APPENDIX 2.4A

BROWNS FERRY NUCLEAR PLANT

PROBABLE MAXIMUM FLOOD (PMF)

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APPENDIX 2.4A
BROWNS FERRY NUCLEAR PLANT
PROBABLE MAXIMUM FLOOD (PMF)

INTRODUCTION

This appendix describes the determination of maximum flood conditions at Browns Ferry Nuclear Plant. The plant could possibly be flooded by the Tennessee River, by a small stream northwest of the plant, and by intense local storms which overtax the site drainage system. Each situation has been examined and is discussed separately in this appendix. The main body of the appendix discusses the determination of maximum flood levels resulting from conditions on the Tennessee River.

The Browns Ferry plant is on the right bank of Wheeler Reservoir at Tennessee River mile (TRM) 294, 55 miles downstream from Guntersville Dam and 19 miles upstream from Wheeler Dam. The 27,130-square-mile watershed drains the rugged southern Appalachian Mountains, the second highest annual rainfall-producing area in the conterminous United States, portions of the Cumberland Plateau and Highland Rim, and extends into parts of six states.

Definition

The term “probable maximum flood” (PMF), is used by TVA to describe the hypothetical flood which would result from an occurrence of the probable maximum precipitation (PMP) critically centered on the watershed as defined by the National Weather Service. The computational procedures used to translate this PMP rainfall into flood flows result in a flood hydrograph which defines the upper limit of potential flooding at the plant. Such a flood was earlier called the "maximum possible flood" by the Browns Ferry Nuclear Plant. The flood was determined by deterministic procedures, however most hydrologists agree that the probability of occurrence of the flood in a particular year closely approaches zero.

Data Available

The Tennessee River Basin above Wheeler Dam is a gaged watershed. TVA began its program of hydrologic data collection upon its creation in 1933. The program has continually evolved since that date. There are currently 142 rain gages and 42 recording stream gages which measure rainfall and stream-flows in the basin above Wheeler Dam. The period of above-average hydrologic gaging extends back to 1935 when TVA began its expanded program of hydrologic data collection.

The nearest location with extensive, formal flood records is 37 miles downstream at Florence, Alabama, where continuous records are available since 1871. Knowledge about significant floods extends back to 1867 based upon newspaper and historical reports.

TVA has developed procedures for predicting stream flows for use in the daily operation of the reservoir system. The forecast procedure begins with rainfall and proceeds through all the hydrologic calculations necessary to translate this rainfall into reservoir inflows. The present forecast procedure for Wheeler Reservoir has been in continuous use with modifications dictated by experience since 1952.

An important element of these flood forecasts was the analysis of flood events using rainfall developed by the Hydrometeorological Branch, Office of Hydrology, National Weather Service (NWS). The results of NWS rainfall studies are contained in Hydrometeorological Report No. 41, "Probable Maximum and TVA Precipitation Over the Tennessee River Basin Above Chattanooga," published in June 1965, and HMR 47,"Meteorlogical Criteria for Extreme Floods for Four Basins in the Tennessee and Cumberland River Watersheds," issued May 1973.

SUMMARY OF RESULTS

Maximum possible discharge from the Tennessee River at Browns Ferry Nuclear Plant is 1,200,000 cubic feet per second (cfs) with corresponding maximum elevation at the plant of 572.5. The PMF elevation includes allowances for failure of portions of an earth saddle dam at Watts Bar dam and earth embankment sections at Chickamauga, Nickajack, and Guntersville Dams located upstream of the plant.

The maximum possible discharge from the small stream northwest of the plant is 17,200 cfs. The channel system has been designed to prevent flooding of the plant in the event such a flood should occur.

At the plant the maximum concentration of drainage is northwest of the main building complex. Flow restrictions will cause water surface elevations to reach El. 566.6 between the office and service buildings.

