Note: Changes made to the Executive Summary for the Draft SEIS are indicated by a vertical bar in the left margin

EXECUTIVE SUMMARY
of
FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

for

BROWNS FERRY NUCLEAR PLANT OPERATING LICENSE RENEWAL

ATHENS, ALABAMA

TENNESSEE VALLEY AUTHORITY

March 2002

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S.1 PURPOSE AND NEED FOR THE PROPOSED ACTION

Project Overview

The Tennessee Valley Authority (TVA) proposes to extend operation of Units1, 2, and 3, at its Browns Ferry Nuclear Plant (BFN) located in Limestone County, Alabama. This would require obtaining a renewal of the units' operating licenses from the Nuclear Regulatory Commission (NRC). Renewal of the current operating licenses would permit operation for an additional 20 years past the current (original) 40-year operating license terms which expire in 2013, 2014, and 2016, for Units 1, 2, and 3, respectively.

This Supplemental Environmental Impact Statement (SEIS) is being prepared to provide the public and TVA decision-makers an assessment of the environmental impacts of extending unit operation. Table S.1 shows key milestones for the preparation of the SEIS. License renewal by itself involves existing BFN facilities, and does not involve any new construction or modifications beyond normal maintenance and minor refurbishment. However, there are other proposed projects not directly related to license renewal. One of these projects is the recovery of Unit 1, which has been in a non-operational status for 15 years. Other projects include the addition of a dry cask storage facility for spent nuclear fuel and a few new office buildings. In the interest of completeness, these actions are being included in this SEIS.

Table S.1 Planned Milestones for BFN Operating Licenses Renewal SEIS

Action	Date
Issue Notice of Intent (65 FR 47817)	February 15, 2001
Public Scoping Meeting	March 6, 2001
Close of public scoping period	March 23, 2001
Issue Notice of Availability of Draft SEIS	December 14, 2001
Public meeting on Draft SEIS	January 17, 2002
Close of public comment period	January 30, 2002
Release Final SEIS	March 2002
Issue Record of Decision	May 2002

Tiering from Energy Vision 2020

Tiering from TVA's *Energy Vision 2020* Programmatic EIS incorporates it by reference in this SEIS and allows concise and efficient consideration of the strategies and programmatic issues related to both maintenance of existing generation capacity in TVA's power system and the addition of new geneation capacity. *Energy Vision 2020* evaluated an array of power supply resources, both supply-side and demand-side. These alternatives were ranked using several criteria, including environmental performance. Favorable alternatives were formulated into strategies that would effectively meet baseload energy and peak capacity needs of TVA's customers under a range of future conditions ("futures"). A number of these strategies were then combined to create TVA's short- and long-range energy resource plans, or collectively, TVA's integrated resource plan (IRP).

Nuclear generation is expected to play a vital role in helping TVA meet energy supply demands through the *Energy Vision 2020* study period (1996 through 2020). The *Energy Vision 2020* Resource Integration Strategy Matrices identified five nuclear units, located at three sites, as existing generating assets on the TVA system - BFN Units 2 and 3, Sequoyah Nuclear Plant Units 1 and 2, and Watts Bar Nuclear Plant Unit 1. These five units were determined to contribute 5,517 megawatts, or 20% of the TVA system total projected capacity of 27,995 MW in 2005.

The operating nuclear units at BFN will reach the end of their current operating licenses during the *Energy Vision 2020* study period. *Energy Vision 2020* anticipated that Units 2 and 3 would be excellent candidates for license extensions. *Energy Vision 2020* also discussed both the short-term and the long-term options for BFN Unit 1. For the short-term, the IRP concluded that it was not viable to restart BFN Unit 1 because there were more optimal power supply strategies identified to meet load growth, particularly in consideration of cost, impact on short-term rates, impact on debt, and competitiveness. In order to preserve long-term flexibility, the decision was made to maintain BFN Unit 1 as an inoperative deferred nuclear asset. This enabled TVA to maintain lower rates and debt for the short-term and consider other alternatives for BFN Unit 1 as conditions changed.

