fish to temperatures above 40°C; similarly, the length of exposure to the highest temperatures is not known. Any mortality occurring will probably be the result of increased predation on temporarily stunned fish.

These data probably overestimate the magnitude of entrainment in the jet mixing zone owing to (1) use of surface concentrations of larval fish; (2) rough approximations of the volume of the mixing zone and its rate of turnover under 3-unit, open-mode operation; and (3) step integration of the complex curve for numbers of fish in the meter-net samples versus time. The values of 11.99×10^9 and 5.8×10^9 given above probably represent the upper limit for the 91-day period. Based on limited data from samples taken at the 5m depth in the channel, lower limits would be approximately 60 percent of upper limits, or 7.2×10^9 and 3.5×10^9 respectively, given the same assumptions of operation, volume, and rate of turnover.

(c) Impingement - Young fish entering the intake forebay will be subjected to current velocities of up to 54 cm/s (1.8 ft/s). Those fish which are unable to withstand this current and which will not pass through the approximate 1-cm square (3/8 by 3/8 inch) mesh of the traveling screens, will be impinged. The literature on sustainable swimming speeds of fish is limited; moreover, published accounts often are not comparable in terms of experimental design and objectives of the study. The sustained swimming speed of young smallmouth bass (2.2 cm in length) has been estimated

to be from 2 to 13 body lengths per second (3.6 to 30 cm/s) depending on acclimation temperature.[7] It is difficult to estimate the duration over which these speeds can be maintained since tests cited were continued for a maximum of only about 15 minutes. One-hour sustained swimming speeds for walleye and yellow perch larvae have been reported to approach maximum values of 5 cm/s for 1.6-cm fish.[8] Similar results with largemouth bass larvae have shown that 30-minute sustained swimming speeds were 4 to 5 body lengths per second (4 to 5 cm/s).[9] Assuming a commonly accepted value of 4 to 6 body lengths per second as a maximum sustained swimming speed for periods of 30 to 60 minutes, the intake velocity of 54 cm/s is likely to trap and expose to possible impingement most fish of less than 8 to 12 cm (3 to 4.5 inches) in length. Mechanical injury owing to impingement and the high velocity cleaning jets will result in high mortalities of fish so trapped.

However, experience at operating TVA steam plants indicate that the number and severity of fish captures on the traveling screens vary from plant to plant and from season to season. Shad minnow runs are normally experienced in the spring and fall, and the number of minnows captured on the screens varies from just a few to several thousand. Captured fish range up to 6 inches in length, but very few larger fish are captured on the screens. Occasionally, game fish are captured on the screens; however, this is not a common occurrence, and at some downriver plants no game fish have been noted on the screens.

Table 2.7-2 shows channel dimensions and water velocities in the channel and across the traveling

screens for major TVA steam plants. The channel velocities were calculated using the cross-sectional area of the channel and assuming normal water levels. Calculations are based on all units of a plant being in operation. The screens at these plants have 3/8-inch openings, the same as at Browns Ferry.

(d) Condenser passage - Young fish which pass through the Browns Ferry intake screens will be subjected to a temperature increase of 13.9 deg C (25 deg F). Total duration of passage is estimated at from 7 to 11 minutes, assuming open-mode operation; of this, 5 to 9 minutes will be spent in heated water. Figure 2.7-2 gives estimates of the number of young fish which would have been subjected to condenser passage during the period noted in 1971. Integration of the areas under the curves O-3, H-3, and C-3 yields estimates of 12.5×10^9, 10.5×10^9, and 6.5×10^8 fish, respectively, for continuous 3-unit operation under open, helper, and closed modes, respectively. Mortality owing to condenser passage is presently considered to be a product of absolute temperature rise and duration of exposure to increased temperatures, but no data are available to establish limits on these parameters.[2] Data obtained at the Connecticut Yankee Atomic Power Plant showed no surviving warmwater fish larvae or juveniles at 35°C (95°F) immediately below the plant discharge.[10] Presumably these fish all passed through the condensers and were subject to a 12.5 deg C increase. Assuming that these data are extrapolable to the Browns Ferry plant and using available temperature records obtained at Wheeler Dam tailrace in 1971, nearly total mortality would have been experienced during the period from May 17 to the end of the sampling period. On the basis of the above estimates

of numbers withdrawn, this would amount to a mortality of 11.8×10^9 fish under open-mode, 3-unit operation. Fish withdrawn before May 17 (amounting to 6.31×10^8) would have been subject to mortalities ranging from approximately 30 to 100 percent. Mortalities under helper- and closed-mode operation are expected to be 100 percent.

The assessment of condenser passage on larval fish must be made with the following limitations and considerations in mind:

1. Estimates are based on one year of sampling, comprising the 91-day period from April 27 through July 27, 1971; no estimates of yearly variation are available.
2. It was assumed that concentrations (and hence total numbers) of fish available to the plant intake were equal to those noted in the inshore-surface samples below the plant (TRM 293). Preliminary analysis of the upstream samples (TRM 298) indicates that the total numbers available here may in fact be higher, although the extreme peak concentration (see figures 2.7-1 and 2.7-2) may not have been reached. To the extent that this is true, total condenser passage may be underestimated. In addition, the data do not represent intake of species present as larvae before April 27.
3. It was assumed that all water taken in by the plant would come from the inshore area. Recent 3-dimensional model studies have verified this assumption at flows of 40,000 ft^3/s. The validity of this assumption for other flows is unknown.

4. The estimates of condenser passage assume continuous 3-unit operation by the specified mode only for the entire 91-day period observed in 1971. Actual passage would vary with changes in mode of operation and number of units employed.
5. It was assumed that concentrations of larval fish would be continuously available to the plant intake, i.e., the supply of fish to the intake would not be exhausted during the 91-day period of interest.
6. The data presently available do not allow estimation of the total population of young fish in the reservoir. Therefore, no definitive judgments of the significance to the reservoir of the estimated total losses are possible, beyond the comment that the exploitation of subadult age classes of fish is judged generally to be inadvisable where commercial and sport populations are concerned.

Under open-mode operation the larval fish will be returned to the reservoir and will be available as food to those organisms not requiring or selecting for live food. Fish withdrawn during helper-mode operation will presumably pass through the cooling towers; the degree to which these will serve as a food resource on being returned to the reservoir is unknown. Under closed-mode operation any fish withdrawn from the reservoir will constitute a total loss.

The significance of these losses to the fishery resource of the reservoir is not clear. Applying

a survival coefficient of from 1×10^{-4} to 1.9×10^{-4} between the larval stage and recruitment to the adult population, operation of the plant (3-unit operation) would have in effect removed between 1.2×10^{6} and 2.4×10^{6} adults under open-mode; between 1.1×10^{6} and 2.0×10^{6} adults under helper-mode; and between 0.6×10^{5} and 1.2×10^{5} adults under closed-mode operation. Based on an estimated adult standing stock of 32.6×10^{6} fish in Wheeler Reservoir, this reduction amounts to from 3.8 to 7.3 percent of the harvestable (adult) population under open-mode; from 3.2 to 6.1 percent under helper-mode; and from 0.2 to 0.4 percent under closed-mode operation.

Approximately 90 percent of these losses would be borne by gizzard and threadfin shad; it is estimated that 5 percent would be commercial and sport species and that the remainder would be other forage species.

The above calculations are based on the assumption that mortality caused by plant operations is additive to natural mortality. However, little is known regarding the mechanisms involved in establishing total mortality rates in fish populations. Mortality of young fish passing through the plant's cooling system is obviously density-dependent; natural mortality of the same fish may or may not be.[11,12] Whether the plant-induced mortality will be compensated for and, if so, to what extent is not known.

If compensation does not occur to any significant extent, several changes in the characteristics of the fishery resource may result. Decreased spawning stocks may result in lower production of young. Compensation for this has been shown to

occur in some cases and not in others.[13] Thinning of the populations may lead to increased growth.[12,14] This would be advantageous in the case of commercial and sport species but disadvantageous in the case of the shads and other forage species. If commercial and sport species are adversely affected by noncompensated mortality, fishing success and therefore fishing mortality may be decreased.

The most important aspect of plant-induced mortality is likely to revolve around the effects of such mortality on shad and other forage species, and the resulting effects on species which rely on these forage species as a food source. The principal value of shad to the total fisheries resource is that of a prey species. Gizzard shad, because of their rapid growth rate, serve as forage only during their first year of life; threadfin shad grow more slowly and probably remain within the range of predation for most of their life span. Other forage species, i.e., small cyprinids, are preyed upon during their entire life span.

At present Wheeler Reservoir appears to support a surplus population of gizzard shad. The magnitude of this apparent surplus is unknown; it is difficult, therefore, to judge the significance of plant-induced mortality of this species in terms of the fishery resource of the reservoir. Reduction of the gizzard shad population may reduce the total amount of forage fish or other forage species may increase as a result. Any significant reduction of the total forage resource would have adverse effects on growth and production of desirable commercial and sport species, but a shift to a forage resource less dominated by gizzard shad would be beneficial,

provided the other forage species can withstand the pressure of increased predation. On the balance, for the reservoir ecosystem, it is judged that local reductions of forage fishes will not affect reservoir food chains.

In summary, knowledge on entrainment cause and effect relations is limited, especially on the scale needed to judge the Browns Ferry impact questions. However, classic work with systems ecology and population dynamics, plus knowledge of the Tennessee River system, indicates that several phenomena are likely to occur. It is expected that condenser passage of larval fish will produce a profound local depression of larval populations which may be reflected locally in reduced numbers of juveniles and adult fishes. While several unknowns exist in terms of the total reservoir ecosystem, the impact of entrainment and condenser passage of larval fish is not expected to be significant, although immigration into depopulated areas will undoubtedly occur and may result in changes in relative abundance of some species.

The extent to which condenser passage of phytoplankton and zooplankton will adversely affect food supplies of young fish is unknown. Planktonic organisms, especially phytoplankton, copepods, and small cladocerans, which are killed during condenser passage, may still serve as a source of particulate food for young fish. Furthermore, it is conceivable that the concentration of particulate food will increase in the area below the discharge diffusers owing to withdrawal from the highly productive inshore waters. Young fish which survive entrainment in the jet mixing zone or condenser

passage may have available conditions ideal for accelerated growth, i.e., elevated temperature and abundant food. If condenser-passed organisms are disintegrated, the area below the jet mixing zone may have a lower concentration of particulate food relative to that of the unaffected reservoir.

(3) Juveniles and adults - Effects of plant operations on juvenile and adult fish will be attributable to (1) impingement on intake screens, (2) discharge of heated water, (3) concentration or changes in abundance of food organisms below the discharge diffusers, and (4) effects of plant-induced mortality on eggs and young fish which may be transferable to subsequent age classes. This latter aspect has been discussed above. Discussion of items (1) through (3) appears in Volumes 2 and 3. The following represents a brief review of previous discussion and additional considerations.

Construction and operation of mechanical draft cooling towers has necessitated construction of a multiple-gate structure in the intake basin. The proposed design has three intake gates; the velocity through each of these gates is estimated to be 48 cm/s (1.6 ft/s), assuming equal hydraulic efficiency for all gates. Under these conditions juvenile and adult fish should have freedom of movement in and out of the intake basin, and there should be no significant losses due to impingement.

Possible changes in distribution of juvenile and adult fish owing to the thermal discharges are discussed in Volume 2 and are based largely on studies by TVA and others.[15] Significant increases in numbers of forage fish (including shad), largemouth

bass, white bass, carp, and gar in a steam plant discharge cove relative to a control cove have been noted on Lake Norman.[1] Bluegill, black crappie, white crappie, and redhorse were found in significantly fewer numbers in the same comparison. The extent to which these differences are solely attributable to thermal preferences is not clear; dissolved oxygen concentrations, establishment and destruction of reservoir stratification, and currents may also have been factors.

Changes in distribution of fishes below the jet mixing zone will occur, owing to differing thermal preferenda among species. Although the extent of this occurrence and the particular species involved cannot now be positively identified, the changes should not constitute a significant adverse effect on fish species or their utilization by man.

Growth of juveniles and adults may be increased in those species having a positive preference for the thermally enriched zone owing to increased temperatures and to possible increased food concentration.

Concentrations and relative abundances of food organisms are likely to change in the area below the jet mixing zone for at least the following reasons:

1. When the intake water demand is satisfied by upstream overbank water, the organisms collected by the intake and dispersed to a more limited area of the old channel will result in a higher concentration within the jet mixing zone and downstream.

2. When riverflow exceeds diffuser discharge by less than a factor of 10, all riverflow is hydraulically demanded by the diffusers; thus, all planktonic organisms will pass over the diffusers and through the jet mixing zone in the old river channel.
3. The mixing of condenser-passed organisms with bypassing riverflow will change the total concentration per unit volume.
4. At riverflows less than ten times diffuser discharge, the physical changes produced by the diffuser demand will concentrate all planktonic organisms from the channel and left overbank upstream in the downstream old river channel where they will mix with the higher density of similar organisms dispersed from the right overbank by the diffuser.

Within this framework it is expected that zooplankton and phytoplankton will increase in abundance due to reproduction under potentially more favorable conditions resulting from increased temperatures and increased availability of nutrients. Larval fish will be concentrated physically due to hydraulic action of the diffusers.

Populations of benthic macroinvertebrates in the thermally enriched zone may be stimulated in growth and development. Some observers have noted that increased temperatures resulted in earlier emergence times of aquatic insects.[16] This may result in emergence when atmospheric conditions are not suitable for reproduction.

Although this food resource may be diminished, the adverse impacts on aquatic insects will not significantly decrease the total food resource available to fish because of the high productivity of Wheeler Reservoir. The extent to which increased thermal regimes accelerate rates of turnover, i.e., decrease generation times, in such organisms has not been thoroughly studied.

(4) Effects on sauger and smallmouth bass -

(a) Sauger - Sauger are neither commonly nor widely distributed in shallow overbank silted areas or in shallow embayments. They prefer and select areas of moderate current over rock, gravel, and mixed rubble in streams and tailraces or about reefs in deep water zones of lakes and reservoirs. They may move between or among the various types of habitat and substrate zones but apparently do not spend much time in the areas indicated as not being preferred zones. To our knowledge no reefs exist in the deep pool water above Wheeler Dam (TRM 275-287), and sauger are seldom caught there. Most netting and cove rotenone records indicate less than 1 percent of all fish captured by these methods are sauger. In the Wheeler Reservoir transition zone between pool and river channel (TRM 287-308) a few sauger are captured by netting or by electrofishing near heated water outfalls in the fall and winter. Nearly all efforts by sport fishermen are expended between TRM 308.0 and Guntersville Dam at TRM 384.8.

Sauger, especially maturing individuals, may be spread throughout the reservoir, but sampling

indicates relatively few individuals downstream of the plant site. Water warmed 10 deg F above ambient in the late fall and early winter appears to attract sauger rather than act as a barrier to the movements.[17] When sauger begin moving on spawning or early winter runs, they generally move in such a way that by November or early December they concentrate near dams and near existing municipal, industrial, and steam plant thermal discharges. These concentrations are documented and are of such common occurrence that sauger fishermen in the Tennessee Valley begin concentrated efforts below the dams and in and about steam plant discharge basins in November and continue these efforts through April and even early May.

Spawning in suitable habitats occurs downstream of Guntersville Dam between 15 and 50 miles upstream of the nuclear plant. Most spawning occurs 40 to 50 miles upstream. Eggs adhere to the bottom substrates. The eggs hatch in 10 days to 2 weeks, and the fry drift downstream. The fry live on reserve food from the yolk sac for 5 to 7 days. Travel time from the spawning area to Browns Ferry varies due to separate and combined operation of Guntersville and Wheeler Dams. A simple or most common travel time is difficult to realistically compute because of dam operations and the complex topography. The average flows and velocities have been computed for a number of dam operation schedules. With all schedules the larvae could begin feeding by the time they reach the heated water area where zooplankton are expected to be more abundant in the heated water wedge. The thermal effect during March to May is expected to improve survival of larval fish which do not pass through the condensers because of lower stress resulting from an increased food supply.

(b) Smallmouth bass - Smallmouth bass are distributed in two distinct, well separated zones of Wheeler Reservoir, neither of which should experience much effect from the Browns Ferry Nuclear Plant's warmwater effluent. The upstream population appears to prefer the tailrace and river channel below Guntersville Dam (TRM 348.8-308.0). The downstream population is associated with the limestone bluffs from TRM 288.0 to Wheeler Dam, TRM 274.9, and Elk River, the main Wheeler Tributary, from mouth (TRM 284.5) to source. Elk River is principally a smallmouth bass-rock bass stream.

Smallmouth bass generally are not migratory; they are considered resident fish in an area. Usually they move locally in a vertical plane along shoreline features and show a seasonal response to temperature. Estimates of their exposure to thermal impact during the interim period can be made by examining the calculated linear temperature die-away curves for Browns Ferry shown in Appendix IV of this volume.

4. Effects on plankton, periphyton, and benthic fauna - Normal intake velocity through the 3/8-inch-square mesh traveling screens will be 1.8 ft/s. At this velocity most zooplankton and phytoplankton in the vicinity will be entrained.

In early summer *Hexagenia* leave their burrows at night and swim up into the water column where they drift with the current. Their cross-sectional diameter is less than the 3/8-inch by 3/8-inch mesh opening on the traveling screens. If caught crosswise, they appear to be flexible enough to bend and pass through the mesh openings.

Chaoborus and chironomid midges are capable of similar flexing. Spring populations of the predaceous crustacean plankter Leptodora kindtii would pass through the openings as would all other normal planktonic forms.

The effect on these organisms of passage through the condensers has been discussed in Volume 2, section 5.6, and Volume 3, section 3.3.

5. Effect of entrainment on dissolved oxygen - Essentially all plankton and fish larvae will be killed in passing through the plant cooling water system during periods of time when temperatures in the condensers exceed 95-100°F, and the organic waste load resulting will tend to depress concentrations of dissolved oxygen in the reservoir water downstream from the plant. To obtain an estimate of the maximum oxygen depression resulting from discharge of this organic waste load, it was assumed that the maximum concentrations of phytoplankton, zooplankton, and fish larvae found during all the biological sampling done to date in the vicinity of the Browns Ferry plant occurred in the intake water simultaneously, and furthermore, it was assumed that this simultaneous occurrence coincided with a period of time when the cooling water from all three generating units in the plant was being discharged through the diffusers while operating in the open mode. It was also assumed in making this estimate that the riverflow was 22,000 ft^3/s (minimum streamflow for 3-unit operation) and that a 5 degree rise, from 81°F to 86°F, was produced in the entire flow of the Tennessee River.

Based on the low streamflows the resulting extended time of water travel in lower Wheeler Reservoir dictates that the organic load would exert its ultimate biochemical oxygen demand in the lower end of the reservoir. In these calculations it was assumed that no reaeration or reoxygenation of the water would take place in the reservoir either through surface absorption of oxygen or by photosynthesis.

Based on all these very conservative assumptions--each of which tends to maximize the calculated DO depression--the greatest depression in concentration of dissolved oxygen was calculated to be about 0.2 milligrams per liter. Actual DO depression resulting from discharge of organic waste load is expected to be much less. As regards growth of heterotrophic slimes, such growths may result from organic enrichment, but unless DO concentrations are depressed to essentially zero for a significant percentage of the time, they do not result from DO depression.

As shown in figure 2.6-2 of this volume, the DO concentrations of the Wheeler Dam tailrace vary from a maximum of 12 mg/l in the winter to a minimum of about 5.5 mg/l in the summer. Only on infrequent occasions have concentrations less than 6 mg/l been noted. Thus, it is concluded that even when using conservative assumptions the organic waste load on the river produced by passing plankton and fish larvae through the plant cooling system will not result in the violation of water quality criteria or produce any significant water quality problems.

6. Monitoring programs - Concern has been expressed regarding the efficacy of the proposed postoperational monitoring program in determining effects of thermal discharges. The program, as described in Volume 2, is subject to the limitations as noted by TVA biologists and others.[18,2] Site studies are sensitive only to relatively large-scale changes in abundance and distribution of fishes owing to (1) the size of the body of water usually involved; (2) constraints placed on sampling methods by substrates, currents, and submerged topography; (3) limitations of time, money, and personnel; and (4) the dynamic nature (temporal and spatial) of populations of aquatic organisms. However, certain methods of data collection and analysis have been used with varying degrees of success; among these are the use of catch/effort statistics,[15] diversity indices,[19] and relative abundance. These methods will be employed, together with the results of meter-net sampling for young fish, population inventories, creel censuses, and tag-recapture studies, to provide a reasonably comprehensive overview of the fishery resource both before and after commencement of plant operations. The monitoring program for benthic fauna and plankton has been described in Volume 2 and discussed in Volume 3. All aspects of the monitoring program are under continuous reappraisal and other methods may be employed as they prove effective and feasible.

There is a critical need for studies to elucidate thermal effects at the level of individual organism or species. Two recently developed approaches appear promising and will, if feasible in this instance, be incorporated in the postoperational phase of monitoring. The first of these is the electrophoretic analysis of

serum protein components in the blood of fishes. Changes in thermal regimes have been shown to change the amounts of various components. While all of the physiological implications of these changes are not known, implications involving antibody production and disease resistance have been drawn.[20]

The correlation of changes in growth rates with changes in thermal regimes has proved difficult if not impossible in natural systems when the usual methods of analysis are employed.[11] However, recent studies have shown that ratios of RNA to DNA content in fishes[21] and RNA concentrations in invertebrates[22] may be used as indicators of recent growth. These methods appear to have the advantage of being able to detect changes over short periods of time; furthermore, the results obtained in the field can be compared with results obtained under controlled conditions in the laboratory.

The environmental radiation monitoring program for the Browns Ferry Nuclear Plant is described in section 5.6 of Volume 2 and the locations of sampling sites are shown in figures 17 and 18 of the same volume.

At present TVA is reviewing its overall approach to environmental radiation monitoring in respect to the proposed guide for environmental monitoring now being prepared by the Environmental Protection Agency. TVA is in the process of moving one of the remote monitoring stations to the point of maximum predicted concentrations. This move will be completed prior to plant operation. TVA has considered including waterfowl in the environmental sampling program. It is known that most of the ducks hunted in north Alabama are migratory,

moving great distances in the winter and spring. It would be almost impossible to identify the source of any radionuclides found in migratory waterfowl. TVA is presently sampling those vectors which will give the first indication of increased radioactivity levels in the environment. If increases are seen in those vectors being sampled, consideration will then be given to expanding the sampling program to include other biological specimens.

TVA is continuing to carry out a quality control program with the Environmental Protection Agency's Eastern Environmental Radiation Laboratory and the states of Alabama and Tennessee in which samples of soil, vegetation, milk, and air particulate filters are exchanged and analyzed to assure accuracy of the analytical program. This program will assure unbiased results of sample analyses.

Table 2.7-1

SPECIES OF FISH IDENTIFIED FROM METER-NET SAMPLING FOR YOUNG FISH

Gizzard shad	Dorsoma cepedianum
Threadfin shad	D. petenense
Freshwater drum	Aplodinotus grunniens
Skipjack herring	Alosa chrysochloris
Carp	Cyprinus carpio
Mooneye	Hiodon tergisus
Channel catfish	Ictalurus punctatus
Blue catfish	I. furcatus
Flathead catfish	Pylodictus olivaris
Crappie	Pomoxis spp.
White (and yellow?) bass	Morone spp.
Bluegill	Lepomis macrochirus
Longear sunfish	L. megalotis
Green sunfish	L. cyanellus
Gar	Lepisosteus (prob. osseus)
Emerald shiner	Notropis atherinoides
Logperch	Percina caprodes
Cyprinid	Pimephales (vigilax?)

Other than shad, freshwater drum and emerald shiner are most abundant

Table 2.7-2

INTAKE CHANNEL DIMENSIONS AND VELOCITIES

MAJOR STEAM PLANTS

Plant	Channel Length (feet)	Channel Width (feet)	Channel Velocity (ft/s)	Velocity Across Screens (ft/s)
Allen	-	-	1.0±	1.7
Bull Run	600	60	0.9	2.3
Colbert	100	300	1.0	2.1
Gallatin	2,700	70	1.5	1.8
John Sevier	1,000	150	1.0	2.0
Johnsonville	1,600	250	1.0	2.0
Kingston	4,500	60	2.0	2.0
Paradise	200	100	1.5±	2.0
Shawnee	2,000	120	2.0	2.0
Widows Creek A	1,100	150	1.0	1.7
Widows Creek B	200	50	1.0	2.5

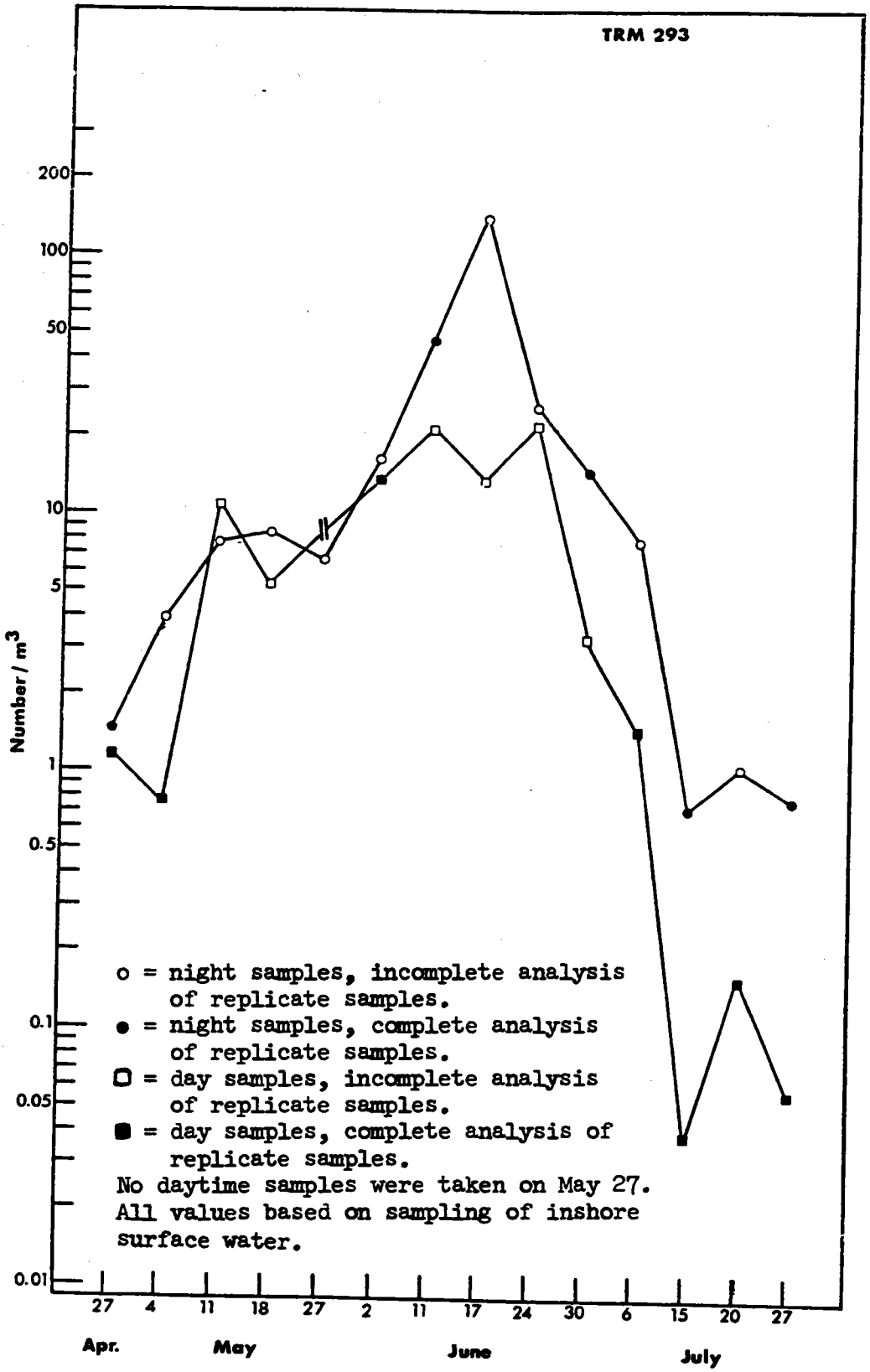

Figure 2.7-1
Catch of Young Fish by
Meter-net Sampling,
Vicinity of
BROWNS FERRY NUCLEAR STEAM PLANT

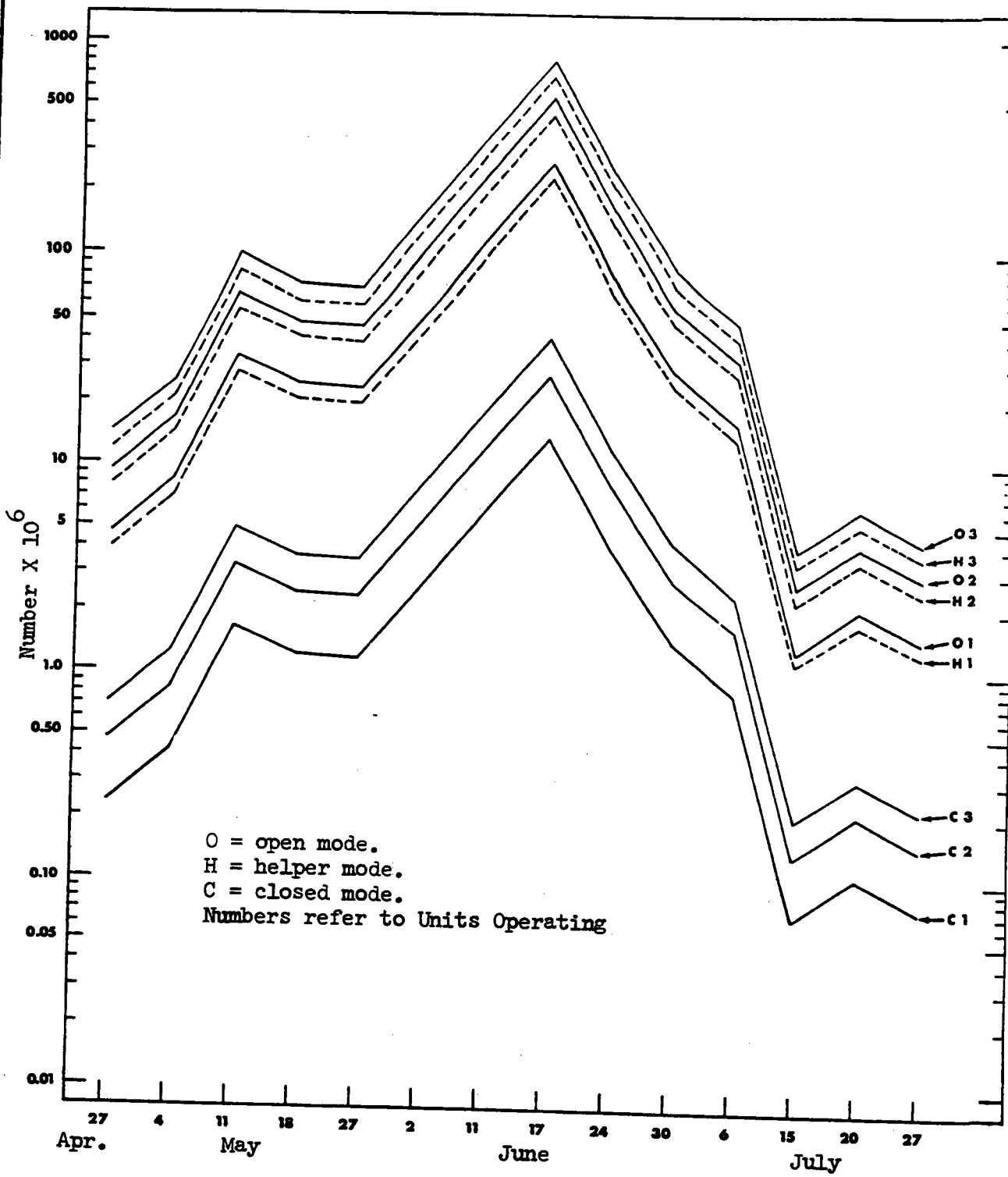

Figure 2.7-2

Estimated Daily Withdrawal and Passage of Young Fish through Condensers at BROWNS FERRY NUCLEAR STEAM PLANT

2.8 Other Impacts - The following potential environmental impact sources have been considered in addition to those discussed elsewhere in this statement.

1. Condenser cooling water intake - debris removal - The greatest portion of material collected on the travelling screens in the condenser cooling water intake structure consists of leaves, twigs, and other similar floating debris. Because of the nature of this material, it is nontoxic and generally compatible with the reservoir environment. Relatively small amounts are accumulated by the screens and very little benefit to the environment could be attributed to its collection. It is TVA's position that the cost of collection of the material would exceed the benefit it would yield to the environment.

2. Environmental effects of delays - As stated in Volume 3, adverse effects on the environment because of delays in operation of the plant will include increased emissions of particulates, sulfur dioxide, and other materials to the atmosphere at other plant sites. In addition, it was stated that delays would result in reduced system reliability, possibly resulting in the necessity to reduce loads in the TVA service area.

No specific health effects have been identified which can be attributed directly to either of these consequences. However, minimizing environmental impacts associated with the operation of power facilities and providing an adequate level of reliability in power supply minimizes the potential for any health effects which may exist.

3. Impacts on local geology - The construction and operation of the Browns Ferry plant will have no significant impact on the geology of the area.

No valuable mineral resources have been identified in the vicinity of the plant. Should resources such as gas or oil be discovered in the vicinity, the plant does not present an obstacle which would make these resources irretrievable. Data compiled[1] on wells in the vicinity show that because of the substantially high ground water profile in close proximity to the reservoir impacts on ground water usage are negligible.

4. Historical significance of site - Construction of the Browns Ferry plant required relocation of a cemetery and removal of a few structures. The relocation of the cemetery, done in 1966 and involving movement of over 50 graves, was done with considerable care and included a detailed investigation, a part of which was an exhaustive search for relatives of the interred. Complete records of all grave relocation activities were filed. The cemetery is not of large historical significance, and it has been estimated that a maximum of 2,000 visitors per year would be attracted to it. The structures which were torn down were not of major interest to preservationists or tourists.

Future construction will include preparation of the site for the mechanical draft cooling towers. This area has been investigated for historical and archaeological significance and none has been identified. However, should artifacts be discovered during any future construction operations, all appropriate agencies will be notified.

The Alabama Historical Commission has been consulted regarding these matters and has given its concurrence.

5. Impact of plant stack on air traffic - To properly disperse radioactive gaseous effluents a 600-foot stack has been incorporated into the design of the plant. Appropriate coordination with the Federal Aeronautics Administration has been made to assure that the stack would not be a hazard to aviation.

On December 15, 1966, TVA made application for a 325-foot stack to the Air Space Procedures Section, Air Traffic Branch, Federal Aeronautics Administration in Memphis, Tennessee. This application set forth the proposed location, height, painting, lighting, and other necessary information for evaluation by the FAA. Due to the addition of another generating unit and other considerations, an addendum to the original application containing the appropriate information for a 600-foot stack was filed on May 2, 1968. After review and coordination by the FAA, approval was issued on June 26, 1968, in the form of "Notice of Determination of No Hazard, Aeronautical Study No. MEM-OE-68-202."

3.0 AGENCY REVIEW COMMENTS

Responses to agency review comments are included in the topical discussions of this volume. The numbers noted in the margins of the agency comments indicate the sections in which the questions are answered.

Environmental Protection Agency
Department of Transportation
Alabama Development Office, State of Alabama
- Alabama Department of Conservation
- Alabama Historical Commission
- State of Alabama, Department of Public Health
- Comprehensive Health Department
- Bureau of Environmental Health
- Alabama Water Improvement Commission
- North Central Alabama Regional Planning and Development Commission
- Top of Alabama Regional Council of Governments
- Alabama Development Office Coordinator

Department of Commerce
Department of Agriculture
Department of Health, Education, and Welfare
Department of the Interior
Atomic Energy Commission
Federal Power Commission
Department of Housing and Urban Development
Department of the Army

AGENCY REVIEW COMMENTS KEYED TO TOPICAL DISCUSSION

Review Comment			Topical Discussion	
Agency	No.	Page No.	Section No.	Page No.
EPA	1	3.1-6	2.1.1	2.1-2
	2	3.1-6	2.1.1	2.1-2
	3	3.1-6	2.1.2(1)	2.1-5
	4	3.1-6	2.1.2(2)	2.1-6
			2.1.2(3)(a)	2.1-10
	5	3.1-6	2.1.2(4)(a)	2.1-14
			2.1	2.1-1
	6	3.1-6	2.1.2(4)(b)	2.1-16
	7	3.1-6	2.1.1	2.1-2
	8	3.1-6	2.1.2(3)(b)	2.1-12
	9	3.1-7	2.1.3(3)(b)	2.1-26
	10	3.1-7	2.4	2.4-1
	11	3.1-8	2.4.2(1)	2.4-5
	12	3.1-8	2.4.1(1)(a)	2.4-2
	13	3.1-9	2.4.1(1)(b)	2.4-2
	14	3.1-9	2.4.1(2)	2.4-4
	15	3.1-9	2.4.2(2)	2.4-6
	16	3.1-9	2.4.1(2)	2.4-4
	17	3.1-10	2.4.2(2)	2.4-6
	18	3.1-10	2.1.2(2)	2.1-6
	19	3.1-11	2.1.2(2)	2.1-6
	20	3.1-11	2.4.3(3)	2.4-11
	21	3.1-11	2.4	2.4-13
	22	3.1-11	2.3.3	2.3-3
	23	3.1-11	2.4	2.4-13
	24	3.1-11	2.4	2.4-13
	25	3.1-12	2.4	2.4-13
	26	3.1-13	2.3	2.3-9
	27	3.1-13	2.5.3	2.5-10
	28	3.1-13	2.2	2.2-1
	29	3.1-14	2.5.2	2.5-10
			2.5.1(3)	2.5-5
	30	3.1-14	2.5.1(7)	2.5-9
	31	3.1-14	2.5.1(1)	2.5-2
	32	3.1-15	2.8.1	2.8-1
	33	3.1-15	2.7.6	2.7-26
	34	3.1-16	2.7.6	2.7-26
	35	3.1-17	2.6.5	2.6-7
			2.7.3(4)	2.7-21

AGENCY REVIEW COMMENTS KEYED TO TOPICAL DISCUSSION

(continued)

Review Comment			Topical Discussion	
Agency	No.	Page No.	Section No.	Page No.
EPA	36	3.1-18	2.7.3(1)(b)	2.7-6
			2.7.3(2)	2.7-8
			2.7.3(2)(a)	2.7-9
			2.7.3(2)(d)	2.7-13
	37	3.1-18	2.7.5	2.7-25
	38	3.1-19	2.7.3(2)(c)	2.7-12
	39	3.1-19	2.7.5	2.7-25
	40	3.1-20	2.6.1	2.6-1
			2.6.3	2.6-3
	41	3.1-20	2.6	A IV-4
	42	3.1-20	2.6	A IV-9
	43	3.1-21	2.6.3	2.6-3
			2.6.7	2.6-18
	44	3.1-21	2.6.7	2.6-18
	45	3.1-21	2.6.3	2.6-3
	46	3.1-22	2.6.7	2.6-18
	47	3.1-22	2.6.6(3)(c)	2.6-15
	48	3.1-22	2.6.6(3)(e)	2.6-18
	49	3.1-22	2.6.6(3)(a)	2.6-13
	50	3.1-22	2.6.6(3)(b)	2.6-15
	51	3.1-23	8.0	8.0-1
	52	3.1-24	2.3.3	2.3-3
	53	3.1-24	2.3.3	2.3-3
	54	3.1-24	2.3.3	2.3-3
	55	3.1-25	2.3.3	2.3-3
	56	3.1-25	2.3.3	2.3-3
	57	3.1-26	2.5.5	2.5-12
	58	3.1-27	8.0	8.0-1
DOT	59	3.2-1	2.6	A IV-2
DOT	60	3.2-1	2.8.5	2.8-3
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ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 4 1972

OFFICE OF THE
ADMINISTRATOR

3.1

Mr. Lynn Seeber
General Manager
Tennessee Valley Authority
Knoxville, Tennessee 378022

Dear Mr. Seeber:

We have reviewed the Draft Environmental Statement and Supplement for the Browns Ferry Nuclear Plant, Units 1, 2, and 3, and are pleased to provide you with the enclosed report which contains our comments. Our review was performed in accordance with the requirements placed on Federal agencies by the National Environmental Policy Act of 1969.

Our review of the impact statement revealed several deficiencies which made it impossible to verify all of the conclusions reached in the draft. These deficiencies are listed in the conclusions and are described fully in our enclosed review. Before a final review can be completed, we must have access to the additional information required.

On the basis of the information presented in the Draft Environmental Statement, we believe that the major potential environmental impact of the proposed operation of the Browns Ferry plant involves the release of significant quantities of waste heat to the Wheeler Reservoir. We understand that TVA intends to comply with the applicable water temperature standards; however, we do not believe that the plant, as presently designed for once-through cooling, will meet proposed water quality standards. We question the effectiveness and feasibility of the special control measures proposed; namely, stream-flow regulation and/or reducing power level.

We believe that TVA should describe in greater detail the proposed methods of stream-flow regulation and power generation that will be used during the initial period of plant operation in order to meet water quality standards. TVA should also make a definite commitment and outline plans, including timetables, for constructing auxiliary or alternate cooling systems required to insure compliance with proposed Federal and state standards. We would appreciate the opportunity to evaluate these plans before the final environmental impact statement is filed with the Council on Environmental Quality or before fuel loading operations commence. AEC has agreed to consult with EPA before issuing a partial operating license.

Additional information on these issues and other comments are contained in the enclosed report. We would be pleased to discuss any of these comments. If we can assist you further in this matter, please let us know.

Sincerely yours,

Robert W. Fri
Deputy Administrator

Enclosure

EPA D-TVA-06018-23

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

Browns Ferry Nuclear Plant Units 1, 2, and 3

ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

December 1971

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INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency has reviewed the draft environmental impact statement for the Browns Ferry Nuclear Plant, Units 1, 2, and 3, prepared by the Tennessee Valley Authority and issued on November 8, 1971.

The following are our major conclusions:

1. On the basis of the information provided in the draft environmental statement, it is not possible to support the conclusions presented in the statement. Additional information is needed on accident analyses, thermal effects, air quality, and solid waste disposal.

2. The plant cooling water system will not allow present and proposed water temperature standards to be met without additional control measures. The statement does not present the information needed to evaluate the compatibility of the proposed control measures with other streamflow and power generation requirements.

3. We suggest that TVA follow AEC guidance in cost/benefit analysis. Such guidance is being prepared by the AEC and is in the proposed rule making stage or in final draft form.

4. We commend TVA for the decision to employ extended radioactive waste treatment systems for both gaseous and liquid effluents. Additional information on the capacity of these proposed systems to handle the waste from all three reactor units should be made available.

RADIOLOGICAL ASPECTS

Transportation of Fuel and Solid Wastes

Some 350 truck shipments per year may be required to deliver fuel assemblies and remove spent fuel and radioactive solid wastes from the Browns Ferry site. The conclusion that there will be no undue hazard to the public or adverse environmental effect from potential transportation accidents should be supported by the following information:

2.1.1 a. the most probable shipping routes between the plant and the spent fuel reprocessing plant or waste burial ground;

2.1.1 b. the major cities or other population centers enroute;

2.1.2(1)
2.1.2(2) c. the estimated radionuclide inventory per fuel assembly at the time of shipment;

2.1.2(3)(a)
2.1.2(4)(a) d. the calculated maximum dose received by an individual as well as the integrated population dose;

2.1
2.1.2(4)(b) e. the estimated probabilities of accidents.

2.1.1 In estimating the population dose due to transportation accidents, it is more appropriate to use the maximum population density of any area through which the shipment must pass rather than the average population density for the entire route. The assumption of a 100-foot minimum approach may be valid only for normal conditions and may not be realistic in the event of a serious rail accident which could attract crowds.

2.1.2(3)(b)

2.1.3(3)(b) It is important to discuss the procedures and equipment employed to transfer the spent fuel shipping cask from the vehicle used for transport from the plant to the rail car used for shipment to the

reprocessing plant. This is an off-site operation which increases the potential effect of accidents which may occur during or as a result of the transfer operation.

Waste Treatment and Effluent Discharge

2.4 The commitment of the Tennessee Valley Authority to employ extended radioactive waste treatment systems for both gaseous and liquid wastes is consistent with the need to reduce radioactive emissions to the lowest practicable level and is commended. Achievement of the lowest practicable effluent discharge requires effective administrative waste routing procedures as well as equipment installation. (We recommend that the TVA make every effort to establish procedures that will minimize radionuclide releases to the environment.)

2.4.2(1) Review of this facility indicated that additional capacity to treat high-conductivity liquid wastes was required. The proposed addition of evaporative treatment should provide sufficient capacity for routine effluents. The radionuclide reductions assumed for the operation of this equipment appear to be satisfactory and achievable in practice, providing there is no appreciable liquid carry-over in the evaporator. Recent experience with reactors of this type indicates that water leakage into the pressure suppression torus can produce appreciable volumes of contaminated liquid. The capability of the waste treatment system to handle this liquid should be discussed.

The proposed extended gaseous waste system will employ a hydrogen recombiner to reduce off-gas volume and six charcoal beds to retain noble-gas fission products; the decayed effluent will be dis-

charged through a 600 foot stack. The stated holdup times of this system are 7.7 days for xenon radioisotopes and 16.5 hours for krypton isotopes. Based upon these retention times, the calculated reductions in gaseous effluent emission rates appear to be reasonable. It is estimated that the period of full-power reactor operation with only a 30-minute gaseous effluent holdup would be approximately nine months for Unit 1 and two months for Unit 2. These systems are expected to be operative prior to the startup of Unit 3.