THE WATERSHED

<u>Physiography</u>

The Tennessee River at Browns Ferry Nuclear Plant, mile 294, drains a 27,130-square-mile watershed area above the plant. Guntersville Dam, 55 miles upstream, has a drainage area of 24,450 square miles. Wheeler Dam, the next dam downstream, the headwater of which affects flood elevations at the plant, has a drainage area of 29,590 square miles.

The major tributaries upstream of Chattanooga, drainage area 21,400 square miles, except for the Clinch and Holston Rivers rise to the east in the rugged southern Appalachian Highlands. They flow northwestward through the Appalachian Divide, which is essentially defined by the North Carolina-Tennessee border, to join the Tennessee River which flows southwestward. The drainage pattern is shown on Figure 1. The Tennessee, Clinch, and Holston Rivers flow southwest through the valley and ridge physiographic province which, while not as rugged as the Southern Highlands, features a number of mountains including the Clinch and Powell Mountain chains. Downstream of Chattanooga the only major tributary is the Elk River which joins the Tennessee River above Wheeler Dam and downstream from the plant. About 10 percent of the watershed rises above El. 3000 feet with a maximum elevation of 6684 feet at Mount Mitchell, North Carolina. The watershed is about 60 percent forested with much of the more mountainous area being 100 percent forested.

Climate

The climate of the watershed is classified as humid temperate. Above Wheeler Dam annual rainfall averages 51 inches and varies from a low of 40 inches at sheltered locations within the mountains to high spots of 90 inches on the southern and eastern divide. Rainfall occurs relatively evenly throughout the year. The lowest monthly average is 3.0 inches in October. The highest monthly average is 5.1 inches in March.

Major flood-producing storms are of two general types: the cool season, winter type and the warm season, hurricane type. Most floods at Browns Ferry Nuclear Plant, however, have been produced by winter-type storms in the flood-season months of January through April.

Watershed snowfall is relatively light, averaging only about 14 inches annually. Individual snowfalls are normally light with an average of 13 snowfalls per year. Snowfall is not a factor in maximum flood determinations.

RESERVOIR SYSTEM

General Description

The Tennessee River, particularly above Chattanooga, Tennessee, is one of the most regulated rivers in the United States. A prime purpose of the TVA water control system is flood control with particular emphasis on protection for Chattanooga, 170 miles upstream from Browns Ferry Nuclear Plant.

There are 22 major reservoirs in the TVA system upstream from Browns Ferry Nuclear Plant, 11 of which have substantial reserved flood detention capacity on March 15. Table 1 lists pertinent data for TVA's major dams. In addition, there are six major dams owned by the Aluminum Company of America (ALCOA). The ALCOA reservoirs often contribute to flood reduction, but they do not have dependable reserved flood detention capacity. The locations of these dams are shown on Figure 1.

Flood Detention Capacity

Flood control above the plant is provided largely by tributary reservoirs. On March 15, near the end of the flood season, these provide a minimum of 4,484,000 acre-feet equivalent to approximately 5.5 inches on the 15,237 square-mile area they control. This is approximately 82 percent of the total available above the plant. The four main river reservoirs-Fort Loudoun, Watts Bar, Chickamauga, and Guntersville-provide 997,400 acre-feet equivalent to 1.6 inches on the 11,893-square-mile area above the plant and lying below the major tributary dams.

The flood detention capacity reserved in the TVA system varies seasonally, with the greatest amounts during the January through March flood season. Figures 2 and 3 show typical tributary and main river reservoir seasonal operating guides. Total assured system detention capacity above Wheeler dam varies from 3.8 inches on January 1 to 3.7 inches on March 15 and decreases to 1.1 inch during the summer and fall. Actual detention capacity may exceed these amounts, depending upon inflows and power demands.