Energy Vision 2020 noted that deferring the decision to recover BFN Unit 1 for several years would allow additional time to acquire information regarding nuclear unit performance and economics, TVA's need for power, and the possible role of nuclear power in minimizing total environmental impacts. Moreover, *Energy Vision 2020* concluded that under certain conditions, recovery of BFN Unit 1 could emerge as a low-cost supply option. This set of conditions, referred to as a "high performance" future, consisted of the high load forecast, low cost to complete the nuclear units, low operations and maintenance costs, and a high nuclear capacity factor. Since issuing *Energy Vision 2020*, a number of developments covering each of these areas has made it timely to consider further the recovery of BFN Unit 1 to meet TVA's long-term resource requirements.

- Acknowledging the recent rapid growth in baseload demand, TVA currently estimates that approximately 2,000 GWh annually by 2005, and 5,000 - 15,000 additional GWh annually by 2010 will be needed.
- Adjusted to 2002 dollars, *Energy Vision 2020* projected median Unit 1 completion at nearly $3.1 billion; current estimates are $1.64 billion.
- *Energy Vision 2020* projected annual additions and improvements costs to be $41 million; actual 2001 costs for BFN were $24 million.
- BFN operations and maintenance costs for 2001 are 17% below the low forecast in the IRP.
- The IRP low forecast estimate for nuclear fuel costs in 2001 was 47.9 cents per million BTU; the actual cost for BFN in 2001 is 47.1 cents per million BTU.
- The IRP assumed 67% annual average capacity factor. BFN has averaged 92% capacity factor over the past five years.

BFN's performance and costs have improved to the point that it is now considered by the Institute of Nuclear Power Operations (INPO) to be among the top performing nuclear plants in the country. It is a Top Quartile performer on Total Production Costs and the INPO Performance Index, and a Top Decile performer on Non-Fuel Production Costs, Net Capacity Factor, and Outage Duration. In conclusion, there is now strong support for the lowered estimates of capital cost, improved operating performance, and high demand case that would bolster recovery of BFN Unit 1 as a low cost power supply option.

Tiering from the BFN Environmental Statement

An earlier Environmental Statement prepared by TVA evaluated the effects on the environment of construction and operation of BFN. The Atomic Energy Commission (AEC), a former regulatory agency of the federal government which has since been superseded by the NRC, participated in the preparation of this statement as a cooperating agency. The AEC concluded on August 28, 1972, that the statement was adequate to support the proposed license to operate the plant.

This SEIS will reference (and not repeat) analyses contained in the original 1972 Environmental Statement wherever possible. However, since methodologies may have changed or additional information may have been obtained over the years, each subject area will be reevaluated in the light of current knowledge and practices. Additional topics are addressed as appropriate.

Unit Uprates

Independent of the matters considered in this SEIS, TVA has reviewed the environmental impacts of, and has approved, an Extended Power Uprate (EPU) project which will increase the maximum operating power level of Units 2 and 3 to 120% of their originally licensed thermal power levels. If Unit 1 is returned to service, it is currently contemplated that it would also be uprated to 120% of its originally licensed thermal power level.

Purpose of the Proposed Action

The purpose of the proposed action (extending unit operation and possibly recovering Unit 1) is to continue to make maximum use of existing power production facilities and the BFN site into the foreseeable future.

Need for the Proposed Action

TVA, in its annual report to the Southeastern Electric Reliability Council, projected continued growth in demand of total net energy (baseload) at about the median level through 2010. These data reflect an average energy growth rate of approximately 2% per year. Acknowledging the recent rapid growth in baseload demand, TVA currently estimates it will need approximately 2,000 GWh annually by 2005, and 5,000 - 15,000 additional GWh annually by 2010.

Continued energy generation from BFN is a major component of TVA's generating assets, representing 8% of generating capacity and about 13% of annual energy generation in FY2000. Because of its low operating costs, BFN will continue to be a key generating asset even if some TVA customers were to elect other suppliers for some of their requirements under electricity deregulation.