We agree with the decision of the Tennessee Valley Authority to reduce potential off-site radiation doses; however, it is not clear that the proposed system represents selection of equipment to obtain the lowest practicable levels of discharge. Other boiling water reactor plants are installing up to eight charcoal beds for each unit, but TVA proposes to use six for three units. Insufficient information is provided on the gas volumes and flow rates in the proposed extended gaseous holdup system to indicate the basis for the proposed design to process the effluents from three reactors.

2.4.1(1)(a) Additional information on aging characteristics and degradation of the charcoal beds should be provided and periodic testing of the
2.4.1(1)(b) retention characteristics should be performed. Estimates of the buildup of radionuclides on the charcoal beds, particularly the particulates formed from noble gas precursors, should be provided and the consequences of their possible presence on the ultimate disposal of the charcoal should be discussed.

Discharges of radioactive materials to the environment are highly dependent on the integrity of the fuel cladding. The estimates of
2.4.1(2) annual discharges found in the environmental statement (Table 19) are based on cladding perforations existing in 0.8% of fuel rods. Similar estimates of releases (prior to evaporation and/or demineralization) are provided in Table 3.1-4 of the supplement to the environmental statement, but the associated annual dose estimates (Table 3.1-5 and 3.1-6) are based on 0.5% failed fuel. Similar design releases are also found in the reply to question 9.2 in supplement 15 to the final safety analysis report but 0.25% failed fuel is assumed. In addition to these estimates, a value of 0.2% failed fuel is assumed for estimating coolant radionuclide inventories for the accident evaluation. Although different values could be accepted for design purposes and for estimates of probable releases, insufficient information is provided on actual operating experience to substantiate any of these values.

Based on Dresden I operating experience, it would appear that
2.4.2(2) the routine liquid effluents from one reactor unit would correspond with that discussed in the environmental statement for three units without the additional demineralizers or evaporator. Estimates of gaseous radionuclide release rates prior to the operation of the extended
2.4.1(2) holdup system, when compared to those released by Dresden I, are also in disagreement by a similar factor. These discrepancies may be due to the applicant's estimate of fuel cladding defects and should be resolved.

Estimates of annual discharges for individual radionuclides in
2.4.2(2) liquid effluents differ from extrapolations based on a limited number

of measurements at the Dresden plant. These differences may be partially due to reliance on theoretical decontamination efficiencies rather than on operating experience or due to differences in the design and operation of waste treatment systems between the two facilities. Existing information on specific radionuclide levels in the effluents from currently operating reactors is too limited to resolve these discrepancies. The radionuclides which may be underestimated are cesium-134, cesium-137, strontium-89, strontium-90, cobalt-58, and cobalt-60. Periodic analysis of the effluent as proposed by the Atomic Energy Commission should be employed to confirm the predicted values.

Information provided in the environmental statement supplement (p. 2-14) indicates that the reactor coolant cleanup system sludge will
2.1.2(2) have an average concentration of 8.7 curies per cubic foot while the final safety analysis report (section 9.3) indicates that the average concentration after a 60-day decay period will be 16 curies per cubic foot. It is not clear whether this reduction is due to an increased cooling time or to newer information. This difference appreciably affects the overall quantity of radioactive materials disposed of as solid waste for burial and should be discussed in greater detail.

The containers which will be used for shipment of high-level solid waste have been changed from 55 gallon drums (holding approximately
2.1.2(2) 7 cubic feet) as stated in the final safety analysis report (section 9.3) and the draft environmental statement (p. 5-46) to casks holding approximately 150 cubic feet (p. 2-14 of the environmental statement supplement). These casks are recoverable and the container used for the

burial operation is not specified or described. The integrity of this latter container is important to prevent radionuclide release from spent demineralizer resins and other materials as a result of leaching or other processes. A description of the burial container and the procedures for transferring wastes between the shipping and burial containers should be described.

Dose Assessment

The models and assumptions used to determine the radiation exposure to the surrounding population due to normal operation should be described or referenced to the appropriate sections of the final
2.4.3(3) safety analysis report. In particular, it is not clear whether the following sources of exposure were considered:

a. direct external radiation exposure from the reactor and turbine buildings;

2.4 b. radionuclides released to the atmosphere as a result of containment venting;

2.3.3 c. potential releases from coolant leakage through the reactor heat removal system;

2.4 d. radionuclides released from the condenser vacuum pumps during startup when the condenser vacuum must be re-established;

2.4 e. gland-seal leakage;

2.4 f. auxiliary building ventilation system.

Because of the addition of extended radioactive waste treatment systems which should significantly reduce the normal sources of effluents, these

usually minor sources of radiation exposure may become of primary importance in determining the ability of this facility to meet the proposed discharge criteria of the Atomic Energy Commission.

Table 2.3-2 of the environmental statement supplement indicates that the total integrated whole body dose at the site boundary for
2.3 40-year operation of three units with 0.5% failed fuel is 233 millirems (mrem). The same table indicates that operation with one unit having 1% failed fuel and two units with 0.5% failed fuel would result in an annual dose of 3.7 mrem. This would be equivalent to 148 mrem over 40 years. Because the percentage of failed fuel is higher in the latter case, it is not clear why the associated dose estimate is lower. This discrepancy should be resolved.

NON-RADIOACTIVE WASTES

2.5.3 The draft environmental statement indicates (p. 9-1) that about 2 million gallons of fuel oil will be burned per year for the operation of auxiliary boilers and generators. Assuming that low sulfur (0.2%) fuel oil will be burned, this source could produce the following effluents:

Particulates	8 tons/year
Sulfur oxides	32 tons/year
Carbon monoxide	0.04 tons/year
Hydrocarbons	5 tons/year
Nitrogen oxides	105 tons/year

The impact of these releases on regional air quality should be discussed.

2.2 It is suggested that consideration be given to the quantity of ozone produced by transmission facilities, especially the 500 kV lines, and the related impact on the environment as outlined in recent National Ambient Air Quality Standards for oxidants. The technical literature since the late 1950's contains much information on the effects of ozone on animal and human tissues and the similarity of ozone damage to that of ionizing radiation in producing chromosome aberrations. Direct extension of these animal data to the human case (with the concurrent possibility of considerable error) indicates that presently permitted industrial ozone exposure limits (up to 0.1 ppm or 4 ppm hr/week for a 40 hour work week) would be expected to result in break frequencies that are orders of magnitude greater than those resulting from permitted radiation exposure.

2.5.2 Sanitary waste treatment utilizing two parallel extended aeration plants with effluent chlorination appears adequate during the

construction period. However, during plant operation when only operating personnel and visitors are contributing wastes, underloading of the facility (even with one unit out of service) may result in inadequate treatment of the wastes. This possibility should be considered. Consideration should also be given to providing organic
2.5.1(3) waste treatment, in addition to filtration, of detergent (equipment
2.5.1(7) cleaning and decontaminating, laundry, shower, handwash, etc.) and ammonia wastes.

Procedures for handling and treating chemical wastes as described
2.5.1(1) in the environmental statement (section 5.4) are generally adequate. Sludge from the water treatment plant should not be discharged to the river but should be disposed of by landfill or some other acceptable method. Material removed from the moving screens on the condenser
2.8.1 cooling water intake should not be discharged to the reservoir. Estimates of this discharge should be provided.

MONITORING AND SURVEILLANCE

The applicant's preoperational and operational radiation monitoring
2.7.6 programs appear to be generally adequate in terms of scope, sample locations, sampling frequency, media sampled, and types of analyses performed. The maximum concentrations of iodine and particulates are predicted to occur at 2200 meters within the northwest sector which also contains the largest population group within two miles of the site. Therefore, consideration should be given to the relocation of a monitoring station to this area.

Although background sampling has been conducted in the vicinity for several years, there is no mention of current air quality in the area. The TVA air quality monitoring program should be extended to
2.5.3 cover the Browns Ferry site so that contributions of the emissions of the oil-fired generators and boilers to the over-all air quality of the region can be assessed.

Whether changes in the population structure of aquatic biota can be detected by the proposed ecological monitoring programs is highly
2.7.6 questionable. Experience has shown that drastic changes in the population structure, in the order of 25 to 50 percent, are required before current census techniques can detect population changes in reservoirs of this size; therefore, it is unlikely that monitoring programs will detect other than gross changes in the reservoir populations.

THERMAL EFFECTS

Waste heat will be removed by a condenser cooling water flow of 1,890,000 gallons per minute taken from Wheeler Reservoir. The water
2.6.5 will undergo a 25°F temperature rise during passage through the steam condenser. The design thermal criteria for the Browns Ferry Facility are based on the original Alabama Standard of 93°F maximum and a maximum rise of 10°F over ambient, which were excepted from approval by EPA predecessor agencies. Accordingly, no supplemental cooling is provided and the heated condenser water is discharged directly to Wheeler Reservoir through a diffuser system designed to provide rapid mixing of the heated condenser water with water in the reservoir. However, it is anticipated that Water Quality Standards for the Tennessee River in Alabama when promulgated by the Administrator of EPA, will provide for a maximum temperature limit of 86°F with a 5°F maximum rise criterion.

Table 3.2-1 of the supplement indicates that the facility, as presently designed, will exceed existing thermal standards during critical periods of water temperature and flow. Anticipated thermal standards will be exceeded with greater frequency. It appears, therefore, that some type of auxiliary cooling facilities will be necessary, at least for critical periods.

The supplement states (pp. 3-89, 3-90) that TVA will comply with whatever thermal standards are ultimately adopted and, until any needed auxiliary cooling facilities can be provided, will operate the Browns Ferry plant and regulate the flow of water through Wheeler Reservoir so as to meet applicable thermal standards. It is not clear from the

information provided in the statement that these proposed actions would be compatible with other power generation and streamflow requirements.

Biological Effects

Although we recognize that other agencies will provide specific comments relative to the effects of thermal discharges on important

2.7.3(4) aquatic species, EPA reviewers have identified general areas of concern.

During the period from March through May most of the important species in the reservoir will spawn. Only minor temperature rises can be tolerated by eggs that are incubating. The National Technical Advisory Committee on Water Quality Criteria in 1968 recommended provisional maximum temperatures compatible with the well-being of various species of fish and associated biota. Based on these recommendations, it appears that the sauger and small-mouth bass would be adversely affected by the thermal discharge resulting from the proposed once-through cooling system. Other game fish could also be at a disadvantage in their competition with more thermally tolerant species.

Sauger, white bass, and shad (grizzard and threadfin), three important species of fish in Wheeler Reservoir, move upstream into headwater areas and tributaries to spawn. It is questionable whether these species can move through a thermal barrier of up to 10°F above ambient without experiencing a thermal shock. Both shad and white bass move upstream to spawn in April when, according to data presented (p. 5-22 of the statement), the temperature for a distance of two miles downstream could be raised as much as 8.1°F above ambient. Also, based on the historic low flow of 10,000 cfs, temperature increases four miles down-

stream could be as high as 10 °F over ambient. It should be noted that the two species of shad found in Wheeler Reservoir are particularly susceptible to temperature fluctuations.

2.7.3(1)(b)
2.7.3(2)
2.7.3(2)(a)
2.7.3(2)(d)

Spawning, egg development, and egg hatching under undisturbed conditions are synchronized with the availability of food for the developing fry and fingerlings. Early hatching as a result of elevated temperatures will probably result in starvation and high mortality of fry, particularly of nest-building species such as large-mouth and small-mouth bass, crappie, and sunfish that spawn in the shallow overbank areas.

2.7.5

Wheeler Reservoir has been recognized as a reasonably mature aquatic system and has probably reached an equilibrium in terms of total biomass. Biomass within given food chains may also have reached equilibrium although the abundance of certain species may fluctuate widely. Thermal enrichment, within certain limits, may increase the total biomass. The increased temperature will also reduce the water's capacity for absorbing oxygen and increase the biological activity which will approximately double for each 10°F temperature rise. The combined effects of lower dissolved oxygen capacity, increased biomass, and increased respiration will be most severe in early morning just before sunrise when the dissolved oxygen concentration is at its daily minimum.

The Alabama water quality standards for interstate waters specify that the dissolved oxygen concentration of Wheeler Reservoir and waters protected for fish and wildlife shall be at or above 4 mg/l at all times. EPA has proposed that Alabama adopt somewhat more restrictive

criteria (minimum of 5 mg/l) and these are under negotiation. The environmental impact statement should discuss the effect of elevated temperatures and oxygen depletion on the aquatic biota in Wheeler Reservoir and on the ability of the reservoir to meet water quality standards after the facility reaches full operation.

Power plant cooling system intake structures and travelling
2.7.3(2)(c) screens can have a significant adverse effect on fish and other aquatic life. An evaluation of these effects at the Browns Ferry plant is not presented.

The high intake velocity of the cooling water may sweep in plankton and fish larvae and then expose them to a thermal shock
2.7.5 of 25°F. Most of these plankton and larvae will be killed and add to the organic load downstream. If the dissolved oxygen concentration decreases sufficiently, heterotrophic slime growth could be stimulated. This might be a source of taste and odor problems for public water supplies downstream, especially during summer low-flow and high temperature conditions. This situation should be discussed.

It is not always possible to predict accurately biological changes as a result of entrainment of the plankton population. The reservoir is currently highly productive, and it is conceivable that the kill of plankton through entrainment in the plant cooling water might have a beneficial effect in reducing the productivity of the reservoir, thereby also reducing the algal blooms.

Thermal Modeling

The estimates of the number of days that thermal criteria would
2.6.1 have been equaled or exceeded are low for several reasons:
2.6.3

a) Average daily releases at Wheeler Dam were used. Flow at the site is subject to variations due to hydroelectric generation at both Wheeler and Guntersville Stations, and periods of low or no flow may exist for varying periods of each day.

b) Temperatures from Wheeler Dam were used. These temperatures will tend to be below average for the water body during periods of stratification in the reservoir.

c) Proposed thermal criteria include maximum values for each month -- from a high of 86°F in the summer to a low of 51°F in January and February.

d) Figure 3.2-6 shows the heat wedge moving upstream above the
2.6 plant intake area during the low flow conditions ($Qr < 40,000$ cfs). Stream flow data for water years 1960-1964 indicated an average flow of about 32,000 cfs during summer months. This means that heat will be recycled through the plant which will result in a heat build up in the reservoir between the plant intake and outlet points.

e) Downstream surface temperature calculations are developed from
2.6 equilibrium temperatures and exchange coefficients based on monthly average meteorological data. While this provides some indication of downstream cooling trends, similar projections should be developed under both high and low flow conditions to estimate the distances from the discharge required to dissipate the heat load added to the river.

Equilibrium temperatures and exchange coefficients for critical weekly meteorological conditions should be utilized in such calculations.

Discussions of thermal characteristics of the reservoir and associated environmental effects presented in the statement and
2.6.3
2.6.7 supplement are generally based on steady-state physical modeling. However, the hydraulics and flow patterns of Wheeler Reservoir are presently controlled by the operations of the Guntersville and Wheeler Hydroelectric Stations. It would appear that steady-state conditions are seldom achieved and that periods of low or no flow probably exist frequently with varying duration. No information is presented on frequency and duration of these low or no flow occurrences, or for the resultant temperature patterns in the reservoir. Therefore, it is difficult to completely assess the associated thermal and biological effects of Brown Ferry discharges.

A minimal total river flow of 33,000 cfs is required to meet a 5°F rise criterion for three-unit operation assuming complete
2.6.7 mixing in the river. However, stratification, should it occur, will prevent total mixing unless flows are very much greater than 40,000 cfs. The estimated frequency and duration of flows at or below 33,000 cfs should be presented.

2.6.3 Temperature data for the period 1938 through 1943, summarized in

Table 12, do not provide adequate background temperature data for evaluation. Data from 1966 and 1967, as well as other available temperature data, should be included. Statistical evaluation of the 1966
2.6.7 through 1970 temperature data from Wheeler Dam also should be provided.

While the statement considers the interaction of all three Browns Ferry units, it does not provide information on possible thermal interactions between Browns Ferry and other TVA stations. Such information in the final environmental impact statement would allow a better understanding of the thermal interactions between existing power plants on the river. Estimates of plant load factors and seasonal demand curves in various future years should be included.

Alternative Cooling Methods

The evaluation of cooling towers and other alternatives for meeting
2.6.6(3)(c) thermal standards presented in the supplement would be improved if the following environmental considerations were included:

a) Upland locations for cooling towers in order to minimize siltation and further damage to the shoreline areas;

b) Diapers or other control techniques to minimize siltation during any future construction;

2.6.6(3)(e) c) Specific noise levels for mechanical draft cooling towers;

2.6.6(3)(a) d) The effects of diminished cooling water discharge on the concentrations of radioactive and chemical waste releases;

e) Supportive information on the techniques for minimizing
2.6.6(3)(b) plume drift from cooling tower operation.

COST/BENEFIT EVALUATION AND ANALYSIS OF ALTERNATIVES

8.0 The quantification of damage to the environment from a proposed or actual action is presently a relatively inexact science. Subtle changes in the surrounding ecosystems may not be readily recognized, and the conversion of a potential or real environmental effect into a dollar value is often a subjective judgement. Yet, there are techniques to quantify certain aspects of a facility's impact which can be related to a monetary value. Applicable techniques have been described in a recent draft guide issued by the Atomic Energy Commission. To this extent, a cost/benefit analysis should be provided. Effort already has been provided in the draft environmental statement supplement to quantify the costs of certain alternative radioactive waste treatment systems and cooling systems.

ABNORMAL SITUATIONS

Although TVA has addressed the possible consequences of postulated accidents at the Browns Ferry plant which could release radioactive
2.3.3 materials to the environment, the probabilities of occurrence of these accidents have not been adequately discussed. Consideration must be given to quantifying these probabilities, where possible, because the expected environmental risk due to potential accidental radionuclide releases is determined by the consequence of the release and the associated probability of occurrence. For the less severe accidents, the probability might be estimated by combining the observed probabilities of the component events as obtained from operating experience. In the case of the more serious accidents, where there is no applicable experience, reliability analysis could be employed to estimate the probability of occurrence.

Class 1 accidents are almost certain to occur and, in the case of volatile fission products which will ultimately be purged to the atmos-
2.3.3 phere, the consequences can be considered trivial only if an upper limit on the quantity of radioactive material involved is specified. The consequences of a class 9 accident are serious enough that probability-of-occurrence estimates should be investigated to strengthen the assumption that the expected environmental impact is negligible.

There appear to be inconsistencies between the assumptions employed for the estimation of radiation doses from potential accidents in the
2.3.3 final safety analysis report and the draft environmental statement supplement. The assumptions and models used for accident analysis

should be referenced to the applicable portions of the safety analysis report or otherwise described. Among the discrepancies which should be resolved are the following:

a. An iodine partition factor of 10,000 is assumed in the draft environmental statement for the control rod drop accident; in the final safety analysis report (Table 14.9-2) a value of 100 is assumed.

b. A value of 0.2% for the number of fuel rods which have defective cladding is used to predict the coolant radionuclide inventory for
2.3.3 accident evaluations. This value is less than the value of 0.5% assumed for the estimation of effluents under normal conditions.

c. The adverse meteorological conditions assumed in the draft environmental statement supplement appear to produce radiation doses
2.3.3 which differ by only a factor of seven or eight from dose estimates calculated using annual average meteorological conditions. The use of the most limiting meteorological conditions for both annual average and short-term dispersion indicates that this ratio should be greater than 100. The assumptions used for the adverse condition should be explicitly stated.

The list of agencies consulted by TVA in the preparation of an emergency plan for both on-site and transportation accidents indicates that TVA has consulted the appropriate Federal, state, and local agencies required to implement protective action in the event of a radiological emergency. It is important that the final emergency plan be approved by the participating state agencies prior to initial fuel loading.

2.5.5 Storage and transportation methods and procedures to prevent the contents or a ruptured tank or accidental leakage or spillage of oil or other hazardous materials from reaching surface watercourses should be presented. Discussions should include an analysis of the possibility and probable quantities of materials which could be discharged due to earthquake, flood, tornado, plant malfunction, human error, or other abnormal occurrences.

8.0 GENERAL DEVELOPMENT IMPLICATIONS

As a result of the additional electrical power provided by this plant it is anticipated that there will be increased population and industrial growth in this region. This growth, should it occur, will place additional demands on the available water supply and may contribute to air and water quality degradation and other environmental problems.

TVA, as a regional planning agency with considerable experience and knowledge on the relationship between social and natural systems, should take steps to help develop, through interaction with municipal, state, and Federal agencies, a land and water use plan for the region. This plan should be designed to achieve a balance between population and resource use of the region which will permit a high standard of living and a quality environment.

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (WS)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: 202 426-2262

27 AUG 1971

Dr. F. E. Gartrell
Director of Environmental
Research and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

This is in response to your letter of 15 July 1971 addressed to Mr. Herbert F. DeSimone, Assistant Secretary for Environment and Urban Systems, Department of Transportation, concerning the draft environmental impact statement for the Browns Ferry Nuclear Plant, Units 1, 2 and 3, located on the North Shore of Wheeler Reservoir on the Tennessee River, Limestone County, Alabama.

3.2

2.6(A-IV-2) The concerned operating administrations and staff of the Department of Transportation have reviewed the draft statement. It is the determination of this Department that the impact of this project upon transportation is minimal. Page 5-5 of the draft statement states that navigation channel markers will indicate the location of safe water depths over the diffuser piping. Since the U. S. Coast Guard is charged with the responsibility for installation, maintenance and operation of aids to navigation upon the navigable waters and in view of the lack of an indication in the draft statement of any coordination with the Coast Guard on this aspect of the project, it is requested that this matter be taken up with the Commander, 8th Coast Guard District in New Orleans, Louisiana.

2.8.5 Figure 4 under the list of figures shows the artist's concept of the Browns Ferry Nuclear Facility. A large stack is depicted. Nowhere in the report is there an indication of the height of this stack and it may possibly be a hazard to air navigation and should be discussed with the Federal Aviation Administration Regional Office in Atlanta, Georgia. Page 7-4 of the draft statement discusses future alternatives and the possible use of cooling towers. This Department would have some concern should cooling towers be planned, especially as it concerns air navigation hazard (height) and possible fog and icing of highways and bridges. It is assumed that should cooling towers be seriously considered in the future, the environmental impact statement will address itself to these possible adverse effects.

This Department recommends completion of the project. The environmental impact statement appears to address itself to those possible problem areas that may represent a concern to the Department of Transportation.

The opportunity to review and comment on the draft environmental impact statement for the Browns Ferry Nuclear Plant, Units 1, 2 and 3 is appreciated.

Sincerely,

W. M. BENKERT
Captain, U. S. Coast Guard
Acting Chief, Office of Marine
Environment and Systems

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (WS/83)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: (202) 426-2262

14 December 1971

Dr. F. E. Gartrell
Director of Environmental
Research and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

This is in response to your letter of 8 November 1971 addressed to Mr. Herbert F. DeSimone, Assistant Secretary for Environment and Urban Systems concerning the supplement and additions to the draft environmental impact statement of the Browns Ferry Nuclear Plant Units 1, 2 and 3 located on the north shore of Wheeler Reservoir on the Tennessee River, Limestone County, Alabama. The original draft statement for this project was previously reviewed by the Department of Transportation as indicated in our letter to you of 27 August 1971.

The supplement and additions to the draft statement for the Browns Ferry Nuclear Project were reviewed by both the staff and concerned operating administrations of the Department of Transportation.

The following is noted from the review of the Federal Railroad Administration:

2.2.2 "We are pleased to see the environmental impact of new transmission lines discussed in such detail. However, the question of inductive coupling or direct faulting with the signal and communication lines of railroads is not addressed. We would suggest that the statement reflect that there are neither railroads involved or that satisfactory protection has been mutually agreed upon with any railroad company involved."

Noted in the review of the Department's Office of Hazardous Materials was the following:

"Although we have no specific comment on the supplement or the additions, we do note, however, that the supplement discusses the transport of nuclear materials in significantly greater detail than any of the other environmental impact statements which have been seen previously. While it is difficult to evaluate the content of the statement relative to transport, the supplement is not inconsistent with existing AEC and DOT regulatory requirements or industry practices."

The supplement and additions also address themselves to those transportation concerns which were pointed out to you in our letter of 27 August 1971.

The Department of Transportation concurs in the project and recommends early completion.

The opportunity to review and comment on the supplement and additions to the draft environmental impact statement on the Browns Ferry Nuclear Project Units 1, 2 and 3 is appreciated.

Sincerely,

J. M. AUSTIN
Deputy Chief, Office of Marine
Environment and Systems
By direction of the Commandant

3.3-1

STATE OF ALABAMA

ALABAMA DEVELOPMENT OFFICE

R. C. "RED" BAMBERG, Director

GEORGE C. WALLACE
Governor

September 8, 1971

9/10/71
CC: M. I. Foster
A. J. Gray
R. H. Marquis, 629 NSB-K
T. H. Ripley, FOR, Norris
F. E. Gartrell, 720 EB-C, (original)
C. M. Stephenson
J. E. Watson, 818 PRB-C
ND&RS Files, 604 AB

TO: Mr. M. I. Foster, Director
Division of Navigation Development & Regional Studies
Tennessee Valley Authority
Knoxville, Tennessee 37902

H. P. K. Walmsley

FROM: H. P. K. Walmsley
Administrator
Grant and Reference Services
State Clearinghouse

P-4 E-11 Brown's Ferry Nuclear Plant Units 1, 2 & 3

3.3

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT

Applicant: Tennessee Valley Authority

Project: Draft Environmental Statement – Brown's Ferry Nuclear Plant Units 1, 2 & 3

State Clearinghouse Control Number: ADO-84-71

The Draft Environmental Impact Statement for the above project is in the process of review by the appropriate State agencies in accordance with Office of Management and Budget Circular A-95, Revised.

The comments received to date from the reviewing agencies are attached. Additional comments will be forwarded as they are received.

Please contact us if we may be of further assistance. Correspondence regarding this proposal should refer to the assigned Clearinghouse Number.

Attachments

A-95/05: DE

STATE OF ALABAMA

ALABAMA DEVELOPMENT OFFICE

R. C. "RED" BAMBERG, Director

GEORGE C. WALLACE
Governor

September 24, 1971

TO: Mr. M. I. Foster, Director
Division of Navigation Development & Regional Studies
Tennessee Valley Authority
Knoxville, Tennessee 37902

FROM: H. P. K. Walmsley
Administrator
Grant and Reference Services
State Clearinghouse

P-4 E-11 Browns Ferry Nuclear Pl. Units 1, 2, + 3

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT

Applicant: Tennessee Valley Authority

Project: Draft Environmental Impact Statement
Browns Ferry Nuclear Plant Units (1), (2) and (3)

State Clearinghouse Control Number: ADO-84-71

The Draft Environmental Impact Statement for the above project has been reviewed by the appropriate State agencies in accordance with Office of Management and Budget Circular A-95, Revised.

All of the comments received from the reviewing agencies have now been forwarded for your consideration.

Please contact us if we may be of further assistance. Correspondence regarding this proposal should refer to the assigned Clearinghouse Number.

Attachments

A-95/05:DE
cc: Department of Conservation
Historical Commission
Comprehensive Health Department
Bureau of Environmental Health
Mr. Gary Volketz - North Central Alabama Regional Planning & Development Commission
Mr. Dean Matthews - Top of Alabama Regional Council of Local Governments
Mr. Richard Dowdy - Alabama Development Office Coordinator
Mr. Ed Hudspeth - Alabama Development Office Coordinator

STATE OFFICE BUILDING • MONTGOMERY, ALABAMA 36104 • (205) 269-7171

REQUEST FOR REVIEW OF PROJECT NOTIFICATION

TO:

Mr. Reynolds Thrasher
Conservation Department

CH Number ADO-84-71

Applicant Tennessee Valley Authority

Program Environmental Impact Statement
Browns Ferry Nuclear Plant — Units 1,2 & 3

DATE: August 3, 1971

Return Prior to: August 16, 1971
Date

Please review the attached notification of intent to apply for Federal funds, and indicate your comment below. Consideration should be given to conformance with other plans or projects proposed or in effect.

ALABAMA DEVELOPMENT OFFICE
AUG 27 1971
STATE CLEARING HOUSE

Comments: (Please check one block.)

- [ ] No Interest
- [ ] Concur
- [ ] Need More Information (explain below)
- [ ] Cannot Concur (explain below)

Additional Comments:

See attached comments from the Game and Fish Division.

Signature

Please Return Original to:
Alabama Development Office
Office of State Planning
State Clearinghouse
State Office Building
Montgomery, Alabama 36104

FORM CH-2
9/70

ALABAMA DEPARTMENT OF CONSERVATION

64 North Union Street - Montgomery, Alabama 36104

CLAUDE D. KELLEY
DIRECTOR
SIDNEY B. BLEDSOE
ASSISTANT DIRECTOR

August 25, 1971

DIVISION OF GAME & FISH
CHARLES D. KELLEY, CHIEF

MEMORANDUM TO: Mr. Reynolds W. Thrasher, Chief
Bureau of Outdoor Recreation

FROM: Ralph H. Allen, Jr., Chief
Game Management Section

Ralph H. Allen Jr

SUBJECT: Environmental Impact Statement On Browns Ferry Nuclear Plant - TVA

Game and Fish personnel have reviewed the TVA's Environmental Impact Statement on the Browns Ferry Nuclear Plant and offer the following comments.

TVA states several times in the report that they will meet any future applicable temperature standards. They apparently used the figures of 95° F. maximum and 93° F. average cross section and a 10° F. rise in designing the plant. They state (Page 5-10) that "These temperature limits have been used in design and are in line with those accepted by the Alabama Water Improvement Commission". A temperature maximum of 95° F. has not been accepted by the Alabama Water Improvement Commission. These figures are not in line with the temperatures recommended by the National Technical Advisory Committee for waters supporting populations of largemouth bass, smallmouth bass, crappie, bluegill, walleye and sauger. On Page 3-14 TVA states that "Investigations have shown the following fish to be important to sport use: largemouth bass, smallmouth bass, spotted bass, white bass, crappie, bluegill and sauger". Why didn't TVA use this outstanding report to design their plant so as to prevent damage to the valuable sport fishery resources rather than design for the maximum temperatures expected to be approved by the Alabama Water Improvement Commission? On Page 4-1 is the statement that TVA has consulted with several Federal, State and local agencies and officials since 1966 in the planning and construction of the Browns Ferry Plant. The Alabama Department of Conservation is listed as one agency with which they consulted. It is sufficient to say that they did not follow our advise concerning water temperatures maximums which we recommended. Mr. Churchill and Mr. Derryberry have attended several meetings where the Game and Fish Division officially recommended water temperature maximums of 90° F. for fish and wildlife waters and a maximum of 86° F. for waters containing sauger, walleye, or smallmouth bass. All three of these species are found in Wheeler Reservoir.

Memo to: Mr. Reynolds W. Thrasher
August 25, 1971
Page Two

TVA's temperature data listed in Tables 10, 11 and 12 support our recommendations of 86° F. maximum for the Tennessee River. Table 12 lists only one surface temperature reading (at Mile 305) above 86° F. for the period of 1938 through 1943. Table 11 lists the highest observed temperature reading at
2.7.3(1)(a) Mile 300.3 as 83.1° F. during the period May, 1964 to May, 1965. Table 10 shows 84° F. as the maximum (at 1 ft.) temperature recorded at Mile 277.0 for 1964-65. On Page 3-18 TVA states that "Temperature data at Tennessee River Mile 305.0, collected by TVA's Hydraulic Data Branch during 1938 through 1943 indicates the temperature pattern observed one year is very similar to that observed in other years". On Page 7-3 is the statement that "TVA's experience at all of its steam plants, and particularly at Paradise, indicates that a maximum temperature of 93° F. and a 10° F. rise should adequately protect aquatic life in the Tennessee River". This statement, of course, does not agree with the National Technical Advisory Committee's recommendations for the fish species found in the Tennessee River. There is no scientific research that I know of which indicates 93° F. is suitable for game fish such as largemouth bass, smallmouth bass, sauger, crappie and walleye.

The Browns Ferry Plant is designed to have a 25° F. rise in the condensers. TVA admits that this will kill fish larva and other desirable organisms. The report attempts to rationalize this with statements such as the following one found on Page 5-27; "However, since only ten percent of the water passing the site at mean annual flow passes through the condensers, any adverse effects are not expected to be significant." The three units pump 1,980,000 gallons per minute. This amounts to about 360 ac. ft. of water per hour and 8,640 ac. ft. of lake water per 24 hour day. I doubt that the destruction of fish larvae and desirable fish food organisms in 8,640 ac. ft. of Wheeler Reservoir water each day is insignificant.

On Page 5-16 of the report, mention is made of the use of a polymer which will be discharged to the river. No data is given that indicates studies
5.1(1) have been made that insure no toxicity or fish residue problems will result from such discharges. I think the following question requires an answer from TVA: Will the construction and operation of Browns Ferry Nuclear Plant result in any fish contamination problem such as we are not experiencing with mercury and PCB?

On Page 5-3 is the statement that "There is little likelihood that the warm water discharges would result in any adverse effect on water-contact recreation in Wheeler Reservoir". On Pages 4 and 13 of the National Technical Advisory
.6.1 Committee report is the recommendation that "In primary contact recreation waters, except where caused by natural conditions, maximum water temperatures should not exceed 30° C. (85° F.)". TVA designed this plant to raise the water temperature up to 93° F. As a professional fishery biologists this is somewhat out of my field. My only purpose for mentioning this is to point out one other area where TVA's statements conflict with the recommendations of such groups as the National Technical Advisory Committee.

Memo to: Mr. Reynolds W. Thrasher
August 25, 1971
Page Three

On Page 5-4 TVA states that "Although during some months fish may avoid the immediate area of the plant discharges, in the winter the fish are likely to be attracted to the warm water". It appears that this statement is intended to imply that the benefits of heat for attracting fish in winter offset any summer damage while actually this abnormal concentration may pose a greater danger to the future abundance of certain desirable species. Certain important sport species that spawn in winter or early spring such as walleye and sauger will be attracted to the heated area during the time of year when they should be on their spawning migration. It is still unknown what effect this exposure to heated water will have on the development of sexual products of such fish. I do not believe TVA's biological studies are designed to answer this important question. If this exposure hinders or prohibits successful reproduction of sauger or walleye, then a series of such heated discharges could eventually eliminate a fishery for such species. 2.7.3(1)(a) 2.7.3(1)(b)

Several statements in the report indicate that TVA is concerned over the amount of radioactive material that will be released from the plant into the environment. Apparently this concern over the release of materials from nuclear plants is shared by such renown nuclear experts as Dr. George L. Weil, Nuclear Consultant of Washington, D. C., as indicated by the enclosed clipping which appeared in the Montgomery Advertiser on August 22, 1971.

RHA:jcb

Approved:

Charles D. Kelley, Chief
Game and Fish Division

cc: Mr. Sam Spencer

A-Plants Are Called 'Dangerous'

SEATTLE (AP) — A nuclear energy consultant says the Atomic Energy Commission and utility companies are misleading the public about the risk involved in nuclear power plants.

Dr. George L. Weil, a nuclear energy consultant from Washington, D.C., said nuclear power plants are dangerous, expensive and are only a short-term solution to power needs.

He said nuclear power plants contain "monumental amounts" of radioactive materials which must be contained. AEC studies have shown that accidents at some nuclear facilities could kill "Tens of thousands of people, cause many billion dollars worth of damage and make the area uninhabitable," Weil said.

"If the public wants to take the risks involved with nuclear power," Weil said, "they should know what the risks are — but they are being totally misled by the Atomic Energy Commission, the utility companies and others."

R/

REQUEST FOR REVIEW OF PROJECT NOTIFICATION

TO:

Mr. W. Warner Floyd
Historical Commission

CH Number ADO-84-71

Applicant Tennessee Valley Authority

Program Environmental Impact Statement
Browns Ferry Nuclear Plant -- Units 1,2 & 3

DATE: August 3, 1971

Return Prior to: August 16, 1971
Date

Please review the attached notification of intent to apply for Federal funds, and indicate your comment below. Consideration should be given to conformance with other plans or projects proposed or in effect.

ALABAMA DEVELOPMENT OFFICE
SEP 10 1971
STATE CLEARING HOUSE

Comments: (Please check one block.)

- ☐ No Interest
- ☐ Concur
- ☐ Need More Information (explain below)
- ☐ Cannot Concur (explain below)

Additional Comments:

The Alabama Historical Commission cannot accurately appraise the environmental impact of the Brown Ferry project upon the historic resources of this area because our agency had no opportunity to review the project until the demolition of old structures and the construction of the project had been completed. 2.8.4

W. Warner Floyd
Signature

Please Return Original to:
Alabama Development Office
Office of State Planning
State Clearinghouse
State Office Building
Montgomery, Alabama 36104

FORM CH-2
9/70

STATE OF ALABAMA

ALABAMA HISTORICAL COMMISSION
305 SOUTH LAWRENCE STREET
MONTGOMERY, ALABAMA 36104

W. WARNER FLOYD
EXECUTIVE DIRECTOR

TELEPHONE NUMBER
269-6839

March 16, 1972

P-4 Browns Ferry Nuclear Plant
E-11 Units 1, 2 & 3

Mr. George R. DeVeny
Regional Planner
Division of Navigation Development
and Regional Studies
Tennessee Valley Authority
Knoxville, Tennessee 37902

Dear Mr. DeVeny:

We have consulted with local preservations in the area of the Brown's Ferry Nuclear Plant and have found nothing which will be adversely affected by the addition to the plant.

The original construction of the plant required the relocation of an old cemetery which contained the graves of several early pioneers. Properly restored and preserved the cemetery would have attracted only approximately 2,000 visitors a year. While complete restoration of the cemetery would not have been feasible, it is our opinion that the cemetery was relocated with considerable care.

Structures located on Tract 13, several of which are over 50 years old, were, in our judgement, not of major interest to preservationists and tourists.

Sincerely,

W. Warner Floyd

W. Warner Floyd

WWF/jan

ALABAMA DEVELOPMENT OFFICE
SEP 22 1971
STATE CLEARING HOUSE

REQUEST FOR REVIEW OF PROJECT NOTIFICATION

TO:

Mr. Preston Blanks
Comprehensive Health

CH Number ADO-S4-71

Applicant Tennessee Valley Authority

Program Environmental Impact Statement
Browns Ferry Nuclear Plant — Units 1,2 & 3

DATE: August 3, 1971

Return Prior to: August 16, 1971
Date

Please review the attached notification of intent to apply for Federal funds, and indicate your comment below. Consideration should be given to conformance with other plans or projects proposed or in effect.

Comments: (Please check one block.)

- [ ] No Interest
- [x] Concur
- [ ] Need More Information (explain below)
- [ ] Cannot Concur (explain below)

Additional Comments:

Concur subject to questions raised in memorandum from Mr. Arthur Beck, State Health Department, to ADO, this subject.

C. Preston Blanks Jr.
Signature

Please Return Original with Draft Statement to:
Alabama Development Office
Office of State Planning
State Clearinghouse
State Office Building
Montgomery, Alabama 36104

FORM CH-2
9/70

REQUEST FOR REVIEW OF PROJECT NOTIFICATION

TO:

Mr. A. N. Beck, Director
Bureau of Environmental Health

CH Number ADO-S4-71

Applicant Tennessee Valley Authority

Program Environmental Impact Statement
Browns Ferry Nuclear Plant — Units 1,2 & 3

DATE: August 3, 1971

Return Prior to: August 16, 1971
Date

Please review the attached notification of intent to apply for Federal funds, and indicate your comment below. Consideration should be given to conformance with other plans or projects proposed or in effect.

Comments: (Please check one block.)

- ☐ No Interest
- ☒ Concur
- ☐ Need More Information (explain below)
- ☐ Cannot Concur (explain below)

Additional Comments:

See attached statements.

Signature

Please Return Original to:
Alabama Development Office
Office of State Planning
State Clearinghouse
State Office Building
Montgomery, Alabama 36104

FORM CH-2
9/70

State of Alabama
Department of Public Health
State Office Building
Montgomery, Alabama 36104

IRA L. MYERS, M. D.
STATE HEALTH OFFICER

August 31, 1971

M E M O R A N D U M

TO: Alabama Development Office

FROM: Mr. A. N. Beck

SUBJECT: ADO-84-71, Environmental Impact Statement Browns Ferry Nuclear Plant

As a result of the review by the members of the Bureau of Environmental Health the following questions need resolving prior to completing our determinations:

1. In order to determine if any air pollution or pollution effects may be generated by the operation of this plant we need to know what types of fuel oil or fuel gas is to be burned in the auxiliary boilers along with the quantities and the altitude of the stack through which these boilers discharge. Further, if there is an incinerator proposed for the site we need to know the type, the amount of material to be burned in the incinerator, and the number of chambers in the incinerator. 2.5.3 2.5.4

2. A review of the Environmental Statement and the final Safety Analysis Report does not indicate how normal solid waste materials are to be disposed of. We request the applicant supply this information so that we can determine the effects of solid waste on the environment. 2.5.4

3. Although the applicant has indicated that he is going to put in "An advanced rad waste system". This system will not be operational when Unit I becomes operational. Further, the applicant indicates a tentative time schedule for the gaseous radwaste system, but does not indicate a time schedule for the completion of the liquid "Advanced rad waste system". We request a time schedule from the applicant for this liquid advanced rad waste system. It should be noted that projected radiation doses to the environs will be in excess of those in the proposed Appendix I to 10 CFR Part 50 until the "Advanced rad waste systems" are in operation.

STATE OF ALABAMA

WATER IMPROVEMENT COMMISSION

ROOMS 324-326
STATE OFFICE BUILDING
MONTGOMERY 4, ALABAMA

IRA L. MYERS, M. D.
CHAIRMAN

ARTHUR N. BECK
TECHNICAL SECRETARY

September 2, 1971

MEMORANDUM

TO: Alabama Development Office

FROM: Arthur N. Beck, Technical Secretary, Water Improvement Commission

SUBJECT: CH No. ADO-84-71, Draft Environmental Statement by Tennessee Valley Authority on Browns Ferry Nuclear Plant, Units 1, 2 and 3

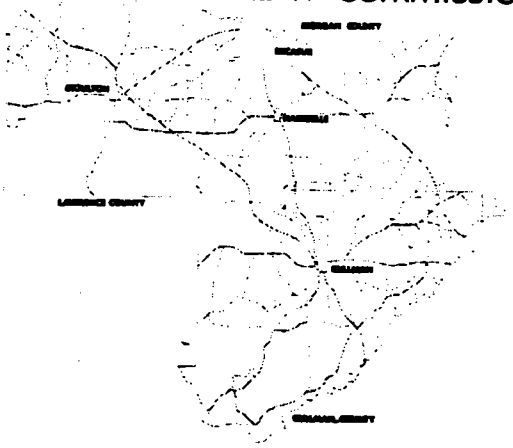
A review of the Tennessee Valley Authority's Draft Environmental Statement, Browns Ferry Nuclear Plant, reveals that the impact of the operation of this plant on water quality will be principally limited to thermal effects with other factors being inconsequental. The method for handling the discharge of condenser cooling waters, that of dispersion through diffusers, was selected by TVA on the basis of water quality standards adopted by the Alabama Water Improvement Commission and considerable investigation into the efficiency of diffusion of heated water within Wheeler Reservoir of the Tennessee River. Water quality standards adopted by the Alabama Water Improvement Commission in 1967 as related to thermal discharges permitted a maximum temperature in waters receiving cooling water discharges of 93°F after reasonable mixing. These standards further limited the temperature rise to not more than 10°F. The above standards were not approved by the appropriate Federal agency as indicated in TVA's environmental statement. Furthermore, the Environmental Protection Agency held a water quality standards conference for interstate waters within Alabama on April 5-7, 1971, during which conference the Environmental Protection Agency recommended that the maximum temperature rise resulting from the discharge of heated water shall not exceed 5°F in streams and 3°F in the surface waters of lakes and reservoirs. The recommendations of EPA also limited the maximum temperatures for streams and reservoirs supporting smallmouth bass, sauger and walleye to 86°F during the summer months. Subsequent discussions regarding temperature standards have led to the tentative proposal of a temperature standard limiting the maximum temperature rise to 5°F and the maximum temperature to 86°F in waters supporting smallmouth bass, sauger and walleye. The above restrictions would apply after reasonable mixing of heated waters with the receiving stream or reservoir. Since the Tennessee River is regarded as a smallmouth bass, sauger and walleye fishery, the above temperature standards, if adopted by the State and Federal Government, would apply to that portion of the Tennessee River into which cooling waters from the Browns Ferry Nuclear Plant would be discharged.

The Tennessee Valley Authority recognizes the probability of revisions in temperature standards originally adopted by the Alabama Water Improvement Commission and states that it will meet any future applicable standards for the Tennessee River as it may be affected by the discharge of cooling waters from the Browns Ferry Nuclear Plant. In view of the fact that definitive temperature standards are yet to be officially adopted by either the State or the Environmental Protection Agency, the commitment of TVA to meet any future applicable temperature standards is satisfactory to the Alabama Water Improvement Commission.