Wheeler Dam, the headwater elevation of which affects flood elevations at the plant, has a drainage area of 29,590 square miles, 5,140 square miles more than Guntersville Dam. There is one major tributary dam, Tims Ford, in the 5,140-square-mile intervening watershed. On March 15, near the end of the flood season, this project provides a minimum of 167,000 acre-feet equivalent to approximately 5.9 inches on the 529-square-mile controlled area. Wheeler Dam contains 326,500 acre-feet of detention capacity on March 15 equivalent to 1.3 inches on the remaining 4,611 square miles.

HYDROGRAPH DETERMINATION

General Description

The hydrologic model used to determine flood hydrographs at Browns Ferry Nuclear Plant and downstream at Wheeler Dam is one in which the total basin is divided into unit areas, the outflows of which are combined to determine total basin outflows. Unit hydrographs are used to compute flows from unit areas. These flows are combined with appropriate time sequencing to compute inflows into the most upstream reservoirs which in turn are routed through the reservoirs using standard techniques. Resulting reservoir outflows are combined with the additional local inflows and continued downstream using appropriate time sequencing or routing procedures. The hydrologic model results ensure that each of the unit areas reflect watershed response to rainfall and the total system will reproduce the largest floods experienced since completion of the basic TVA reservoir system.

Unit Hydrographs

The total watershed for the Guntersville-Wheeler Reservoir inflow estimating system is divided into 62 unit areas as shown by Figure 4. A unit hydrograph has been developed for each of the unit areas from flood hydrographs either recorded at stream gaging stations or estimated from flood data using reservoir headwater elevation, inflow, and discharge data. Figure 5, which contains 14 sheets, shows the unit hydrographs developed for each unit area. Table 2 contains essential dimensional data of each unit hydrograph.

Reservoir Routing

Tributary reservoir routings were made using standard reservoir routing procedures and flat pool storage conditions. The tributary reservoirs, Tellico and Melton Hill, and the main river reservoirs were routed using unsteady flow techniques.

Unsteady flow routings were computer solved with a mathematical model based on the equations of unsteady flow. This model is described in a paper by Jack M. Garrison, Jean-Pierre Granju, and James T. Price entitled "Unsteady Flow Simulation in Rivers and Reservoirs," Journal of the Hydraulics Division, ASCE, Volume 95, No. HY5, September 1969. Boundary conditions prescribed were inflow hydrographs at the upstream boundary, local inflows, and headwater discharge relationships at the downstream boundary based upon standard operating rules or rating curves where geometry controlled, as appropriate.

Verification

The total area hydrologic model for estimating flood hydrographs was verified by using it to reproduce the March 1973 and the December 2004 floods which are two of the largest floods of record. A comparison between the observed elevations on Wheeler reservoir and the computed outflow at Wheeler Dam for the 1973 flood are shown in Figures 6 and 7, respectively, and for the 2004 flood in Figures 8 and 9, respectively.

The unsteady flow model was used to verify historic flood events in all reservoirs where unsteady flow routing was used. Since the Tellico Dam was not closed until 1979, there is no information available to verify the 1973 flood. Therefore, Federal Emergency Management Agency (FEMA) published 100- and 500-year profiles were used for the verification of this portion of the model.

Verifying the reservoir models with actual data approaching the magnitude of the PMF is not possible, because no such events have been observed. Therefore, using flows in the magnitude of the PMF (1,200,000 - 1,400,000 cfs) steady state profiles were computed using the two steady state models. An example of this comparison between the profiles for the two models is shown for Wheeler Reservoir in Figure 10. This approach was applied for each of the unsteady flow reservoir models. Similarly, the tailwater rating curve was compared at each project as shown for Guntersville Dam in Figure 11. In this figure, the initial tailwater curve is compared to results from the steady flow models.

Breached Earth Embankments

The main river dams upstream from Wheeler include earth embankments which could fail if overtopped. Maximum flood level determinations at Browns Ferry Nuclear Plant are based on the postulated failure of any earth embankment which is overtopped with time of failure based on results of the breach analysis of each embankment.