S.2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

Description of the No Action Alternative

The No Action Alternative would result from a decision to not extend operation of the BFN units beyond the expiration dates of the current operating licenses. Since it currently appears economically infeasible to recover Unit 1 without license renewal, such a decision would effectively terminate any further consideration of restarting that unit at this time. Operation of Units 2 and 3 would cease upon expiration of their operating licenses in 2014 and 2016, respectively, and the plant would then be required to choose a decommissioning option.

This No Action Alternative would not help meet the public's demands for more energy from the TVA power system. If TVA took no action at all to meet growing demands, TVA's ability to continue to supply low-cost, reliable power to its customers would be impaired. The impacts of higher priced and undependable electricity supplies would be manifested in customer hardship. Higher costs of electricity could trigger industrial slowdowns or work force outages, and could potentially negatively affect the economic stability of the region served by TVA. Not meeting demand and using less reliable sources of generation could have environmental and health consequences as well if the result was disruption of electric service to the public. For example, if the electricity needed to power air conditioners in the homes of elderly people is disrupted, heat related injuries and death could result.

Consequently, it would be unreasonable for TVA to take no action at all to meet growing demands. Rather, in this context, No Action means that TVA would turn to some other means of responding to energy demands on its power system. These means have been assessed in TVA's Energy Vision 2020 EIS and are identified in the short- and long-term energy resource plan that the TVA Board approved after the completion of that EIS process.

Proposed Action Alternatives

Two Action Alternatives are consistent with the stated project objectives and the updated cost comparison of alternatives previously evaluated in *Energy Vision 2020*.

Alternative 1 is to continue to operate Units 2 and 3 for an additional 20-year period beyond the expiration dates of the current licenses. No major equipment changes are projected to be needed for continuing operation as-is, but some planned upgrades and additions would involve facilities modifications. Due to the planned EPU of Units 2 and 3, a sixth mechanical draft cooling tower would be erected.

Alternative 2 is to add refurbishment and restart of Unit 1 to Alternative 1 (i.e., extended operation of all three BFN units at the EPU level of 120% of the originally licensed power level). Restart of Unit 1 could occur as early as 2007 if a favorable decision is made and recovery efforts are initiated. Unit 1 recovery would necessitate construction of a new administration building to make space available to incoming (temporary) workers and to move (permanent) office workers away from radiation sources associated with operating Unit 1 with hydrogen water chemistry.

Restarting Unit 1 would also require additional cooling tower capacity beyond that envisioned for Alternative 1. The additional cooling tower capacity required could be obtained by a

combination of constructing new towers, refurbishing the old original cooling towers, or even dismantling and replacing one or more of the old original cooling towers with an updated and more efficient design. The following sub-alternatives to provide the required additional cooling tower capacity are evaluated in this SEIS:

Alternative 2A is to add two new linear mechanical draft cooling towers to the six that would be functional for operation of Units 2 and 3 at EPU, making a total of eight very similar cooling towers. Making room for these new towers would require removal of most of a large hill which was created by excavation of drainage canals associated with construction of the original six cooling towers.

Alternative 2B is similar to Alternative 2A except that the two new cooling towers would be some type other than the current linear mechanical draft cooling towers, such as round mechanical draft or modified hyperbolic design.

Alternative 2C is to demolish the remaining four original cooling towers (two burned down, and only one has been replaced) and to construct 5 new large linear mechanical draft cooling towers, all in roughly the same location as the original six towers. The size of the existing (relatively new) tower 3 would also be increased. This alternative would not require removal of a significant portion of the spoils hill adjacent to the cooling towers, but could involve lowering the height of the hill by several feet to decrease wind resistance.

Alternative 2D is to add a sixth mechanical draft cooling tower in the currently vacant position (4) where a tower that was destroyed by an accidental fire in 1986 has never been replaced. This addition of a sixth cooling tower differs from that proposed for Alternative 1 (see above) in that the tower would be somewhat larger than the recently replaced 16-cell linear mechanical draft cooling tower 3.