ANB/cbw

NORTH CENTRAL ALABAMA REGIONAL PLANNING & DEVELOPMENT COMMISSION

5th Floor
City Hall Tower
402 Lee St.,N.E.
Decatur, Alabama 35601
P.O. Box 1069



GARY L. VOKETZ
EXECUTIVE
DIRECTOR
205-355-4515

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August 6, 1971

Mr. M. I. Foster, Director
Division of Navigation Development
and Regional Studies
Tennessee Valley Authority
Knoxville, Tennessee 37902

P-4 Browns Ferry Nuclear Plant,
E-11 Units, 1, 2 + 3

Dear Mr. Foster:

This is to inform you that the North Central Alabama Regional Planning and Development Commission, functioning in its role as the "Regional Clearinghouse", has completed the review of TVA's Draft Environmental Statement for Browns Ferry Nuclear Plant Units 1, 2 and 3.

The review was conducted in accordance with the Bureau of the Budget's Circular A-95 and took into consideration the consistency of the project with regional plans and the environmental aspects that the project has as related to the North Central Alabama Region.

In regard to the review of the project, I wish to make the following comments:

1. The project and the environmental impact it will have will not have any adverse affect on regional land use plans of the NCARP & DC.

2. TVA, as has been the case for many years, is concerned with planning and development throughout the Tennessee Valley. This concern has remained evident as related to the Browns Ferry Nuclear Plant project. Consultation with the regional planning agencies of north Alabama concerning the project has been held since the beginning of the project. TVA continues to maintain an effective continuing working relationship with these agencies, always considering their concerns.

Mr. M. I. Foster
Page 2
August 6, 1971

3. The project, as described in the Environmental Impact Statement you furnished this office, is in conformity with comprehensive plans of the North Central Alabama Regional Planning and Development Commission.

4. Upon the review of the project, we have determined to the best of our knowledge that you have considered and incorporated means of achieving state, regional and local objectives related to a project of this nature, as specified in Section 401(a) of the Intergovernmental Cooperation Act of 1968.

If we may be of further assistance, please advise.

Yours truly,

Scott Maples

Scott E. Maples
Planner

for

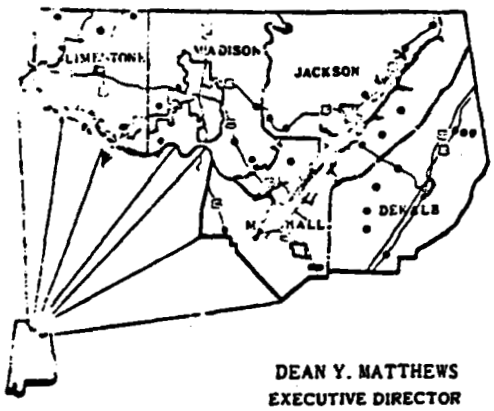
Gary L. Voketz
Executive Director

SEM:lm

cc: Director
Division of Radiological
and Environmental Protection
Atomic Energy Commission
Washington, D. C. 20545

Mr. Dean Y. Matthews, Director
Top of Alabama Regional Council
of Governments
Huntsville, Alabama 35801

Mr. H. P. K. Wamsley
Alabama Development Office
Montgomery, Alabama 36104



Top of Alabama Regional Council of Governments

A NON-PROFIT CORPORATION

P. O. BOX 308
HUNTSVILLE, ALABAMA 35804

6th FLOOR - CITY HALL
TELEPHONE 205/536-3388

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ORVILLE J. VANDERGRIFF

BURWELL WILBANKS

HOYT WILSON

August 11, 1971

ALABAMA DEVELOPMENT OFFICE
AUG 13 1971
STATE CLEARING HOUSE

Mr. M. I. Foster, Director
Division of Navigation Development
and Regional Studies
Tennessee Valley Authority
Knoxville, Tennessee 37902

ADO-84-71

Dear Mr. Foster:

This is to advise that we have reviewed the Environmental Impact Statement Draft of the Tennessee Valley Authority regarding the Browns Ferry Nuclear Plant Units 1, 2, and 3.

We are quite impressed with the extensive attention given to all aspects of the Browns Ferry facility and its effects on the environment.

We concur wholeheartedly in the continued construction and operation of this facility.

It is our belief that the Browns Ferry Nuclear Plant is a national asset costing 1/2 billion dollars which will help supply a critical demand for power. The generation of electric power through nuclear energy is, in our opinion, much less damaging to the environment than through the use of fossil fuels.

It is further noted that there has been little or no adverse public reaction to the Browns Ferry Nuclear Plant within our region. We subscribe to 9 area newspapers.

Sincerely,

Dean Y. Matthews

Dean Y. Matthews
AIA, Director

DYM/vgp
cc: Mr. H. P. K. Walmsley
Director, Atomic Energy Commission

REQUEST FOR REVIEW OF PROJECT NOTIFICATION

TO:

Mr. Dick Dowdy
ADO

CH Number ADO-84-71

Applicant Tennessee Valley Authority

Program Environmental Impact Statement
Browns Ferry Nuclear Plant -- Units 1,2 & 3

DATE: August 3, 1971

Return Prior to: August 16, 1971
Date

Please review the attached notification of intent to apply for Federal funds, and indicate your comment below. Consideration should be given to conformance with other plans or projects proposed or in effect.

Comments: (Please check one block.)

- [ ] No Interest
- [x] Concur
- [ ] Need More Information (explain below)
- [ ] Cannot Concur (explain below)

ALABAMA DEVELOPMENT OFFICE
AUG 9 1971
STATE CLEARING HOUSE

Additional Comments:

Concur provided TVA continues to try and minimize adverse environmental effects.

RLW
Signature

Please Return Original with Draft Statement to:
Alabama Development Office
Office of State Planning
State Clearinghouse
State Office Building
Montgomery, Alabama 36104

FORM CH-2.
9/70

REQUEST FOR REVIEW OF PROJECT NOTIFICATION

TO:

Dr. Ken Johnson
ADO

CH Number ADO-84-71

Applicant Tennessee Valley Authority

Program Environmental Impact Statement
Browns Ferry Nuclear Plant — Units 1,2 & 3

DATE: August 3, 1971

Return Prior to: August 16, 1971
Date

Please review the attached notification of intent to apply for Federal funds, and indicate your comment below. Consideration should be given to conformance with other plans or projects proposed or in effect.

Comments: (Please check one block.)

- ☐ No Interest
- ☑ Concur
- ☐ Need More Information (explain below)
- ☐ Cannot Concur (explain below)

Additional Comments:

ALABAMA DEVELOPMENT OFFICE
AUG 18 1971

Signature

Please Return Original to:
Alabama Development Office
Office of State Planning
State Clearinghouse
State Office Building
Montgomery, Alabama 36104

FORM CH-2
9/70

THE ASSISTANT SECRETARY OF COMMERCE
Washington, D.C. 20230

September 20, 1971

Dr. Francis E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

Please refer to the draft environmental impact statement prepared by TVA for Browns Ferry Nuclear Plant, Units 1, 2 and 3.

The enclosed comments, prepared by the National Oceanic and Atmospheric Administration of the Department of Commerce, are presented for your consideration in preparing the final environmental impact statement. You will note that NOAA has attached a copy of an earlier set of comments developed in 1966 by the Institute for Atmospheric Sciences with reference to the Design and Analysis Report (Volumes I and II) of the same Browns Ferry Project.

Sincerely,

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Enclosure

Comments on

Draft Environmental Statement

by
Tennessee Valley Authority
for
Browns Ferry Nuclear Plant Units 1, 2 and 3

Prepared by

Air Resources Environmental Laboratory
National Oceanic and Atmospheric Administration
August 13, 1971

At the request of the U. S. Atomic Energy Commission, Division of Reactor Licensing, comments on the meteorological aspects of the Preliminary Safety Analysis Report for the Browns Ferry facility were prepared by this Laboratory and transmitted to the AEC on September 27, 1966, a copy of which is attached. Currently, again at the request of the AEC, the Final Safety Analysis Report (FSAR) is under evaluation by this Laboratory.

As pointed out in the attached comments, the controlling diffusion condition for the routine effluent emission from the 183-meter stack is one of rapid rather than poor diffusion. From the onsite meterological data presented in the FSAR, we have calculated the maximum average annual concentration at the ground to be 2×10^{-8} curie m^{-3} per curie sec^{-1} released at a distance of 1200 m from the stack. This agrees with the value used by the applicant to arrive at an annual average release limit listed on page 5-50 of the Environmental Statement.

Although in our evaluation of the FSAR we are considering the effect of inadverbent radioactive releases to the atmosphere as a result of
2.3 the so-called maximum credible accident, no metnion of this is made
2.3.3 in the Environmental Statement.

Attachment

Environmental Science Services Administration
Washington, D.C. 20235

September 27, 1966

Mr. Walter C. Belter, Chief
Environmental & Sanitary Engineering Branch
Reactor Development & Technology Division
U. S. Atomic Energy Commission
Washington 23, D.C.

Dear Mr. Belter:

This refers to the letter of July 26, 1966 from Edson G. Case Assistant Director of the Division of Reactor Licensing requesting comments of the following:

Browns Ferry Nuclear Power Station
Tennessee Valley Authority
Design and Analysis Report, Volumes 7 and 11
Dated July 13, 1966

These comments are attached, and we would appreciate your including them with other Reactor Development & Technology Division comments or forwarding copies to the Division of Reactor Licensing.

Sincerely yours,

Isaac Van der Roven, Chief
Environmental Meteorology Branch
Air Resources Laboratory

Attachment
As stated

cc: J. Newell, AEC
bcc: Dr. Gifford, ATDL
IVR:hmm

Comments on

Browns Ferry Nuclear Power Station
Tennessee Valley Authority
Design and Analysis Report, Volumes I and II
Dated July 13, 1966

RECEIVED
SEP 3 1971

Prepared by

Environmental Meteorology Branch
Institute for Atmospheric Sciences
September 27, 1966

The Browns Ferry site is on the southwestern edge of the Appalachian Mountain region and as such is influenced by the frequent occurrence of the stagnant, anticyclonic flow characteristic of the Southeastern United States. As shown by Hosler [1] the site is within a maximum region of low nighttime wind speeds and cloudiness which is conducive to surface-based radiational inversions. This condition is exemplified by the nearby Colbert Steam Plant inversion frequency data given in the Design and Analysis Report (page II-3-5) from which one would conclude an almost 100% occurrence of surface inversions <u>at night</u>.

In the computation of downwind surface concentrations and dosages of radioactivity the most sensitive parameter, besides the source strength, is the assumption of a 100 m high release point. The maximum ground concentration or dosage from an elevated source will be higher during unstable condition than during stable regimes since, during periods of instability over reasonably level terrain, the stack effluent reaches the ground much closer to the stack location than is the case during stable conditions. As a consequence the controlling atmospheric condition at the site boundary is one of more rapid vertical dilution rather than poor vertical dilution. This is evident from the relative concentrations shown in Table XIV-13 of the report and is graphically shown in figure 7 of Slade [2], where for a 100 m stack height and a wind speed of 1 m/sec a maximum surface concentration of 1.4×10^{-5} Ci/m^3 per Ci/sec results under type C (slightly unstable) diffusion at the site boundary distance of 1200 m. This compares well with the N-2 category (neutral stability, 1 m/sec) shown in Table XIV-13.

Locally high concentrations can occur during fumigation conditions, that is, at the time the radiational inversion is destroyed. The fumigation condition which presumably can occur at the site boundary could cause relative surface concentrations of 7×10^{-5} Ci/m^3 per Ci/sec released assuming a mixing depth of 100 m, a wind speed of 1 m/sec and a σ_y value of 60 meters. This could be a controlling situation with

regard to radioactive doses except that fumigation of this type is associated with the propagation in the vertical of the effect of surface heating after sunrise and as such would last about an hour as a maximum. The high frequency of nocturnal surface inversions coupled with the lack of marked peakedness in the wind direction distribution would indicate frequent morning fumigations but with no one area subject to repeated fumigation episodes.

In the accident case of a radioactive superheated steam cloud issuing from the turbine building after portions of the roof and siding were blown out, the model used to predict the height of rise of the centerline of the cloud does not seem appropriate for the conditions being considered. The reference by Singer, Frizzola and Smith [3] cited in the report points out the empirical nature of the height of the plume centerline prediction equation, the meagerness of the data and the narrow range of observed centerline heights. A summary of their test data shows a maximum observed rise of 160 feet and a wind speed range of from 2 to 11 miles per hour. An extrapolation of a rise to 5,000 feet and of a wind speed of 50 mph, as was done in the hazard analysis, would seem a questionable procedure.

In summary, the general diffusion climate of the site seems somewhat below average with regard to the probability of slow dilution rates. However, because of the assumption of a 100 m stack release the controlling atmospheric condition for concentrations at the site boundary is one of rapid rather than poor dilution in the vertical.

References

[1] Hosler, C. R., 1961: "Low-level Inversion Frequency in the Contiguous United States". Monthly Weather Review, Vol. 89, pp. 319-339.

[2] Slade, D. H., 1966: "Estimates of Dispersion from Pollutant Releases of a Few Seconds to 8 Hours Duration". ESSA Technical Note 39-ARL-3, 26 pp.

[3] Singer, I. A., Frizzola, J. A., and Smith, M. E., 1964: "The Prediction of the Rise of a Hot Cloud from Field Experiments". AIHA Journal, Vol. 14, No. 11, pp. 455-458.

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

SEP 15 1971

Mr. F. E. Gartrell
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Mr. Gartrell:

We have had the draft environmental statement for TVA's Browns Ferry Nuclear Plant Units 1, 2, and 3 reviewed by the relevant agencies in the Department of Agriculture and comments from three USDA agencies are attached.

Three copies of the environmental statement are returned herewith.

Sincerely,

T C Byerly

T. C. BYERLY
Assistant Director
Science and Education

Enclosures

Environmental Statement

Browns Ferry Nuclear Plant, Units 1, 2, and 3 - TVA

The subject environmental statement has been carefully reviewed by the Agricultural Research Service as pertains to the agricultural use of soil and water.

This report is well prepared and most informative. TVA's policy of keeping the discharge of all wastes at the lowest practicable level by using the best and highest degree of waste treatment available under existing technology, within reasonable economic limits, is most commendable. However, in the past the lowest practicable levels of waste disposal, with the passage of time, have turned out to not be low enough.

2.7.6 As envisioned, the monitoring programs established by TVA, including the quality control procedures, should reveal any possible impairment of soil and water resources for agricultural use. The monitoring program should be continued even though results are negative in any one particular year. Long term incidents might otherwise be missed. Divatent cations move slowly and therefore accumulate slowly and for that reason, the monitoring should be continuous. The monitoring program, for reasons of bias, not necessarily those of TVA, might ought to be conducted by a State or Federal agency.

Sept. 7, 1971

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
WASHINGTON, D.C. 20250

IN REPLY REFER TO
1920

August 23, 1971

Tennessee Valley Authority Draft Environmental Statement
Browns Ferry Nuclear Plant Units 1, 2 and 3

We have reviewed the draft environmental statement prepared by the Tennessee Valley Authority for the construction and operation of a three-unit nuclear power generating station in Limestone County, Alabama.

The plant is located on an 840-acre tract on the north shore of Wheeler Reservoir on the Tennessee River. It will consist of a reactor containment building, turbine, radwaste and service buildings, transformer and switch yards, a stack and sewage treatment plant. There is no indication that TVA is providing any public recreation facilities at the site.

2.7.6 The statement indicates that TVA has closely coordinated its activities with concerned Federal, State and local agencies in all phases of project planning, construction, and monitoring relating to radiological and biological factors that can be affected by the operation of the plant. The statement sufficiently describes the environmental radioactivity monitoring program; however, we would recommend that it be more specific as to distance of sampling sites from the plant site.

2.4 The statement does not mention possible effects of accidental radioactive releases on the environment. Unless an accident can be ruled out as impossible, the statement should discuss potential consequences. In this connection the possible need for alternate or supplementary waste treatment facilities should be considered. In addition, the establishment of higher water quality standards and the detection of unanticipated adverse environmental effects may require additional waste treatment facilities. It would seem important that radioactive disposal processes be provided sufficient flexibility in order that additional controls can be added.

SOIL CONSERVATION SERVICE, USDA, COMMENTS

Draft Environmental Statement Prepared by

Tennessee Valley Authority for

Browns Ferry Nuclear Plant Units 1, 2 and 3, Alabama

2.6.6(3)(c) This statement fails to discuss the measures, if any, to be undertaken to minimize soil erosion during construction of the facilities.

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

December 27, 1971

VIA AIR MAIL

Mr. F. E. Gartrell
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Mr. Gartrell:

We have had the supplement to the draft environmental statement for the Browns Ferry Nuclear Plant Units 1, 2, and 3 reviewed in the relevant agencies of the Department of Agriculture. Comments from the Forest Service and the Soil Conservation Service are enclosed. Also enclosed are three copies of the statement.

Sincerely,

T. C. Byerly
D.J.W.

T. C. BYERLY
Assistant Director
Science and Education

Enclosures

USDA-Forest Service Comments

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Supplement to Draft Environmental Statement

We have reviewed the subject supplemental statement prepared by the Tennessee Valley Authority for the construction and operation of a three-unit nuclear power generating station in Limestone County, Alabama.

Since no new information on the monitoring program is presented, our comments of August 11, 1971, on this phase of the project are still valid.

Beginning on page 2-14, the supplemental statement discusses radio-
2.1.1(2) active waste shipment to an offsite burial ground. The statement
2.1.1(3) sufficiently describes shipping safeguards, but is not clear as to
2.1.2(2) how waste containers are shielded to prevent radioactive contamination to subsurface and groundwater at the disposal site. The report might also provide more specific information on the location and site characteristics of the burial ground.

We note that all transmission lines for the Browns Ferry Nuclear Plant, including 70 miles of new construction, have been completed. Environmental considerations involved in the location, construction and maintenance of the transmission systems are clearly presented except that the statement is silent on methods used for disposal of waste vegetation cleared from land acquired for new lines. We trust that TVA in future statements will report its intentions with respect to utilization of non air polluting practices alternative to open burning in disposing of vegetation cleared from rights-of-way.

The supplementary statement indicates that TVA has studied the expected releases from Browns Ferry Nuclear Plant and investigated the alternative
2.5.3 thoroughly for keeping the radioactivity in effluents to unrestricted areas as low as practicable. In connection with gaseous radioactive wastes, the report describes a decay process and four alternative ways to reduce radioactive gaseous discharges at the Plant. However, no mention is made of the amount and contents of the disradioactive gases which would be released. The environmental statement should give consideration to what these emissions would contain and discuss any effects they would have on the environment.

SOIL CONSERVATION SERVICE, USDA, COMMENTS

Draft Environmental Statement Prepared by

Tennessee Valley Authority for

Browns Ferry Nuclear Plant Units 1, 2, and 3, Alabama

Supplements and Additions

Construction of these facilities will necessitate the disturbance of soil and vegetative cover. Assistance in minimizing soil erosion and the resultant sedimentation is available from the Soil Conservation Service through local soil and water conservation districts.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

SEP 10 1971

F. E. Gartrell, Dr. P. H.
Director of Environmental
Research and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

The draft environmental statement, Browns Ferry Nuclear Plant - Units 1, 2, and 3, sent with your memorandum of July 15, 1971, has been reviewed within this Department. On the basis of information contained in the draft statement, it appears that this facility can be operated without undue impact on the environment or an unacceptable hazard to the public health and safety.

Sincerely yours,

Merlin K. DuVal, M.D.
Assistant Secretary for
Health and Scientific Affairs

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
WASHINGTON, D.C. 20201

OFFICE OF THE SECRETARY

JAN 21 1972

F. E. Gartrell, Dr. P. H.
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

Your draft supplements and additions to the draft environmental statement, Browns Ferry Nuclear Plant - Units 1, 2, and 3, transmitted with your memorandum of November 8, 1971, have been reviewed within this Department. Based on information contained in these statements, it does not appear that there will be unacceptable radiation exposures to the public nor other environmental health hazards resulting from construction and operation of the proposed nuclear generating station.

2.8.2 In part 3.7 of the supplements and additions to the report, Electric Power Supply and Demand, you may wish to include a discussion in subpart 2, Consequences of Delays, a statement concerning health effects which could result from such delays. This might include both an estimate of the health impact of utilizing alternate sources of power as well as that which could result from power shortages due to a reduction in the reliability of the region's power supply.

Sincerely yours,

Merlin K. DuVal, M.D.
Assistant Secretary for
Health and Scientific Affairs

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

JAN 18 1972

Dear Dr. Gartrell:

This is in response to your request that we review the draft environmental statement, and its supplement, prepared by your agency for the Brown's Ferry Nuclear Plant, Units 1, 2, and 3, AEC Docket Nos. 50-259, 50-260, and 50-296. We have reviewed these and other materials available on the project and offer the following comments for your consideration:

The statement adequately documents the fish and wildlife, recreational, and mineral resources of the project area, together with the ongoing and planned studies designed to determine the impact of all three units of the project on these resources and the environment. The project will not adversely affect any existing or known potential unit of the National Park System or properties eligible or potentially eligible for registration as National Natural Landmarks or National Historic Landmarks. Archaeological surveys conducted revealed that no Indian mounds, town sites, artifacts, or any other items of archaeological significance occur at the 840-acre plant site. Although we do not anticipate that the project will affect the geologic environment significantly, some consideration of this impact should be included in the statement.

2.8.3

We are pleased that recreation areas and facilities, including a visitor lobby, will be provided at the project. The numerous reservoirs on the Tennessee River and tributaries provide high quality recreation for the public. Although the Brown's Ferry project alone will not affect water-oriented recreation adversely, construction of additional units could have a cumulative, adverse effect on this activity. For example, if the quantity of heated water added to Wheeler Reservoir becomes great enough to cause algal blooms, undesirable decay byproducts would detract from the value of water-oriented public use of the area. Any plans TVA has for adding units to this project or for constructing additional nuclear or fossil-fueled plants at Wheeler Reservoir should be discussed in the statement.

2.6.7

About 4,200 cfs of condenser cooling water will be pumped from Wheeler Reservoir, passed through the condensers where it will be heated 25° F., and discharged back to the reservoir through a diffuser system

3.7

designed to dissipate the waste heat as rapidly as possible. We understand that, at times, special streamflow regulation, reduction of power production, or both would be necessary to meet the proposed Alabama water quality standards. Those standards, which would require that the temperature of the receiving waters not be increased by more than 10° F. nor raised above 93° F. after reasonable mixing, have not been approved by the Environmental Protection Agency. The EPA has recommended to the State of Alabama that it adopt standards that specify a maximum rise of 5° F., with a maximum allowable water temperature at 86° F.

A special 5-year (1966-1970) study of climatic and hydraulic conditions indicated that with all three units operating at full capacity, the proposed standards would have been exceeded on 9.0 percent and the recommended standards on 48.5 percent of the days of the 5-year study period. During the spring and summer months this added heat would raise the temperature in the receiving waters above 96° F.--the lethal temperature for most fish larvae and plankton. Many fish spawn in the reservoir throughout the discharge area during this period. It is obvious that operating the project with the planned once-through cooling-diffuser system will violate the proposed and recommended water quality standards and will cause significant damage to important aquatic resources of Wheeler Reservoir.

The supplement to the environmental statement discusses four alternative heat dissipation methods that could be used independently or in conjunction with the present diffuser design. Each alternative could be added to the project at some later time, if required to cool the project effluent to comply with more stringent water quality standards and protect aquatic life from significant thermal damage. However, a complete analysis of the spray canal alternative was not made because large-scale operating experience with this system is lacking. The TVA concluded that the mechanical draft cooling tower system probably would be the most attractive alternative for the project.

2.6(AIV-3) The water from the diffuser pipes will be discharged into the reservoir through downstream oriented 2-inch holes. The continual hydraulic disturbance of the reservoir bottom downstream from the diffuser will cause excessive entrainment of silt, which may damage the important aquatic habitat. This probable effect should be discussed in the statement.

2.3.3 The supplement presents a preliminary analysis of the consequences of nuclear accidents in response to recent AEC guidelines. Our review of this analysis indicates that the consequences of the most serious

type of accident (Class 9 - breakdown of the containment structure and release of radionuclides from the core) has not been considered. Such consequences were not considered, because the probability of occurrence in terms of environmental risk is negligible compared to that of the other classes of accidents. Also, the supplement indicates that it is not possible to quantify the probability of occurrence of any accident at this time. This indicates that the evaluation of risks associated with accidents cannot be considered reliable. Even if the probability of a Class 9 accident is extremely low, this does not justify calling the associated environmental risk "negligible" when the environmental consequences of Class 9 accidents have not been considered. The failure to evaluate the probable consequences of Class 9 accidents is a glaring omission that should be treated in some detail to allay public concern for safety of the project, even though the probability of such an accident is remote.

6.0
7.0

Additional wording is needed in the statement to demonstrate that all short-term and long-range uses and the irreversible and irretrievable commitments of resources have been considered and that the best possible plan for protecting the environment has been developed.

2.5.1

We recognize that the comprehensive monitoring studies scheduled or underway may satisfy the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity. However, we believe the statement concerning chemical discharges on pages 3-103 of the supplement that, "Those concentrations are not expected to have a significant adverse environmental impact on water quality in the Wheeler Reservoir." is premature at best and likely untrue. This section of the statement should include a detailed discussion of the effects the project will have on the production of living natural resources, including fish and wildlife.

7.0

The section on irreversible and irretrievable commitments of resources should be expanded to describe and identify the extent that construction and operation of the project will destroy living natural resources, including fish and wildlife and their habitats, and foreclose the natural production from these habitats. These are irretrievable losses. The once-through cooling system will have an adverse impact on the important fish and wildlife resources of Wheeler Reservoir. The TVA has recognized that it is economically and engineeringly feasible to construct adequate cooling facilities at the project, and that it is inevitable that more stringent water quality standards will be adopted by Alabama and approved by the EPA in the near future. In view of the foregoing, and the Administration's emphasis on clean waters and abating all forms of pollution at the source, TVA should

2.6.6
2.6.6(3)(d)

be required to proceed with the necessary detailed studies to more carefully review the possibility of incorporating the spray canal cooling alternative into the project. Also, TVA should carefully reexamine its conclusion that mechanical draft cooling towers would be the more expeditious installation for the project. The visual aesthetic impacts of the cooling facilities selected should be discussed in the statement.

In any event, some type of supplemental cooling facility is definitely needed at the project and can be justified on the grounds that natural resources of this magnitude must be protected from significant damage for the overall benefit and enjoyment of the public.

Government agencies should be leaders striving to demonstrate that major power facilities can be constructed and operated without significantly damaging the basic natural resources.

The environmental statement and its supplement are incomplete and should be revised to treat the suggestions discussed above.

We appreciate the opportunity to comment on this statement and its supplement.

Sincerely yours,

Deputy Assistant Secretary of the Interior

Dr. F. E. Gartrell
Director of Environmental
Research and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

FEB 10 1972

Docket Nos. 50-259,
50-260
and 50-296

Dr. Francis Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
720 Edney Building
Chattanooga, Tennessee

Dear Dr. Gartrell:

This is in response to Mr. James E. Watson's letter of November 5, 1971 transmitting the Supplements and Additions to the Draft Environmental Statement for the Browns Ferry Nuclear Plant, Units 1, 2, and 3. We have reviewed the Draft Environmental Statement, as well as the Supplements and Additions, in accordance with the requirements placed on Federal Agencies by the National Environmental Policy Act of 1969.

Consistent with the letter from Mr. Harold L. Price, to Mr. Watson dated June 30, 1971, we have concentrated our review on the radiological impact of normal plant operation and the impact of radiological accidents.

While we agree with your conclusion that "no significant environmental effects should result from planned radioactive releases----," we believe that the document should be strengthened as indicated in enclosure 1. Many of the suggested changes are based on models and calculational techniques that we are applying to other nuclear plants.

Enclosure 2 represents our analyses of the Environmental Impact of Radiological Accidents Utilizing the uniform models and calculations mentioned above. We believe the guide for accident analyses issued by the Commission as a proposed amendment to Appendix D of 10 CFR Part 50 December 1, 1971 should be used by TVA in preparing its final statement.

If we can assist you further in this matter, please let us know.

Sincerely,

Lester Rogers

Lester Rogers, Director
Division of Radiological and
Environmental Protection

Enclosures:
1. Comments on Radiological Impact Section
2. Environmental Impact of Accidents

COMMENTS ON RADIOLOGICAL IMPACT SECTION

2.4.2(2) 1. The relative abundance of the various isotopes, reported by TVA in the liquid waste, prior to any processing, does not agree with information developed by the AEC, based on experience with operating boiling water reactors.

2.4.2(2) 2. TVA has assumed credit for operation at design efficiencies of waste treatment equipment such as demineralizers, evaporators, recombiners, and charcoal beds. Our experience has been that these systems may not operate as efficiently as specified by the equipment manufacturer. Thus, TVA's activity releases may be less conservative than indicated in the statement.

2.4.3(2) 3. Even taking into account comments 1 and 2 above, we are unable to reconcile the calculated doses from liquid wastes with AEC methods and results. That is, using a higher release activity and a mix which should yield a higher dose, our calculations yield whole body dose results lower than those in the TVA statement.

2.4.3(1) 4. The statement does not include any information on estimated amounts of the radioiodines and particulates in the gaseous wastes. Since the general area is agricultural, there are milk cows and possibly dairy herds in the area. We believe, at the very least, the dose to the infant thyroid via the milk route should be considered.

2.4.3(2) 5. There is no information in the statement concerning estimated GI Tract dose. It has been AEC practice to include this information when it is significant.

2.4.3(2) 6. There is no information in the statement concerning radiation doses to species other than man. Some statement concerning this radiological impact is normally included in an AEC-developed statement.

2.7.6 7. Since the area is an important waterfowl habitat, and considerable waterfowl hunting takes place, we believe it would be appropriate to consider including waterfowl in the environmental sampling program.

2.3.3 8. We believe a map of the site with the boundary of the exclusion area clearly marked would improve the statement.

If TVA desires to meet with the regulatory staff to discuss items 1 through 3 we are ready to meet with you at your convenience.

ENVIRONMENTAL IMPACT OF ACCIDENTS

Protection against the occurrence of postulated design basis accidents in the Browns Ferry Nuclear Power Station is provided through the defense in depth concept of design, manufacture, operation and testing, and the continued quality assurance program used to establish the necessary high degree of assurance for the integrity of the reactor primary system. These aspects will be considered in the Commission's Safety Evaluation for the Browns Ferry Station. Off-design conditions that may occur are limited by protection systems which place and hold the power plant in a safe condition. Notwithstanding this, the conservative postulate is made that serious accidents might occur, even though unlikely, and engineered safety features are installed to mitigate the consequences of these postulated events. The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental effects standpoint have been analyzed using estimates of probabilities and realistic fission product release and transport assumptions. For site evaluation in our safety review, extremely conservative assumptions were used for the purpose of evaluating the adequacy of engineered safety features and for comparing calculated doses resulting from a hypothetical release of fission products from the fuel, against the 10 CFR Part 100 siting guidelines. The computed doses that would be received by the population and environment from actual accidents would be significantly less than those presented in our Safety Evaluation. The Commission issued guidance to applicants on September 1, 1971, requiring the consideration

of a spectrum of accidents with assumptions as realistic as the state of knowledge permits. TVA's response was contained in the "Tennessee Valley Authority Draft Environmental Statement Supplements and Additions," received by the Commission on November 8, 1971.

TVA's report has been evaluated, using the standard accident assumptions and guidance issued by the Commission as a proposed amendment to Appendix D of 10 CFR Part 50 December 1, 1971 (Federal Register, Vol. 36, No. 231).

Nine classes of postulated accidents and occurrences ranging in severity from trivial to very serious have been identified by the Commission. In general, accidents in the high potential consequence end of the spectrum have a very low occurrence rate, and those on the low potential consequence end are characterized by a higher occurrence rate. The Commission's and TVA's examples for these classes of accidents are shown in Table I. Our examples are based on the proposed amendment to Appendix D, entered in the Federal Register on December 1, 1971, whereas TVA's are not. The examples given are reasonably homogeneous in terms of probability within each class.

Certain assumptions made by TVA, such as the assumption of an iodine partition factor in the suppression pool during a loss-of-coolant accident and the efficiency assigned to the charcoal filters in the standby gas treatment system, in our view, are unduly optimistic; but the use of alternative assumptions does not significantly affect the overall environmental risk.

Our estimates of the dose which might be received by an assumed individual standing at the site boundary in the windward direction, using the assumptions in the proposed Annex to Appendix D, are presented in Table II. Our estimates of the integrated exposure in man-rem that might be delivered to the population within 50 miles of the site are also presented in Table II. TVA's estimates were based on the 1970 population density figures, and 60 mile distance from the site, whereas our man-rem estimates were based on the projected population around the site for the year 2010.

To establish a realistic annual risk, the calculated doses in Table II should be multiplied by estimated probabilities of their occurrences. In general, we consider the events in Classes 2 through 5 as improbable, i.e., not likely, during the 40-year life of the plant. Accidents in Classes 6 through 7 are relatively less probable, but still are possible. The probability of occurrence of Class 8 accidents is very small. Accidents in this class are considered design basis accidents and are conservatively evaluated in the AEC's safety review.

The postulated occurrences in Class 9 involve failures more severe than those required to be considered for the design basis of protection systems and engineered safety features (i.e., Class 8 accidents). Their consequences could be severe; however, the probability of their occurrence is so small that their environmental risk is extremely low. Defense in depth (multiple physical barriers), quality assurance for design, manufacture, and operation, continued surveillance and testing, and conservative design

are all applied to provide and maintain the required high degree of assurance that potential accidents in this class are, and will remain, so small in probability that the environmental risk is negligible and therefore need not be considered in our summary of radiological consequences to the population.

The information given in Table II indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary to concentrations of radioactive materials within or comparable to the Maximum Permissible Concentrations (MPC) of 10 CFR Part 20, Table II. The tabulated information also shows that the estimated integrated exposure of the projected population within 50 miles of the station from each postulated accident would be orders of magnitude smaller than that from the naturally occurring radioactivity, which corresponds to approximately 137,200 man-rem/yr based on a natural background level of 0.115 rem/yr. When multiplied by the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. It is concluded from the results of the "realistic" analysis that the environmental risks due to postulated radiological accidents at the Browns Ferry Station are exceedingly small and need not be considered further.

TABLE I

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

of Class	Description	AEC Examples[1/]	TVA Example(s)
1	Trivial incidents	Routine releases	Small spills, small leaks inside containment.
2	Small releases outside containment	Steamline relief valves releases and small spills and leaks.	Spills, leaks, and pipe breaks.
3	Radwaste system failures	3.1 Equipment leakage or malfunction. 3.2 Release of waste gas storage tank contents. 3.3 Release of liquid waste storage tank contents.	Equipment failure, serious malfunction or human error.
4	Fission products to primary system	4.1 Fuel cladding defects. 4.2 Off-design transients that induce fuel failures above those expected.	Fuel failures during normal operation. Transients outside expected ranges of variables.
5	Fission products to primary and secondary system (PWR)	Not applicable	Class 4 and heat-exchanger leak.
6	Refueling accidents	6.1 Fuel bundle drop. 6.2 Heavy object drop onto fuel in core.	Dropping fuel element. Drop heavy object onto fuel. Mechanical malfunction or loss of cooling in transfer tube.
7	Spent fuel handling accident	7.1 Fuel assembly drop in fuel storage pool. 7.2 Heavy object drop onto fuel rack. 7.3 Fuel cask drop.	Transportation incident on site. Drop fuel element. Drop heavy object onto fuel. Drop shielding cask--loss of cooling to cask.

1/ Numerical values of radiological releases shown in Table II.

of Class	Description	AEC Examples[1/]	TVA Example(s)
8	Accident initiation events considered in design basis evaluation in the Safety Analysis Report	8.1 Loss of coolant accidents. 8.1 (a) Break in instrument line from primary system that penetrates the containment. 8.2 Rod drop accident. 8.3 Steamline breaks.	Reactivity transient. Rupture of primary piping. Flow decrease-steamline break.
9	Hypothetical sequences of failures more severe than Class 8	None	Successive failures of multiple barriers normally provided and maintained.

1/ Numerical values of radiological releases determined by the AEC shown in Table II.

TABLE II

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS DETERMINED BY THE A.E.C.

Class	Event	Estimated Fraction of 10 CFR Part 20 Limit at Site Boundary 1/	Estimated Dose to Population in 50 mile Radius, man-rem
1.0	Trivial incidents	2/	2/
2.0	Small releases outside containment	2/	2/
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	.003	0
3.2	Release of waste gas storage tank contents	0.011	1.23
3.3	Release of liquid waste storage tank contents	Neg.	Neg.
4.0	Fission products to primary system		
4.1	Fuel cladding defects	2/	2/
4.2	Off-design transients that	0.003	0.38
5.0	Fission products to primary and secondary systems (PWR)	N.A.	N.A.
6.0	Refueling accidents		
6.1	Fuel bundle drop	<.001	0.033
6.2	Heavy object drop onto fuel in core	.0025	0.0288
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel storage pool	<.001	0.033
7.2	Heavy object drop onto fuel rack	<.001	0.013
7.3	Fuel cask drop	0.002	0.263

1/ Represents the calculated whole body dose as a fraction of 500 mrem (or the equivalent dose to organ).

2/ These releases will be comparable to the design objective indicated in the proposed Appendix I to 10 CFR Part 50 for routine effluents (i.e., 5 mrem/yr to an individual from all sources).

Class	Event	Estimated Fraction of 10 CFR Part 20 Limit at Site Boundary 1/	Estimated Dose to Population in 50 mile Radius, man-rem
8.0	Accident initiation events considered in design basis evaluation in the safety analysis report		
8.1	Loss-of-coolant accidents		
	Small break	<.001	0.071
	Large break	<.001	0.404
8.1 (a)	Break in instrument line from primary system that penetrates the containment	<.001	0.004
8.2	Rod drop accident	0.004	0.41
8.3	Steamline breaks		
	Small break	<.001	0.094
	Large break	0.05	5.85

1/ Represents the calculated whole body dose as a fraction of 500 mrem (or the equivalent dose to organ).

2/ These releases will be comparable to the design objective indicated in the proposed Appendix I to 10 CFR Part 50 for routine effluents (i.e., 5 mrem/yr to an individual from all sources).

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:
PWR-ER

December 22, 1971

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

This is in response to your letter of November 8, 1971, requesting the comments of the Federal Power Commission on the Draft Environmental Statement for the Browns Ferry Nuclear Plant - Units 1, 2 and 3, Supplement and Additions.

The enclosed staff report, prepared by the Commission's Bureau of Power, sets forth specific information relative to the projected load and power supply conditions for the Applicant and for the Southeastern Electric Reliability Council of which the Applicant is a member. The report illustrates the need for the three units at the peak load period following their currently scheduled commercial service dates.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power

Enclosure
Report on the Browns Ferry Nuclear Plant
Supplemental Environmental Statement

"Meeting Today's Challenges Providing for Tomorrow's Goals"
1920 1970
50th ANNIVERSARY

FEDERAL POWER COMMISSION
BUREAU OF POWER

Report on the Browns Ferry Nuclear Plant
Supplemental Environmental Statement

In his letter dated November 8, 1971, the Director of Environmental Research and Development, Tennessee Valley Authority, requested the comments of the Federal Power Commission on need for power to be supplied by the three 1,065 megawatt Browns Ferry nuclear electric generating units. We understand that the environmental aspects of this plant are currently undergoing supplemental analysis and that the Atomic Energy Commission wishes to consider such factors as: the effect of delays in facility operation upon the public interest, particularly "the power needs to be served by the facility; the availability of alternative sources, if any, to meet those demands on a timely basis; and delay costs to the licensee and to consumers." Thus our comments are directed to these points in a review of the need for the facilities as concerns the adequacy and reliability of the Applicant's electric system and the systems of the Southeastern Electric Reliability Council area, the regional reliability council which includes the Applicant. This is in accordance with the National Environmental Policy Act of 1969, and the Guidelines of the President's Council on Environmental Quality dated April 23, 1971.

The Browns Ferry Nuclear Plant has three 1,065 megawatt electrical units in various stages of construction. The Applicant states it now expects authorization for full power operation for Unit No. 1 in October 1972, Unit No. 2 in July 1973, and Unit No. 3 in February 1974. These dates recognize already suffered delays in the initially planned full power operation dates of five months, four months, and one month respectively for the three units. The Applicant states its system experiences winter and summer peaks with the highest annual peak loads in its service area usually occurring between November and March. However, due to seasonal firm power exchange agreements with other power systems, the total loads which its generating capacity must actually serve during the remainder of this decade will be greater in the summer than in the preceding winter. This is to say that the already suffered delay of five months for Unit No. 1 will affect the concerned systems in meeting their 1972 summer peak demands, and the four month delay for Unit No. 2 likewise will be of concern in meeting early summer 1973 demands. The one month delay experienced to date for Unit No. 3 is not likely to be at great consequence unless further slippage should affect the availability of the unit for service during the summer of 1974.

The following report of the Bureau of Power considers the needs for Unit No. 1 to meet the 1972-73 winter peak load responsibility and for both Units No. 1 and No. 2 to meet the 1973 summer peak load

responsibility. It also shows the situation that could obtain in the 1972 summer and the 1973-74 winter peak demand periods since the Applicant has advised that Unit No. 1 is not expected to be in commercial operation until after the projected 1972 summer peak, and Unit No. 3 until after the projected 1973-74 winter peak.

In preparing this report, the staff of the Bureau of Power has considered the Applicant's Draft Environmental Statement -- Supplements and Additions -- Browns Ferry Nuclear Plant Units No. 1, No. 2, and No. 3; related reports made in response to the Commission's April 1970 Statement of Policy on Adequacy and Reliability of Electric Service (Order No. 383-2), and the FPC staff's independent analyses of these documents together with related information from other FPC reports.

Need for the Facilities

The following tabulation shows the load to be served by the Applicant and the systems of the Southeastern Electric Reliability Council, including the Applicant, and the relationship of the Browns Ferry units to their expected available reserve margins at the times of the 1972 summer, 1972-73 winter, 1973 summer, and 1973-74 winter peaks. These are the anticipated initial service periods of the new units, but the life of these units is expected to be some 35 years, and they are expected to constitute a proportionate part of the Applicant's total generating capacity throughout that period. Therefore, they will be depended upon to supply power to meet future demands over a period of many years beyond the initial service needs discussed in this report.

The Applicant states that, in addition to the Browns Ferry nuclear units, its net capability forecasts reflect 660 megawatts of new gas-turbine capacity scheduled for May 1972, Cumberland No. 1 (1,275 megawatts) fossil-fired unit scheduled for July 1972, and Cumberland No. 2 (1,275 megawatts) fossil-fired unit scheduled for April 1973. In addition to the Applicant's 2,130 megawatts of nuclear capacity (Browns Ferry No. 1 and No. 2) included in the evaluation period, other members of the Southeastern Electric Reliability Council are including ten[1/] nuclear units aggregating approximately 8,000 megawatts in their forecasted net capability for the same period. Of these ten units, only Robinson No. 2 is currently operating. Some of the remaining nine have already experienced delays which have prevented their meeting initially forecast operating dates, and there is no absolute certainty that any

1/ To meet 1972 Summer peak: Turkey Point No. 3 (728 MW), Turkey Point No. 4 (728 MW), Surry No. 1 (788 MW), Surry No. 2 (788 MW), Robinson No. 2 (700 MW), and Oconee No. 1 (885 MW).
To meet 1972-73 Winter peak: Oconee No. 2 (885 MW)
To meet 1973 Summer: Crystal River No. 3 (855 MW), Hatch No. 1 (786 MW), and Oconee No. 3 (885 MW).

TVA SYSTEM RESERVE MARGIN

	1972 Summer Peak	1972-73 Winter Peak	1973 Summer Peak	1973-74 Winter Peak
Without Browns Ferry Units				
Net Capability - Megawatts	20,746	20,540	22,021	21,810
Load Responsibility - Megawatts 1/	18,040	18,140	20,120	19,715 6/
Reserve Margin - Megawatts	2,706	2,400	1,901	2,095
Reserve Margin - Percent of Load Responsibility	15.0	13.2	9.4	10.6
With Browns Ferry Units				
Net Capability - Megawatts	20,746	21,605 3/	24,151 4/	23,940 5/
Load Responsibility - Megawatts 1/	18,040	18,140	20,120	19,715 6/
Reserve Margin - Megawatts	2,706	3,465	4,031	4,225
Reserve Margin - Percent of Load Responsibility	15.0	19.1	20.0	21.4
Percent of Reserve Represented by These Units	2/	30.7	52.8	50.4

SOUTHEASTERN REGION SYSTEMS RESERVE MARGIN

Without Browns Ferry Units				
Net Capability - Megawatts	75,768 7/	76,508 8/	84,915 9/	85,455
Load Responsibility - Megawatts 1/	65,471	63,211	72,941	69,590 6/
Reserve Margin - Megawatts	10,297	13,297	11,974	15,865
Reserve Margin - Percent of Load Responsibility	15.7	21.0	16.4	22.8
With Browns Ferry Units				
Net Capability - Megawatts	75,768 7/	77,573 3/ 8/	87,044 4/ 9/	87,585 5/
Load Responsibility - Megawatts 1/	65,471	63,211	72,941	69,590 6/
Reserve Margin - Megawatts	10,297	14,362	14,103	17,995
Reserve Margin - Percent of Load Responsibility	15.7	22.7	19.3	25.9
Percent of Reserve Represented by These Units	2/	7.4	15.1	11.8

1/ System load plus net of firm receipts and deliveries.
2/ Units not available.