The relationship to compute the rate of erosion in an earth dam failure is that developed by the Bureau of Reclamation. The expression relates the volume of eroded fill material to the volume of water flowing through the breach. This relationship is used only to determine the time of failure of an overtopped earth embankment. At the determined time of failure, the embankment is postulated to fail instantaneously and completely.

The solution to determine if an earth embankment would fail begins by solving the erosion equation using a headwater elevation hydrograph assuming no failure. Erosion is assumed to occur across the entire earth section and to start at the downstream edge when headwater elevations reach 0.1 foot above the dam top elevation. When erosion began to lower the dam top elevation, the computations included headwater elevation adjustments for increased reservoir outflow resulting from the breach.

During the PMF analysis the earthen embankments at Cherokee, Fort Loudoun, Tellico and Watts Bar dams were shown by the hydraulic model to be susceptible to overtopping. The protection of these embankments was recognized as important to TVA dam safety as well as the protection for the nuclear plants. Therefore, these embankments were protected, temporarily, with HESCO Concertainers® and are planned to be replaced by permanent protection measures against overtopping. The additional height of these temporary flood barriers are included in the hydraulic model analysis and show that the embankments at these four dams would not be overtopped. Nickajack Dam and Guntersville Dam embankments were modified as a part of the TVA Dam Safety Program based on analysis at the time and were modified in 1992 and 1995, respectively. However, the west saddle dam at Watts Bar, and earthen embankments at Nickajack, Guntersville, and Chickamauga dams were overtopped based on results of the hydraulic model analysis and are postulated to fail.

The postulated failure of Guntersville Dam earth embankments in the Browns Ferry PMF is typical of the results obtained using this procedure. Figure 12 is a general plan of Guntersville Dam showing elevations and sections. The failure calculations were made assuming that 1026 feet of the south embankment could fail to average original ground elevation 564 and the remaining 864 feet of the south embankment fails to elevation 599 which is the elevation of the switchyard adjacent to the embankment. Five hundred feet of the north embankment could fail to average ground elevation 606, the elevation of the parking area adjacent to the north embankment.

PROBABLE MAXIMUM PRECIPITATION

Probable maximum precipitation (PMP) for the watersheds above Wheeler and Guntersville Reservoirs has been defined for TVA by the Hydrometeorological Branch of the National Weather Service. Two basic storm situations have the potential to produce a maximum flood at Browns Ferry Nuclear Plant. These are (1) storms producing maximum rainfall on the 21,400-square-mile watershed above Chattanooga with the downstream orographically fixed storm pattern, and (2) storms producing maximum rainfall on the 16,170-square-mile watershed above Wheeler Dam and below the major tributary dams. Previous analyses also considered a third storm situation, the 7,980 square mile storm. However, rainfall depth on the watershed above Wheeler reservoir eliminated the 7,980 square mile storm as a candidate storm.

Estimates of PMP for the watershed above Chattanooga are fully defined in HMR No. 41. PMP depths for the 21,400-square-mile watershed above Chattanooga are tabulated below. This storm would occur in March. Two possible isohyetal patterns producing these depths are presented in HMR No. 41. The pattern critical to this study is the "downstream pattern" shown in Figure 13.

PMP depths for the 16,170-square-mile watershed above Wheeler Dam but below the major tributaries are contained in HMR No. 47. PMP depths for the 16,170-square-mile watershed are also tabulated below. The isohyetal pattern for the storm is shown in Figure 14. The pattern and depths are for a storm centered within 35 miles of Nickajack Dam. A 72-hour storm 3 days antecedent to the main storm was assumed to occur in all PMP situations with storm depths equivalent to 40 percent of the main storm outlined in Bulletin 41.