For purposes of this SEIS, each of the cooling tower configurations for Alternatives 1, 2A, 2B, and 2C described above represents the maximum expected change in terms of the number and size of required additional towers. Alternative 2D represents the minimum change in the number and size of required additional towers. BFN cooling water discharges comply with a National Pollutant Discharge Elimination System (NPDES) permit issued by the Alabama Department of Environmental Management (ADEM). The impact analyses presented in this SEIS assume that thermal limits in the current BFN discharge permit are unchanged and continue to be met for all alternatives via increased cooling tower capacity or de-rating power operation during periods of extreme weather, or both, with these alternative configurations.

Table S.2 provides a summary and comparison of the proposed action alternatives.

Table S.2 Summary of Proposed Action Alternatives

Attribute/ Feature	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Units	Units 2 & 3 only	Units 1, 2, & 3	Units 1, 2, & 3	Units 1, 2, & 3	Units 1, 2, & 3
Power Level	EPU[1]	EPU[1]	EPU[1]	EPU[1]	EPU[1]
Cooling Towers	6 Linear Mechanical Draft[2]	8 Linear Mechanical Draft[3]	6 Linear Mechanical Draft + 2 Round[4]	6 Large Linear Mechanical Draft[5]	6 Large Linear Mechanical Draft[6]
Spoils Berm Reconfiguration	Minor (possibly lower hill height)	Major (relocate most of berm)	Major (relocate most of berm)	Minor (possibly lower hill height)	None to minor (possibly lower hill height)
New Buildings	Modifications / Fabrication	Mod/Fab plus Administration	Mod/Fab plus Administration	Mod/Fab plus Administration	Mod/Fab plus Administration
New Spent Fuel Storage	Dry Cask Storage Facility	Larger Dry Cask Storage Facility	Larger Dry Cask Storage Facility	Larger Dry Cask Storage Facility	Larger Dry Cask Storage Facility

[1]Extended Power Uprate = 120% of originally licensed power level.
[2]Four of the original six Ecodyne towers plus the existing Balcke-Durr tower in position 3 plus one new large or expandable tower in currently vacant position 4.
[3]Same as Alternative 1 plus two new large towers located in space currently occupied by spoils berm.
[4]Same as Alternative 1 plus two new round mechanical draft or modified hyperbolic ("hybrid") towers.
[5]Replace the four existing original Ecodyne towers plus one new large tower in position 4 plus expand the existing Balcke-Durr tower in position 3.
[6] Four of the original six Ecodyne towers plus the existing Balcke-Durr tower in position 3 plus one new larger tower in currently vacant position 4.

Associated Cooling Water Intake Flow Rates

Subsequent to issuance of the original three-unit National Pollutant Discharge Elimination System (NPDES) permit in 1984, BFN has made various equipment upgrades and calibration improvements which collectively have resulted in per-unit increases in reported once-through cooling water flow rates of 21.5%. Note that more than half of the increase in reported values is due to improved measurement accuracy; the actual increase in flow is approximately ten percent. For continued operation of Units 2 and 3 the flow rates of once-through cooling water withdrawn from the reservoir remain within the levels evaluated as part of previous studies conducted during three-unit operation at BFN; therefore, impingement of adult fish and entrainment of fish eggs and larvae are expected to remain within levels previously evaluated for Alternative 1. With the return of Unit 1, the total site once-through cooling water flow rate would increase by about ten percent. This increased CCW intake volume would potentially result in increased impingement of adult fish and entrainment of fish eggs and larvae, but it is not expected to result in significant impacts to fish populations of Wheeler Reservoir. TVA will confirm the expected levels of impingement and entrainment by monitoring under current two unit operation and following return of Unit 1 to service. TVA's Vital Signs monitoring program will also continue to assess aquatic ecological communities in Wheeler Reservoir. Although not expected, if based on these monitoring studies it is determined that increased impingement and entrainment are resulting in unacceptable environmental impacts, TVA would assess the technologies, operational measures,

and restoration measures that could be undertaken to remedy this and institute appropriate measures in consultation with appropriate federal and Alabama agencies.