3/ Includes Browns Ferry No. 1.
4/ Includes Browns Ferry No. 1 and No. 2.
5/ Includes Browns Ferry No. 1 and No. 2, but not No. 3 which is now delayed beyond assumed January peak.
6/ Could be 625 megawatts greater, if AEC load increase is supplied.
7/ Includes as in service for this and subsequent peak periods: Turkey Point No. 3, Turkey Point No. 4, Surry No. 1, Surry No. 2, Robinson No. 2, and Oconee No. 1 nuclear units.
8/ Includes as in service for this and subsequent peak periods: Oconee No. 2 nuclear unit.
9/ Includes as in service for this and subsequent peak periods: Crystal River No. 3, Hatch No. 1, and Oconee No. 3 nuclear units.

will meet currently forecast operating dates. Very recent information indicates that Oconee No. 1 unit will be delayed at least three additional months from March to June 1972 because of equipment problems which will require factory repair. There are also indications that some of the other scheduled units will likely suffer further delay.

The Applicant states "With the exception of the summer of 1972 (reserve margin 15.0 percent), the margins shown in the above tabulation (19.1 percent, 20.0 percent, and 21.4 percent) are expected to be adequate if the currently projected schedules of capacity additions are achieved." Without the timely installation of the Browns Ferry units, the Applicant's acceptable levels of reserve margin of 19.1 percent for 1972-73 winter, 20.0 percent for 1973 summer, and 21.4 percent for 1973-74 winter are reduced to 13.2 percent, 9.4 percent, and 10.6 percent respectively. The Applicant lists among its presently operating thermal electric generating units one of 1,150 megawatts, one of 950 megawatts, two of 704 megawatts, one of 575 megawatts, and two of 550 megawatts. To these medium to large units will be added the two Cumberland units of 1,275 megawatts each and two of the three Browns Ferry units of 1,065 megawatts each by the time of the 1973-74 winter peak. At that time, the integrity of the 4,225 megawatts of reserve margin the Applicant deems acceptable will be rested in four large units, the smallest being 1,065 megawatts capacity. The preceding 1973 summer's reserve margin of 4,031 megawatts, also deemed acceptable by the Applicant, is almost satisfied by the three largest units. Because of the relative efficiencies and economies of scale in the operation of these large units, it would not be normal to expect these units to be scheduled out for routine or normal maintenance during these periods, consequently the forced outage of any of these units during these periods has a proportionally large effect upon the system's ability to withstand second or third contingencies. The reserve margins indicated in the foregoing tabulations are gross in that they include allowances for scheduled maintenance, forced outages, errors in load forecasting, and spinning reserve requirements, and recent experience with new large generating units indicates frequent forced outages of such units during the initial months of their operation.

If the same implied reserve margin criterion is applied to the load responsibilities of the Southeastern Electric Reliability Council regional resources as to the TVA system, the analysis indicates the 1972 summer to be a critical period and similarly the 1973 summer without the first Browns Ferry unit. However, the region is dependent upon a little more than 10,000 megawatts of nuclear capacity, including two of the Browns Ferry units, being in timely service over this period to meet the levels of reserve margin shown. This 10,000 megawatts represents approximately 72 percent of the total reserve margin shown

for 1973 summer, and the delay of more than one of these units from their presently scheduled dates is a real possibility with a resulting undesirable deterioration of the reserve margins shown.

Transmission Facilities

Because of the proximity of the plant to the Applicant's existing 500-kilovolt EHV transmission grid, all new transmission line construction was within a 20-mile radius of the plant, and totaled approximately 70 miles. Two existing 500-kilovolt lines were looped through the plant, yielding four line terminals, and two new 500-kilovolt lines, each approximately ten miles in length, were constructed from the plant site to a nearby industrial load center. In addition to these six 500-kilovolt lines whose main function is to deliver power from the plant into the bulk power transmission system, two 161-kilovolt lines were constructed into the plant site from the existing 161-kilovolt network. In addition to furnishing construction power to the site, these two lines will provide backup station service to the nuclear plant for emergency operation. This transmission construction program is complete.

The Applicant states that in the design, routing, and construction of these transmission facilities measures were employed to minimize land-use impact. These included multiple use of existing rights-of-ways, selection of aesthetically designed materials and structures, and routing to reduce visual exposure.

Alternates for the Proposed Facilities

Within the time available, there are no known alternate additions of base load generating capacity which could be substituted for these units. Although some utilities have found it possible under somewhat special circumstances to meet a shorter time schedule, the Applicant states that the lead time, from the decision to purchase gas turbines until their commercial operation, is about 18 months. On this basis, immediate decision to substitute this type of normally considered peaking generation for any part of the Browns Ferry generation would not be productive in meeting loads any sooner than the mid-summer of 1973.

The regional reliance upon the timely operation of the ten nuclear generating units noted above, not including the three Browns Ferry units, provides percentages of reserve margins as shown in the earlier table of 15.7, 21.0, 16.4, and 22.8 respectively for the four critical load periods tabulated. With the possibility of further delays affecting some of these ten units, the Applicant cannot rely upon substantial aid from other utilities within the region. The Applicant

states that another 600 megawatts of seasonal exchange power from the South Central Electric Companies for the 1972-73 winter appears to be the only likely source of firm power from outside the region. To obtain this, notice must be given by February 1972.

The relatively few miles of transmission lines added, for a plant of this size, are already constructed.

Conclusions

The staff considers that the 2,130 megawatts of capacity represented by Browns Ferry No. 1 and No. 2 units is needed to assist in meeting the Applicant's 1972 summer, 1972-73 winter, 1973 summer, and 1973-74 winter peaks and provide reasonable reserve margins for adequacy and reliability of electric service. Prudent and responsible operations include provisions for loss of capacity due to forced outages of generating capacity, occurrence of loads higher than those forecast, operating margins required to fulfill obligations to participants in the interconnected systems, and operating margins to provide for flexibility in the allocation of load to generating resources because of abnormal bulk power system conditions. Also, in systems with significant hydroelectric generation, such as the Applicant's, provisions must be made for capacity in thermal generation to meet the contingencies inherent in hydroelectric resources under varying seasonal hydro conditions.

The Applicant estimates the energy costs from these units during the 1973-75 period to be about 1.8 to 1.9 mills per kilowatt hour, and replacement energy which would be used in lieu of this nuclear energy to cost from 3.5 to 10.0 mills per kilowatt hour, depending upon its source -- older TVA units, purchases, or gas turbines. The staff has examined these cost ranges and finds them to be reasonable. Using these costs, the Applicant conducted a computer study which indicated that each month's delay on these three units would result in increased production expenses on the TVA system of approximately $4 million. The Applicant states that if construction were to be suspended, an additional construction cost of approximately $3 million per month of suspension would be incurred, not including a substantial interruption cost. These costs must ultimately be borne by the consumer.

T. A. Phillips

12/16/71

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
AREA OFFICE
DANIEL BUILDING, 15 SOUTH 20TH. STREET, BIRMINGHAM, ALABAMA 35233

REGION IV
REGIONAL OFFICE
ATLANTA, GEORGIA

August 16, 1971

IN REPLY REFER TO:
4.1SQ

Mr. F. E. Gartwell
Director of Environmental
Research and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Re: Brown's Ferry Nuclear
Plant - Units 1, 2, and 3.

Dear Mr. Gartrell:

SUBJECT: Request for HUD Comments on Draft Environmental Impact Statement

We are pleased to acknowledge receipt of the above referenced request for HUD comments under the requirements of the National Environmental Policy Act of 1969 (PL 91-190).

We have reviewed the information submitted along with your referral and, to the extent of our available staff resources, have investigated the environmental impact, adverse effects, alternatives, short term uses of the local environment and long term productivity and irreversible and irretrievable commitment of resources which the project involves. From the information available to us, we find no basis for comment because of special HUD interest or expertise. However, we would call your attention to the areas indicated on the attached "HUD Comments on Draft Environmental Impact Statement" which we feel would assist your agency in the evaluation and execution of this project.

We were unable to determine if this proposal has been submitted to the Area-wide Regional Planning Agency as required under OMBA-95(revised effective April, 1971).

Please advise your field staff that if they were to indicate such submission within the body of the Environmental Statements submitted to this agency it would materially assist and expedite your requests for our comments.

Should further clarification of our review be deemed necessary, please contact Mr. Peter Field, Director, Production Division, 15 South 20th Street, (Daniel Building - Sixth Floor), Birmingham, Alabama 35233 at 205-325-3697.

Sincerely,

Raymond M. Sherry

Raymond M. Sherry
Special Assistant to Area Director
(Planning Requirements)

DHUD COMMENTS ON DRAFT
ENVIRONMENTAL IMPACT STATEMENT

Project Identification:
Brown's Ferry Nuclear Plant, Units 1, 2, and 3

Project Location:
Limestone County, Alabama

The following includes the general caveats and remarks which we feel should be brought to the attention of any State, local or Federal agency which has requested DHUD review of and comment on a draft Environmental Statement under the Environmental Policy Act of 1969 and the CEQ Guidelines. We have checked those comments which seem to be particularly applicable to the draft statement identified above; however the letter of transmittal will amplify these general comments if appropriate.

COMMENTS

☒ Inasmuch as HUD has no direct program involvement in Historic sites or structures effected by the subject project, we defer to the Advisory Council on Historic Preservation with respect to Historic Preservation matters.

☐ HUD has direct program involvement in the Historic Preservation aspects of the proposed project and appropriate comment is included in the transmittal letter.

☐ The subject project effects an urban park or recreational area and appropriate comment is included in the transmittal letter.

☒ The subject project effects only rural parks and recreational areas and HUD therefore defers to the Forest Service of the Department of Agriculture, the Bureau of Outdoor Recreation, Bureau of Land Management, National Park Service and the Bureau of Sports Fisheries and Wildlife with respect to comments on the Parks, Forests and Recreational effects thereof.

☐ This project will probably involve a statutorily required HUD review under Section 4(f) of the Transportation Act of 1966. Therefore, we defer comment on the parks and recreational aspects of the project pending request by D.O.T. for such a review.

☒ This review covers the HUD responsibilities under Section 4(f) of the Transportation Act of 1966.

☐ The Draft Environmental Statement fails to reflect clearance or consultation with the appropriate local planning agency which is: _____.

☐ The Draft Environmental Statement fails to reflect consultation or clearance with the appropriate areawide planning agency which is: _____.

☐ The Draft Environmental Statement fails to reflect consultation or clearance with the appropriate State Clearinghouse as required by Circular A-95, Office of Management and Budget. The A-95 Clearinghouse of jurisdiction is: _____.

☐ The project apparently requires the displacement of businesses or residences. The Draft Environmental Statement does not reveal full consideration of the requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646). If relocation assistance is desired, please contact Mr. Peter Field, Director, Production Div., Daniel Bldg., 15 So. 20th Street, Birmingham, Ala. at 205-325-3697. In the local community the person or office most familiar with relocation resources is: _____.

☐ The draft statement does not discuss apparently feasible alternatives which may have a more beneficial effect on the urban environment. See letter of transmittal for possibly overlooked alternatives.

☒ In general, HUD defers to other agencies with respect to establishing and enforcing air and water quality standards, thermal pollution standards, radiation and general safety standards. We have no formal jurisdiction over such matters and no comments contained herein should be construed as assuming such responsibility or jurisdiction.

☒ Since this project raises issues involving radiation safety, we recommend consultation with: Dr. Joseph Lieberman, Radiation Office, E.P.A., 5600 Fishers Lane, Parklawn Building, Rockville, Maryland 20852.

☐ We recommend that you write or call the Office of Management and Budget for a copy of "Directory of State, Metropolitan and Regional Clearinghouses under B.O.B. Circular A-95," and consult with such clearinghouses as appropriate.

August 13, 1971
DATE

Carlton L Lowe
PREPARED BY
(FIELD REPRESENTATIVE)

August 16-1971
DATE

John D. Page Jr.
CONCURRED IN
(PROGRAM MANAGER)

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
AREA OFFICE
DANIEL BUILDING, 15 SOUTH 20TH. STREET, BIRMINGHAM, ALABAMA 35233

REGION IV
REGIONAL OFFICE
ATLANTA, GEORGIA

November 22, 1971

IN REPLY REFER TO:
4.1SQ

Mr. F. E. Gartrell
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Re: Brown's Ferry Nuclear Plant
Units 1, 2, and 3

Dear Mr. Gartrell:

SUBJECT: Request for HUD Comments on Draft Environmental Impact Statement

We are pleased to acknowledge receipt of the above referenced request for HUD comments under the requirements of the National Environmental Policy Act of 1969 (PL 91-190).

We have reviewed the information submitted along with your referral and, to the extent of our available staff resources, have investigated the environmental impact, adverse effects, alternatives, short term uses of the local environment and long term productivity and irreversible and irretrievable commitment of resources which the project involves. From the information available to us, we find no basis for comment because of special HUD interest or expertise. However, we would call your attention to the areas indicated on the attached "HUD Comments on Draft Environmental Impact Statement" which we feel would assist your agency in the evaluation and execution of this project.

We were unable to determine if this proposal has been submitted to the Areawide Regional Planning Agency as required under OMBA-95(revised effective April, 1971).

Please advise your field staff that if they were to indicate such submission within the body of the Environmental Statements submitted to this agency it would materially assist and expedite your requests for our comments.

Should further clarification of our review be deemed necessary, please contact Mr. Peter Field, Director, Production Division, 15 South 20th Street, (Daniel Building - Sixth Floor), Birmingham, Alabama 35233 at 205-325-3697.

Sincerely,

Raymond M. Sherry

Raymond M. Sherry
Special Assistant to Area Director
(Planning Requirements)

DHUD COMMENTS ON DRAFT
ENVIRONMENTAL IMPACT STATEMENT

Project Identification:
Browns Ferry Nuclear Plant
Units 1, 2 + 3

Project Location:
15 miles N.W of Decatur, ALA.
on the Tennessee River

The following includes the general caveats and remarks which we feel should be brought to the attention of any State, local or Federal agency which has requested DHUD review of and comment on a draft Environmental Statement under the Environmental Policy Act of 1969 and the CEQ Guidelines. We have checked those comments which seem to be particularly applicable to the draft statement identified above; however the letter of transmittal will amplify these general comments if appropriate.

COMMENTS

☐ Inasmuch as HUD has no direct program involvement in Historic sites or structures effected by the subject project, we defer to the Advisory Council on Historic Preservation with respect to Historic Preservation matters.

☐ HUD has direct program involvement in the Historic Preservation aspects of the proposed project and appropriate comment is included in the transmittal letter.

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☐ This project will probably involve a statutorily required HUD review under Section 4(f) of the Transportation Act of 1966. Therefore, we defer comment on the parks and recreational aspects of the project pending request by D.O.T. for such a review.

☐ This review covers the HUD responsibilities under Section 4(f) of the Transportation Act of 1966.

☐ The Draft Environmental Statement fails to reflect clearance or consultation with the appropriate local planning agency which is: _____
_____.

☐ The Draft Environmental Statement fails to reflect consultation or clearance with the appropriate areawide planning agency which is: _____
_____.

☐ The Draft Environmental Statement fails to reflect consultation or clearance with the appropriate State Clearinghouse as required by Circular A-95, Office of Management and Budget. The A-95 Clearinghouse of jurisdiction is: _____
_____.

☐ The project apparently requires the displacement of businesses or residences. The Draft Environmental Statement does not reveal full consideration of the requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646). If relocation assistance is desired, please contact Mr. Peter Field, Director, Production Div., Daniel Bldg., 15 So. 20th Street, Birmingham, Ala. at 205-325-3697. In the local community the person or office most familiar with relocation resources is: _____
_____.

☐ The draft statement does not discuss apparently feasible alternatives which may have a more beneficial effect on the urban environment. See letter of transmittal for possibly overlooked alternatives.

☑ In general, HUD defers to other agencies with respect to establishing and enforcing air and water quality standards, thermal pollution standards, radiation and general safety standards. We have no formal jurisdiction over such matters and no comments contained herein should be construed as assuming such responsibility or jurisdiction.

☑ Since this project raises issues involving radiation safety, we recommend consultation with: Dr. Joseph Lieberman, Radiation Office, E.P.A., 5600 Fishers Lane, Parklawn Building, Rockville, Maryland 20852.

☐ We recommend that you write or call the Office of Management and Budget for a copy of "Directory of State, Metropolitan and Regional Clearinghouses under B.O.B. Circular A-95," and consult with such clearinghouses as appropriate.

11/22/71
DATE

Donald R. Jones
PREPARED BY
(FIELD REPRESENTATIVE)

DATE

CONCURRED IN
(PROGRAM MANAGER)

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1070
NASHVILLE, TENNESSEE 37202

IN REPLY REFER TO
ORNED-P

18 January 1972

3.11

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

Your letter of 8 November 1971 forwarding a copy of the Supplement and Additions to the draft environmental statement for Browns Ferry Nuclear Plant - Units 1, 2 and 3, to Dr. Louis M. Rousselot, Assistant Secretary for Defense (Health and Environment), was referred to this office for reply.

The areas discussed in the Supplement and Additions in which the Corps of Engineers has special expertise or jurisdiction appear to have been adequately covered. Since the navigational aspects of this project were coordinated with this agency in previous years, there should be no conflicts with any present or projected programs of the Corps of Engineers.

Line maintenance operations were discussed on page 2-28 of the Supplement and Additions, and did not indicate the use of chemicals of any kind. Excluding "brownouts" from transmission line rights-of-way, maintenance is considered appropriate and will definitely lessen the visual impact of these cleared areas.

The opportunity to review the Supplement and Additions to the draft environmental statement for Browns Ferry Nuclear Plant is appreciated.

Sincerely yours,

WM. F. BRANDES
Colonel, Corps of Engineers
District Engineer

CF:
Dir, Div of Radiological & Env.
Protection, AEC, WASH, DC
Mr. Charles R. Ford, Chief, Ofic
of Civ Functions, OUSA, WASH, DC
Mr. John A. Busterud, OASD (Env
Qlty) WASH, DC

ENVIRONMENTAL PROTECTION AGENCY
REGION IV
1421 Peachtree St., N.E., Atlanta, Georgia 30309

May 22, 1972

Dr. F. E. Gartrell
Director, Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Subject: Browns Ferry Nuclear Plant Final Environmental Impact Statement

Dear Doctor Gartrell:

In regard to the TVA-EPA meeting of March 5, 1972 and the previous comments, telecommunications, and meeting of December 9, 1971 concerning the Final Environmental Impact Statement on the Browns Ferry Nuclear plant, we offer the following further comments:

As to TVA's present position on thermal criteria, we believe that EPA has satisfied the conditions of Section 4(b) of Executive Order 11507 by our letter of December 17, 1971, which defines the thermal criteria applicable to Browns Ferry Nuclear Plant: "Temperature shall not be increased more than 5°F above the natural prevailing background temperature, nor exceed a maximum of 86°F."

On this basis, we encourage TVA to use all environmentally acceptable methods in an attempt to meet the foregoing criteria during the interim period prior to completion of the cooling tower system rather than the proposed 10°F rise/ 93°F maximum temperature. 2.6.5[a] 2.6.7[b] 2.7.1 2.7.2

Since it appears that applicable criteria can be met with minimal effort when only one unit is in operation by regulating releases from upstream and downstream dams and/or reduction in power levels during critical periods we recommend this course of action. 2.6.5[a] 2.6.7[b] 2.7.2 Table 2.6-3

When two or three units are in operation, however, these methods of control will be harder to maintain, especially during peak power demand periods. Therefore, it is recommended that during the estimated eighteen-month operational period prior to completing the cooling towers, all environmentally acceptable methods be used in an attempt to meet applicable water quality standards, including controlled releases from impoundments, reduced power levels, continuous use of completed cooling towers in the closed cycle mode, etc. Completion of the cooling towers should be expedited to the maximum degree feasible. 2.6.1 2.6.5[a] 2.7.2 Table 2.6-3

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a. pp. 2.6-7 thru 2.6-10
b. p. 2.6-20

EPA recognizes that a reduced power level at the Browns Ferry Plant will 2.6.5[a]
necessitate the use of existing fossil fueled plants to provide needed 2.7.1
power, which in turn will result in degradation of water, air and land at these sites. Further, it is understood that a balancing by TVA will be necessary to minimize total environmental effects from the TVA power system during this interim period.

Studies of fish predation by traveling screens are recommended as soon as
practicable at existing power stations and at Browns Ferry when the first 2.7.3(2)(c)
unit begins operation and continued through three-unit operation. Such studies should determine numbers and weights of fish killed by species throughout the year during diurnal collection periods. Sampling should be conducted monthly except during critical periods, which it should be increased to weekly.

Studies are also recommended to determine alternate design configurations and parameters and auxilliary structures and equipment which could significantly reduce or eliminate fish mortality. Items to be investigated should
include, but not be limited to, horizontal travel of screens, increased 2.6.2
screen area, skimmer walls, air curtains, reduced pressure of screen wash sprays, sluicing of trapped fish back to the water at some point away from the screens, and frequency of screen operation (continuous versus intermittent).

Under present analysis techniques it appears that no zone of passage will
exist when flow in the Tennessee River is less than ten times the condenser 2.6.4
flow. Such a condition is in conflict with the recommendations of the National Technical Advisory Committee on Water Quality Criteria. We feel
that a zone of passage must be provided at the Browns Ferry site to assure 2.7.3(1)(a)
that migration of fish is not impeded, especially during critical spawning
periods. We therefore recommend that the far section of the diffuser pipe IV.3
(adjacent to the shallow overbank area) not be used and that closed cycle cooling be provided for the Unit discharging to that section of the diffuser pipe.

Sincerely yours,

Jack E. Ravan

Jack E. Ravan by: JRW
Regional Administrator

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a. p. 2.6-10

TVA RESPONSE TO COMMENT FROM

ENVIRONMENTAL PROTECTION AGENCY (MAY 22, 1972)

The May 22, 1972, letter from the Environmental Protection Agency was received when the environmental statement was in the final stages of preparation. Sections of the statement which cover several of the points raised by EPA are referenced in the margins of the letter, and additional response is made as follows.

TVA's plans for installing mechanical draft cooling towers and the interim operation of the Browns Ferry Nuclear Plant prior to their completion were discussed with representatives of EPA at a meeting on March 16, 1972. EPA's letter is in regard to that meeting.

EPA makes the important observation that for plant operation prior to the availability of cooling towers, a balancing is necessary to minimize total adverse environmental effects from the TVA power system as a whole. TVA agrees, and on that basis has concluded that the plant should be operated to meet the 10°F rise and 93°F maximum temperature criteria during the interim period.

Meeting the proposed thermal standards of a 5°F rise and 86°F maximum would involve the regulation of upstream reservoirs to provide additional streamflow at Browns Ferry, the reduction of generation by the Browns Ferry units, or a combination of the two.

Although it is feasible to use limited regulation by the TVA reservoir system to meet the 10°F rise and 93°F maximum criteria, the greater regulation which would be required to meet the more stringent criteria would result in drawdowns of upstream reservoirs so large that

TVA does not consider this approach to be practicable. Furthermore, the natural temperature of Wheeler Reservoir exceeds the 86°F on many occasions, in which case the proposed standards could not be realized even with upstream regulation.

TVA considers that the adverse impacts to the environment from increased generation by fossil-fueled plants as a result of reducing generation at Browns Ferry would exceed the questionable environmental benefit to aquatic life, particularly in view of the small percentage of time the proposed 5°F rise and 86°F maximum temperature standard would be exceeded during the interim period due to plant generation. TVA does not consider the interruption of service to power consumers to be an acceptable alternative in this case.

After taking the overall system requirements and environmental impacts into account, it is judged that the operation of the Browns Ferry plant to meet the 10°F rise and 93°F maximum temperature criteria during the interim period represents the best method of operation.

4.0 ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

The CEQ guidelines require a discussion of any probable adverse environmental effects which cannot be avoided, such as water and air pollution, damage to life systems, urban congestion, threats to health, or other consequences adverse to the environmental goals set out in Section 101(b) of NEPA.

1. Water pollution - Large quantities of waste heat will be rejected to the waters of Wheeler Reservoir. Mechanical draft cooling towers will be installed to meet thermal standards. Extensive studies on the effects of heated water on aquatic life will be conducted in order to detect significant adverse effects. Both nonradioactive and radioactive wastes will of necessity be discharged to Wheeler Reservoir. Prior to being discharged, however, various treatment is provided to ensure that all applicable standards are met and the quantities and concentrations released are small enough to ensure that any probable adverse environmental effects are insignificant or undetectable. Additional processing of liquid radwaste will be instituted to keep releases as low as practicable.

Some siltation of the reservoir due to the construction of the mechanical draft cooling towers will occur. All reasonable efforts will be made to minimize siltation due to erosion, dredging, etc.

Water, aquatic life, and life systems will be monitored to assure that no significant adverse environmental impacts will occur due to water pollution.

2. Air pollution - Radioactive releases in the form of gaseous wastes will be discharged into the air. Installation of hydrogen recombiners and charcoal beds will assist in holding these releases to the lowest practicable levels. This should avoid significant adverse environmental effects. Careful monitoring will be conducted to ensure this result.

The operation of the cooling towers and diffusers will result in some additional air pollution in the form of heat rejection and releases of significant quantities of water vapor. This water vapor will, during certain atmospheric conditions, result in increased formation of fog and ice.

Small quantities of nonradioactive gaseous discharges to the air will result from operation of the auxiliary boilers and diesel generators. The quantities discharged are small, and comparison of the discharges to ambient standards show that these emissions will have negligible environmental impacts.

3. Impacts on land use - Construction of the base plant buildings, the cooling water diffuser system, and the transmission facilities for Browns Ferry have been completed. Environmental impacts from these activities have occurred.

Approximately 130 acres of land will be graded or excavated for the installation of the cooling towers. This land will be on the 840-acre plant site, and no additional purchase of land will be required.

The base plant will be essentially noiseless and aesthetically pleasing. Addition of the mechanical draft cooling

towers will result in increased noise levels and some expense to the aesthetics of the project and surrounding environment. However, noise levels will be within acceptable limits, and the cooling towers will be made visually acceptable so that their presence and operation should cause no significant impact.

4. Damage to life systems - When cooling water passes through the traveling screens en route to the condensers, fish larvae will be drawn into the intake water. At this time it is not known the extent to which fish larvae are present near the condenser cooling water intake. Studies are under way to determine this and, as operating experience is gained, to develop steps which could reduce the intake of fish larvae. Plankton present in the condenser cooling water will also be destroyed, in the sense that it is changed as a source of food when seasonally subjected to temperatures in excess of 96.8°F in passing through the condensers. This effect may be reduced by the addition of cooling towers since operation with the towers results in smaller quantities of water intake. At the time when the most adverse conditions exist for plankton damage, a maximum of about 25 percent of the total riverflow passes through the condensers. Based on TVA's experience with other large thermal plants, rapid reseeding of plankton populations downstream of the condenser outfall would be expected. To the extent that this plankton serves as a food source to aquatic life, its destruction is an adverse effect which cannot be avoided.

There may be some loss of existing river bottom fauna and habitat in the immediate vicinity of the diffuser pipes.

There will be a loss of 13 acres of this habitat within the cooling water return channel. These are adverse effects which cannot be avoided.

While these effects cannot be avoided, they are not expected to damage significantly any life system. Extensive studies are designed to detect significant adverse effects.

5. Threats to health - The facility is being designed and constructed and will be operated in accordance with all applicable Federal and state regulations in order to assure that the health and safety of the public will be safeguarded.

Significant accidental releases of radioactive products at the plant or during transportation of radioactive materials are very improbable. Should such a release occur, implementation of the radiological emergency plans would mitigate the potential risk to the public.

6. Socioeconomic effects - The primary and secondary social and economic impacts were covered in section 5.0 of Volume 2. As indicated, the total magnitude of these impacts is large; however, the distribution of residences and local material supply sources occurs over a 40-mile radius of the plant site. While this may produce temporary stress on the social infrastructure (schools, roads, housing, and similar services), it will also provide a stimulus to area economical development (jobs, attraction of visitors, etc.). There should be no severe social or economic dislocation as the project construction phases out.

7. Conclusion - The operation of Browns Ferry will result in some adverse environmental effects which cannot be avoided. However, these effects are not expected to conflict with the environmental goals set out in Section 101(b) of NEPA. If any significant adverse effects attributable to operation of the plant become evident through the various environmental monitoring programs, appropriate steps will be taken to correct the situation.

5.0 ALTERNATIVES

Section 102(2)(C) of NEPA requires a discussion of alternatives to the proposed action, and Section 102(2)(D) requires an agency to "study, develop, and describe appropriate alternatives to recommend courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources."

The Browns Ferry Nuclear Plant was initiated before NEPA became effective, and the TVA Board of Directors has determined that it is not practicable to reassess the basic course of action in the design and construction of the plant. The environmental statement considers the ways in which the plant will interact with the environment by reevaluating environmental consequences considered at the outset of the project and minimizing any further adverse environmental consequences that would affect the overall balance of environmental costs and benefits by studying and adopting appropriate alternatives.

1. Alternative heat dissipation methods - The systems which were given consideration as alternative heat dissipation methods include mechanical draft cooling towers, natural draft cooling towers, a spray canal system, and a cooling lake. These alternatives were considered using feasibility, environmental impact, and cost as factors in the analyses.

As described in section 3.4 of Volume 3, the spray canal and cooling lake alternatives were not considered feasible for this site. Consequently, detailed cost analyses were made only on the two types of cooling towers. The results of these studies indicated that the mechanical draft cooling tower alternative was the best choice.

The decision to incorporate this alternative into the plant design and the associated environmental impacts are described in section 2.6 of this volume.

2. Alternative systems for reductions of radioactive discharges - Analyses of alternative systems for the reduction of radioactive discharges include consideration of subsystems for both liquid and gaseous radioactive discharges. These systems were considered using feasibility, environmental impact, and cost as factors in the analyses.

(1) Liquid radwaste alternatives - Systems considered for the reduction of liquid radioactive effluents include demineralizers and evaporators.

As shown in section 3.1 of Volume 3, the evaporator alternative gives greater reductions in radioactive releases and has a considerable cost advantage. Consequently, TVA has concluded that an evaporator along with its associated buildings and equipment should be installed at the Browns Ferry Nuclear Plant.

No other feasible alternatives have been identified which would further reduce liquid radioactive discharges.

(2) Gaseous radwaste alternatives - The system originally designed for treatment of gaseous radioactive discharges included 30-minute holdup and elevated stack release. Four additional systems have been evaluated as alternative methods for reduction of these discharges: hydrogen recombiners, hydrogen recombiners and charcoal adsorbers, hydrogen recombiners and solvent absorption, and hydrogen recombiners and cryogenic distillation. A summary description

of each alternative system considered, the timing of the installation, its cost, and its potential environmental benefit is given in section 3.1 of Volume 3. Of these systems only the hydrogen recombiner with charcoal adsorbers have been proven in this type of service.

The analyses of these alternatives show that balancing the reductions in environmental impacts and costs of each of the feasible systems leads to the conclusion that a system utilizing a hydrogen recombiner in combination with six charcoal beds per unit is the best selection and reduces environmental impacts due to gaseous radioactive releases to the minimum practicable level.

6.0 SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

The local short-term uses of the environment are those required to construct and operate the facility. These include preparation of the site and construction of buildings, the use of the ambient air for the dispersion of gaseous effluents and heat, and the use of Wheeler Reservoir for the dissipation of waste heat, liquid radioactive effluents, and chemical discharges.

Most of the short-term use of the site will result in no significant effect on the long-term productivity of the land affected since only that portion occupied by the reactor systems buildings will be affected for a period much longer than the useful life of the plant. The long-term productivity of no other land will be irreparably damaged.

The operation of the plant will not result in any significant long-term environmental degradation. All effluents discharged to the air and water will be well within levels which are considered acceptable for short-term use, and no long-term effects are expected to occur as a result of these uses. Comprehensive monitoring programs will be carried out to assure detection of the existence of any such effects.

7.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The CEQ guidelines call for a discussion of any irreversible and irretrievable commitments of resources which would be involved in the construction and operation of Browns Ferry. This requires identifying the extent to which operation of the facility curtails the range of beneficial uses of the environment.

The Browns Ferry plant is located in a rural, relatively isolated and sparsely populated area. The plant will not curtail the beneficial use of land, air, water, or living natural resources in the area.

In addition to those commitments described in section 9.0 of Volume 2, some by-products which result from the operation of the plant must also be considered as irreversible and irretrievable commitments of resources. These include damaged components which are radioactive, solid radwaste materials such as spent demineralizer resins, and various chemicals which are used in the plant processes. Chemicals used in plant processes will be widely dispersed to the environment and in most cases will have changed forms and will have lost their value. Reclamation of these chemicals after discharge from the plant is impractical.

The commitments of natural resources associated with this plant's construction and operation are small when compared to the benefits gained.

8.0 BENEFIT-COST WEIGHING AND BALANCING

This section provides an overall assessment of the economic, technical, and other benefits of the Browns Ferry Nuclear Plant weighed against the environmental costs, with the alternatives considered which would affect the balance of values.

While various benefits and environmental costs have been quantified, some are necessarily expressed in qualitative terms. For example, the effect of mechanical draft cooling towers on aesthetics is treated qualitatively, as is the specific contribution of electricity generated at Browns Ferry to the overall resource development of TVA; that is, advancement of physical, social, and economic development cannot reasonably be quantified. Moreover, of those factors subject to quantification, all cannot reasonably be expressed in monetary values. Although the number of fish larvae killed passing through the condensers can be quantified in terms of numbers, translation of that number to a monetary value is not reasonable in view of the wide range of variables influencing the significance of the impact. Environmental impacts, therefore, are quantified in commonly used terms such as numbers of fish, gallons of water, and tons of earth.

The decisions leading to the plans to construct the Browns Ferry facility were made in 1965-66, four to five years prior to the passage of the National Environmental Policy Act, and the Tennessee Valley Authority has determined that it is not practicable to reassess the basic course of action of designing and constructing the plant. The environmental review was limited to an analysis of the alternatives for limiting environmental impacts during the completion of construction of the project and the environmental impacts

which will result from operation of the plant. During this environmental review, significant changes have been made to the plant to minimize the environmental impacts as summarized below:

Gaseous Radwaste - The original system which included 30-minute holdup has been reevaluated and is being modified to include hydrogen recombiners and six charcoal beds per generating unit.

Liquid Radwaste - The original system which included filtration and demineralization has been reevaluated and the system design modified to include an evaporator.

Cooling Water - The original system which included diffusers for dispersing the heat rejected to Wheeler Reservoir is being augmented with mechanical draft cooling towers.

With these modifications the Browns Ferry Nuclear Plant approaches a minimum impact plant. With normal operation from the plant the maximum radiation dose to the hypothetical individual is 1.5 percent of that received from natural background radiation and the dose to the population within 50 miles of the plant in the year 2010 is projected at 0.013 percent of the dose from natural background radiation. Therefore, radiation resulting from operation of the Browns Ferry Nuclear Plant will result in no undue risk to the health and safety of the public.

With the addition of cooling towers to the plant, the plant will operate so as to meet proposed water quality criteria of 5°F temperature rise and a maximum temperature of 86°F.

TVA from its very inception has been deeply committed to the tasks of environmental improvement. The President in transmitting to Congress in 1933 the bill that became the TVA Act said that TVA ". . . should be charged with the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and its adjoining territory for the general social and economic welfare of the Nation." It is on the basis of these principles that TVA plans and conducts all its activities, be they planning, constructing, and operating a nuclear power plant; planning, building, and operating a water control project; providing research to develop a new fertilizer; setting aside areas for fish and wildlife; developing improved hardwood tree strains; or seeking ways to utilize the rugged scenic qualities of some of the region's natural streams. In all of these and TVA's many other varied resource development programs, its management and staff are deeply conscious of their responsibilities to all of the six million people in the TVA region and, more generally, to the 200 million people in the Nation.

This invariably calls for a balancing of the requirements and hopes of a variety of interests, and finally, decision and action in which differences are reconciled insofar as possible to best serve the needs of the greatest number over the longest possible time. Inherent in this is the requirement of finding a balance between the needs of man, including his need for useful employment, and the safeguarding of his physical environment.

In TVA, electric power is regarded as a tool for economic development. Its use has been encouraged as a means for improving the quality of life in the region. Fitted into a comprehensive, unified development program, it has helped ease the burdens of drudgery, provide more jobs and more productive employment, bring the amenities of life to an ever increasing number of people, and improve the health, education and living conditions of the people generally.

An abundant supply of low cost electric energy, integrated with a total resource development program, has been a major factor in the progress achieved by the TVA region since 1933. Employment, income, and productivity have all increased with a shift from a primarily agricultural to an industrial economy.

The uses of electricity are many. To the residential user it provides lighting, refrigeration, cooking, washing and drying of clothes, heating, air-conditioning, and education and entertainment via radio and television, to name but a few. Most stores, banks, and other commercial ventures are dependent upon electricity for conducting business. In industry it is an essential element by which productivity has been increased with an attendant improvement in living standards. While in most industrial activities the cost of electric power is a small fraction of the total cost of production, without electricity modern industry could not provide the Nation with the goods and services it demands. In the aluminum, electro-chemical, and metallurgical industries, electricity is a significant component required in the manufacture of these essential products.

The addition of the Browns Ferry Nuclear Plant to the TVA system will enable TVA to continue to carry out its responsibility to provide an abundant supply of electricity for the TVA region. The benefits of the plant include the value of the electrical power to be generated, the potential for reduction of releases of combustion products to the atmosphere at fossil-fired stations, the recreational and educational value to visitors to the plant, a stimulant to the economic growth of the region through an abundant supply of electrical power, increased payments to local governments of in lieu of tax payments, and increased employment potentials.

The costs of the plant include the commitment of 840 acres of land and 13 acres of reservoir area for the lifetime of the plant; the rejection of 2.44×10^{10} Btu/h to the air either directly or via Wheeler Reservoir, depending upon the mode of operation of the cooling towers; the consumption of 110 ft^3/s of evaporated water; minor releases of radioactivity to the air and to Wheeler Reservoir; erosion of soil during construction; a very low probability of releasing radioactivity due to an accident in the plant or an accident during the transport of radioactive materials; and the monetary costs to construct, operate, and maintain the plant.

At the end of March 1972, a total of $473 million had been expended on the construction of the Browns Ferry Nuclear Plant of the estimated project cost of over $650 million.

TVA has attempted, insofar as practicable, to detail those items covered in the Atomic Energy Commission's proposed guide for benefit-cost analyses for completed or partially completed nuclear facilities in sections 8.1 and 8.2. The weighing and balancing of benefits and costs of subsystems is presented in section 8.3.

Conclusion - This environmental review has reevaluated environmental impacts considered at the beginning of the project; evaluated those not considered earlier; considered alternatives which would lessen environmental impacts; and considered the need for power from the project. After weighing the environmental costs and the technical, economic, environmental, and other benefits of the project, and adopting alternatives which affect the overall balance of costs and benefits by lessening environmental impacts, TVA has concluded that the overall benefits of the project far outweigh the monetary and environmental costs.

8.1 Benefits - The benefits of the Browns Ferry plant are detailed below and are summarized in Table 8.1-1.

1. Electric power produced and sold - Browns Ferry Nuclear Plant includes three units with a dependable capacity of 1,065 MW electrical each, or a total plant capacity of 3,195 MW electrical. The units are scheduled for commercial operation as follows: unit 1 - March 1973; unit 2 - December 1973; and unit 3 - July 1974. Since capacity is planned for on a system basis and TVA has additional generating capacity scheduled for commercial operation during this time period, it is not possible to identify the specific loads which the Browns Ferry nuclear units will serve. For the purpose of the benefit analysis, it has been assumed that the plant serves loads based on the incremental increase in loads for each class of customers estimated between F.Y. 1972 and F.Y. 1980. The estimated peak load and sales for these years are identified in the following table:

	F.Y. 1972		F.Y. 1980		Increase	
	Load	Percent of Total	Load	Percent of Total	Load	Percent of Total
Estimated Peak Demand (MW)	17,326		30,300		12,974	
Estimated Sales (million kWh):						
Residential	28,072	30.8	45,833	28.2	17,761	24.8
Commercial	11,901	13.1	22,667	13.9	10,766	15.0
Industrial	32,908	36.2	55,907	34.4	22,999	32.1
Government	13,815	15.2	30,873	19.0	17,058	23.8
Other Sales	4,249	4.7	7,320	4.5	3,071	4.3
TOTAL SALES	90,945	(100)	162,600	(100)	71,655	(100)

The value of a unit of electric energy to the user varies widely depending on the availability and cost of alternative energy sources. No attempt was made to identify such values in this analysis. However, the price customers pay for electric energy presumably establishes a minimum value to the user. Based on the present rate structures of TVA and the distributors of TVA power, the following average prices to the ultimate consumer are estimated for F.Y. 1972:

Residential	1.413 ¢/kWh
Commercial	1.337 ¢/kWh
Industrial	0.727 ¢/kWh
Government	0.622 ¢/kWh
Other	1.023 ¢/kWh

For the purpose of estimating the present value of the revenue received from the sale of this energy it has been assumed that the Browns Ferry plant will operate as shown in the following table during its 35-year life:

Years	Capacity Factor	Net Generation (million kWh)	Total Transmission and Distribution Losses (million kWh)	Energy Available For Sale (million kWh)
1-15	80%	22,391	1,533	20,858
16-25	55%	15,394	1,053	14,341
26-35	40%	11,195	767	10,428

Using the energy available for sale and the average price paid for electricity shown above, and a discount rate of 8 percent, a present value of the sales from the plant

was established and is presented in the benefit description form.

The results are summarized below:

ELECTRIC POWER PRODUCED AND SOLD - BROWNS FERRY NUCLEAR PLANT

Levelized Annual Energy Generation (kWh)	$20,178 \times 10^6$
Levelized Total Losses (kWh)	$1,409 \times 10^6$
Levelized Energy Available for Sale (kWh)	$18,769 \times 10^6$

	Energy Available For Sale - kWh	Present Value of Sales During Plant Life - Dollars
Energy Sold:		
Residential	$4,652 \times 10^6$	766,000,000
Commercial	$2,820 \times 10^6$	439,000,000
Industrial	$6,024 \times 10^6$	510,000,000
Government	$4,468 \times 10^6$	324,000,000
Other	805×10^6	96,000,000
Total Sold[a]	$18,769 \times 10^6$	2,135,000,000

a. Before cooling tower additions. Average tower power requirements are 9,525 kW.

Historically, electricity rates have declined during most of the past 40 years. Events of the more recent years have caused this trend to reverse. Higher prices for fuels, increases in construction costs, and costs of pollution control equipment have been significant factors causing the increases in rates for electric utilities. It was necessary for TVA to increase its rate schedules in 1967, 1969, and 1970. The effect of these rate increases has resulted in the average cost of electricity to the consumer increasing by 49.0 percent. Thus, the use of current rates could significantly understate the present value of the future sale price.

2. System Reliability - Capacity requirements on the TVA system are determined by the loss of load probability method using a monthly reliability index equivalent to an annual index of 0.1 day per year failure to meet firm loads. Each of the alternatives considered for the Browns Ferry plant meets this criteria. While differences in the reliability of the subsystems associated with the various Browns Ferry alternatives might conceivably affect the unit forced outage rate, thereby slightly changing the reliability index for that particular alternative, it is not feasible to make this determination without actual operating experience with each alternative.

3. Recreation - The recreational benefits of the Browns Ferry plant are estimated at 8,000 visits per year. This estimate of recreational visits is exclusive of the estimate of educational visits to the plant, which is given below. At a value of $0.75 per visit, the present value of these visits is estimated to be $69,930.

4. Air Quality - Since the Browns Ferry plant is a baseload plant approximately 7.4 billion kWh will be available during the baseload period to replace coal-fired generation which would otherwise have consumed about 3 million tons of coal per year. This will result in annual reductions in particulate emissions of 13,800 tons, SO_2 emissions of 194,000 tons, and NO_x emissions of 26,000 tons when based on replacing coal-fired generation with coal of the quality presently being burned.

5. Education - The educational benefits of the Browns Ferry plant are estimated to be 98,000 visits per year. The present value of these visits, at $0.75 per visit, is $856,600. The latter value does not consider the educational visits by persons to the plant during its construction. However, the number of such visits has been used in estimating the 98,000 visits per year.

6. Research - A 3.1 million dollar biothermal research project is to be constructed at Browns Ferry to objectively determine the effect of changes in temperature regimes on warmwater aquatic communities. The natural warm water reservoir communities will be exposed to different controlled temperatures. The resulting effects on growth, reproduction, and mortality will be observed.

This research facility is to be located at the Browns Ferry site for two primary reasons. First, the thermal rise ($25^{\circ}F$) in the condenser water is high enough to permit concurrent experiments to be conducted for a wide range of temperatures. Second, since Browns Ferry will be operated as a base load plant with three

generating units, it is expected that at least one unit will be operating at all times, thereby assuring a continuous supply of heated water for the research activity.

Accurate determination of the effects on aquatic life from thermal discharges would have nation-wide benefits. If the results show that the thermal criteria being adopted by regulatory agencies is excessively restrictive, a considerable savings in expenditures for auxiliary cooling facilities at power plants and other industrial operations could be realized. If the results of the studies show the presently proposed thermal criteria to underestimate the protection needed, then large environmental benefits would result if the adoption of more stringent thermal controls is needed to protect aquatic life.

7. Regional Gross Product - Benefits of the Browns Ferry plant to regional gross product cannot be exactly quantified monetarily. However, a correlation has been made of the average annual dollar flow of gross product with the use of the Browns Ferry electrical power in the TVA power service region. This correlation is based on using the average power generation and relationships between gross product and kilowatt hours equivalent of all energy consumed. The industrial gross product factor was obtained as a product of the relationship between value added and kWh equivalent (Census of Manufacturers, 1967) and the relationship between gross product from manufacturing and value added by manufacturing (Census of Manufacturers, 1967 and Survey of Current Business). The numerical value of the industrial gross product factor was found by this method to be $0.0649 per kWh. The commercial gross product factor was obtained by comparing gross product from commercial activities and an assumed electrical energy output of 25 percent of total energy input to the commercial

sector (Energy in the American Economy, 1850-1975, Schurr and Netschert). Numerical values of this factor were $0.187 per kWh for 1967 and $0.184 per kWh for 1969. Giving slightly more weight to the recent figure, $0.185 per kWh was selected as the commercial gross product factor. Industrial power consumed was assumed to include government use of electrical energy. The resulting average annual dollar flow of gross product is estimated at $1.203 billion.