Basin Depth, Inches

Storm,	72-Hour	Main Storm		
Sq. Mi.	Antecedent Storm	6-Hour	24-Hour	72-Hour
21,400	6.08	4.48	9.43	14.48
16,170	6.22	4.2	9.65	15.55

RAIN-RUNOFF RELATIONSHIPS

Precipitation excess resulting from the PMP storm was computed using multivariable relationships developed and used in the day-to-day operation of the TVA system. These relationships, developed from a study of flood records, relate the amount of precipitation excess expected from a given storm rainfall to the week of the year, an antecedent precipitation index (API), and geographical location. The relationships are such that the subtraction from rainfall to compute precipitation excess is greatest at the start of the storm and decreased to no subtraction where precipitation excess is equal to rainfall in the late part of extreme storms. An API determined from an 11-year period of historical rainfall records (1997-2007) was used at the start of the antecedent storm. The precipitation excess computed for the main storm is not sensitive to variations in adopted initial conditions because of the large antecedent storm.

CONDITIONS CREATING PROBABLE MAXIMUM FLOOD

Critical Storm

Enough storm arrangements including different storm centerings, seasonal variability, and consideration of potential dam failures were investigated to ensure selection of the arrangement which would produce the PMF discharge and elevation at Browns Ferry Nuclear Plant. The critical PMP storm was determined to be the 21,400-square-mile downstream centered storm, which would follow an antecedent storm commencing on March 15. The antecedent storm would produce an average precipitation of 6.08 inches on the basins above Wheeler, would be followed by a 3-day dry period, and then by the main storm which would produce an average precipitation of 14.48 inches in 3 days. Figure 13 is an isohyetal map of the maximum 3-day PMP which was used to compute the PMF.

Precipitation Excess

Median moisture conditions as determined from the 11 year period of historical records (1992-2007) were used to determine the API at the start of the storm sequence. However, the antecedent storm is so large that the precipitation excess computed for the main storm is not sensitive to variations in adopted initial moisture conditions. The precipitation excess from the critical PMP storm was 3.85 inches for the 3-day antecedent storm and 12.74 inches for the 3-day main storm. Table 3 displays the rain and precipitation excess for both the main and antecedent storm for the critical storm for each of the 62 subwatersheds of the hydrologic model.

Reservoir Operations

Reservoir routings were started with all reservoirs at their respective median mid-March elevations. The reservoir operating guides applied during the unsteady flow model simulations mimic, to the extent possible, operating policies and are within the current reservoir operating flexibility. In addition to spillway discharge, turbine and sluice discharges were used to release water from the tributary reservoirs. Turbine capacities are also used in the main river reservoirs up to the point where the head differentials are too small and/or the powerhouse would flood. All gates were assumed to be operable without failures during the flood. The flood from the antecedent storm occupied about 63 percent of the reserved detection capacity at the beginning of the main storm (day 7 of the event). Reservoir levels are at or above guide levels at the beginning of the main storm in all but Apalachia and Fort Patrick Henry reservoirs, which have no reserved flood detention capacity.

Dam Failures

Failure of upstream dams during the adopted PMF would create maximum flood elevations at Browns Ferry Nuclear Plant. For this study maximum headwater levels were determined at each major upstream dam for the PMF. Each dam, where the computed headwater level exceeded the concrete or earthen embankments, was analyzed to determine if it would fail. The current analysis revealed that the west saddle dam at Watts Bar and portions of earth embankments at Chickamauga, Nickajack, and Guntersville dams were subject to postulated failure as a result of overtopping. The concrete portions of all dams, including the main river dams, were found to be stable in these situations.

PROBABLE MAXIMUM FLOOD

The PMF peak discharge at Browns Ferry Nuclear Plant is 1,193,671 cfs. The hydrograph of the calculated discharge is shown in Figure 15. However, the design and licensing basis peak discharge is being maintained as 1,200,000 cfs. Velocities at the site would average 6 feet per second in the channel and up to 4 feet per second in the overbank at the time of peak discharge.

The PMF elevation at Browns Ferry Nuclear Plant is 571.7. The hydrograph of the calculated PMF elevation is shown in Figure 16. However, the design and licensing basis PMF elevation is being maintained as 572.5.