As noted above, no additional quantification to arrive at a monetary benefit is considered possible. This is because the comparison of dollar value of products produced and energy consumed does not consider other variables in the production of products, such as wages of workers and efficiencies of individual production processes. It should be noted that a plentiful energy source has long been considered essential in the economic and industrial expansion of any region. As required by the TVA Act, as amended, TVA maintains an ample supply of electrical energy in the area in which it conducts its operations. A comparison of statistics in the TVA region with national statistics implies there is some beneficial effects of this plentiful energy source. In 1960 gross regional product was 2.26 percent of national; in 1970 this had increased to 2.69 percent. In 1960 personal income in the region was 64 percent of the national value; in 1970 this had increased to 75 percent. TVA considers that the availability of electricity as a plentiful energy source has helped realize these growth rates.

8. Payments in lieu of taxes - Estimates of payments in lieu of taxes includes estimates of payments to states and local governments by TVA and by distributors of TVA electricity. Estimates are based on current rates of payment related to the energy which will be generated by the plant.

9. Employment - Benefits to employment have been listed as the average annual number of workers whose jobs could be related to the consumption of electrical power produced by the Browns Ferry plant. An industrial employment factor, relating kWh equivalent consumed in manufacturing to employment in manufacturing was determined from national data from the Census of Manufacturers, 1967. A value of 5.4588 workers per million kilowatthours was obtained. A commercial employment factor was obtained by analysis of data from Energy in the American Economy, 1850-1975, by Schurr and Netschert. For 1967 this relationship was 14.83 workers per million kWh; for 1969, 13.39 workers per million kWh. The intermediate value of 14 was chosen for estimating the commercial portion of the employment value listed. Based on the portion of the Browns Ferry Nuclear Plant generation allocated to commercial and industrial use, the potential exists for expanding the number of new jobs by 96,750.

Table 8.1-1

BROWNS FERRY NUCLEAR PLANT - BENEFITS*

Alternative Plant Number**		1	2	3	4
Description		Base Plant	Minimum Water Impact	Minimum Land/Air Impact	Plant License Request
Electric Power Produced and Sold in Thousands of Dollars (present worth)	Industrial Commercial Residential Government Other Uses	766,000 439,000 510,000 324,000 96,000	***	766,000 439,000 510,000 324,000 96,000	***
Recreation Visits @ $.75 each-thousands of $ (present worth)		69.9	69.9	69.9	69.9
Air Quality - Potential to Reduce Pollutants in tons/yr	SO_2 NO_x Particulates	194,000 26,000 13,800	194,000 26,000 13,800	194,000 26,000 13,800	194,000 26,000 13,800
Educational Visits @ $.75 ea. thousands of $ (present worth)		856.6	856.6	856.6	856.6
Research		See Text			
Gross Regional Product Credit		See Text			
Payments in Lieu of Local Taxes in thousands of dollars (present worth)		144,505	***	144,505	***
Employment Benefits--potential jobs provided		96,750	***	96,750	***

*AEC Guide to Benefit-Cost Analyses followed in preparation of tables.
**Alternatives have the following subsystems:

Alternative	Heat Dissipation System	Gaseous**** Radwaste	Liquid Radwaste
1	diffuser	30-minute holdup	filtration and demineralization
2	Mechanical draft towers--closed cycle only	30-minute holdup	base plant and evaporator
3	diffuser	ORGDP or cryogenic	base plant and evaporator
4	mech. draft cooling towers--combined cycle	hydrogen recombiners and 6 charcoal beds	base plant and evaporator

***Reduced slightly from base to account for losses for cooling tower power.
****Base plant 30-minute holdup included in all alternatives.

8.2 Monetary and Environmental Costs - The monetary (generating) and environmental costs of the Browns Ferry plant for four alternative combinations of subsystems are detailed below and are summarized in Table 8.2-1. The four alternative combinations represent the base plant (at the start of the environmental review), the plant with minimum water impact, the plant with minimum air and land impacts, and the final plant (after environmental review). In addition, incremental generating costs and differences in environmental costs for alternatives for the liquid radwaste system, gaseous radwaste system, and heat dissipation system are summarized in Tables 8.2-2, 8.2-3, and 8.2-4, respectively.

Generating costs - The generating costs for the alternative combinations of subsystems have been computed using the following assumptions: current base plant capital cost estimates of $610 million; a power generating cost of 1.9 mill/kWh ($0.0019/kWh); a declining plant capacity factor as discussed in section 8.1-1; incremental generating costs for alternative subsystems as listed on Tables 8.2-2, 8.2-3, and 8.2-4; an 8 percent discount rate; and an assumed plant lifetime of 35 years. The results are summarized in Table 8.2-1.

1. Heat discharged to water body -

(1) Cooling capacity - The maximum total plant heat rejection to Wheeler Reservoir will be 2.44×10^{10} Btu/h on open-mode, 1.36×10^{10} Btu/h on helper-mode, and 4.5×10^{8} Btu/h on closed-mode cooling tower operation. The volumes of water in the mixing zone

for cooling water discharges have been estimated in Appendix IV to be about 165 acre-feet for open and helper modes and about 55 acre-feet for closed mode.

(2) Aquatic biota - It is TVA's judgement that there is no basis for assuming irretrievable loss of aquatic biota owing to thermal discharges of the plant. For comparative purposes the volume of water within the 5°F isotherm (165 acre-feet) is assumed to be affected; this 5°F isotherm represents the Alabama criterion for maximum temperature rise. This volume constitutes only 0.0165 percent of the volume of Wheeler Reservoir. The surface area bounded by the 5°F isotherm was calculated to be 8.3 acres. This area is only 0.0124 percent of that of the reservoir. In 1970 the commercial catch from Wheeler Reservoir had a value of $264,000. On the basis of the affected area, 0.0124 percent of this would have a cost of about $33. In 1970-71 the sport catch, based on a continuous 12-month creel census of approximately 60,000 acres of the reservoir, had a value of $314,016. Given the same area within the 5°F isotherm (8.3 acres) the area involved would be 0.0138 percent of the census area, and the monetary value would be about $43. The total annual commercial and sport value in the affected area would then be about $76.

Phytoplankton and zooplankton biomass estimates were made assuming the affected plankton were in the top meter of the reservoir in the estimated 8.3 acres of surface area bounded by the 5°F isotherm. Results varied in the various seasons as indicated below:

Season	Phytoplankton Biomass		Zooplankton Biomass	
	Total Pounds	Pounds/Acre	Total Pounds	Pounds/Acre
Winter	830	100.0	40.7	4.9
Spring	888	107.0	10.8	1.3
Summer	1,096	132.0	38.2	4.6
Fall	486	58.6	45.7	5.5

The actual effects on these populations cannot be accurately assessed. In general, it is known that about 96°F constitutes a limit above which lethal effects are noted. Since this limit will be exceeded only in the diffuser mixing zone, and then only on certain occasions, mortality effects are considered negligible. There could even be increases of populations of these species due to the increased metabolism rates expected at higher temperatures.

It should be noted that the above estimates are based on interim plant operation without cooling towers.

(3) Migratory fish - It has been judged that a barrier, in the strict sense of preventing or significantly decreasing or retarding fish migration, will not result. A detailed discussion is provided earlier in Section 2.7, Biological Impact.

2. Effects on water body of intake structure and condenser cooling systems - Two primary areas for effects on Wheeler Reservoir due to removal of cooling water are in changes to fish and plankton populations. Estimates of these effects are presented below.

(1) Larval fish entrainment losses - Larval fish which pass through the plant in the cooling water flow will to a great extent be killed in this passage due to the temperature rise in the condensers and to mechanical shock. An accurate assessment of

the effects on larval fish populations cannot be made at this time. Studies made during the spawning season of 1971 gave preliminary results of the species composition and relative species abundance from which some general observations can be made. Throughout the sampling period shad dominated the catch (90 percent) and gizzard shad outnumbered threadfin shad. About half of the remaining fish in the samples were other rough or forage fish (5 percent) and the other half were sport fish (5 percent). Additionally, it was determined that larval fish concentrations in the overbank areas are orders of magnitude higher than in the channel area of the reservoir. Thus the actual concentration entering the Browns Ferry plant could vary widely depending on the ratio of channel to overbank water which enters the plant.

For purposes of analysis, the following assumptions have been made:

1. Larval fish concentrations in the intake at Browns Ferry are those noted in inshore-surface samples.

2. Survival rate from larval fish to adult is 1×10^{-4}.

3. The results from one sampling station, comprising replicate weekly day and night samples for a 91-day period, provides a representative case for analysis.

4. Condenser passage results in 100 percent mortality of larval fish.

5. Open mode cooling.

The data indicate that the quantity of water flowing through the Browns Ferry condenser cooling system during the representative time period would have contained 12.5×10^9 larval fish. Assumption 2 yields a representative mortality of 12.5×10^5 adults. The use of other modes (helper, closed) would reduce the above values by 16 percent and 95 percent, respectively, for the representative time period.

Very little is known regarding population dynamics of warmwater reservoir fishes, especially in a mixed fish population. The resulting impact of the projected larval fish mortalities cannot therefore be accurately estimated. The magnitude of the projected losses of larval fish as discussed in subsequent pages does, however, suggest the possibility of a significant adverse impact. To provide assurance that the operation of the Browns Ferry plant is not adversely affecting fish populations in Wheeler Reservoir, larval fish monitoring will continue following plant startup. Should there be significant adverse effects due to plant operation, corrective action will be taken.

(2) Plankton entrainment - Phytoplankton and zooplankton passing through the cooling water system should for the most part survive for a large portion of the year since the lethal temperature limits for plankton are higher than for larval fish. Estimates of total daily quantities (by weight) were made for the various tower operational modes based on concentrations indicated in quarterly samples taken in January, April, July, and October of calendar years 1969-71, estimates of the withdrawal volumes of the various modes, and the assumptions of uniform draw by the intake and uniformity of sample distributions in horizontal and vertical cross sections. Additionally, estimates of maximum phytoplankton standing crop were made by converting the chlorophyll a content to equivalent biomass.

Plankton entrainment estimates are summarized as follows:

Cooling System Operational Mode	Season	Phytoplankton (pounds/day)	Zooplankton (pounds/day)
open (on river)	winter	61,200	2,980
	spring	65,600	819
	summer	81,000	2,820
	fall	35,900	3,340
helper (on river plus towers)	winter	51,000	2,480
	spring	54,700	682
	summer	67,500	2,350
	fall	29,940	2,790
closed (on towers)	winter	3,050	149
	spring	3,270	41
	summer	4,040	141
	fall	1,790	167

Based on the expected amount of operation of the cooling towers in each mode, total estimated annual losses of phytoplankton are 4,182 tons; no estimate is available for zooplankton losses.

The inherent weaknesses in the estimates of plankton amounts are as follows:

1. The samples are "grab" samples that are not actually replicated at a point, only across a river transect.
2. Phytoplankton cell numbers may double in as short an interval as one day.
3. Zooplankton standing crop is estimated with day samples.
4. Zooplankton standing crop may change drastically within as short an interval as one week.
5. Communities of genera are measured and described—not species populations and/or size and age groups within species populations.
6. Only indirect biomass estimated have been made to date.
7. Seasonal trends develop within phytoplankton stocks as the result of changing solar energy values. The present monitoring program would underestimate these trends during the winter and spring quarters and overestimate in the fall quarter since samples

are taken during the first or second week of the quarter. However, present sample schedules fit existing flow or discharge cycles in the river.

3. Chemical discharge to water body - As discussed earlier in section 2.5 of this volume, the concentrations of chemicals to be discharged from the Browns Ferry plant will be within water quality standards prior to discharge. Thus there are no environmental costs associated with chemical discharges to Wheeler Reservoir.

4. Consumption of water - Although evaporation and drift loss rates of 110, 220, and 220 acre-feet per day are estimated in the open, closed, and helper modes of cooling tower operation, no significant effects on either downstream water supplies or irrigation supplies occur due to the insignificant size of these loss rates relative to average daily streamflow (89,000 acre-feet/day).

5. Chemical discharge to ambient air - Resulting ambient pollutant levels due to gaseous emissions from the plant's auxiliary boilers and diesel generators have been conservatively estimated assuming combustion of 5.3×10^6 gallons per year of fuel oil with 0.5 percent sulfur content. The maximum levels, as percents of the ambient air quality standards, are listed below:

Pollutant	Percent of Secondary Ambient Air Quality Standard
Particulates	0.19
Sulfur dioxide	0.68
Carbon monoxide	0.000014
Hydrocarbons	0.46
Nitrogen oxides	0.19

No odor originating from the plant should be perceptible at any point offsite.

6. Salts discharged in drift from cooling towers - The cooling water chemical content will be approximately double the chemical content of the makeup water. However, at these levels the cooling water will meet Public Health Service Drinking Water Standards. Thus, no significant effects are expected from drift discharges from the towers.

7. Chemical contamination of ground water - Chemicals discharged from the plant are at such concentrations when discharged that water quality standards are met. Thus, there exists no potential for chemical contamination of ground water.

8. Radionuclides discharged to water body - Doses are calculated according to the methods described in Appendix II and are derived from the numbers listed in Tables 3 and 6 of Appendix II by using scaling factors of 43.4, 5.42, and 0.434 for respective alternatives for liquid radwaste treatment. Maximum dose rates or dose commitments for each annual intake are reported.

(1) People - external - The maximum dose rates for an individual apply to skin exposure of a swimmer. Population dose rates are for skin doses and apply to both above-water activities and inwater activities.

(2) People - ingestion - Maximum dose commitments to the G.I. tract for the water and fish pathways are shown for both the individual and the population within 50 miles of the Browns Ferry Nuclear Plant.

(3) Primary producers and consumers - Dose rates (rads/year) are for internal and external exposure to green algae growing near the Browns Ferry diffusers.

(4) Fish - Dose rates (rads/year) are for total exposure to a fish living in the vicinity of the Browns Ferry Nuclear Plant.

9. Radionuclides discharged to ambient air -

(1) People - external - Individual and population external dose rates from the nuclides expected to be released to the air are computed as described in Appendix I. The maximum external dose to any organ, including the whole body, is the dose delivered to the skin. This dose rate is presented for all alternatives.

(2) People - ingestion - Individual and population thyroid doses from the ingestion of iodine released to the air are computed as described in Appendix I. This dose rate is presented for all alternatives.

(3) Plants and animals - The dose rate to plants and animals from radionuclides expected to be discharged to the air is assumed to be the same as the external dose rate to people.

10. Radionuclide contamination of ground water -

(1) People - Dose commitments for the annual intake of ground water are based on the calculations for the ingestion of Tennessee River water at the Browns Ferry site (Table 3 of Appendix II). It is assumed that the radioactivity concentration in ground water within 500 feet of the Tennessee River is 5 percent of

that present in the river below the Browns Ferry Nuclear Plant. A conservative estimate of the human population drinking ground water within 500 feet of the river is 7,300 persons between Browns Ferry and Pickwick Landing Dam. The maximum population dose commitment (thyroid) for an annual release of 1.0 Ci in the liquid effluent is:

$$\underset{\text{man}}{(7{,}300)} \quad \underset{\text{rem/yr}}{(0.05 \times 6.0 \times 10^{-6})} = \underset{\text{man-rem/yr}}{2.2 \times 10^{-3}}$$

Population dose commitments for the liquid radwaste alternatives are obtained by multiplying 2.2×10^{-3} man-rem/yr by 43.4, 5.42, and 0.434 for the respective cases. Individual dose commitments are obtained by multiplying 3×10^{-7} rem/yr by the same factors.

(2) Plants and animals - Calculations of doses to aquatic plants and animals living in the Tennessee River near the Browns Ferry Nuclear Plant are described in Appendix II. The maximum dose rate to any species is calculated to be 4.7×10^{-3} rad/yr for an annual release of 1.0 Ci. It is assumed that ground water within 500 feet of the Tennessee River contains a maximum of 5 percent of the radioactivity concentration present in the river below the Browns Ferry Nuclear Plant. Therefore, doses to plants and animals resulting from the radioactivity concentration in the ground water are expected to be very small.

11. Fogging and icing -

(1) Effects on local ground transportation - The analysis of effects on local ground transportation of fogging and icing of the heat dissipation alternatives is based on the procedural methods described in section 3.4 of Volume 3. As indicated in the same

volume, natural draft cooling towers and cooling ponds are not expected to have any effect on ground transportation. The analysis showed that spray canal plumes could affect ground transporation 385 hours per year. Closed cycle mechanical draft towers could affect ground transportation 445 hours per year. Combined cycle mechanical draft cooling towers could affect ground transportation 80 hours per year.

(2) Effects on air transportation - Analysis of Paradise power plant natural draft cooling tower plume behavior as described in section 3.4.3 of Volume 3 shows that the maximum extent of plumes or fogs from any of the six alternative cooling systems is about 5 miles. Since the nearest airport is located 11 miles east-southeast of the Browns Ferry site, no interference with commercial airport operation is anticipated.

(3) Local Effects on water transportation - The effects of river fogging (steam fogging) from diffuser releases were evaluated by relating dry bulb temperature, relative humidity, wind speed and water temperature to predict the frequency of occurrence of river fogging capable of affecting traffic. Analyses of the effects of mechanical draft towers and spray canals on river fogging are based on the procedural methods described in Section 3.4 of Volume 3. These analyses showed that river traffic could be affected 147 hours per year by fogging induced by use of the diffusers alone and 107 hours when operating combined cycle. Spray canals could affect river traffic 500 hours per year. Closed cycle mechanical draft cooling towers could interfere with river traffic 610 hours per year, and combined cycle mechanical draft towers could affect river traffic 110 hours per year.

(4) Effects on plants - Vegetation should not be damaged by fogs or plumes generated by any of the alternative cooling systems because daily exposure to excessive moisture should be of short duration (5 hours or less for all six alternative schemes) and should occur most frequently during predawn and postdawn hours, periods when vegetation is normally exposed to naturally occurring high relative humidities and dew.

12. Raising or lowering of ground water levels - Water withdrawals for the Browns Ferry plant should have no effect on local ground water levels since Wheeler Reservoir water levels are maintained according to TVA's reservoir operating guides. Normal fluctuations in water levels in the reservoir are from elevation 550 in winter to elevation 556 in late spring.

13. Ambient noise - Ambient noise levels due to operation of the Browns Ferry plant will be attributable to operation of the mechanical draft cooling towers. Noise levels from the towers are discussed in Section 2.6, Heat Dissipation. Operation of the base plant is essentially noiseless at the site boundary except for very infrequent operation of the air blast circuit breakers.

14. Aesthetics - Aesthetics cannot be quantified. The design of the Browns Ferry Nuclear Plant has as one objective the creation of harmony between plant and environment. The architectural design and site development should provide an aesthetically pleasing appearance and mitigate the transition in land use of the project area from agricultural to industrial. The addition of mechanical draft cooling towers will, to a certain extent, be an expense to the project aesthetics and surrounding environment, but careful design should make these cooling towers visually acceptable.

15. Permanent residuals of construction activity - Individual subtopics are discussed below.

(1) Accessibility of historical sites - No historical sites are affected by the plant or its transmission system additions.

(2) Accessibility of archaeological sites - No areas of known archaeological significance are affected by the plant or its transmission system additions.

(3) Setting of historical sites - Plant construction has not modified the local landscape at any historical site since none were affected.

(4) Land use - Site land requirements are about 840 acres for the base plant. Alternatives for heat dissipation have the following land requirements:

Heat Dissipation Alternative	Plant Land Area Required (acres)	New Land Area Required (acres)
Diffuser	—	-
Mechanical draft cooling towers	250	0
Natural draft cooling towers	70	0
Spray canal	135*	350
Cooling lake	135*	10,000

The additional land required for either spray canal or cooling lake would have had to be converted from farming or rural use to power plant use.

*Includes some reservoir shoreline area.

(5) Property -

(a) Impact of the plant site on property values - Browns Ferry Nuclear Plant site was acquired by TVA in December 1967 and construction began in 1968. Consequently, any impact of the plant on land values in the proximity should be evident by now. To ascertain the effects on property values in the area TVA investigated all real estate transactions occurring within a 5-mile radius of the plant site since 1965. In addition, information concerning 152 transactions occurring since 1962 within Limestone County as a whole have been analyzed to develop reference-point data. Since 1965 some 60 real estate transactions have taken place within the 5-mile zone. Twenty of these are residential lakefront lots; 25 are rural residential homesites near Athens, Alabama; and 15 are sales of farm properties.

The 20 residential lakefront lots investigated have risen in price from $2,500 in 1965 to $3,500 in 1972, an increase of approximately 5.7 percent per year. The prices of rural residential properties 3 to 5 miles away from the plant range from $200 to $3,150, depending primarily on location relative to Athens, Alabama, and the kind of road frontage serving the property.

The 15 farm property sales within the 5-mile zone have soils equal to or better than the county average. Almost all the land is row cropped and has a cotton allotment. In the impact study zone the farmland prices average $472 an acre with a median value of $489 an acre. Elsewhere throughout the country farmland averages $417 an acre with a median value of $381 an acre. Most of the agricultural land near the plant site is in large holdings, and many owners believe

that the future highest and best use of their land will be industrial, although no pending location by industry is now known or contemplated.

Investigations revealed no adverse effect on real estate values within 5 miles of the Browns Ferry Nuclear Plant site. Sale prices for farmland and rural residential properties equal or exceed prices of comparable properties in other areas of Limestone County. Lakefront subdivision lots in the 5-mile zone apparently are not as desirable as those downstream on the Elk River embayment, and any difference in value is attributable to such factors as silt problems, prevailing winds, dock damage on the main channel, and poor road access. In no event did the investigations show any discernable effect, either adverse or otherwise, attributable to proximity to the nuclear plant site.

(b) Impact of transmission lines on property values - All transmission lines required for the Browns Ferry Nuclear Plant have been completed. Right of way acquisition began in 1963 and extended through 1967. Except for a corridor in the vicinity of Decatur, Alabama, most of the property traversed by the Browns Ferry transmission line system is farmland and low-density rural residential property.

Recent investigations by TVA revealed no discernable loss in value attributable to the transmission lines outside the right of way proper. The only measurable damage occurs within the right of way where buildings are prohibited. Investigations in other agricultural, residential, and industrial areas throughout the TVA power service area show similar land value behavior

characteristics, and TVA anticipates no adverse effects by transmission lines on lands in the Browns Ferry Nuclear Plant site area. TVA can find no evidence that the presence of the transmission line system will inhibit orderly land development in the area and normal transition from agricultural use to residential, commercial, and industrial use should future demands require such transition.

(6) Flood control - The Browns Ferry project has no implication for flood control.

(7) Erosion control - The average amount of soil displaced by erosion due to construction activities at the Browns Ferry site is estimated to be 10,000 tons per year throughout the construction period. This estimate includes the effects of direct erosion of cleared land and also the displacement of dredge material in Wheeler Reservoir. Before the decision to add cooling towers at Browns Ferry, this estimate was only slightly less: 9,875 tons per year. Additions of other alternative cooling facilities could be expected to contribute approximately the same quantities of land erosion as the construction of mechanical draft cooling towers with the exception of a spray canal or a cooling lake. No exact estimates were made for these, but larger erosion rates would be expected.

16. Transportation - Browns Ferry will receive 18 truck shipments of new fuel in a normal year; 32 rail shipments of spent fuel will be made in a normal year; and about 53 shipments of radioactive waste will be made in a normal year. In addition, deliveries of fuel oil and chemicals will require receiving about 300 tank-truck shipments in a normal year. The

environmental review has demonstrated that the transportation shipments to and from the plant considering normal and accident conditions can be accomplished with a minimum impact.

17. Accidents - A spectrum of postulated accidents ranging in severity from trivial to very serious have been divided into 9 classes by AEC. This characterization of accident by classifications brackets the qualitative assessment of environmental costs and aids the development of the overall balancing of environmental costs and benefits. Table 2.3-2 of section 2.3 in this volume gives a summary of the radiological consequences of the postulated accidents. This environmental risk for the range of postulated accidents considering the probability of occurrence indicates that the annual potential exposure to the population from all postulated accidents is a very small fraction of the exposure of the same population from natural background radiation and, in fact, is well within naturally occurring variations in background radiation levels.

Table 8.2-1

BROWNS FERRY NUCLEAR PLANT
GENERATING AND ENVIRONMENTAL COSTS

		Alternative (Defined at end of table)	1	2	3	4
		Generating Costs - Thousands of Dollars	1,056,863	1,118,054	1,068,554	1,111,454
1. Heat Discharge to Water Body	1.1 Cooling capacity - Btu/hr heat rejection		2.44×10^{10}	3.6×10^{8}	2.44×10^{10}	2.44×10^{10} open 1.36×10^{10} helper 4.5×10^{8} closed
	acre-feet water affected (5°F isotherm)		165	55	165	165 open 165 helper 55 closed
	1.2 Aquatic biota - within affected area		see text			
	1.3 Migratory fish		no barrier	no barrier	no barrier	no barrier
2. Effects on Water Body of Intake Structure and Condenser Cooling Systems	2.1 Primary producers and consumers		varies seasonally - see text			
	2.2 Fisheries - larval fish mortality during 91-day sample period		12.5×10^{9}	6.5×10^{8}	12.5×10^{9}	12.5×10^{9} open 10.5×10^{9} helper 6.5×10^{8} closed
3. Chemical Discharge to Water Body	3.1 People - dilution volume to meet standards		0	0	0	0
	3.2 Aquatic biota - affected population		0	0	0	0
	3.3 Water quality - chemical dilution volume required to meet standards		0	0	0	0

Table 8.2-1 (contd.)

BROWNS FERRY NUCLEAR PLANT
GENERATING AND ENVIRONMENTAL COSTS

Alternative (Defined at end of table)		1	2	3	4
Generating Costs - Thousands of Dollars		1,056,863	1,118,054	1,068,554	1,111,454
4. Consumption of Water	4.1 People - acre-feet of water evaporated per day	110	220	110	110 open 220 helper 220 closed
	4.2 Property - affects on irrigation supplies	none	none	none	none
5. Chemical Discharge to Ambient Air	5.1 Air quality - chemical - highest percentage of standard	0.68%	0.68%	0.68%	0.68%
	5.2 Air Quality - odor	none	none	none	none
6. Salts Discharged from Cooling Towers	6.1 People - gal/yr of affected water	0	0	0	0
	6.2 Plants affected	none	none	none	none
7. Chemical Contamination of Ground Water	7.1 People - gallons of water contaminated	0	0	0	0
	7.2 Plants affected	none	none	none	none
8. Radionuclides Discharged to Water Body	8.1 People - rem/yr External contact man-rem/yr	$2x10^{-6}$ $5x10^{-3}$	$2x10^{-8}$ $5x10^{-5}$	$2x10^{-8}$ $5x10^{-5}$	$2x10^{-8}$ $5x10^{-5}$
	8.2 People - ingestion rem/yr man-rem/yr	$1x10^{-3}$ 80	$1x10^{-5}$ 0.8	$1x10^{-5}$ 0.8	$1x10^{-5}$ 0.8

Table 8.2-1 (contd.)

BROWNS FERRY NUCLEAR PLANT
GENERATING AND ENVIRONMENTAL COSTS

Alternative (Defined at end of table)			1	2	3	4
Generating Costs - Thousands of Dollars			1,056,863	1,118,054	1,068,554	1,111,454
	8.3 Primary consumers	rad/yr	$2x10^{-2}$	$2x10^{-4}$	$2x10^{-4}$	$2x10^{-4}$
	8.4 Fish	rad/yr	$5x10^{-2}$	$5x10^{-4}$	$5x10^{-4}$	$5x10^{-4}$
9. Radionuclides Discharged to Ambient Air	9.1 People - External	rem/yr	0.170	0.170	$5x10^{-4}$	$1.6x10^{-3}$
		man-rem/yr	890	890	1.6	23
	9.2 People - ingestion	rem/yr	$2x10^{-4}$	$2x10^{-4}$	$1.8x10^{-4}$	$1.8x10^{-4}$
		man-rem/yr	0.79	0.79	0.73	0.73
	9.3 Plants and Animals	rad/yr	0.170	0.170	$5x10^{-4}$	$1.6x10^{-3}$
10. Radionuclide Contamination of Ground Water	10.1 People -	rem/yr	$1x10^{-5}$	$1x10^{-7}$	$1x10^{-7}$	$1x10^{-7}$
		man-rem/yr	0.1	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$
	10.2 Plants and animals		see text			
11. Fogging and Icing Hours/Year	11.1 Ground transportation		0	445	0	80
	11.2 Air transportation		0	0	0	0
	11.3 Water transporation		147	610	147	217
	11.4 Plants		0	0	0	0

Table 8.2-1 (contd.)

BROWNS FERRY NUCLEAR PLANT
GENERATING AND ENVIRONMENTAL COSTS

		Alternative (Defined at end of table)	1	2	3	4
		Generating Costs - Thousands of Dollars	1,056,863	1,118,054	1,068,554	1,111,454
12.	Raising/Lowering of Ground Water Levels	12.1 People - Gal. Water affected	0	0	0	0
		12.2 Plants - acres affected	0	0	0	0
13.	Ambient Noise	13.1 People	see text			
14.	Aesthetics	14.1 Appearance	see text			
15.	Permanent Residuals of Construction Activity	15.1 Accessibility of historical sites	see text			
		15.2 Accessibility of archeological sites	see text			
		15.3 Setting of historical sites	see text			
		15.4 Land use	see text			
		15.5 Property	see text			
		15.6 Flood control	none	none	none	none
		15.7 Erosion control tons/year	9,875	10,000	9,875	10,000
16.	Transportation	16.1 Transport of radioactive material	see text			
17.	Accidents	17.1 Radiological effects	see text			

Table 8.2-1 (contd.)

BROWNS FERRY NUCLEAR PLANT
GENERATING AND ENVIRONMENTAL COSTS

Alternatives have the following subsystems:

	Alternative	Heat Dissipation System	Gaseous* Radwaste	Liquid Radwaste
1.	Base plant	diffuser	30-minute holdup	filtration and demineralization
2.	Minimum water impact	mechanical draft towers--closed cycle only	30-minute holdup	base plant and evaporation
3.	Minimum land/ air impact	diffuser	ORGDP or cryogenic	base plant and evaporation
4.	Plant license request	mechanical draft cooling towers--combined cycle	hydrogen recombiners and 6 charcoal beds	base plant and evaporation

*Base plant 30-minute holdup included in all alternatives.

Table 8.2-2

BROWNS FERRY NUCLEAR PLANT

ALTERNATIVES FOR LIQUID RADWASTE SYSTEM

COSTS WHICH VARY FROM BASE PLANT

Alternative Liquid Radwaste System	Filtration and Demineralization	Additional Demineralization	Filtration Demineralization, and Evaporation
Incremental Generating Cost (thousands of dollars)	base	5,711	1,991
Dosage Rates to People due to Radionuclides Discharged to Water Body - External Contact			
(rem/yr)	2×10^{-6}	3×10^{-7}	2×10^{-8}
(man-rem/yr)	5×10^{-3}	6×10^{-4}	5×10^{-5}
Dosage Rates to People due to Ingestion			
(rem/yr)	1×10^{-3}	1×10^{-4}	1×10^{-5}
(man-rem/yr)	80	10	0.8
Dosage Rate to Primary Consumers (rad/yr)	2×10^{-2}	3×10^{-3}	2×10^{-4}
Dosage Rate to Fish (rad/yr)	5×10^{-2}	7×10^{-3}	5×10^{-4}
Dosage Rates to People due to Radionuclide Contamination of Ground Water			
(rem/yr)	1×10^{-5}	2×10^{-6}	1×10^{-7}
(man-rem/yr)	0.1	1×10^{-2}	1×10^{-3}

Table 8.2-3

BROWNS FERRY NUCLEAR PLANT

ALTERNATIVES FOR GASEOUS RADWASTE SYSTEM

COSTS WHICH VARY FROM BASE PLANT

Alternative Gaseous Radwaste System	30-Minute Holdup	Hydrogen Recombiners	Hydrogen Recombiner and Six Charcoal Beds per unit	Hydrogen Recombiner and Twelve Charcoal Beds per unit	ORGDP Systems	Cryo-genic
Incremental Generating Cost (thousands of dollars)	base	6,000	9,000	10,500	Not Esti-mated	9,700
Dosage Rates to People from External Contact						
rem/yr	0.170	1.6×10^{-2}	1.6×10^{-3}	6×10^{-4}	5×10^{-4}	5×10^{-4}
man-rem/yr	890	260	23	6.8	1.6	1.6
Dosage Rates to People from Ingestion						
rem/yr	2×10^{-4}	1.8×10^{-4}	1.8×10^{-4}	1.8×10^{-4}	1.8×10^{-4}	1.8×10^{-4}
man-rem/yr	0.79	0.73	0.73	0.73	0.73	0.73
Dosage Rate to Plants and Animals						
rad/yr	0.170	1.6×10^{-2}	1.6×10^{-3}	6×10^{-4}	5×10^{-4}	5×10^{-4}

Table 8.2-4

BROWNS FERRY NUCLEAR PLANT
ALTERNATIVES FOR HEAT DISSIPATION SYSTEM
COSTS WHICH VARY FROM BASE PLANT

Alternative Heat Dissipation System	Mechanical Draft Towers Combined Cycle	Mechanical Draft Towers Closed Cycle	Natural Draft Cooling Towers	Diffusers	Spray Canal	Cooling Pond
Estimated Incremental Generating Cost (Thousands of Dollars)	43,600	59,200	54,200*	Base	None made	None made
Reservoir Heat Affected Volume (acre-feet/mode)	165 - open 165 - helper 55 - closed	55	165 - open 165 - helper 55 - closed	165	165 - open 55 - closed	165 - open 55 - closed
Reservoir Heat Input (Btu/hr-mode)	2.44×10^{10} - open 1.36×10^{10} - helper 4.5×10^{8} - closed	4.5×10^{8}	2.44×10^{10} - open 1.36×10^{10} - helper 4.5×10^{8} - closed	2.44×10^{10}	2.44×10^{10} - open 4.5×10 - closed	2.44×10^{10} - open 4.5×10^{8} - closed
Larval Fish Mortality due to Condenser Passage (fish-mode)	12.5×10^{9} - open 10.5×10^{9} - helper 6.5×10^{8} - closed	6.5×10^{8}	12.5×10^{9} - open 10.5×10^{9} - helper 6.5×10^{8} - closed	12.5×10^{9}	12.5×10^{9} - open 6.5×10^{8} - closed	12.5×10^{9} - open 6.5×10^{8} - closed
Water Consumed (acre-feet/day)	140	220	140	110	140	140
Transportation Affected (hr/yr) Ground -	80	445	0	0	385	0
Water -	217	610	0	147	500	0
Additional Land Required (acres)	0	0	0	0	350	10,000
Erosion (T/yr)	10,000	10,000	10,000	9,875	> 10,000	> 10,000

* For closed-cycle operation, $67,600 thousand.

8.3 Environmental Cost-Benefit Weighing and Balancing of Alternative Subsystems - Tables 8.2-2, 8.2-3, and 8.2-4 present the economic costs and environmental impacts for the alternative subsystems evaluated for liquid radwaste, gaseous radwaste, and heat dissipation respectively. This section presents weighing and balancing of the costs and benefits associated with each of these subsystems.

1. Liquid radwaste system - As discussed in section 3.1 of Volume 3, the liquid radwaste system as originally designed would have resulted in releases of approximately 40 curies per year of radioactivity (exclusive of tritium) into Wheeler Reservoir. Two alternatives were considered for reducing these releases: (1) modify the operation of the liquid radwaste treatment system to demineralize low conductivity liquid from the floor drain, or (2) install an evaporator to treat the liquid radwaste. The evaporator was estimated to have an installation cost of $1,000,000 with an annual operating cost of $85,000 for a total cost of $1,991,000. Demineralization of the floor drains was estimated to cost $490,000 annually for a total cost of $5,711,000. As indicated in Table 8.2-2, installation of the evaporator shows an economic advantage of $3.7 million and results in ad additional reduction factor over the demineralization of floor drain alternative. Based on this analysis TVA has concluded that an evaporator along with its associated buildings and equipment should be installed. TVA considers that there are no other feasible alternatives which would further reduce the liquid radioactive discharges. The system chosen for treatment of radioactive liquids yields a very low (0.00005 mrem) annual total body dose to any individual which is 0.001 percent

of the numerical guidance value provided by the proposed Appendix I to 10 CFR Part 50. The maximum annual dose to any body organ is only 0.01 mrem which is 0.2 percent of the numerical guidance value provided by the proposed Apendix I.

2. Gaseous radwaste system - As discussed in section 3.1 of Volume 3, the gaseous radwaste system as originally designed included 30-minute holdup and elevated stack release. Four alternative ways to reduce radioactive gaseous discharges at Browns Ferry were evaluated. These included:

1. Hydrogen recombiners
2. Hydrogen recombiners and charcoal absorber
3. Hydrogen recombiners and absorption by solvent (ORGDP system)
4. Hydrogen recombiners and cryogenic distillation

Table 8.2-3 presents an evaluation of hydrogen recombiners and hydrogen recombiners augmented with either 6 or 12 charcoal beds per unit, ORGDP system, or cryogenic distillation.

As shown in table 8.2-3, the original system (30 minute holdup) assuming a release rate of 100,000 μCi/s per unit resulted in a 170 mrem dose to people from external contact. The addition of hydrogen recombiners at an investment of $6 million resulted in reducing this dose from 170 mrem to 16 mrem for a reduction of 154 mrem. The augmenting of the hydrogen recombiners with 6 charcoal beds per unit at an incremental cost of $3 million (total cost of $9 million) resulted in a further reduction of 14.4 mrem to 1.6 mrem per year. Further augmentation of the hydrogen recombiner and 6 charcoal beds to include a total of 12 charcoal beds at an incremental cost of $1.5 million (total cost of $10.5 million) resulted in a further reduction of only 1 mrem to 0.6 mrem per year.

Both the ORGDP system and cryogenic system offered the potential for reducing the dose to people from external contact to a level of 0.5 mrem per year. A cost estimate was not developed for the ORGDP system; however, indications were that it would be considerably less expensive than the other alternatives being considered. The cryogenic system was estimated to cost $9.7 million. Neither of these systems have demonstrated performance and reliability in nuclear plant service. The only experience to date with the ORGDP system has been with bench and pilot size systems. The cryogenic distillation system, while proven for industrial applications, is a complex system compared to charcoal absorption systems and could experience operating problems and presents the potential for accidental release of concentrated waste to the environment.

Based on this analysis, TVA has concluded that the recombiner and six-charcoal bed (per unit) alternative which results in a dose reduction of 168.4 mrem per year to 1.6 mrem per year, represents the best balance of economic cost, reduction in environmental impact, and feasibility. TVA believes the benefits to be gained by further reducing the radioactive gaseous releases are not commensurate with the cost associated with the reduction. The proposed system results in a "fence post dose" of 1.6 mrem. This very low "fence post dose" is 16 percent of the numerical guidance provided by the proposed Appendix I. It also represents a very small percentage (about 1 percent) of the naturally occuring background dose.

3. Heat dissipation - The original plant design called for condenser waste heat dissipation by means of diffusers on

the bottom of Wheeler Reservoir. The original method was designed to permit a maximum 10°F temperature rise which was the proposed Alabama thermal water quality criteria at the time of initial plant planning. A recent change in the proposed Alabama thermal criteria limiting the temperature rise to a maximum of 5°F concurrent with the environmental review of Browns Ferry, prompted TVA to give further consideration to alternative methods of heat dissipation. The alternatives considered were mechanical and natural draft cooling towers, a spray canal, and a cooling lake. Details on these alternatives, including cost estimates, when deemed feasible, are given in Volume 3, section 3.4.

Analyses were performed using the following factors as a basis: feasibility, environmental considerations, and economic considerations. The analyses were carried to the extent required to determine the acceptability of each alternative when considering these factors. This resulted in a complete analysis of only the cooling tower alternatives.

Estimates of environmental impacts were made as discussed above in section 8.2. The results are summarized in Table 8.2-4.

The spray canal alternative would require a cooling canal approximately 5 miles in total length and 200 feet wide with 700 spray modules and would require the purchase of an additional 350 acres of land. The analysis of the spray canal alternative showed no significant reductions in environmental impacts that could not be accomplished with the cooling tower alternatives. Due to the limited operating experience with spray canals and the absence of any installations with a heat rejection of the magnitude of Browns Ferry, the spray canal was not considered a feasible alternative for this plant.

The cooling lake alternative would require a lake of approximately 5,000 acres and the purchase of an additional 10,000 acres of land. Due to the unfavorable topography at the Browns Ferry site, impoundment of a reservoir of this size would require many miles of canals and high dikes and would have resulted in a reservoir level 50-100 feet above the existing reservoir. Thus, it was concluded that a cooling lake is not a feasible alternative for this plant.

A comparison of the mechanical and natural draft cooling tower alternatives was made in the same operating mode. The principal disadvantages of the mechanical draft cooling towers when compared to natural draft cooling towers are the possible higher frequency for fogging and icing and higher noise levels. However, the mechanical draft cooling towers showed an economic advantage of $10.6 million and required approximately two years less to construct. The first set of mechanical draft towers can be in operation prior to commercial operation of Browns Ferry Unit 3. Based on the analysis of the feasibility considerations (including short construction time), environmental considerations and economic costs, TVA has concluded that the mechanical draft cooling towers offer the best balance of these factors for providing auxiliary cooling for the Browns Ferry plant.

The mechanical draft cooling towers to be installed can operate in the open, helper, or closed mode. The combined cycle information presented in Table 8.2-4 is based on making maximum use of the heat dissipation capability of the reservoir and reflects operation 7 percent of the time

in the closed mode, 21 percent of the time in the helper mode, and 72 percent of the time in the open mode. When compared to mechanical draft tower closed cycle alternative, the combined cycle shows an economic advantage of $15.6 million. While the environmental impacts are greater for combined cycle operation, the only potentially significant impact is that resulting from larval fish mortality due to condenser passage. The significance of these larval fish mortalities is not known. Since the environmental costs of this impact cannot be determined at this time, TVA plans to utilize the combined cycle operating method due to the significant economic advantage. TVA has the capability to modify plant operation during critical periods should environmental monitoring indicate significant adverse effects on fish populations in Wheeler Reservoir.

9.0 CONCLUSION

The Browns Ferry Nuclear Plant was initiated before NEPA became effective, and the TVA Board of Directors has determined that it is not practicable to reassess the basic course of action in the design and construction of this plant. However, the environmental impacts considered at the outset of the project have been reevaluated so as to minimize adverse consequences. For example, extended radwaste treatment, additional chemical treatment facilities, and mechanical draft cooling towers have been provided.

The three-volume final detailed environmental statement traces the environmental considerations and manner in which they were incorporated into TVA's decision-making process. In addition, this process has identified the principal ways in which the plant will interact with the environment as (1) minute additions of radioactivity to the air and water, (2) release of large quantities of heat to the environment, and (3) change in land use from farming to industrial.

The addition of the Browns Ferry Nuclear Plant to the TVA system will enable TVA to continue to carry out its responsibility to provide an ample supply of electricity for the TVA region. After weighing the environmental costs and the technical, economic, environmental, and other benefits of the project and adopting alternatives which affect the overall balance of costs and benefits by lessening environmental impacts, TVA has concluded that the overall benefits of the project far outweigh the monetary and environmental costs.

It is concluded that the plant as now designed closely approaches a minimum impact plant and can be operated without significant risk to the health and safety of the public.

APPENDIX I

RADIOLOGICAL IMPACT OF GASEOUS EFFLUENTS

The following doses to humans living in the vicinity of the Browns Ferry Nuclear Plant (BFNP) are calculated for routine releases of radioactive gases:

1. external beta doses
2. external gamma doses
3. thyroid doses due to inhalation of radioactive iodine
4. thyroid doses due to reconcentration of radioactive iodine in milk produced near the site.

The doses which appear in the tables in this appendix are calculated assuming operation of three units with an average annual noble gas release rate of 100,000 μCi/sec/unit (after 30 minutes decay). The basic assumptions and calculational methods used in computing the doses due to gaseous effluents are described in this section.

Gaseous radionuclides will be released from the Browns Ferry Nuclear Plant through the 600-foot plant stack and from vents on top of various plant buildings. In calculating downwind, ground level air concentrations or radioactive gases from stack releases, an elevated, point source dispersion equation is used (see equation 1).

Stack Release

$$X_{km} = \sum_{i=1}^{3} \sum_{j=1}^{6} \frac{\sqrt{2}\, Qf_{ijk}}{\sqrt{\pi}\, \sigma_{zim} u_j \theta\, x_m} \exp\left[\frac{-h_j^2}{2\sigma_{zim}^2} \quad \frac{-\lambda x_m}{u_j}\right] \quad (1)$$

To calculate downwind, ground level air concentrations of radioactive gases resulting from releases from building vents, a ground level, volume source dispersion equation is used (see equation 2). The radioactive gases are assumed to be caught in the turbulent wake downwind of the building and mixed across the vertical building height.