Wind Waves

Some wind waves are likely when the PMF is cresting at Browns Ferry Nuclear Plant. The flood would be near its crest elevation for a day beginning about 6-1/2 days after cessation of the PMP storm.

A reasonably severe windstorm producing 45 mph sustained wind speeds could occur coincidentally with the PMF. A wind from the SE will produce the largest waves at the site. A wind of this magnitude and from this direction can generate 5-foot waves (crest to trough). The analysis of wave heights used the “1% wave” of which about 5 per hour will occur. Consequent wave runup above the flood level would be about 5 feet on a vertical wall.

Maximum Elevation

A maximum flood elevation of 578 at the plantsite results from a combination of the PMF and wind wave runup on a vertical wall.

LOCAL DRAINAGE

In addition to flooding from the Tennessee River, Browns Ferry Nuclear Plant could possibly be flooded by intense local storms. Flooding sources include: (1) the small unnamed stream northwest of the plant, a portion of which has been relocated (see Figure 21), (2) the area draining to the switchyard drainage channel, (3) the main plant area, and (4) the area draining to the cooling tower system of channels. These areas, labeled Area 1 through Area 4 respectively, are shown on Figure 22. Direction of flow for runoff is indicated by arrows. Figure 22a shows the plant topography.

These areas were evaluated for a local storm producing probable maximum precipitation (PMP). PMP has been defined for TVA by the Hydrometeorological Branch of the National Weather Service and is described in Hydrometeorological Report No. 56 (HMR-56), "Probable Maximum and TVA Precipitation Estimates with Areal Distribution for Tennessee River Drainages less Than 3,000 Mi^2 in Area." HMR-56 supersedes HMR-45, which was used to define PMP in the original analysis. A 6-hour storm which would produce a total of 34.4 inches of rainfall with a maximum 1-hour amount of 16.7 inches was determined to be critical and was used to develop probable maximum flood inflows. The mass curve is shown in Figure 22b. Runoff was conservatively assumed equal to rainfall.

Ice accumulation would occur only at infrequent intervals because of the temperate climate. Maximum winter precipitation concurrent with ice accumulation would impose less severe conditions on the drainage system than would the local PMP, which is associated with severe summer thunderstorm activity.

Local Stream

An unnamed stream northwest of the plant with drainage area of 1.35 square miles formerly flowed through the plant area. Figure 21 shows this watershed. The stream has now been diverted to flow along the west boundary of the plant as shown in Figure 22. The channel is designed with capacity sufficient to carry the maximum possible (probable maximum) flood without flooding the plant.

The peak flood discharge was estimated using a 1-hour unit hydrograph developed synthetically by comparison with gaged watersheds in the region. The adopted unit hydrograph is shown on Figure 23.

The maximum possible (probable maximum) peak discharge is 17,200 cfs. This compares with 14,000 cfs determined in the original analysis. The maximum possible (probable maximum) flood hydrograph for this stream and the site PMP hyetograph are shown on Figure 24.

The alignment of the relocated channel is shown on Figure 22, typical sections are shown on Figure 25, and plan and profiles, including water surface profiles and minimum grade levels between the channel and plant, are shown on Figures 26, sheets 1 and 2. Maximum water surface elevations were completed using standard step backwater methods. As shown on Figures 26, sheets 1 and 2, the channel will pass 17,200 cfs with maximum water surface elevations below the ground, the dike, and the road which protect the plant and cooling tower areas from flooding.