Building Release

$$\chi_{km} = \sum_{i=1}^{3} \sum_{j=1}^{6} \frac{\sqrt{2\pi}\ \sigma_{yim} Q f_{ijk}}{(\pi\sigma_{yim}\sigma_{zim} + cA) u_j \theta x_m} \exp\left(\frac{-\lambda x_m}{u_j}\right) , \qquad (2)$$

where

χ_{km} = average annual, ground-level air concentration of a particular nuclide in sector k at distance x_m, (Ci/m^3),

f_{ijk} = fraction of the release period during which the wind blows in direction k, with speed j, and atmospheric stability condition i,

Q = release rate of nuclide, (Ci/sec),

σ_{yim} = horizontal standard deviation of the plume for stability condition i at distance x_m, (m),

σ_{zim} = vertical standard deviation of the plume for stability condition i at distance x_m, (m),

h_j = effective release height for wind speed j, (m),

cA = correction factor to account for initial mixing of the gases in the turbulent wake of the reactor building, (m^2),

x_m = downwind distance at which air concentration is calculated, (m),

u_j = wind speed j, (m/sec),

θ = sector width, (radians),

λ = radioactive decay constant for a particular nuclide, (sec^{-1}).

These equations are used to predict the average annual ground level air concentration of the gases over the width of a 22.5° sector. In equation 2, c is taken as 0.5 and A is taken as the minimum cross sectional area of the reactor building.

For these analyses, σ_{yim} and σ_{zim}, as measured by TVA,[1] are used. The frequencies, f_{ijk}, in equations 1 and 2 are obtained by TVA meteorologists using meteorological data measured at the BFNP site. The data are grouped for three stability conditions (very stable, moderately stable, and unstable) and for six wind speed ranges (0-3, 4-7, 8-12, 13-18, 19-24, $\geq$ 25 mph).

1. External beta doses - The individual beta doses are computed using an immersion dose model described by the equation:

$$D_\beta = 4.64 \times 10^9 \, \overline{E}_\beta \, \chi, \qquad (3)$$

where

D_β = external beta dose due to submersion in a cloud, (mrem/yr),

4.64×10^9 = a constant used in calculating external beta dose, $\left(\frac{\text{mrem/yr}}{\text{Ci-Mev/dis-m}^3}\right)$,

$\overline{E}_\beta$ = average beta energy of isotope being considered, (Mev/dis),

χ = average annual, ground level air concentration as calculated by equation 1 or 2, $\left(\frac{\text{Ci}}{\text{m}^3}\right)$.

In this equation, a geometry correction factor of 0.64 is included to account for the semihemispherical cloud and a geometry correction factor of 0.5 is included to account for self shielding by the human body.

The χ used in equation 3 is the same as χ_{km} in equations 1 and 2. To obtain the total beta dose derived from a mixture of several noble gases and radioiodines, equation 3 is applied for each isotope, and the resulting doses are summed. The average beta energies for the isotopes being considered are calculated from information contained in the reference.[2]

In computing the total population beta dose within 50 miles of the BFNP, the area is divided into 16 directional sectors and 11 concentric rings, i.e., the area within 50 miles of the plant is divided into 176 small area elements. A beta dose is computed at the center of each element and multiplied by the number of persons residing in that element. A summation of the element dose multiplied by element population over all elements gives the total population dose within 50 miles of the plant. In calculating the population dose, the projected population for the year 2010 is used.

For each source, the annual releases of the various isotopes considered in these analyses are given in Table 1, and the corresponding individual and population external beta doses are given in Table 2.

2. External gamma doses - The elevated release, immersion dose approach grossly underestimates the external ground level gamma dose at downwind distances where the bulk of the radioactive plume is above the ground. In this situation, the immersion dose approach predicts

a dose based on the very low ground level air concentration while the major contribution to the ground level gamma dose comes from the radioactive materials contained in the overhead plume.

For a very stable atmospheric condition, the bulk of a radioactive plume released from the 600-foot stack at BFNP will remain overhead for distances beyond the 50-mile radius within which population doses are calculated. To adequately assess the ground level gamma doses from an overhead plume, the plume must be divided into a finite number of volume elements (sources), and the dose contributions from all volume elements to each point on the ground under consideration must be calculated and summed. Such a model has been developed by TVA[3] for use in computing site boundary doses for the BFNP. This finite volume element model does not give a representative estimate of ground level gamma doses at downwind distances beyond 10 miles from the release point. Ground level gamma doses for both elevated and building releases were calculated using a "hybrid" computer model which executes the following sequence:

1. A ground level gamma dose is calculated at 1,200 m downwind from the release point using the finite volume element gamma dose model for an elevated or a building release (whichever is appropriate).
2. A ground level gamma dose is calculated at 100,000 m downwind from the release point using the building (ground level) release, immersion dose model.
3. A log-log interpolation is performed between these two end points to obtain gamma doses at intermediate points.

The TVA finite volume element model is described in detail in the references[3,4] and will not be discussed further in this appendix. The immersion dose model used to compute the ground level gamma dose at 100,000 m is given by equation 4.

$$D_\gamma = 7.21 \times 10^9 \, \overline{E}_\gamma \chi \qquad (4)$$

where

D_γ = external gamma dose due to submersion in a cloud, (mrem/yr),

7.21×10^9 = a constant used in calculating external gamma dose, $\left(\frac{\text{mrem/yr}}{\text{Ci-Mev/dis-m}^3}\right)$,

$\overline{E}_\gamma$ = average gamma energy of isotope being considered, (Mev/dis),

χ = average annual, ground level air concentration as calculated by equation 1 or 2, (Ci/m^3).

In this equation, a geometry correction factor of 0.5 is included to account for the semihemispherical cloud. The air concentration χ at 100,000 m is obtained using equation 2.

Where several isotopes contribute to the external gamma dose, the dose due to each isotope is computed and a summation (over all isotopes) is executed to obtain the total external gamma dose. The average gamma energies used in calculating external gamma doses were computed from data contained in the reference.[2]

The total population gamma dose within 50 miles of BFNP is calculated using the method described for the population beta dose. The annual individual and population external gamma doses, calculated for the releases shown in Table 1, are given in Table 2.

3. <u>Thyroid doses due to iodine inhalation</u> - The dose equation used in calculating inhalation doses for routine releases of radioiodine from BFNP is:

$$D = 8.76 \times 10^3 \, \chi(BR) \, (DCF), \qquad (5)$$

where

D = thyroid dose committed during release period, (mrem committed/yr),

8.76×10^3 = a constant representing the number of hours per year, $\left(\frac{\text{hr}}{\text{yr}}\right)$,

χ = average annual, ground level air concentration as calculated by equation 1 or 2, (Ci/m^3),

BR = breathing rate for person receiving dose, (m^3/hr),

DCF = dose commitment factor for iodine inhalation, (mrem/Ci inhaled).

The Federal Radiation Council[5] recommended a one-year-old child as the critical receptor for thyroid doses due to intake of radioiodine. In accordance with this recommendation maximum individual doses are calculated for a one-year-old child. Population doses are calculated using adult parameters and the same method described for beta doses.

The breathing rate used for a one-year-old child is 0.29 m^3/hr[6] and for an adult is 0.83 m^3/hr.[7] The inhalation dose commitment factors for the one-year-old child and for the adult are obtained for the five radioiodine isotopes considered using data from the reference.[8]

For each source, the annual radioiodine releases are shown in Table 1, and the calculated annual individual and population iodine inhalation doses are shown in Table 3.

4. <u>Thyroid doses due to iodine ingestion</u> - The equation used in calculating the thyroid doses to a receptor due to iodine ingestion through the milk food chain is:

$$D = 3.15 \times 10^7 \ (\chi) \ (v_g) \ (M) \ (CR) \ (DCF) \qquad (6)$$

where

D = thyroid dose committed during release period, (mrem committed/yr),

3.15×10^7 = a constant representing the number of seconds per year, $\left(\frac{sec}{yr}\right)$,

χ = average annual, ground level air concentration as calculated by equation 1 or 2, (Ci/m^3),

v_g = radioiodine deposition velocity, (m/sec),

M = empirically determined value of milk concentration of radioiodine per unit deposition rate, $\left(\frac{Ci/l}{Ci/m^2\text{-day}}\right)$,

CR = milk consumption rate, (l/day),

DCF = dose commitment factor for iodine ingestion, (mrem/Ci ingested).

In calculating milk ingestion doses due to routine releases of radioiodine from BFNP, only I-131 and I-133 isotopes are considered. The other iodine isotopes listed in Table 1 (I-132, I-134, and I-135) have short half lives (<7 hours) and will have essentially disappeared due to radioactive decay before significant reconcentration in the milk occurs.

The one-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 (2.6 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 BFNP is consumed within the area. Cows are assumed to graze the pastures during the entire year. The numerical values used for the parameters v_g[9], M[10], CR[11], and DCF[11,8] were taken from the references indicated.

The individual and population milk ingestion doses are reported in Table 3.

5. <u>Maximum average annual radioiodine concentration</u> - The maximum average annual concentration of each radioiodine isotope released from the BFNP occurs in the NNW sector. These maximum concentrations (and the points at which they occur) are shown for each source in Table 4. These concentrations are calculated using equations 1 and 2.

Table 1

CALCULATED ANNUAL GASEOUS RELEASES DURING NORMAL OPERATION OF THREE UNITS WITH RELEASES CONSISTENT WITH A NOBLE GAS RELEASE RATE OF 100,000 μCi/sec/unit (after 30 minutes decay)

	Source of Release							
	Routine Release Sources				Alternate Waste Treatment Systems			
Isotope	Containment Purge[b] (E)[a] (Ci/yr)	Mechanical Vacuum Pump[b] (E) (Ci/yr)	Turbine Building[c] (B) (Ci/yr)	Waste Treatment 6 Charcoal Beds[d] (E) (Ci/yr)	Waste Treatment 30 Minutes Decay[d] (E) (Ci/yr)	Waste Treatment Recombiners Only[d] (E) (Ci/yr)	Waste Treatment 12 Charcoal Beds[d] (E) (Ci/yr)	Waste Treatment Gas Removal Systems[e] (E) (Ci/yr)
I-131	1.8 (-2)[f]		1.1 (-2)		6.5 (-3)[g]			
I-132	2.1 (-3)		1.0 (-1)		6.0 (-2)[g]			
I-133	1.4 (-2)		7.5 (-2)		4.5 (-2)[g]			
I-134			2.1 (-1)		1.2 (-1)[g]			
I-135			1.1 (-1)		6.5 (-2)[g]			
Kr-83m				9.3 (+2)	2.7 (+5)	2.2 (+4)	3.4 (+2)	3.4 (+2)
Kr-85m				4.3 (+4)	5.3 (+5)	1.9 (+5)	9.9 (+3)	7.7 (+2)
Kr-85				1.9 (+3)	1.9 (+3)	1.9 (+3)	1.9 (+3)	3.8
Kr-87				2.1 (+3)	1.4 (+6)	4.2 (+4)	1.9 (+3)	1.9 (+3)
Kr-88				3.2 (+4)	1.7 (+6)	3.2 (+5)	4.7 (+3)	2.2 (+3)
Kr-89								
Xe-131m	2.0			9.2 (+2)	1.4 (+3)	1.4 (+3)	6.1 (+2)	2.8
Xe-133m	4.0			2.8 (+3)	2.6 (+4)	2.5 (+4)	3.4 (+2)	5.2 (+1)
Xe-133	1.6 (+2)	5.8 (+3)		2.9 (+5)	7.8 (+5)	7.5 (+5)	1.1 (+5)	1.5 (+3)
Xe-135m	2.0 (+1)			2.5 (+3)	6.5 (+5)	2.5 (+3)	2.5 (+3)	2.5 (+3)
Xe-135	6.5 (+1)	8.6 (+2)		2.1 (+3)	2.1 (+6)	1.2 (+6)	2.1 (+3)	3.3 (+3)
Xe-137				1.4 (+4)	6.3 (+4)	1.4 (+4)	1.4 (+4)	1.4 (+4)
Xe-138				8.4 (+3)	2.0 (+6)	8.4 (+3)	8.4 (+3)	8.4 (+3)

a. (E) = stack release; (B) = building release
b. Release taken from the Browns Ferry Nuclear Plant FSAR
c. Based on 100 gal/day/unit leakage, a total DF of 2×10^3, and no decay
d. Based on air ejector flow rate of 18.5 scfm; includes release due to gland seal leakage
e. Assumes a DF of 1,000 for all isotopes; includes release of gland seal leakage
f. 1.8×10^{-2}
g. Assumes a DF of 100 due to washout

Table 2

CALCULATED ANNUAL EXTERNAL GAMMA AND BETA DOSES DURING NORMAL OPERATION OF THREE UNITS

WITH RELEASES CONSISTENT WITH A NOBLE GAS RELEASE RATE OF 100,000 μCi/sec/unit (after 30 minutes decay)

	Source of Release							
	Routine Release Sources				Alternate Waste Treatment Systems			
	Containment Purge	Mechanical Vacuum Pump	Turbine Building	Waste Treatment 6 Charcoal Beds	Waste Treatment 30 Minutes Decay	Waste Treatment Recombiners Only	Waste Treatment 12 Charcoal Beds	Waste Treatment Gas Removal Systems
Maximum Individual Gamma Dose (mrem)	2.1 (-4)[a] (1509m)	2.2 (-3) (1509m)	4.0 (-5) (1509m)	1.3 (1509m)	1.5 (+2) (1509m)	1.3 (+1) (1509m)	4.9 (-1) (1509m)	4.1 (-1) (1509m)
Maximum Individual Beta Dose (mrem)	2.0 (-4) (2400m)	4.5 (-3) (2400m)	2.0 (-5) (1509m)	3.4 (-1) (2400m)	2.2 (+1) (2400m)	3.3 (2400m)	1.6 (-1) (2400m)	8.0 (-2) (2400m)
Total Population Gamma Dose Within 50 miles (man-rem)	8.3 (-3)	1.8 (-1)	1.6 (-4)	1.5 (+1)	6.7 (+2)	1.9 (+2)	3.9	9.5 (-1)
Total Population Beta Dose Within 50 miles (man-rem)	5.3 (-3)	1.3 (-1)	7.9 (-5)	7.2	2.2 (+2)	7.1 (+1)	2.6	3.6 (-1)

a. 2.1×10^{-4}

Table 3

CALCULATED ANNUAL THYROID DOSES DUE TO IODINE INTAKE DURING NORMAL OPERATION OF THREE UNITS

WITH RELEASES CONSISTENT WITH A NOBLE GAS RELEASE RATE OF 100,000 μCi/sec/unit (after 30 minutes decay)

	Source of Release							
	Routine Release Sources				Alternate Waste Treatment Systems			
	Containment Purge	Mechanical Vacuum Pump	Turbine Building	Waste Treatment 6 Charcoal Beds	Waste Treatment 30 Minutes Decay	Waste Treatment Recombiners Only	Waste Treatment 12 Charcoal Beds	Waste Treatment Gas Removal Systems
Iodine Inhalation								
Maximum Individual Thyroid Dose (mrem)	6.3 (-4)[a] (2400m)	-	3.9 (-2) (1509m)	-	1.2 (-3) (2400m)	-	-	-
Total Population Thyroid Dose Within 50 miles (man-rem)	9.7 (-3)	-	1.0 (-1)	-	1.0 (-2)	-	-	-
Iodine Ingestion via Milk								
Maximum Individual Thyroid Dose at Nearest Dairy Farm (mrem)	3.3 (-2) (4200m)	-	1.5 (-1) (4200m)	-	1.3 (-2) (4200m)	-	-	-
Total Population Thyroid Dose Within 50 miles (man-rem)	1.5 (-1)	-	5.8 (-1)	-	5.6 (-2)	-	-	-

a. 6.3×10^{-4}

Table 4

CALCULATED MAXIMUM ANNUAL IODINE CONCENTRATIONS DURING NORMAL OPERATION OF THREE UNITS

WITH RELEASES CONSISTENT WITH A NOBLE GAS RELEASE RATE OF 100,000 μCi/sec/unit (after 30 minutes decay)

	Source of Release								
	Routine Release Sources					Alternate Waste Treatment Systems			
	Containment Purge	Mechanical Vacuum Pump	Turbine Building	Waste Treatment 6 Charcoal Beds	Total, All Routine Sources	Waste Treatment 30 Minutes Decay	Waste Treatment Recombiners Only	Waste Treatment 12 Charcoal Beds	Waste Treatment Gas Removal Systems
Max. Annual Conc. of I-131, μCi/cc	1.8 (-17)[a] (2400m)	-	2.3 (-16) (1509m)	-	2.4 (-16) (1509m)	6.6 (-18) (2400m)	-	-	-
Max. Annual Conc. of I-132, μCi/cc	2.0 (-18) (2400m)	-	1.9 (-15) (1509m)	-	1.9 (-15) (1509m)	5.6 (-17) (2400m)	-	-	-
Max. Annual Conc. of I-133, μCi/cc	1.4 (-17) (2400m)	-	1.5 (-15) (1509m)	-	1.5 (-15) (1509m)	4.5 (-17) (2400m)	-	-	-
Max. Annual Conc. of I-134, μCi/cc	-	-	3.7 (-15) (1509m)	-	3.7 (-15) (1509m)	9.7 (-17) (2400m)	-	-	-
Max. Annual Conc. of I-135, μCi/cc	-	-	2.2 (-15) (1509m)	-	2.2 (-15) (1509m)	6.4 (-17) (2400m)			

a. 1.8×10^{-17}

APPENDIX II

RADIOLOGICAL IMPACT OF LIQUID EFFLUENTS

The calculation of radiation doses to organisms that are exposed in a natural or incompletely controlled environment is a difficult task. Because of the complexity of biological functions and the interrelationship between organisms and their environments, it is necessary to develop simplified dose models that can predict the more important characteristics of the system under analysis. It is further necessary to apply assumptions that are descriptive of average behavior and average conditions of the ecosystems. While these models may be unable to follow the detailed variances of a system and while the results of an analysis may not be applicable to all members of a population, assumptions are chosen so that the radiation doses are conservative, i.e., overestimated. Only the basic assumptions are given in this appendix along with a brief outline of the models and methods of calculation.

Doses are calculated for the radionuclides listed in Table 1 which are expected to be released during normal operation of the Browns Ferry plant. For convenience, the activities are normalized to a total of 1.0 Ci with the assumption that the nuclides Y-90, Tc-99m, La-140, and Pr-144 are in equilibrium with their respective parents at the time of release. Inclusion of these daughter nuclides increases the total activity by 8.5 percent and the ratios between the activities in Table 1 and those in Table 2.4-2 of this volume are 43.4, 5.42, and 0.434 for the 40 Ci, 5 Ci, and 0.4 Ci values respectively. These activities correspond to the expected annual releases (1) from the system as designed, (2) for interim operation with demineralizers, and (3) for operation with the complete radwaste system including evaporator. Doses in Table 2.4-3 of

this volume are derived from the normalized dose estimates listed in the tables of this appendix by the application of the factors 5.42 and 0.434 as appropriate. Tritium doses are considered separately and are based on a normalized release of 1 Ci per year. The annual tritium dose may be computed by applying the appropriate factor to this normalized value.

Calculations of doses to humans include estimates of the doses to bone, G.I. tract, thyroid, and skin tissues as well as the total body. Dose estimates for organisms other than man are not detailed by organs other than the total body because of a lack of applicable data.

1. Doses to man from the ingestion of water - Calculations of dose commitments from the consumption of Tennessee River water use data for the public and industrial water systems listed in Table 2. Projected populations for the year 2010 are used based on a uniform ratio of 1.77 x 1970 population within 50 miles of the Browns Ferry site. The plant effluent is assumed to be mixed with 65 percent of the riverflow at or near the outfall at Browns Ferry. Although natural water turbulence should increase the total dispersion (and reduce the activity concentration) in the 19.1-mile reach to the first water supply intake at Wheeler Dam, there are uncertainties, e.g., the degree of mixing of the main riverflow with the Elk River inflow at TRM 283. Therefore, it is assumed that complete mixing would not be effected until the water passes Wheeler Dam.

Dilution is calculated using average annual flow data for the Tennessee River as measured during 1899-1968. The average flow ranges from approximately 45,000 ft^3/s at the site to 54,000 ft^3/s at Pickwick Landing Dam. Radioactive decay and the buildup of daughter activity are based on estimates of the transport time using data for water

velocities which vary between 0.2 and 2.6 ft/s within the reach from the nuclear plant site to Pickwick Landing Dam. 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 adsorption on solids and sedimentation, by deposition in the biomass, or by processing within water treatment systems.

Internal doses, D_{ij}, for the jth organ from the ith radionuclide are calculated using the relation

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

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

I_i = the activity of the ith radionuclide taken into the body annually via ingestion, (μCi).

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

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

where $51.2 \times 10^3 = \left(\frac{\text{g-rad}}{\text{Mev}}\right)\left(\frac{\text{disintegrations}}{\mu\text{Ci-day}}\right)\left(\frac{\text{mrem}}{\text{rem}}\right)$

f_{wij} = fraction of the ith radionuclide taken into the body by ingestion that is retained in the jth organ, (dimensionless),

ε_{ij} = effective energy absorbed in the jth organ per disintegration of the ith radionuclide including daughter products, (Mev-rem/dis-rad),

λ_{ij} = the effective decay constant of the ith radionuclide in the jth organ, (day $^{-1}$),

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

m_j = mass of the jth organ, (g).

Tables 3 and 4 show a detailed breakdown of the dose commitments at each public water supply intake.

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 50,000 GPM which corresponds to the minimum flow rate with cooling towers operating in a closed-cycle mode.

Doses to humans from ingestion of Tennessee River water affected by slug releases can be estimated using the data in section A of Tables 3 and 4 provided (1) the distribution of activity is the same as for the dose estimates for normal operation, (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.

2. Doses to man from the consumption of fish - Calculations of the dose commitments from the consumption of fish assume a sport fish harvest[4] of 15.2 lb/acre and an edible commercial fish harvest[5] of 13.7 lb/acre taken from a total of 125,000 acres. It is assumed that the entire harvest of edible fish contributes to the estimated population dose commitment. The radioactivity levels in these fish are estimated by the product of the average concentration of water activity in the reach from TRM 294.0 to TRM 233.0 and a concentration factor for each radionuclide.[6,7] It is assumed that the maximum annual consumption of fish by an individual is 45 lbs. 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. Shellfish consumption is assumed to be negligible.

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 3 and 4.

3. Doses to man due to water sports - 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 ith radionuclide, (μCi/g),

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

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

Population doses are calculated for the reach from the Browns Ferry site (TRM 294.0) to Tennessee River mile 233.0 using estimates of 2,518,000 above-water visits and 480,000 in-water visits per year based on information given in reference 8 and 9. The maximum individual doses for above-water use of the river are estimated for a commerical 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 Browns Ferry site. In order to estimate the maximum possible tritium dose to a swimmer, continuous immersion in the Tennessee River just below the Browns Ferry site is assumed.

4. Doses to organisms other than man - A comprehensive analysis of the radiation doses to species other than man 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 Browns Ferry 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 reconcentrated 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 reconcentrated radionuclides. In general, aquatic plants such as green algae concentrate trace elements to a greater extent than do fish and invertebrates.[6] Therefore, internal dose estimates have been made for ducks and muskrats with the conservative assumption that their diet consists entirely of green algae from algol masses growing near and affected by the Browns Ferry outfall. Equations 1 and 2 from section 1 are used for estimating internal dose. It is assumed that the duck or muskrat has a mass m of 1,000 g, an 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 of interval T. In the absence of data specifically applicable to ducks or muskrats, ICRP data[2] are used for the fractional uptake f_{wi} and for the biological half life of parent radionuclides. The use of human data for the biological half lives is conservative because, in general, warm-blooded vertebrates that are smaller than man exhibit

more rapid elimination rates. Equation 5 is a combination of the above assumptions with equations 1 and 2.

$$D_i = 6.23 \times 10^6 f_{wi} \varepsilon_i (1-e^{-\lambda_i T}) C_{wi} F_{pi}/\lambda_i \text{ mrad}, \quad (5)$$

where T = 1,825 days,

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

F_{pi} = concentration factor[6,7] for aquatic plants, (dimensionless).

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.

Table 5 shows the estimates of the doses to a duck or muskrat.

(2) Aquatic plants, invertebrates, and fish - Radionuclide activity internally deposited in these organisms is estimated from the concentration in the water in the Tennessee River just below the liquid effluent outfall, assuming 65 percent mixing, multiplied by the applicable concentration factors.[6,7] 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. On the other hand, the increased doses to benthic invertebrates from radionuclides having higher concentrations in bottom sediments than in the water are not included in the calculations. 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 contribute energy at the rate of one disintegration of every daughter in a decay chain for each disintegration of the parent. The doses from the ith radionuclide are calculated using the relation:

$$D_i = 1.87 \times 10^7 \, C_{wi} \, F_i \, \varepsilon_i \quad \text{mrad.} \tag{6}$$

Table 6 lists the dose estimates for these organisms.

Table 1

ROUTINE RELEASES OF LIQUID EFFLUENTS[a]

(Normalized to 1.0 Curie)

Nuclide	Release[b] (microcuries)
Co-58	1.2 (4)[c]
Co-60	1.2 (3)
Sr-89	7.4 (3)
Sr-90	5.5 (2)
Sr-91	6.9 (4)
Y-90	5.5 (2)
Mo-99	4.8 (4)
Tc-99m	4.8 (4)
I-131	3.0 (4)
I-133	1.4 (5)
I-135	9.0 (4)
Cs-134	3.9 (2)
Cs-137	5.8 (2)
Ba-140	2.1 (4)
La-140	2.1 (4)
Ce-144	8.3 (1)
Pr-144	8.3 (1)
Np-239	5.1 (5)
Total	1.0×10^6 μCi

a. Tritium is not included
b. The following radioactive daughters are assumed to be in equilibrium with the respective parents at the time of release; Y-90, Tc-99m, La-140, Pr-144.
c. 1.2×10^4

Table 2

TENNESSEE RIVER DRINKING WATER SUPPLY INTAKES WITHIN A 50-MILE RADIUS DOWNSTREAM FROM BROWNS FERRY NUCLEAR PLANT

System	Location (TRM)	Distance (miles)	Populations Served 1970	2010
Wheeler Dam	274.9	19.1	50	90
Wilson Dam	259.4	34.6	2,500	4,400
Sheffield	254.3	39.7	16,000	29,000
Colbert Steam Plant	245.0	49.0	350	620
Cherokee	239.3	54.7	2,400	4,200

Table 3

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
Browns Ferry Site (for comparison)	6.8 (-4)[d]	9.4 (-4)	6.0 (-3)	4.8 (-5) mrem
Wheeler Dam	6.0 (-4)	2.7 (-4)	1.7 (-3)	3.7 (-5) mrem
	5.3 (-5)	2.4 (-5)	1.5 (-4)	3.3 (-6) man-rem
Wilson Dam	3.7 (-4)	1.0 (-4)	7.2 (-4)	2.3 (-5) mrem
	1.7 (-3)	4.4 (-4)	3.2 (-3)	1.0 (-4) man-rem
Sheffield	3.7 (-4)	9.8 (-5)	7.0 (-4)	2.3 (-5) mrem
	1.1 (-2)	2.8 (-3)	2.0 (-2)	6.5 (-4) man-rem
Colbert Steam Plant	3.7 (-4)	9.4 (-5)	6.8 (-4)	2.2 (-5) mrem
	2.3 (-4)	5.8 (-5)	4.2 (-4)	1.4 (-5) man-rem
Cherokee	3.7 (-4)	9.2 (-5)	6.7 (-4)	2.2 (-5) mrem
	1.5 (-3)	3.8 (-4)	2.8 (-3)	9.3 (-5) man-rem
Total Population Dose Commitments	1.4 (-2)	3.7 (-3)	2.7 (-2)	8.6 (-4) man-rem

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

Individual Dose Commitments	0.18	0.25	1.6	0.013 mrem

C. Eating Fish Taken from Wheeler, Wilson, and Pickwick Lakes

Maximum Individual Dose Commitment	1.6 (-4)	2.2 (-2)	1.6 (-3)	4.4 (-5) mrem
Population Dose Commitment	1.3 (-2)	1.8	0.13	3.5 (-3) 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. Normalized to 1.0 Ci total annual release excluding tritium.
c. Based on the estimated population in the year 2010.
d. 6.8×10^{-4}
e. Assuming a continuous discharge of 50,000 GPM (minimum flow with cooling towers)

Table 3 (Continued)

D. Use of the Tennessee River for Water Sports

	Above Water[f]		In Water[g]	
	Skin	Total Body	Skin	Total Body
Maximum Individual Dose	1.8 (-5)	1.4 (-5)	5.0 (-5)	3.9 (-5) mrem
Population Dose	7.7 (-5)	6.0 (-5)	3.0 (-5)	2.3 (-5) man-rem

f. Boating and fishing, for example
g. Swimming and water skiing, for example

Table 4

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

A. Ingestion of Tennessee River Water[c]

Location	Individual (mrem)	Population (man-rem)
Browns Ferry Site (for comparison)	3.9 (-6)[d]	-
Wheeler Dam	3.6 (-6)	3.2 (-7)
Wilson Dam	2.2 (-6)	9.9 (-6)
Sheffield	2.2 (-6)	6.5 (-5)
Colbert Steam Plant	2.2 (-6)	1.4 (-6)
Cherokee	2.2 (-6)	9.2 (-6)
Population Total		8.5 (-5) man-rem

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

Individual Dose Commitment 1.0 (-3) mrem

C. Eating Fish Taken from Wheeler, Wilson, and Pickwick Lakes

Maximum Individual Dose Commitment 6.5 (-8) mrem

Population Dose Commitment 5.2 (-6) man-rem

D. Use of the Tennessee River for Water Sports

Maximum Individual Dose[f] 7.1 (-6) mrem

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 2010
d. 3.9×10^{-6}
e. Assuming a continuous discharge of 50,000 GPM (minimum flow with cooling towers)
f. Assuming continuous immersion

Table 5

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

	1.0 Ci Mixture	1.0 Ci Tritium
Internal	0.49 mrad	4.1 (-5)[b] mrad
External	3.7 (-4) mrad	0 mrad
Total	0.49 mrad	4.1 (-5) mrad

a. Internal dose commitments for each annual intake and external doses from each annual exposure
b. 4.1×10^{-5}

able 6

DOSES TO AQUATIC ORGANISMS LIVING IN THE TENNESSEE RIVER

NEAR THE BROWNS FERRY NUCLEAR PLANT

A. Doses from an Annual Release of a 1.0 Ci Radionuclide Mixture[a]

	Internal (mrad) 3-cm	Internal (mrad) 30-cm	External (mrad)
Plants	0.23	0.48	3.7 (-4)[b]
Invertebrates	3.3	4.7	3.7 (-4)
Fish	0.83	1.2	3.7 (-4)

B. Doses from an Annual Release of 1.0 Ci Tritium

Plants, invertebrates, and fish	7.1 (-6) mrad (internal)

a. Excluding tritium
b. 3.7×10^{-4}

APPENDIX III

RADIOLOGICAL IMPACT OF EXTERNAL EXPOSURE FROM SOURCES INSIDE THE REACTOR AND TURBINE BUILDINGS

A simplified model is utilized to estimate an upper bound for the external radiation dose at the site boundary from sources inside the reactor and turbine buildings. Direct radiation exposure from these sources is eliminated by shielding. Scattered radiation exposure is possible due to the scattering of gamma radiation which exits through the turbine building roof. The following assumptions are employed to establish an upper bound for the radiation dose from this source:

1. N-16 gammas dominant source.
2. Total source term (3 units) is 2.2×10^{12} photons/s.
3. Isotropic point source.
4. Unscattered gammas (6.13 Mev) exit turbine building vertically through a cone defined by the shield walls.
5. No credit is taken for shield effect of turbine building roof.
6. All gammas leaving turbine building are scattered at one scatter mean free path.
7. Fraction scattered toward offsite dose point is calculated from Compton scatter cross section considerations.
8. No further scattering is assumed although the path length from the first scattering point to the dose point is about $2\text{-}\frac{1}{2}$ scatter mean free paths of the once scattered gammas.

Based upon the above assumptions the dose at the site boundary due to scattered radiation from the turbine building is 0.6 mrem/yr. This

dose is less than 0.5 percent of the dose from natural background radiation. Therefore, a more complex analysis, which would be expected to show that the dose is lower, is not warranted. The rapid reduction of this dose at increasing distances beyond the site boundary would limit the population dose from this source to a very low value.

APPENDIX IV

EXCERPTS FROM TVA REPORT 63-38:

Prediction and Control of Water Temperatures in Wheeler Reservoir During Operation of the Browns Ferry Nuclear Plant, April 1972

1. Hydraulic Design and Basic Studies of the Diffuser System - The manifold-type, multiport pipe system adapted for diffusion of the heated condenser water is similar to those used in marine outfalls. The discharged water will issue from the diffuser ports at a relatively high velocity, and the turbulence created by these jets will cause mixing of the heated discharge with the cooler reservoir water.

The diffuser system was designed to meet the following requirements:

1. Each pipe must handle a flow of 1,450 ft^3/s.
2. The total discharge from all three pipes must be uniformly distributed across the 1,800-foot wide main channel.
3. The jet velocity must be sufficiently high to create complete mixing of the condenser discharge with the reservoir flow available to the diffusers.
4. The total head at the entrance to the pipes should not exceed 4.5 feet of water.

A model study was performed at the TVA Engineering Laboratory in 1967 to determine the hydraulic characteristics of the jets issuing from the diffuser holes. The tests were performed at a scale of 1:2, thus providing realistically high model turbulence levels for the range of pipe diameters and hole sizes expected in prototype. The

study showed that the flow will issue from the diffuser ports at nearly a 90° angle and with a discharge coefficient which is a function primarily of the ratio of velocity head to total energy in the pipe.

The design of the diffuser involved selection of a main pipe diameter and discharge port size which, for the design discharge flow, will produce a discharge distribution, jet velocity, and total entrance head as specified above in items 1 to 4. This procedure utilized the discharge coefficients determined by the model study and corrugated pipe friction factors measured at the U.S. Army Corps of Engineers Waterways Experiment Station at Vicksburg, Mississippi.[1] These data were inputs to an analytical model of the diffuser's hydraulic performance which calculated the distribution of the discharge and the energy grade line along the diffuser pipes. The final diffuser design shown in figure 1 was selected on the basis of these calculations.

(Editor's Note: The preliminary design and location of the steel-supported warning signs to mark the portion of the present navigation channel which will be over the diffuser pipes has been informally coordinated with the U.S. Coast Guard, Second District Office, St. Louis, and the Corps of Engineers, Nashville District Office. The signs will be about 1,200 feet apart, leaving a clear navigable width of channel of more than 1,000 feet. When the final design of the signs is completed, it will be formally sent to those two agencies for review and comment.)

(1) <u>2-Dimensional Model Testing of the Jet Mixing Region</u> - Based on the available state-of-the-art knowledge of submerged jets, it was expected that the design discharge velocity of about 9 ft/s would result in efficient mixing of the discharge flow with the ambient flow passing over the diffuser. A 2-dimensional model study was undertaken to examine the characteristics of the mixing induced

by the diffuser discharge and to determine the angle of discharge with the horizontal which would minimize bed scour downstream from the diffuser. These tests were performed at the MIT R. M. Parsons Laboratory for Water Resources and Hydrodynamics during 1967 and 1968. The model scales were 1:15 horizontally and vertically providing the undistorted model required for jet mixing zone studies. The principal results of the investigations were:

1. Mixing of the jets with that portion of the flow passing over the diffusers will occur rapidly. This is illustrated by figure 2 which shows the temperature distribution obtained from model tests in the immediate vicinity of the diffusers for a simulated steady reservoir flow of 20,000 ft^3/s. Within a matter of a few feet from the diffuser, the temperature was reduced to about 11°F above ambient. The maximum temperature at the reservoir bottom was about 6-7°F above ambient over an area extending a distance of about 30 feet from the diffuser. At distances greater than about 50 feet, the observed temperature agreed well with the theoretical fully mixed rise of 5.5°F. Figure 3 shows the temperature distribution for a flow of 26,000 ft^3/s.

   On the basis of the MIT tests, it is expected that the mixing will result in uniform temperature over the full depth within a distance of about 100-200 feet horizontally from the diffuser pipe. The zone of jet mixing will extend no more than 200 feet from the diffuser horizontally and no more than 5-10 feet above the top of the diffuser pipe.

2. Outside of the mixing zone the temperatures will be no greater than the mixed temperature Tm which may be calculated as:

$$Tm = Tr + \frac{\Delta Tc}{\frac{Qm}{Qc} + 1 - R} \qquad (1)$$

where Tr = ambient river temperature

ΔTc = condenser temperature rise

Qc = condenser cooling water flow

Qm = that portion of the total river flow Qr which mixed with the diffuser discharge

R = the fraction of the intake flow which is at temperature Tm, i.e., the amount being recirculated; the remaining fraction (1 - R) will be at the ambient temperature Tr

It is clear from Equation (1) that for large dilutions ($Qm \gg Qr$) the amount of recirculation (the value of R) has only a small effect upon the mixed temperature. It is emphasized that Equation (1) predicts steady-state temperatures that are approached asymptotically after any change in the river flow rate, often over a period of hours. The significance of this is that Equation (1) will predict a temperature rise that is too high for a certain length of time after a decrease in riverflow and too low after an increase. The determination of Qm and the unsteady behavior of the mixing are a part of the 3-dimensional thermal model results described in a later section.

3. Minimum scour was observed with an elevated jet angle of 24° (see figure 1).

(2) 3-Dimensional Thermal Model - The thermal regime induced in Wheeler Reservoir by the operation of Browns Ferry in either the open or helper modes will depend upon a complex interaction between the intake and discharge flows and the regulated flows in the reservoir. The purpose of the 3-dimensional thermal model study has been to assess the performance of the discharge configuration and to determine the relationship between the reservoir flow and the temperature distribution.

The model encompasses a 5-mile reach of Wheeler Reservoir with the Browns Ferry intake and diffuser situated near the center of this reach. The model (see figure 4) is distorted having a vertical scale ratio of 1:50 and a horizontal scale ratio of 1:250.

The 3-dimensional thermal model is designed to give information about the intermediate region between the jet mixing area, immediately adjacent to the diffusers, and the far field upstream and downstream regions. This region is of great importance in evaluating thermal effects because the highest temperatures outside of the mixing zone will occur here. In addition, the dynamics of the flow in the intermediate region may affect the magnitude of the mixing flow, Qm. Finally, the observed behavior of the heated layer provides the required starting boundary condition for downstream heat loss calculations.

The dominant physical phenomena in the intermediate region are the convection of mass and heat, the formation of stratified conditions, and to a lesser extent the loss of heat through the water surface. The scales of the 3-dimensional thermal model were

chosen to ensure correct similitude of the convection, stratification, and surface heat loss. Field studies in the prototype have been conducted and are continuing with the purpose of determining the pattern of reservoir currents and the surface heat loss characteristics in the vicinity of the plant. In the model the distribution of the upstream reservoir flow may be adjusted to replicate prototype current conditions. A study of the surface heat exchange in the model has been made to facilitate the evaluation of surface heat loss upon model temperature data. Careful sensitivity testing is continuing to determine whether or not the upstream distribution of flow, surface heat loss, boundary roughness, and distorted diffuser configuration have any significant effects upon the observed flow and temperature structure. To date, it appears that the first three are not of major significance and probably the diffuser configuration is not either.

A series of steady reservoir flow tests have determined the 3-dimensional flow and temperature distributions in the modeled area for 1-, 2-, and 3-unit operation. These tests indicate the following pattern of behavior:

The intake flow will be withdrawn from the full depth and will consist of water which flows downstream from the shallow area on the plant side and from the righthand side of the main channel. This flow distribution will tend to minimize recirculation of heated water.

Recirculation will occur only in the low-flow situations when all of the upstream flow is being drawn into the mixing zone. It can be shown on theoretical grounds that the

mixed temperature rise will be virtually independent of the degree of recirculation (see Equation (4)). The model data confirm this conclusion.

(Editor's Note: After the cooling towers become operational they will be used during most of these low-flow situations.)

For reservoir flows of large magnitude, i.e., greater than 50,000-70,000 ft^3/s (case 1) the natural flow distribution in the reservoir will not be significantly altered by the mixing action of the diffusers. Velocities will be in the downstream direction over the full depth and over the entire width of the reservoir (see figure 5). No heated water will move upstream from the diffusers, thus preventing any recirculation (R = 0). The mixed flow at temperature Tm leaving the jet mixing region will form a heated surface layer downstream above a lower layer consisting of that portion of the ambient flow which does not pass through the mixing region. The mixing flow Qm will be determined by the amount of flow which passes over the diffuser naturally. Field measurements of currents in Wheeler Reservoir indicate that about 22 percent of the total reservoir flow passes over each of the three diffuser sections, making a total of about 65 percent in the deep river channel. The mixing flow Qm will depend upon how the flow downstream from the intake is redistributed across the channel during operation of the plant. However, the resulting mixed temperature is relatively insensitive to this factor and is given approximately by

$$Tm = Tr + \frac{167,000}{Qr} \qquad (2)$$

where Qr is the total reservoir flow. The value of Tm given by Equation (2) is for one, two, or three units and is shown in figure 8.

For reservoir flows greater than 7-10 times the diffuser flow but less than 50,000-70,000 ft^3/s (case 2) the sum of the intake flow and the mixing flow, Qm, demanded and diverted by the diffusers will be equal to about 7-10 times the condenser flow. The remainder of the riverflow Qr will pass by the side of the diffusers unmixed. The flow pattern in these cases is shown in figure 6. No eddy will be present in the subsurface flow as the portion of the ambient water which passes the diffusers without mixing will be an underflow over the shallow lefthand area. Downstream from the diffusers the ambient flow which did not mix will form a cooler bottom layer beneath an eddying surface layer of water at the mixed temperature. The surface layer will spread laterally across the shallow area and depending on the magnitude of the riverflow may have spread upstream from the diffusers. No recirculation occurs for these cases, making R = 0 in Equation (1).

$$Tm = Tr + \frac{25}{P} \qquad (3)$$

where P is about 7-10 as shown in figure 8. The resulting temperature rise is about 2.5-3.5°F.

For reservoir flows less than about 7-10 times the diffuser flow (case 3) all of the reservoir flow will be drawn into the jet mixing zone. The flow pattern in these cases is shown schematically in figure 7. A large eddy will occur over the total depth in the wide lefthand shallow area adjacent to the diffusers as a result of the diversion of the riverflow. Since no ambient water will pass by the diffusers without mixing, the entire downstream region will be at the mixed temperature over the full depth. A surface layer

of water at the mixed temperature may extend upstream from the diffusers either because of the eddy currents or because of gravitational spreading.

For this case the mixing flow Qm is equal to the total reservoir flow Qr less the intake flow $Qc(1 - R)$ and the mixed temperature is given by:

$$Tm = Tr + \frac{25Qc}{Qr} \qquad (4)$$

which is independent of the amount of recirculation. A plot of Equation (4) is also shown on figure 8.

The upstream movement of a heated surface layer is a highly 3-dimensional phenomena which is only qualitatively similar to the upstream wedge in a 2-dimensional channel. In the cases where the surface layer reaches the upstream boundary of the model, with our present understanding, it is not possible to predict how much further the warm water will extend in the prototype. However, it is expected that the vertical thickness of the layer will decrease in the upstream direction.

The downstream flow of mixed water at temperature Tm will initially be limited to the deep river channel just below the diffusers, but within a few miles of the diffusers it will spread over the full width of the reservoir. As previously discussed, the degree of vertical stratification will be dependent upon the magnitude of the reservoir flow. However, the downstream surface layer will lose heat to the atmosphere at a rate independent of the depth of the heated layer. This will be discussed below.

2. Downstream Water Surface Temperature Predictions - The changes in the downstream reservoir temperature resulting from the

operation of Browns Ferry were determined by routing the initial increase in temperature using the following 1-dimensional, steady-state equation:

$$\Delta Tx = \Delta To \exp\left[\frac{-K}{\rho c}\frac{XB}{Qm + Qc}\right] \qquad (5)$$

where ΔTx = the increase in surface temperature at the end of a routing reach

ΔTo = the increase in surface temperature at the beginning of a routing reach

X = length of routing reach

B = effective width of the reach

K = environmental heat exchange coefficient

Qm = the portion of the total riverflow that mixes with the diffuser discharge

Qc = the diffuser discharge

ρ = density of water

c = specific heat of water

For computational purposes the reservoir was divided into six reaches varying in length from 2.1 to 4.2 miles. Equation (5) was applied successively to each reach by using the temperature rise at the beginning of the reach, ΔTo, to obtain the temperature at the end of the reach, ΔTx, which then became the initial temperature rise for the following reach.

The effective width of the heated water for each reach was based on observations of the 3-dimensional model which showed that the main body of heated water flows downstream spreading laterally across the reservoir and that the full width of the reservoir will be covered at a distance of about 3 miles from the diffusers. Within the

first 3 miles the effective width for heat dissipation will be about one-half of the average reservoir width. The formation of an eddy in the shallow area opposite the plant at low flows was previously described. It was assumed for the purpose of the temperature predictions that no heat will be transported from the main body of flow by the eddy. The effect of this assumption is that the downstream temperature predictions are slightly high when such an eddy exists.

The environmental heat exchange coefficient affects the rate at which the temperature decreases. An increase in the coefficient causes a more rapid die-off. This coefficient is a function of meteorological conditions; hence, it varies seasonally and from year to year. To account for the meteorological variations, temperature routings were made for each month of the 12-year period 1960 through 1971 based upon coefficients determined for the average meteorological conditions that existed during the middle week of the month. From these routings the mean and 95 percent confidence limits of the routed temperatures were computed.