SWITCHYARD DRAINAGE CHANNEL

The 100-acre area draining to the switchyard drainage channel is shown on Figure 22 (Area 2). Runoff from this area is diverted through the channel to the Tennessee River southeast of the plant. Two inflow hydrographs were developed: (1) a lateral inflow hydrograph from the 35-acre area adjacent to the channel, distributed uniformly along the length of the channel, and (2) a point inflow hydrograph from the 65-acre area draining to the upstream end of the channel. The lateral inflow hydrograph is equivalent to the PMP hyetograph using 5-minute intervals. The point inflow hydrograph was developed by considering overland flow travel time for a number of discrete points within the 65-acre area. Travel times were estimated for runoff from each respective point to the channel. Peak flood elevations in the channel were computed using unsteady flow routing methods. In the routing it was conservatively assumed that the three culverts at the oil skimmer structure at the downstream end of the channel would be clogged with debris and would provide no discharge capacity during the flood. The channel can pass the maximum possible (probable maximum) flood without flooding safety-related structures. The maximum water surface elevation at the holding pond at the downstream end of the channel would be 574.8. The maximum water surface elevation at the north corner of the switchyard would not exceed the switchyard elevation of 578’.

Main Plant Area

Plant buildings could possibly be flooded by an intense local storm which would exceed the capacity of the yard drainage system. The main plant area drains 41 acres and is shown on Figure 22 (Area 3). Plant surface drainage was investigated to determine if a plant maximum possible (probable maximum) storm would exceed plant grade El. 565 and cause flooding of safety-related plant structures. All underground drains were assumed to be clogged.

All surface drainage with the exception of that between the office building and service building (patio plaza area) is adequate. Flow from the 3.3-acre patio plaza area northwest of the service building will drain to the employee courtyard west of the service building. Flooding at this location results from runoff collecting in a low point in the area with flood elevations controlled by the narrow opening between the temporary plant engineering building and the radwaste evaporator building. The peak elevation was determined to be 566.6, which is 1.6 feet above plant grade El. 565. The elevation was computed by storage routing the inflow hydrograph equivalent to the PMP hyetograph using 5-minute intervals. The time available between the start of the most intense rainfall and the time flood levels exceed plant grade El. 565 varies from 5 to 21 minutes, depending on the assumed distribution within the critical local PMP 6-hour storm.

In the vicinity of the radioactive waste, reactor, and diesel generator buildings, water-surface elevations will not exceed El. 565. Peak water-surface elevations were determined by storage routing the inflow hydrograph using standard weir formulas and flat pool assumptions. The control section was taken to be the perimeter road south of the reactor building with elevation at 564. The total inflow hydrograph was determined by considering overland flow travel time for a number of discrete points within the 41-acre area. Travel times were determined for runoff from each respective point to the perimeter road. The total area was then divided into subareas of equal travel time, with the longest travel times for those areas farthest from the perimeter road. Each subarea contributes to total flow, with respective subarea inflow hydrographs equivalent to the PMP hyetograph using 5-minute time intervals. The total inflow hydrograph was then computed by summing the respective subarea inflow hydrographs, with each lagged by an amount equal to its travel time. Travel times ranged from 0 to 20 minutes, with 0 reflecting instantaneous watershed response.

Water-surface elevations at the radioactive waste, reactor, and diesel generator buildings at the time of maximum possible (probable maximum) flood flow could be affected if maximum water levels in the cooling water discharge channel downstream were to exceed El. 564. For a short duration during the possible maximum precipitation (PMP) concurrent with cooling towers operation water surface elevation in cooling water discharge channel reaches 564.93, overflowing the perimeter road and mixing with runoff from the main plant area. Water surface elevation at the radioactive waste, reactor, and diesel generator buildings was evaluated and determined not to exceed El. 565.

<u>Cooling Tower System</u>

The 179-acre area draining to the cooling tower system of channels is shown on Figure 22 (Area 4). Runoff from this area is diverted to the Tennessee River through the operation of several gate structures. The cooling tower system of channels has sufficient capacity to pass the combined maximum possible (probable maximum) flood runoff and condenser water without flooding the plant for any mode of plant operation.

Peak water-surface elevations were determined using storage routing methods. Local inflow hydrographs for each of the basins within the cooling tower system of channels were equivalent to the PMP hyetograph using 5-min ute intervals. These hydrographs were augmented where appropriate for condenser water and main plant area runoff.