The discharge Qm + Qc represents that portion of the reservoir flow that will be heated above ambient. As previously discussed Qm + Qc may be equal to or less than the total reservoir flow depending on the magnitude of the total reservoir flow. Qm + Qc affects the rate of temperature die-off and the initial temperature rise in the near field. As Qm + Qc increases the die-off rate and the initial temperature rise decreases.

Predictions were made for 1-, 2-, and 3-unit operation assuming initial temperature rises of 10, 5, and 3.5°F.

(Editor's Note: The complete results of these predictions for each month are included in TVA report 63-38, Prediction and Control of Water Temperatures in Wheeler Reservoir During Operation of the Browns Ferry Nuclear Plant, April 1972. Figures 9 through 20 summarize the results of these predictions for each season of the year for 1-, 2-, and 3-unit operation. The text has been modified slightly to reflect these changes.)

3. The Steady Thermal Regime in Wheeler Reservoir During Open-Mode Operation - Based upon the data in the previous section, the following discusses quantitatively the predicted steady flow and temperature distributions during operation of Browns Ferry plant in the open mode. One-unit operation is treated first followed by discussions of the 2- and 3-unit ones.

(1) 1-Unit Operation - The single-unit condenser flow of 1,450 ft^3/s will result in intake channel velocities of about 0.4 ft/s. Heated water will be discharged through the diffuser section of the active unit and will mix with the reservoir flow in the manner described in the previous sections. The jet mixing zone will be just downstream from the active diffuser section and will be approximately 20 feet high, 200 feet long, and 600 feet wide, thus occupying about 12,000 ft^2 (or 9 percent) of the total reservoir cross section and about 2,400,000 ft^3 of volume. The water leaving the mixing zone will be at the mixed temperature Tm which is dependent upon the reservoir flow Qr as shown in figure 8. For reservoir flows less than about 10,000 to 14,500 ft^3/s the entire reservoir flow will be drawn into the jet mixing zone, either from behind the diffusers or from along the sides of the mixing region.

Predictions of the downstream temperature increase above ambient are shown on figures 9 through 12 for the middle

week of each month shown. Predictions were made for the following cases:

1. A reservoir flow of 3,600 ft^3/s and its associated temperature rise of 10^oF
2. A reservoir flow of 7,200 ft^3/s and its associated temperature rise of 5^oF
3. A reservoir flow greater than 10,200 ft^3/s but less than about 50,000 ft^3/s which gives a temperature rise of 3.5^oF

The relationship between reservoir flow and temperature was taken from figure 8. Complete mixing of the reservoir flow and the condenser flow occurs for the first two cases. For case 3 only 10,200 ft^3/s of the reservoir flow mixes with the condenser flow and the remainder flows as a cooler underflow.

(2) 2-Unit Operation - The 2-unit condenser flow of 2,900 ft^3/s will result in intake channel velocities of about 0.9 ft/s. The location of the mixing zones will depend upon which two units are operating. The total mixing zone will be about 1,200 feet wide and occupy 18 percent of the total reservoir cross sectional area and a volume of 4,800,000 ft^3. The mixed temperature rises in the intermediate zone are shown in figure 8 as a function of the reservoir flow. Complete mixing of the reservoir flow with the discharge will occur for flows of less than 20,000-29,000 ft^3/s.

Predictions of the downstream temperature increase above ambient are shown on figures 13 through 16 for the middle week of each month shown. Predictions were made for the following cases:

1. A reservoir flow of 7,200 ft^3/s and its associated temperature rise of 10^oF

2. A reservoir flow of 14,500 ft^3/s and its associated temperature rise of 5^oF

3. A reservoir flow greater than 20,300 ft^3/s but less than about 50,000 ft^3/s which gives a temperature rise of 3.5^oF

The relationship between reservoir flow and temperature was taken from figure 8. Complete mixing of the reservoir flow and the condenser flow occurs for the first two cases. For case 3 only 20,300 ft^3/s of the reservoir flow mixes with the condenser flow and the remainder flows as a cooler underflow.

(3) 3-Unit Operation - The condenser flow of 4,350 ft^3/s will result in intake channel velocities of about 1.3 ft/s. The discharge will occur over the full 1,800-foot diffuser structure resulting in a mixing zone which will occupy 27 percent of the reservoir cross sectional area and a volume of 7,200,000 ft^3. The mixed temperature rise is shown in figure 8. Complete mixing of the reservoir flow with the discharge will occur for reservoir flows less than 30,000 to 43,500 ft^3/s.

Predictions of the downstream temperature increase above ambient are shown on figures 17 through 20 for the middle week of each month shown. Predictions were made for the following cases:

1. A reservoir flow of 10,900 ft^3/s and its associated temperature rise of 10^oF

2. A reservoir flow of 21,800 ft^3/s and its associated temperature rise of 5^oF

3. A reservoir flow greater than 30,500 ft^3/s but less than about 50,000 ft^3/s which gives a temperature rise of 3.5^oF

The relationship between reservoir flow and temperature was taken from figure 8. Complete mixing of the reservoir flow and the condenser flow occurs for the first two cases. For case 3 only 30,500 ft^3/s of the reservoir flow mixes with the condenser flow and the remainder flows as a cooler underflow.

4. Helper-Mode Operation - The construction of cooling towers at Browns Ferry will make possible the operation of the condenser cooling system in a helper mode where a portion of the heat will be removed from the condenser water by the towers before it is discharged into the river. Although the details of the design are not final, it will involve a somewhat lower condenser waterflow (1,223 ft^3/s) for each unit, a higher condenser rise (31.7^{o}F), and a lower temperature rise in the discharged water than in an open-mode operation. In addition, the flow from a single unit, if it is shown to provide more desirable mixing characteristics, may be discharged through all three diffuser sections. These differences from open-mode operation will result in a different relationship between the reservoir flow magnitude and the temperature rises in the reservoir, but operations in general should result in similar flow and temperature patterns as described for the open mode of operation.

As the designs are firmed up, model tests and field investigations after the units are in operation will be used to predict the 3-dimensional flow and temperature distributions for helper-mode operation as they were predicted for open-mode operation and to determine the most appropriate operating method for achieving the desired temperature standards.

5. Unsteady Reservoir Flows - The temperature rises described above are steady-state values re ned asymptotically after a change in flow conditions. If the reservoir flow is constantly changing, the temperature and flow distribution may never be in a steady-state condition. It is clear that if the reservoir flow remains greater than a certain magnitude, the mixed temperature rise in the reservoir will never exceed the steady-state value corresponding to that minimum flow. If the reservoir flow fluctuates below the minimum value for some short length of time, the temperature rise may not increase significantly. A continuing program of testing in the 3-dimensional thermal model has as its objective the determination of what unsteady flow regulations will be required to keep the induced temperature rises in Wheeler Reservoir below the desired value.

6. Field Measurements - The operation of Browns Ferry Nuclear Plant and the regulations of Wheeler Reservoir flows will be determined by the readings from a system of continuously recording fixed temperature monitors (see figure 21). There will also be intensive surveys by boat and airborne techniques to measure the details of the temperature distribution in the vicinity of the plant. This information will begin to be available as soon as the plant commences 1-unit operation. The field data will be compared with model results to verify and refine the predictions presented in this report and to develop the final required operating procedures.

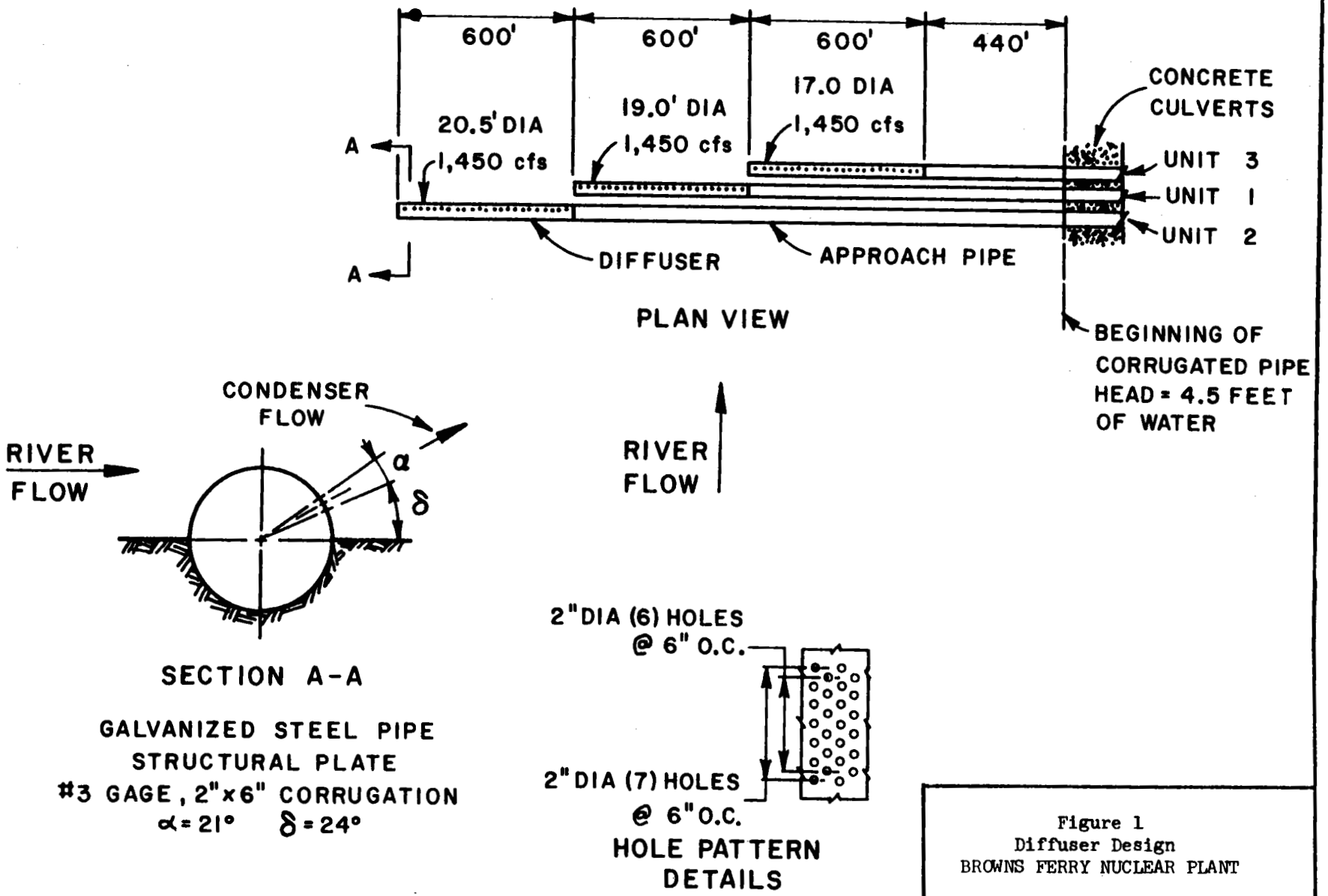


Figure 1
Diffuser Design
BROWNS FERRY NUCLEAR PLANT

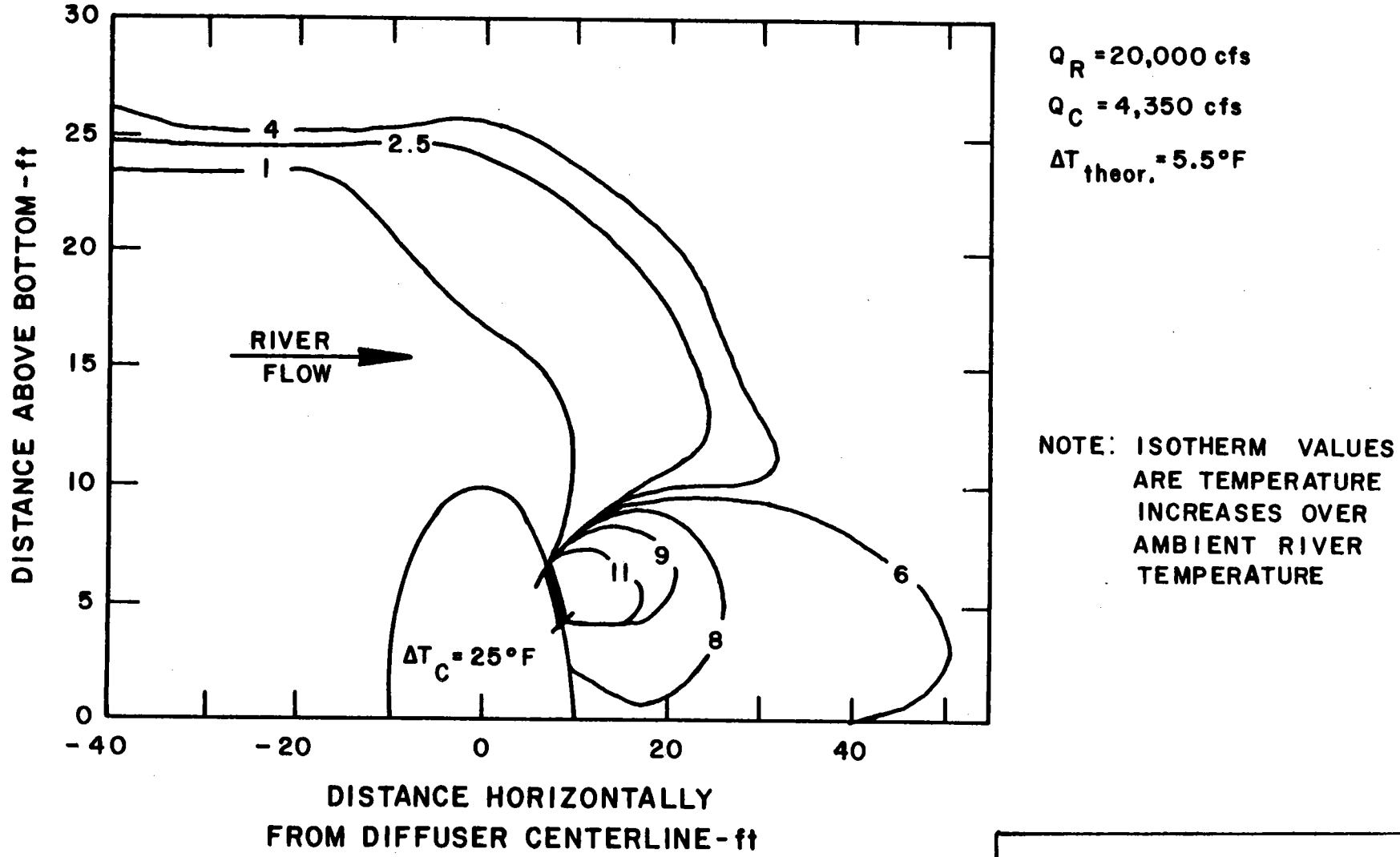
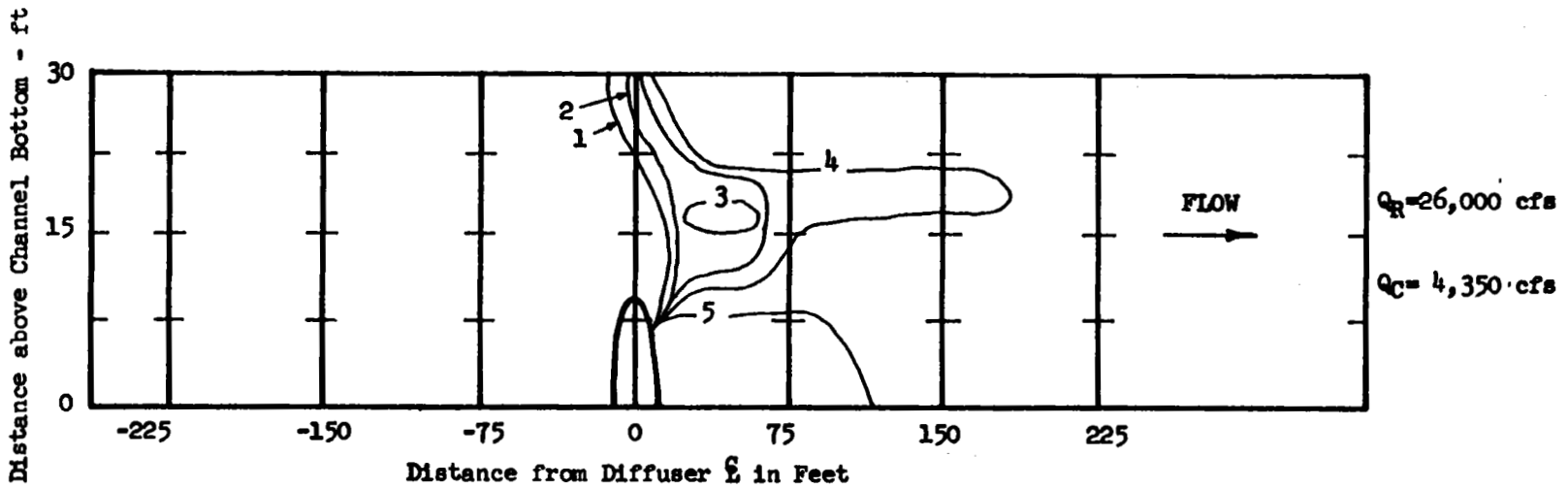


Figure 2
Structure of the
Jet Mixing Region
BROWNS FERRY NUCLEAR PLANT



Note: Isotherm values are temperature increases over Ambient River Temperature

Figure 3
Temperature Rise in the
Jet Mixing Region

BROWNS FERRY NUCLEAR PLANT

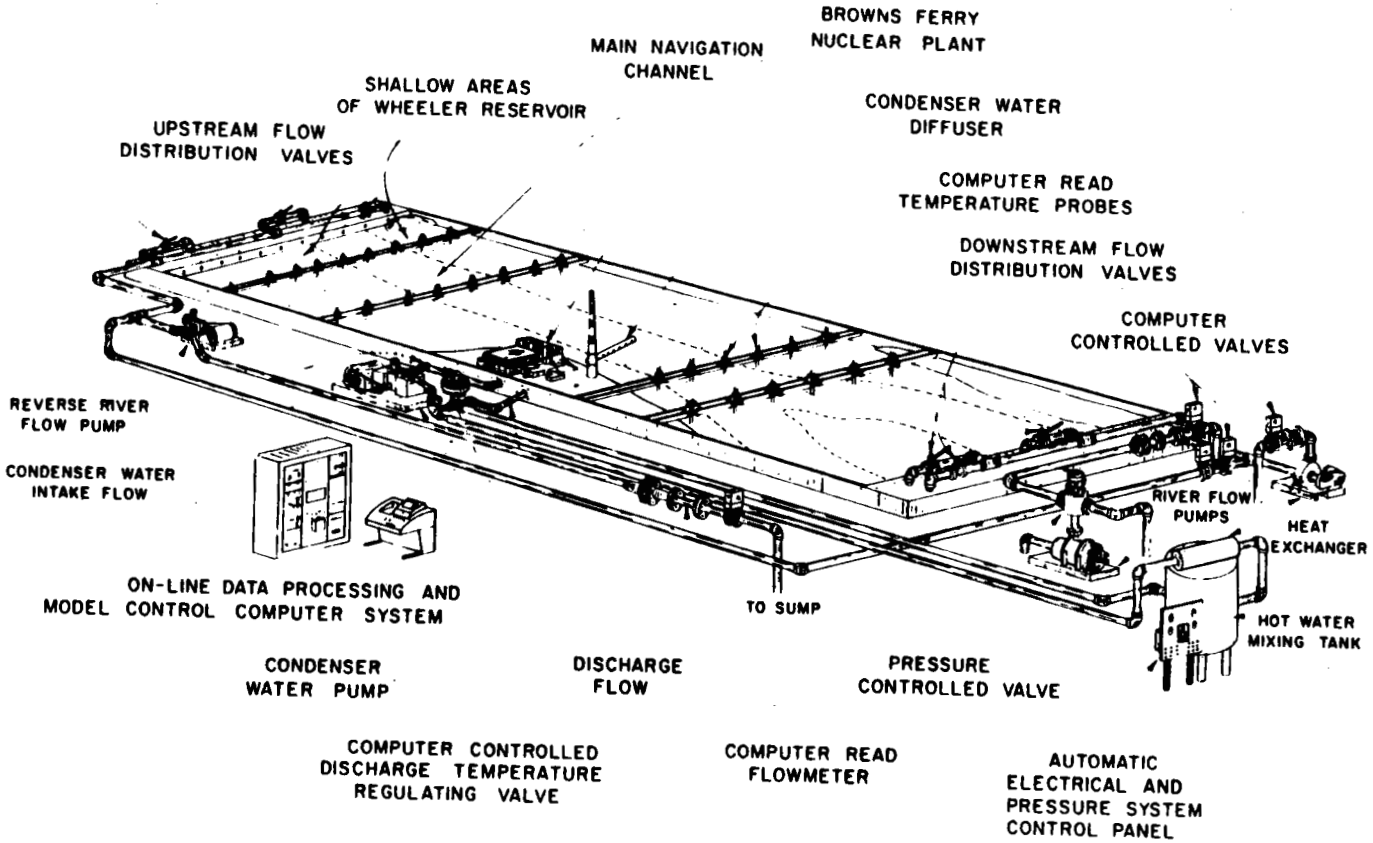


Figure 4
Three Dimensional
Thermal Model

BROWNS FERRY NUCLEAR PLANT

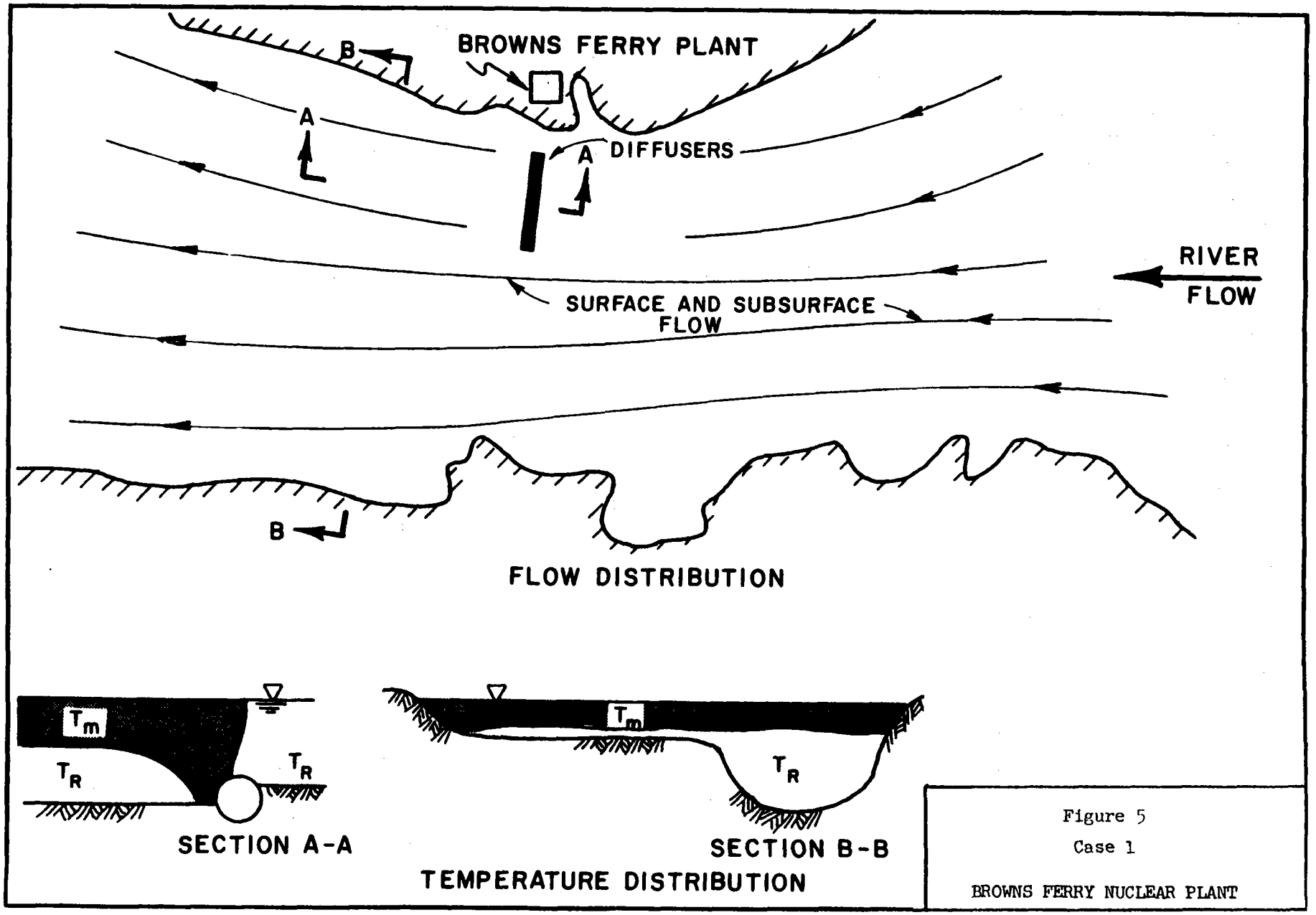


Figure 5
Case 1

BROWNS FERRY NUCLEAR PLANT

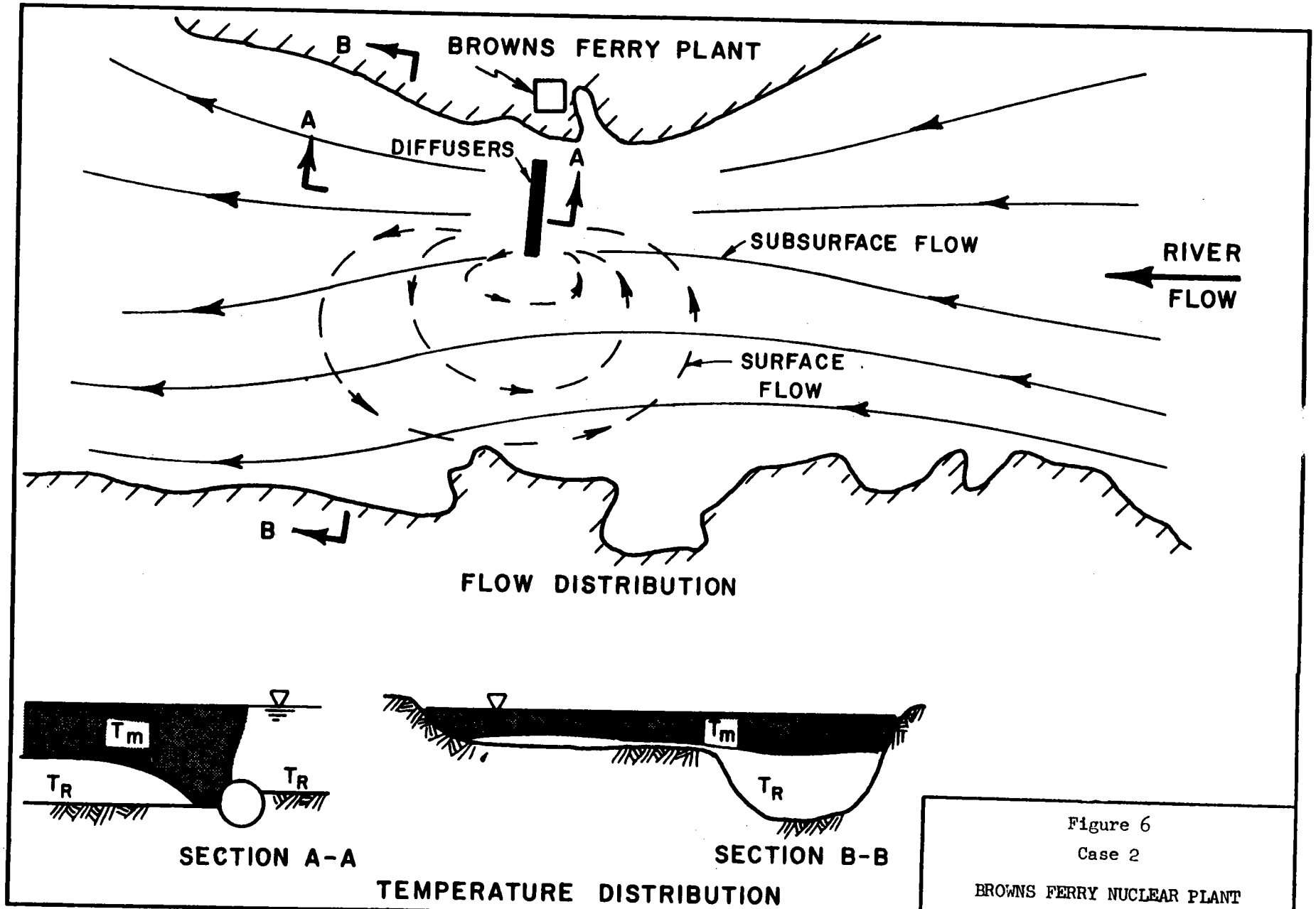


Figure 6
Case 2
BROWNS FERRY NUCLEAR PLANT

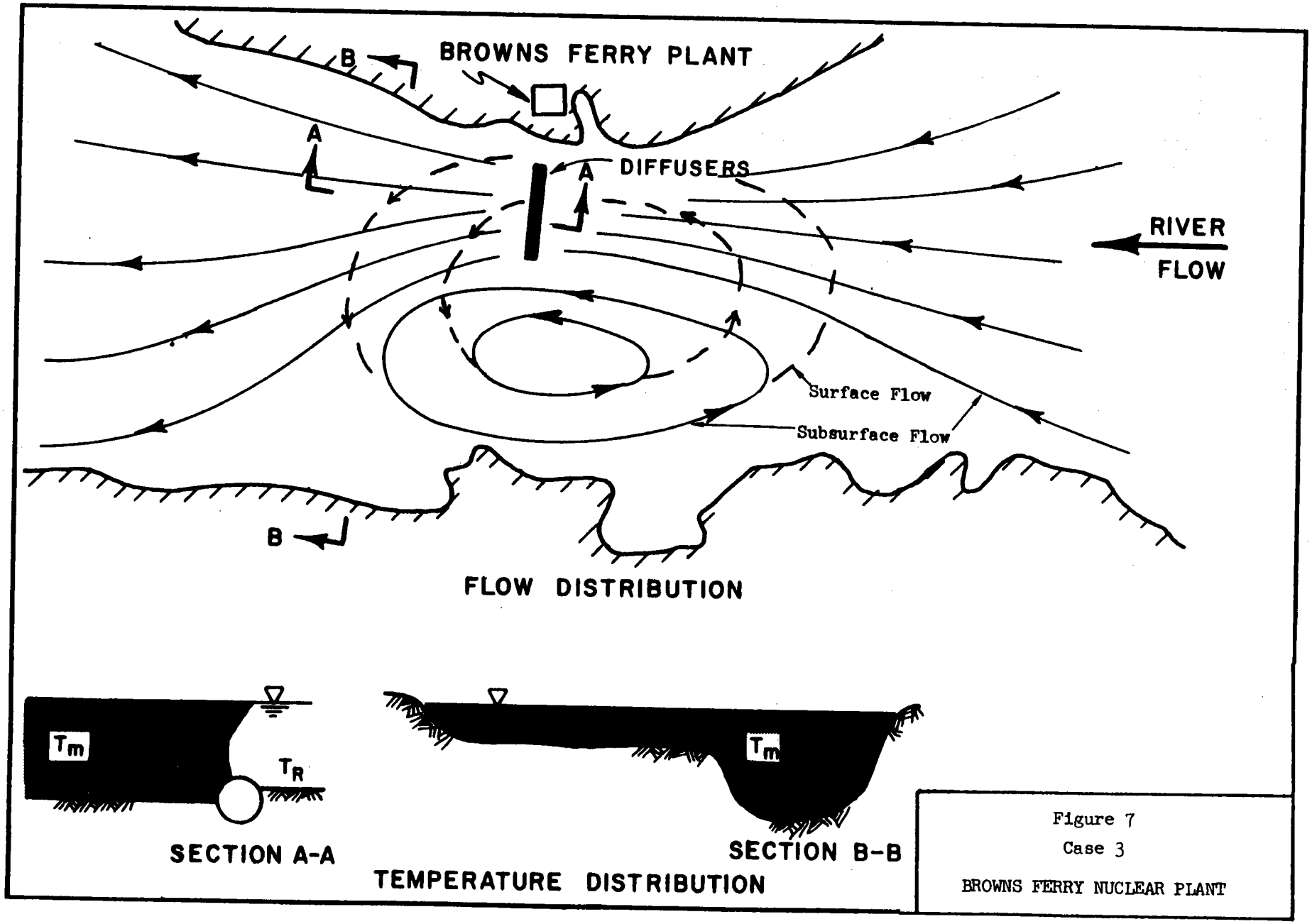


Figure 7
Case 3
BROWNS FERRY NUCLEAR PLANT

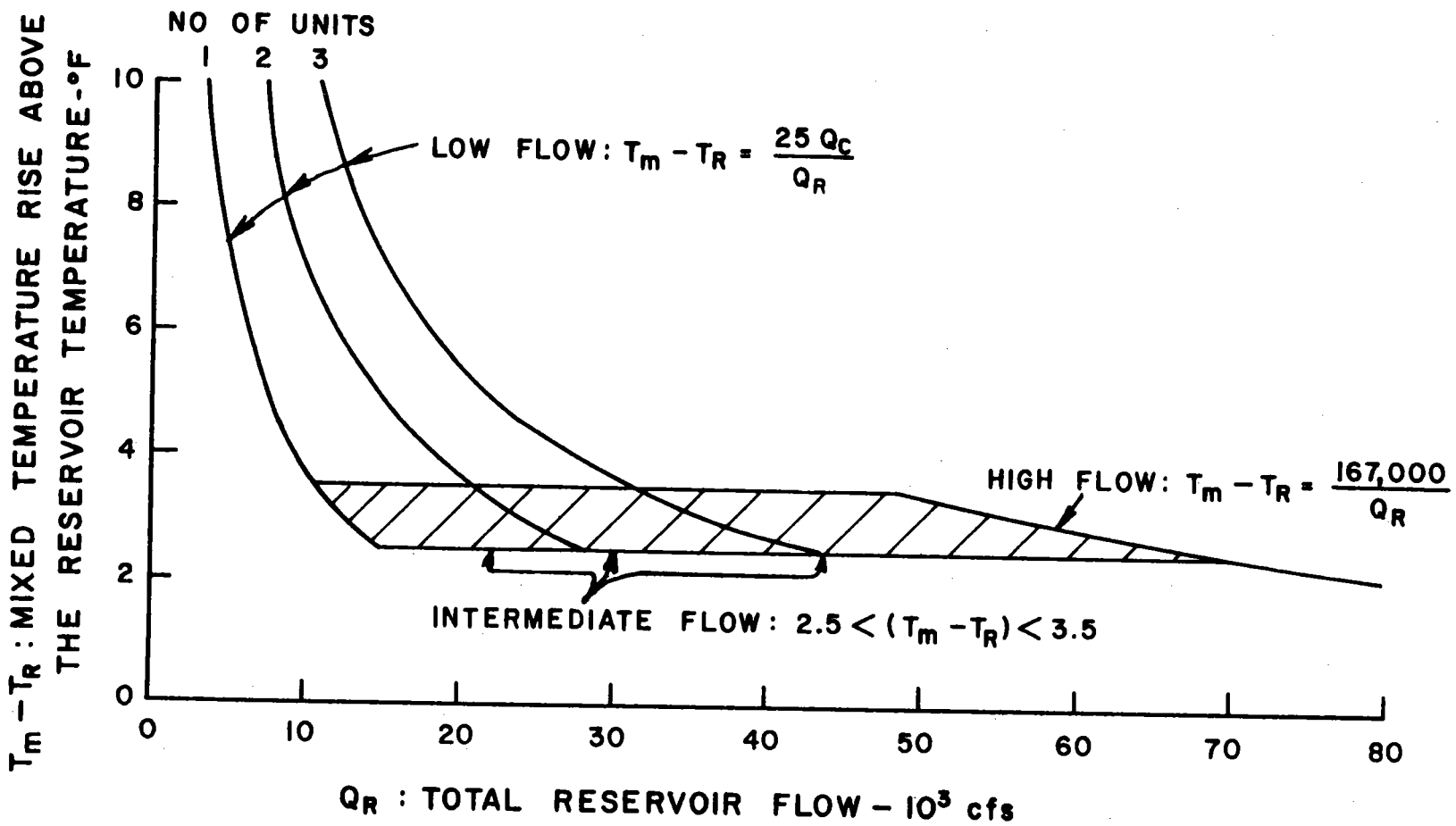


Figure 8
Temperature Rise Outside of the Jet Mixing Region

BROWNS FERRY NUCLEAR PLANT

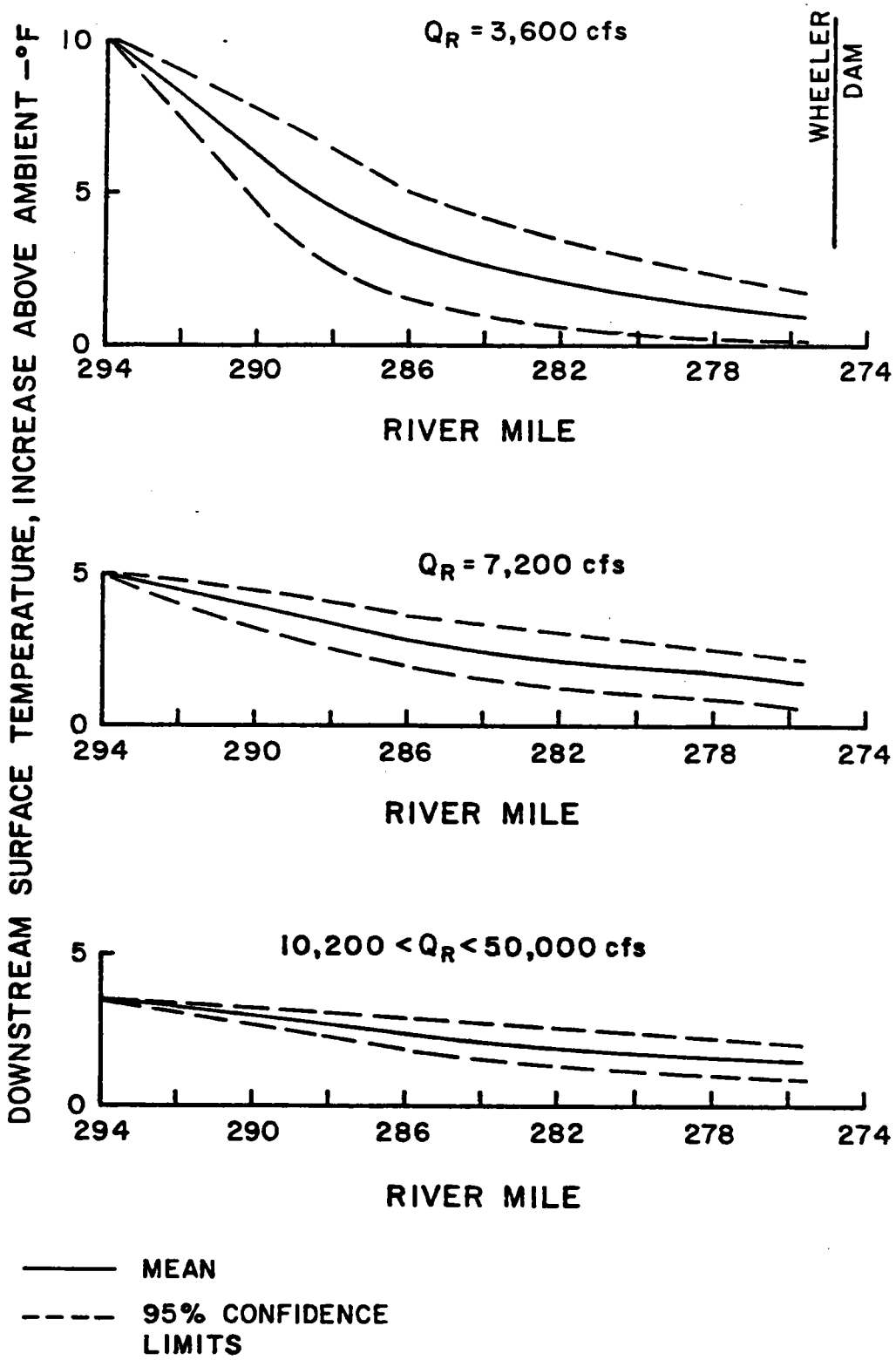


Figure 9
Effect of Plant on Downstream Temperature
January, 1 Unit
BROWNS FERRY NUCLEAR PLANT

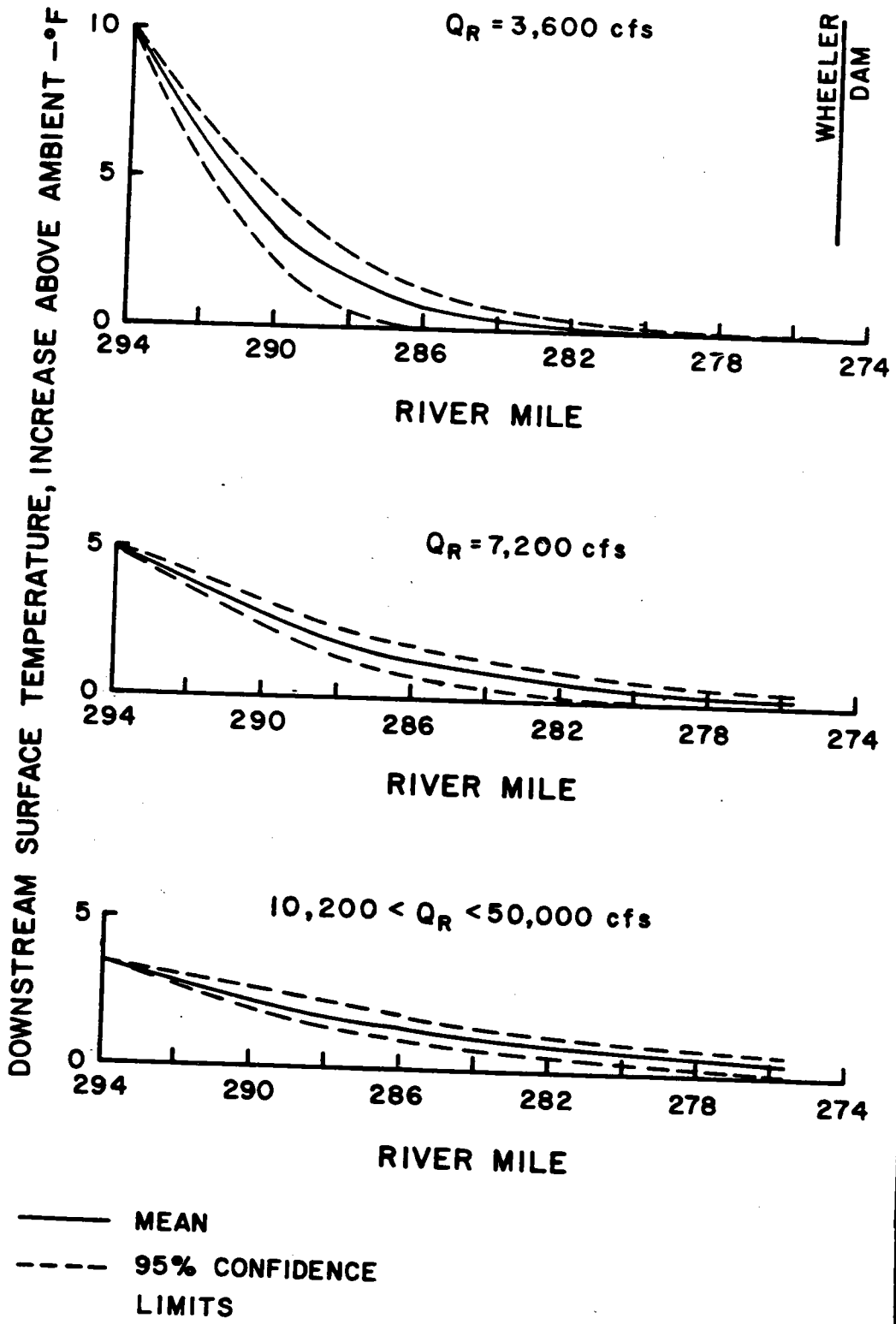


Figure 10
Effect of Plant on Downstream Temperature
April, 1 Unit
BROWNS FERRY NUCLEAR PLANT

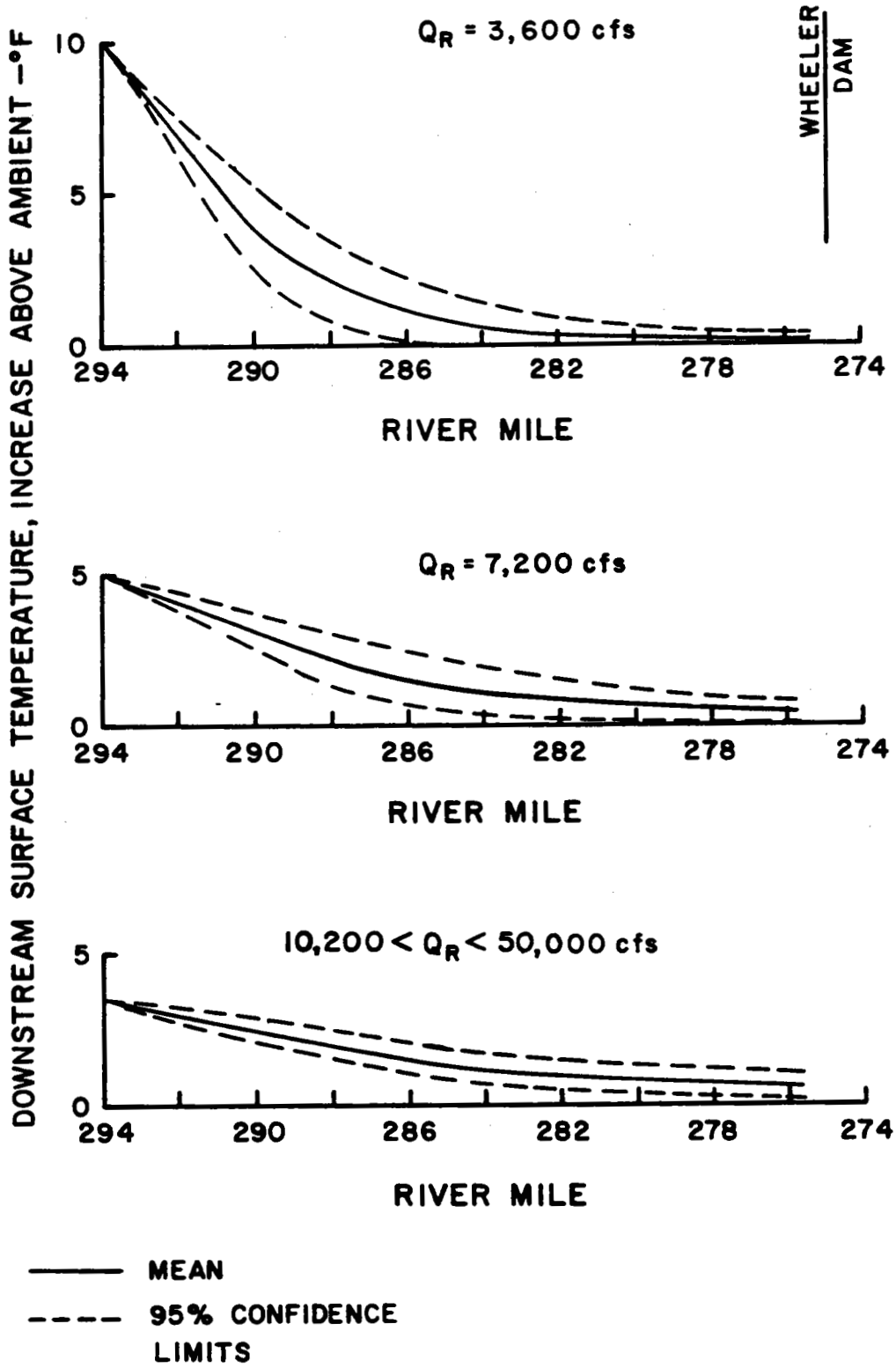


Figure 11
Effect of Plant on Downstream Temperature
August, 1 Unit
BROWNS FERRY NUCLEAR PLANT

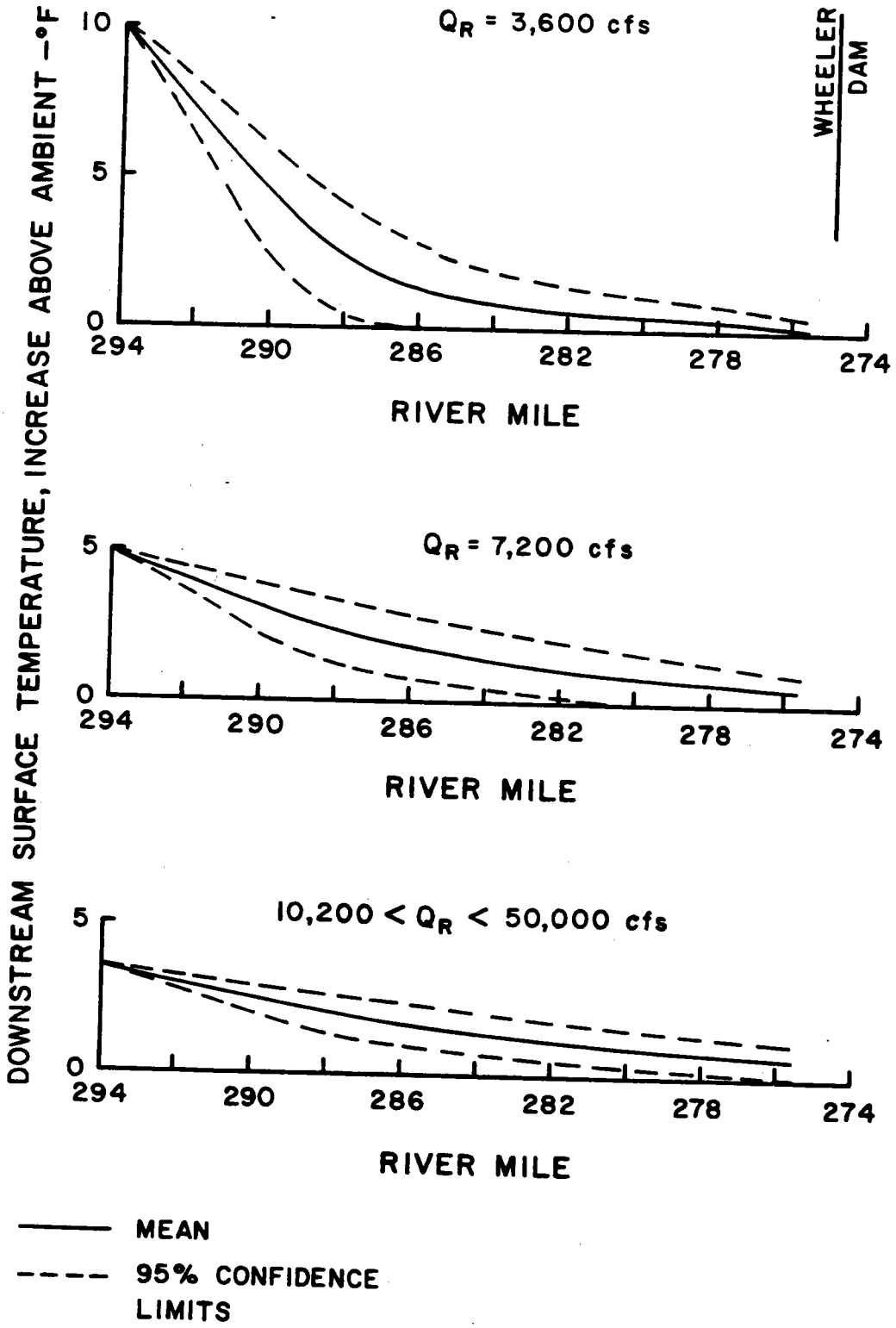


Figure 12
Effect of Plant on
Downstream Temp.
October, 1 Unit
BROWNS FERRY NUCLEAR PLANT

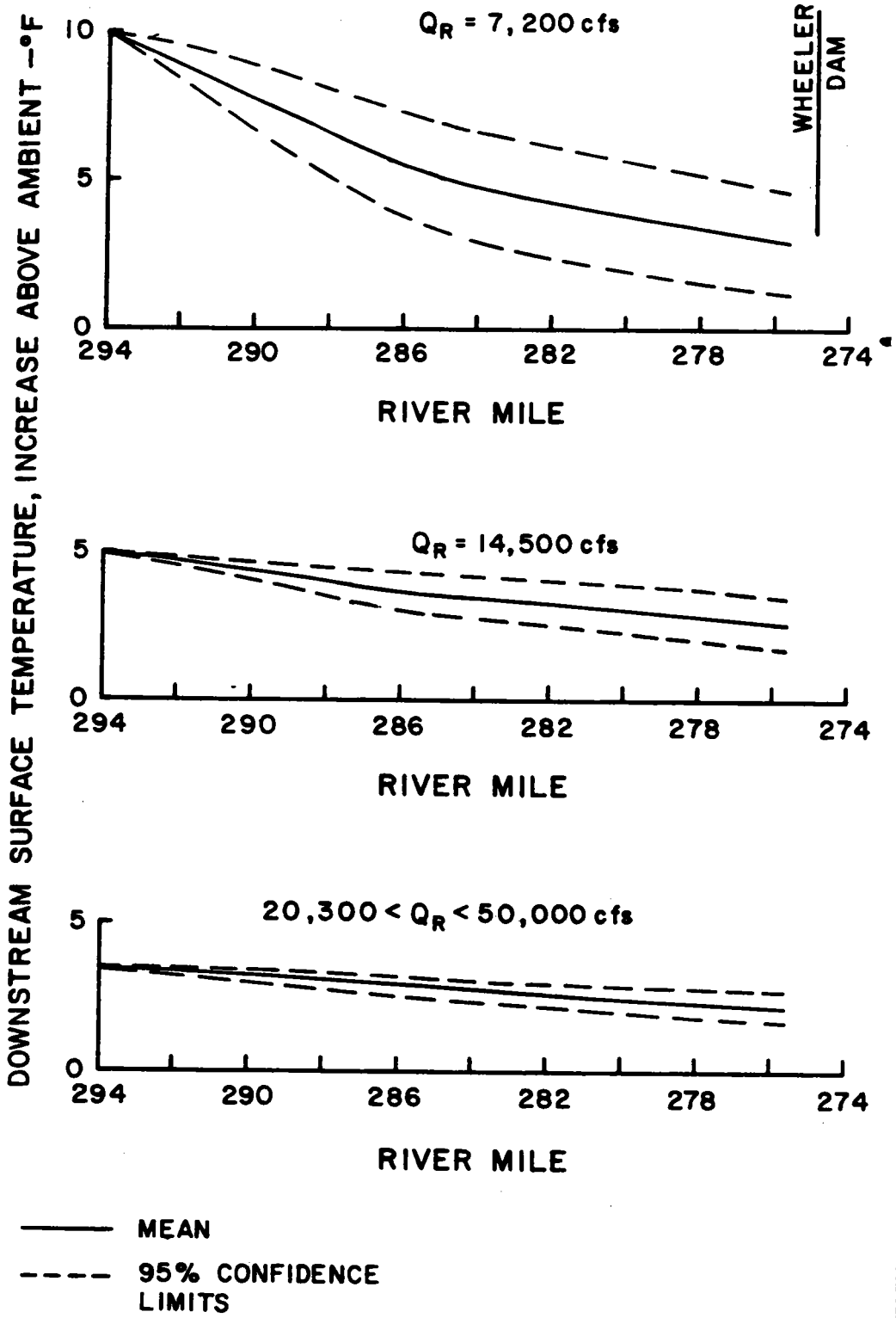


Figure 13
Effect of Plant on Downstream Temperature
January, 2 Units

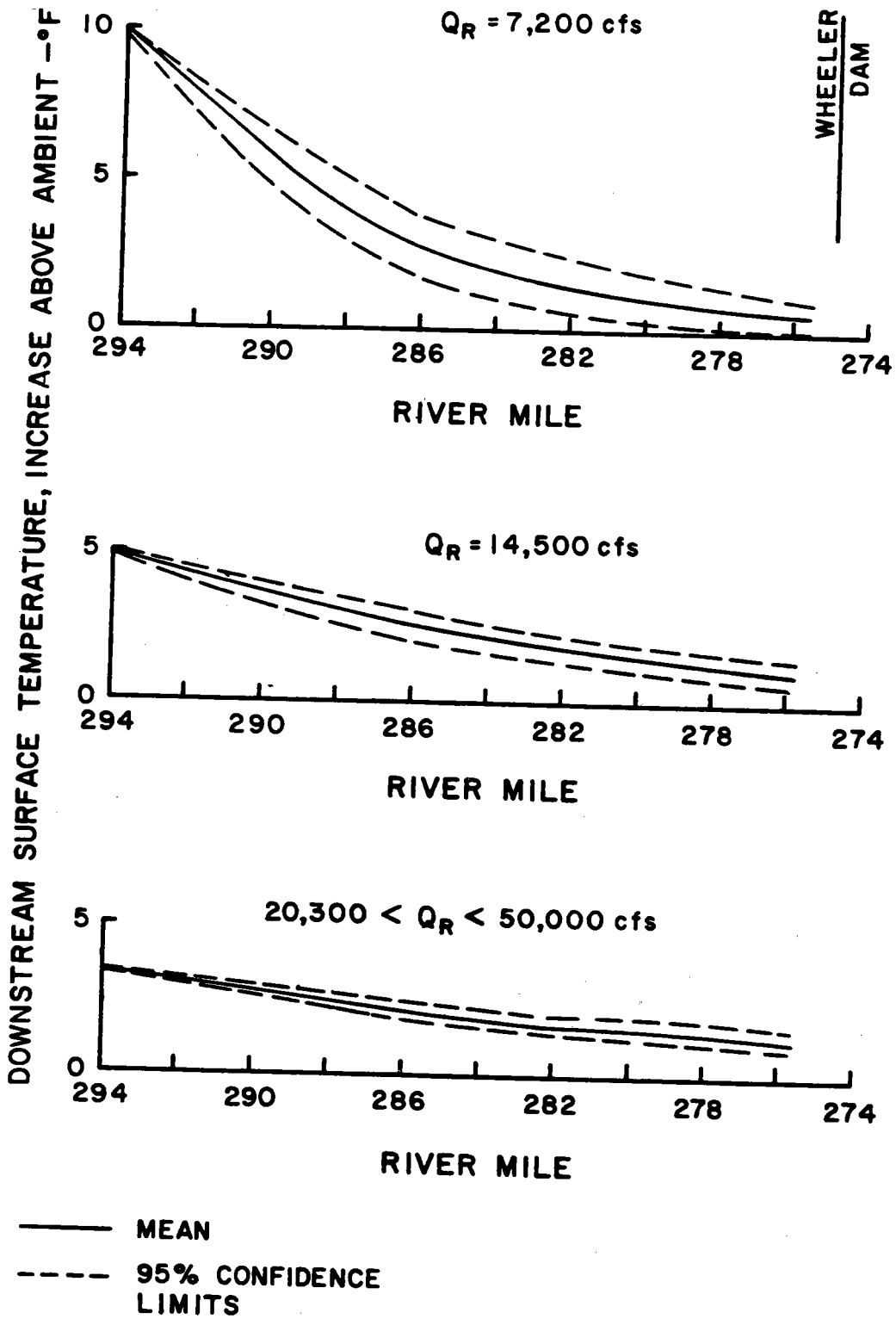


Figure 14
Effect of Plant on
Downstream Temp.
April, 2 Units
BROWNS FERRY NUCLEAR PLANT

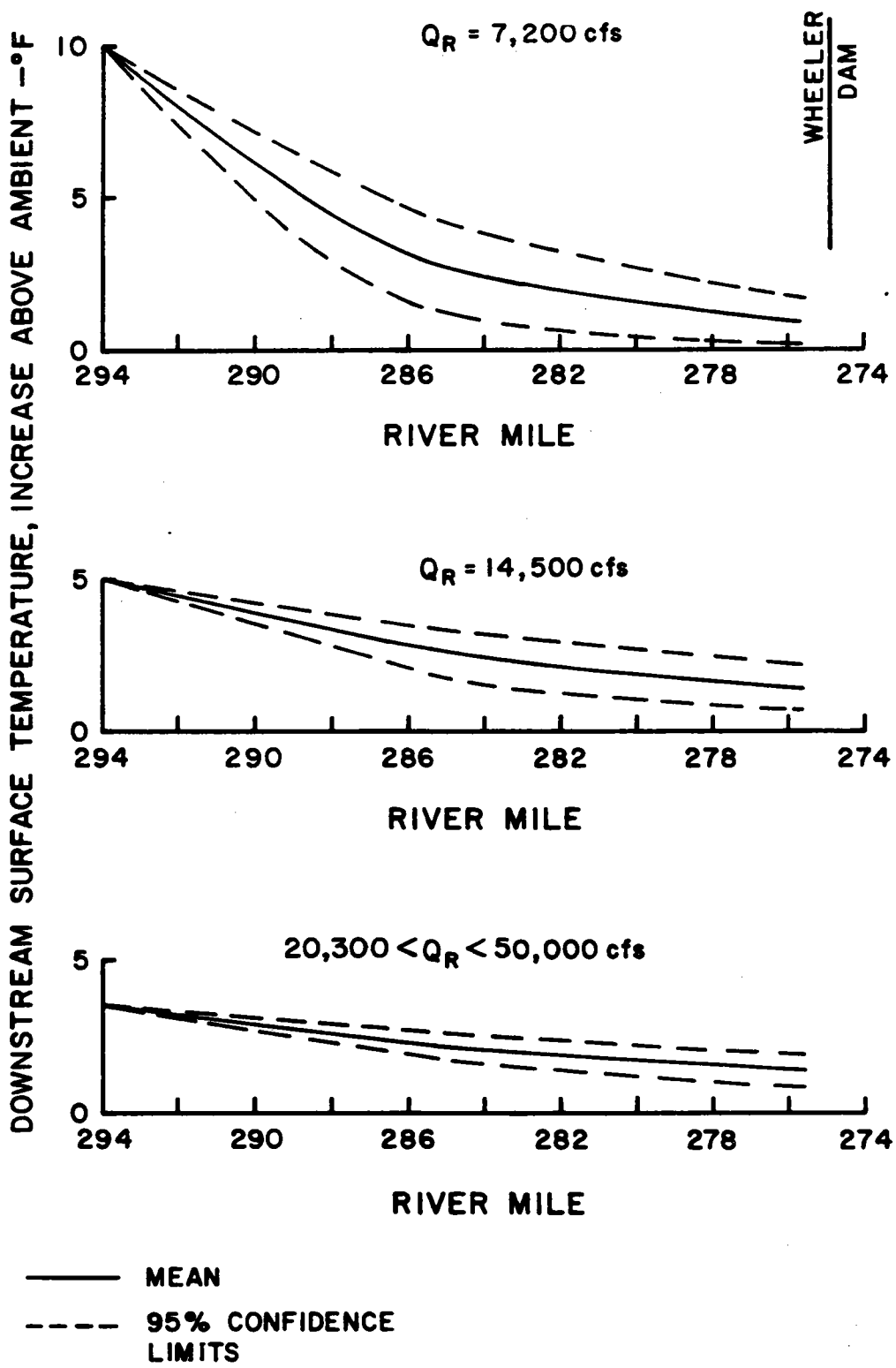


Figure 15
Effect of Plant on
Downstream Temp.
August, 2 Units
BROWNS FERRY NUCLEAR PLANT

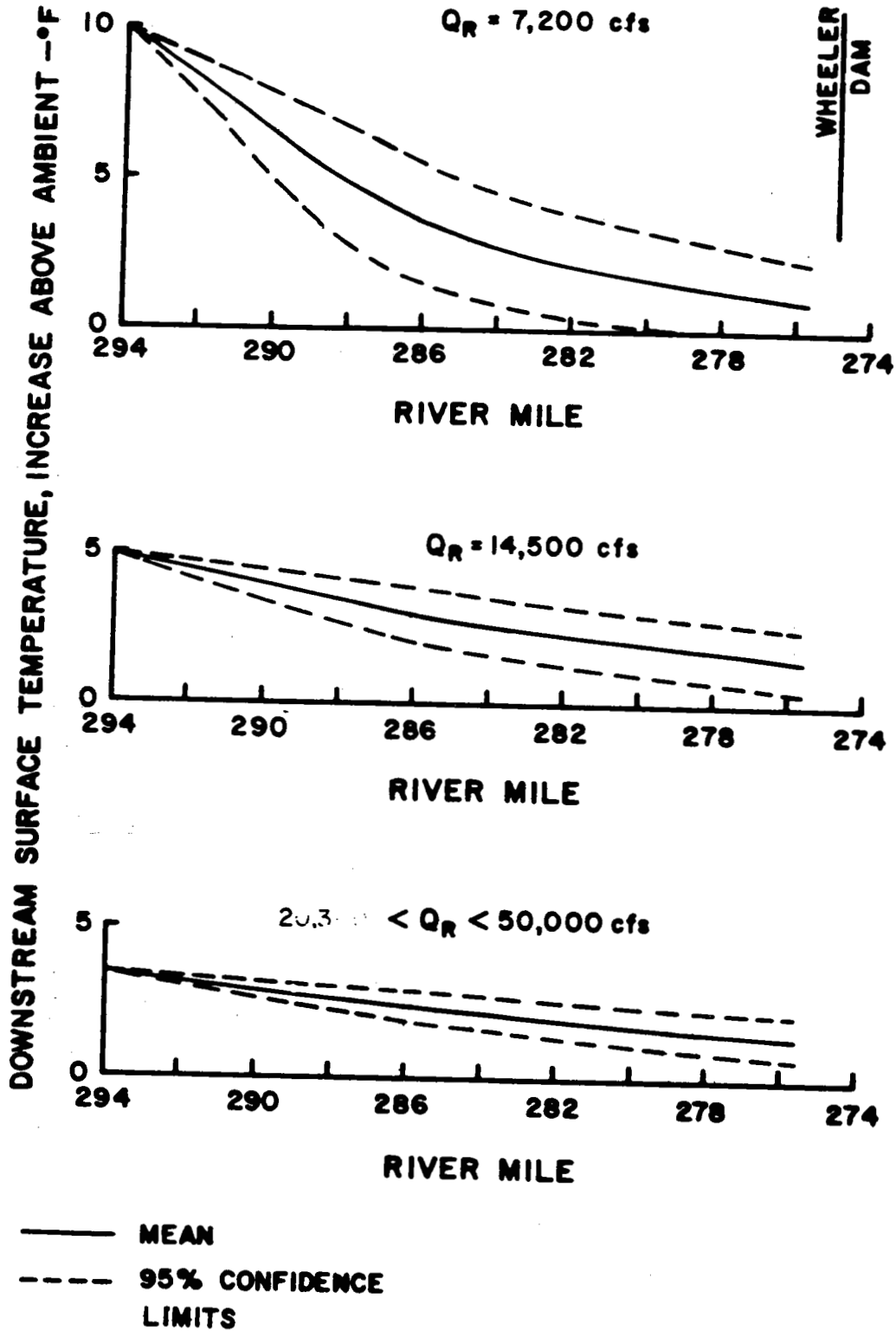


Figure 16
Effect of Plant on
Downstream Temp.
October, 2 Units
BROWNS FERRY NUCLEAR PLANT

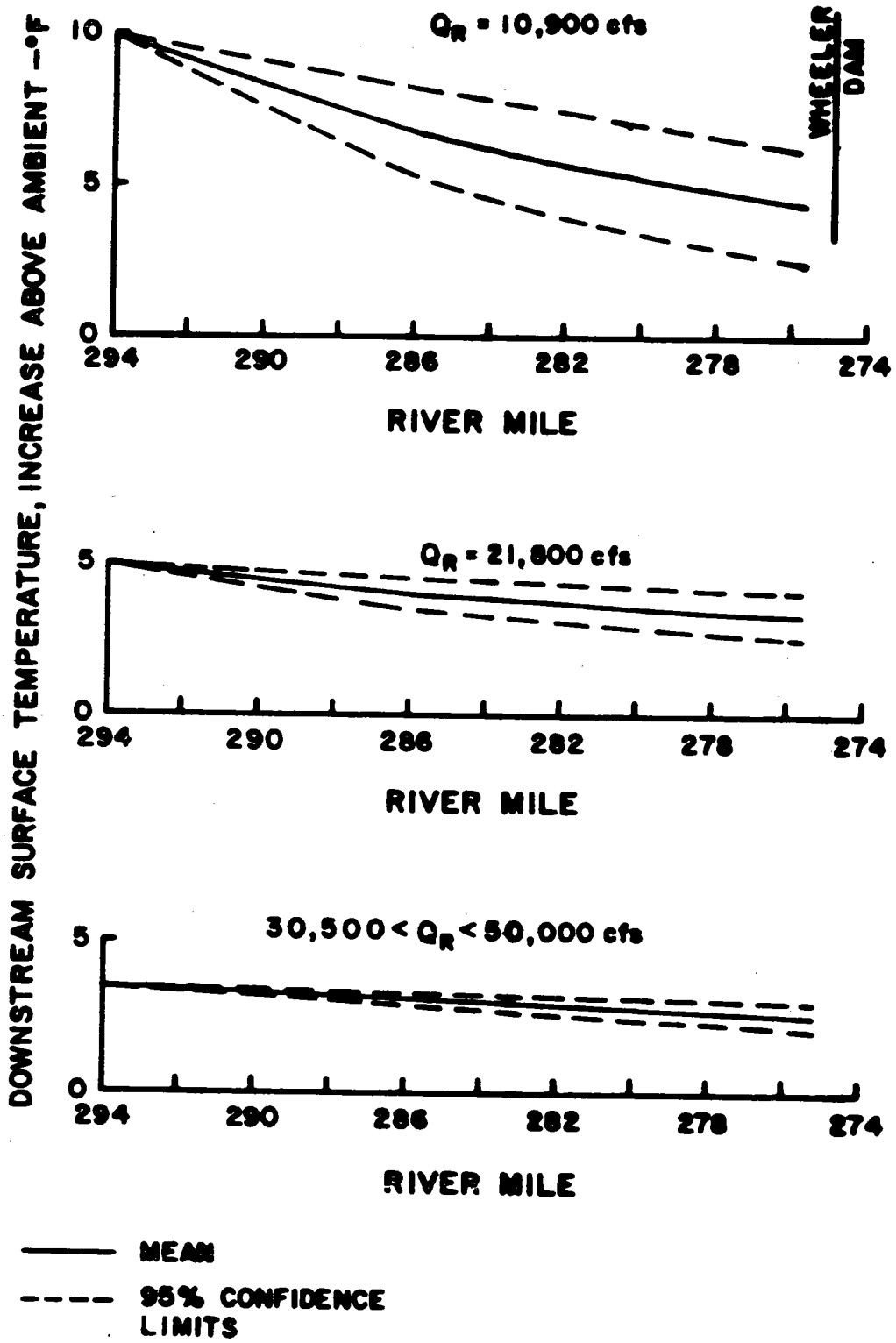


Figure 17
Effect of Plant on
Downstream Temp.
January, 3 Units
BROWNS FERRY NUCLEAR PLANT

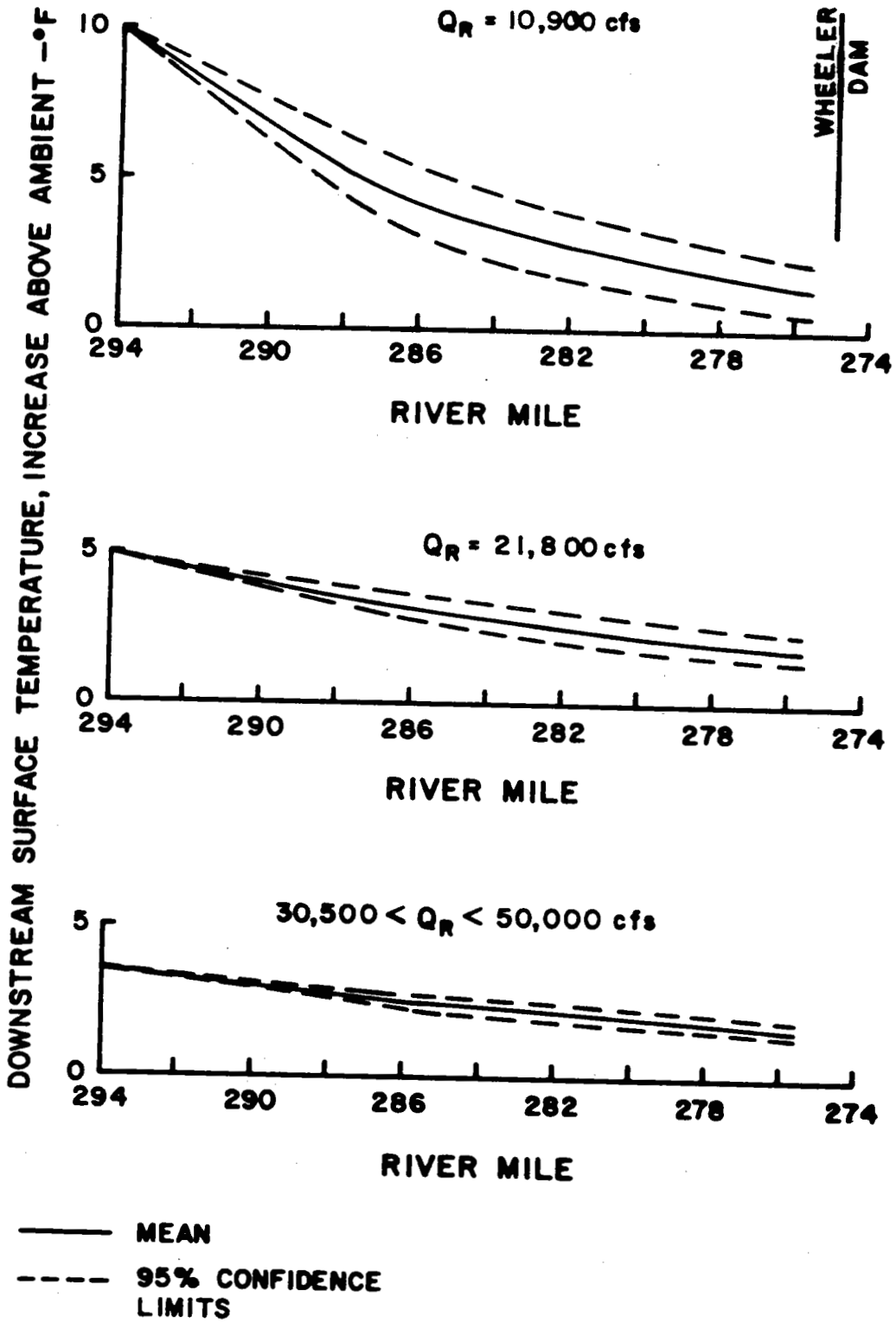


Figure 18
Effect of Plant on
Downstream Temp.
April, 3 Units
BROWNS FERRY NUCLEAR PLANT

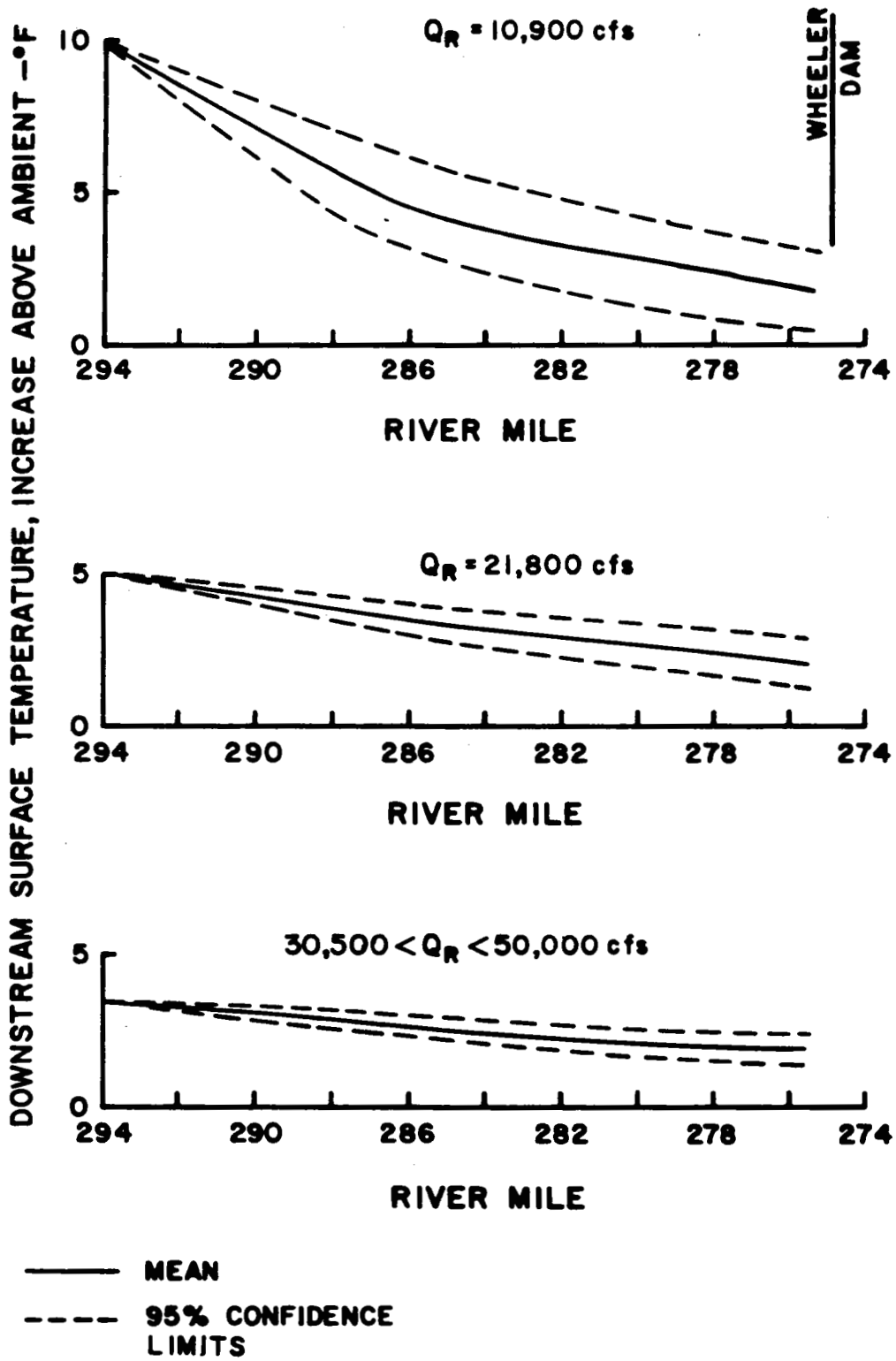


Figure 19
Effect of Plant on
Downstream Temp.
August, 3 Units
BROWNS FERRY NUCLEAR PLANT

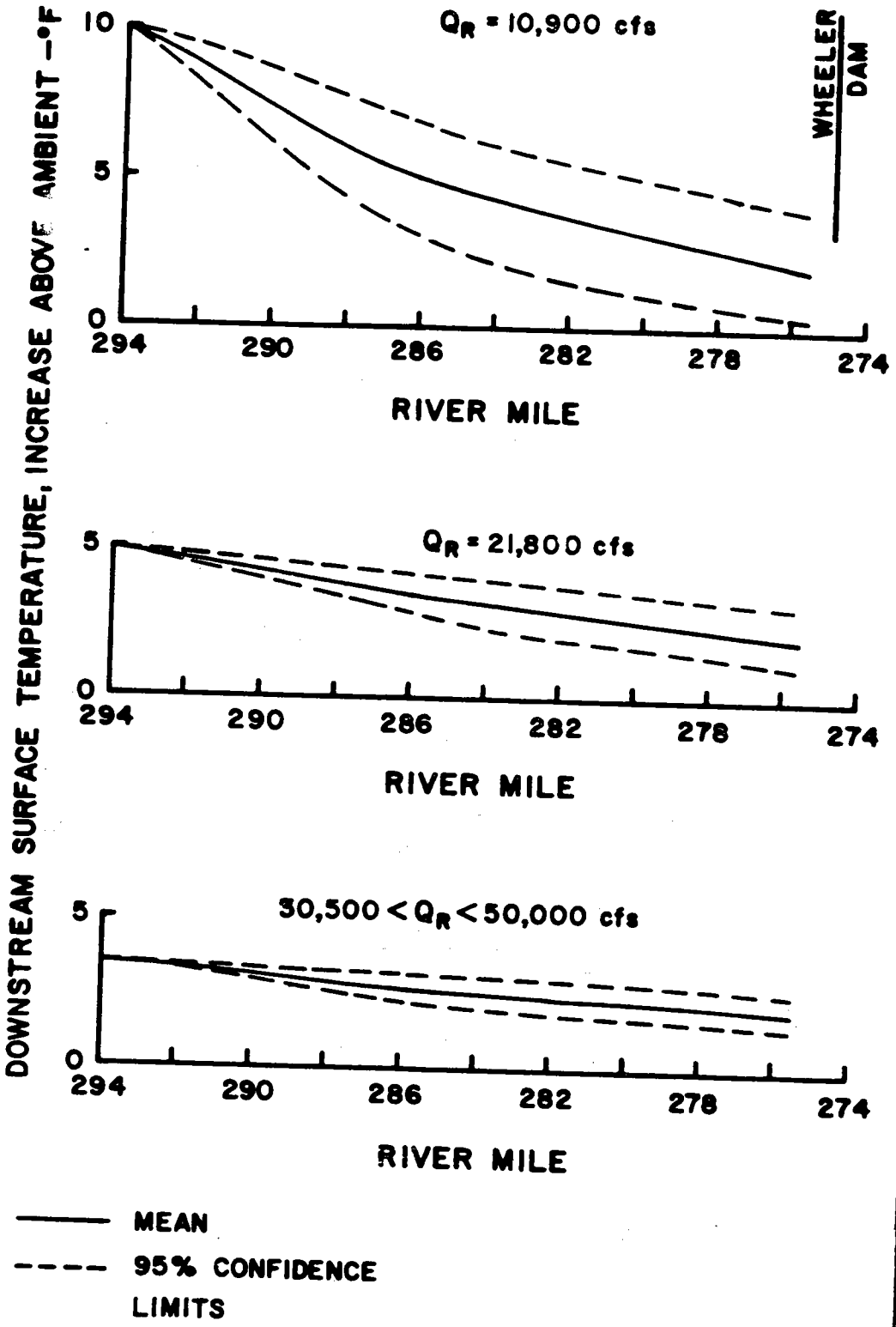


Figure 20
Effect of Plant on
Downstream Temp.
October, 3 Units
BROWNS FERRY NUCLEAR PLANT

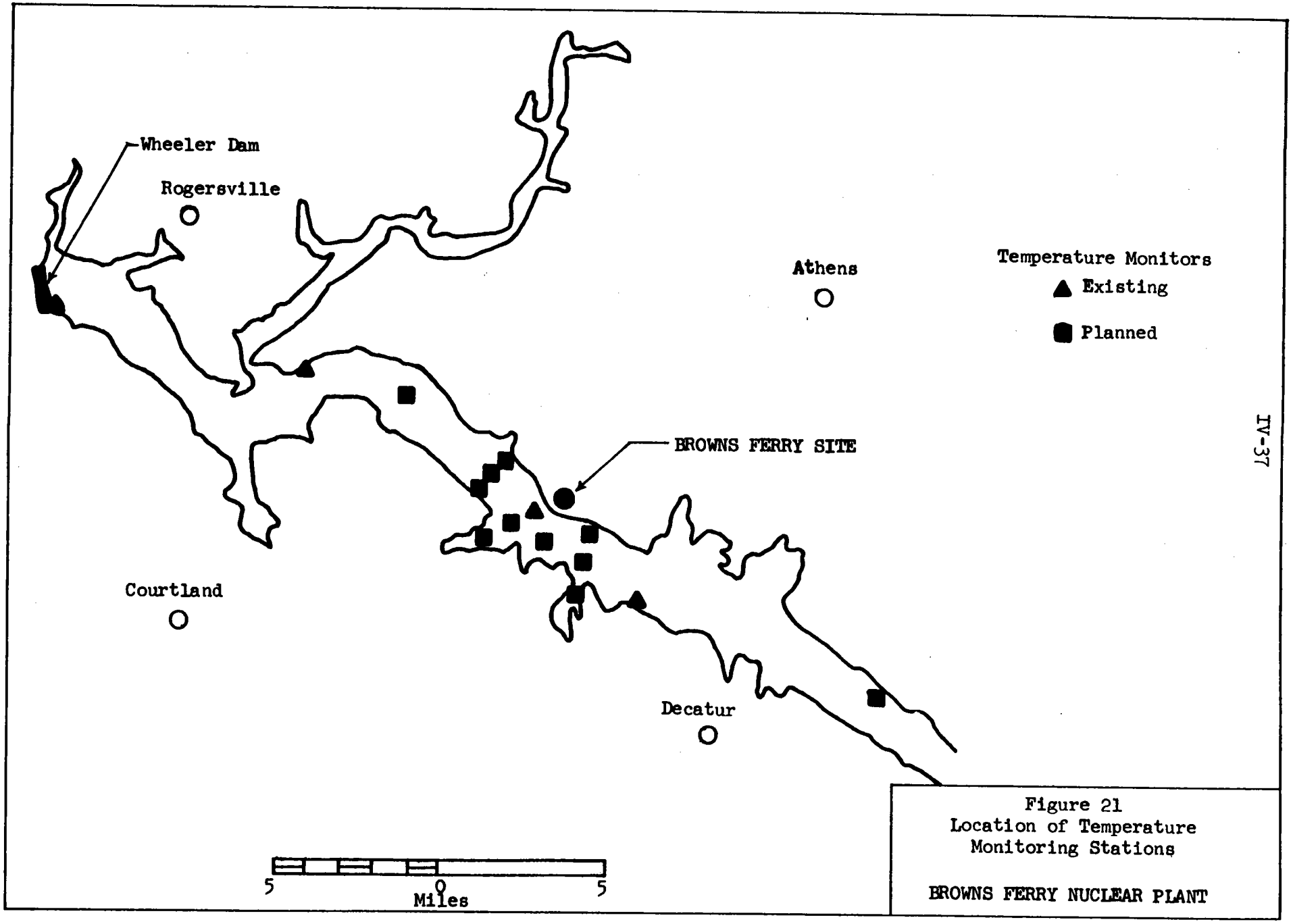


Figure 21
Location of Temperature
Monitoring Stations

BROWNS FERRY NUCLEAR PLANT

APPENDIX V

NOISE LEVEL CALCULATIONS - BROWNS FERRY

MECHANICAL DRAFT COOLING TOWERS

Sound pressure levels were calculated for four points 1,000 feet from the perimeter of the six Browns Ferry cooling towers. The basic equation[1]

$$L_{p\theta} = L_w + DI - f(r) \pm K$$

where $L_{p\theta}$ = sound pressure levels at distance and angle

L_w = sound pressure level

DI_θ = directivity index

$f(r)$ = an attenuation factor based on geometry and distance

K = constant associated with units and spherical directivity

was modified to fit the specific situation of the Browns Ferry cooling towers. The design parameters used were:

1. Tower dimensions of 600-foot length, 50-foot width, and 50- to 60-foot height.
2. Layout as shown in figure 2.6-8.
3. Sixteen fan motors of 200 horsepower each arranged linearly along the major dimensional axis of each cooling tower.

Because fan noise is dominant over water noise in mechanical draft cooling towers, fan noise was used as the design basis in the evaluation. The relationship used to calculate the sound power level of the source was:

$$L_w = 95 + 10 \log (\text{horsepower}),$$ an empirically derived equation.[2]

Empirical data from one major manufacturer of towers listed sound pressure levels for a similar cooling tower in two directions at a 200-foot distance, the correction constant K in the derived equations was calculated by making the modified equation fit that data at 200 feet. This factor is a sum of several correction factors, i.e., the correction factor for a hemispherical calculation, the directivity index factor, the unit conversion factor, and the octave band power level distribution factor. It was assumed that once K has been determined for any distance in one direction, it remains constant, independent of change in distance as long as the direction outward is not changed.

The sound level spectra calculated 1,000 feet from the tower complex along the facility centerlines (the long axis runs approximately parallel to the shoreline, see figure 2.6-8) are shown below:

Predicted Noise Spectrum, Six Mechanical Draft Cooling Towers, 1,000 Feet from Towers, Corrected for Air Absorption at 80°F and 70 Percent RH

Center Frequency, Hz	63	125	250	500	1,000	2,000	4,000	8,000	dB(A)
Listening Stations									
Along centerline of short axis of tower complex (NE by SW)	61	56	53	51	49	44	42	38	54
Along centerline of long axis of tower complex (NW by SE)	55	31	48	44	38	30	15	7	44

It is expected that these theoretical values are well on the high side because the calculated model was based on worst case conditions and there should be further attentuation caused by environmental factors such as building obstruction, shrubbery, trees, wind, temperature gradients,

ground profile, etc. These were not included in the model. These factors can be taken into consideration later once the design parameters and layout configuration are firmly resolved.

The predicted dB(A) noise levels at 1,000 feet may be used to calculate noise levels more distant from the towers by assuming a 6 dB decrease in noise level with each doubling of distance and correcting for air absorption at 80°F and 70 percent RH. Again, attenuation by structures, topography, and vegetation was ignored, thereby leading to conservatively high predictions. A background noise survey was performed by TVA industrial hygienists in November 1971 at nine locations outside the Browns Ferry Nuclear Plant reservation boundary. Background data were taken after midnight to minimize construction noise from the site. These data provide a basis for comparison with predicted operational cooling tower noise.

Comparison may also be made with nonaircraft noise criteria developed by the U.S. Department of Housing and Urban Development (HUD).[1] Noise levels were estimated in the direction of the short axis of the tower complex at locations where excessive noise might become significant to residents of the community. Predicted noise levels were corrected for background noise influence where applicable. The predicted operational noise levels, the measured background noise, and the acceptablitiy of the operational noise with respect to HUD criteria are shown below for the short axis (NE by SW) listening points.

BFNP MECHANICAL DRAFT COOLING TOWER NOISE COMPARISON

NE BY SW DIRECTIONS

Listening Station	Dist. from Source	Dir. from Source	Bkgd Night 11/5/71 dB(A)	Predicted Noise Level Bkgd Corrected, dB(A)	Acceptability by HUD Recommended Noise Criteria
At plant boundary	4,200'	NE	33	38	Normally Acceptable
Outside plant boundary	1 mi	NE	33	37	Normally Acceptable
Nearest residence	2 mi	NE	32	33	Normally Acceptable
Far shore, Wheeler Reservoir	1.9 mi	SW	34	35	Normally Acceptable

Noise levels in the direction of the long axis will be less than that at corresponding distances in the direction of the short axis as shown by the predicted noise spectrum at 1,000 feet from the towers.

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