The Preferred Alternative

TVA has made no decision with respect to the BFN license renewal Alternatives identified in this SEIS, or the other proposed actions. However, based on TVA's analyses of the environmental aspects and costs to date, Alternative 2D is TVA's currently preferred alternative. This is because there are positive environmental effects to be gained, no significant or unacceptable environmental impacts have been identified to date, and the initial cost analysis indicates that recovering Unit 1 for extended operation would be financially feasible and beneficial.

Spent Fuel Storage Options

BFN has been producing power and, consequently, spent nuclear fuel for almost three decades. Considering the Department of Energy (DOE) delay in developing the capability and capacity for receiving utility spent fuel, and assuming current operating conditions, the BFN Unit 3 spent fuel storage pool is projected to lose full core off-load capability in January 2006; therefore, additional spent fuel storage capacity will be required to be developed before then. Thus, spent fuel storage expansion is required significantly before license extension or feasible implementation dates for three-unit operation. However, the addition of spent fuel storage capacity is included in this SEIS as a connected action because license extension and Unit 1 restart would both impact the ultimate size of the facility.

To accommodate the spent fuel storage expansion, TVA has evaluated various options to extend the effective life of the existing BFN spent fuel pools as well as alternatives for separate new spent fuel storage capacity. The preferred spent fuel storage option is construction of a dry cask storage facility, similar to those in use at 18 other U.S. nuclear power plants and planned at others.

S.3 AFFECTED ENVIRONMENT

Air Resources

The local climate and meteorology of the Browns Ferry Nuclear Plant site is characterized in the TVA Environmental Statement, Volume 2, Section 3.3. Variations during the period for which the relicensing is applicable are not expected to be significantly different. Current National Ambient Air Quality Standards for particulate matter, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead are essentially unchanged from those considered in the TVA Environmental Statement of the early 1970s, with one exception. The standard for hydrocarbons in effect at that time was later rescinded and a standard for ozone was implemented. There are currently no nonattainment areas for any of these pollutants in the area of the site. Air quality conditions are expected to remain about the same as now with the exception of possible regulatory constraints that may develop in association with future implementation of new EPA standards on ozone and particulates. However, those standards are the subject of legal challenges.

Sources of non-radiological air pollutants at BFN include the mechanical draft cooling towers, the auxiliary steam generators, the emergency diesel generators, and miscellaneous other small sources such as fuel storage facilities. BFN operates as a minor source under air quality permits approved by the Alabama Department of Environmental Management (ADEM).

Geologic Setting

The BFN area is underlain by flat-lying, underformed limestone of Mississippian age. This immediate region has experienced little structural deformation over the past several hundred million years of geologic time. The BFN is located in an area far removed from any centers of significant seismic activity in historic time. The seismic hazard at BFN is low in comparison to most other areas of the United States.

Solid Wastes Management and Past Practices

Solid wastes generated in conjunction with operation of BFN are managed in accordance with applicable NRC and State and Federal environmental regulations, and disposed in approved and licensed disposal facilities.

General plant trash collected as part of routine plant operations is managed through a TVA-wide contract with a licensed disposal company. Waste material is collected in dumpsters and transported to a State-licensed regional landfill. Generation rates for this type of material are currently approximately 50 tons per month. BFN has an active recycling program that segregates and recycles scrap metal, cardboard, paper, batteries, and aluminum cans at approved State and local recycling facilities.

BFN operates a State-permitted Construction/Demolition landfill within the confines of the BFN site. This landfill is permitted to accept non-hazardous, non-radioactive solid wastes including scrap lumber, bricks, sandblast grit, crushed metal drums, glass, wiring, non-asbestos insulation, roofing materials, building siding, scrap metal, concrete with reinforcing steel, and similar

construction and demolition wastes. The generation rate for this type of material over the past two years is approximately 0.04 tons per day.

BFN generation rates for low level radioactive waste materials are approximately 30-40 cubic meters per month. Spent resins are packaged, de-watered and stored on-site in concrete storage modules, or shipped for burial in a licensed disposal facility. Dry active waste is collected within the plant, and transported to a waste processor for volume reduction and subsequent shipment to a licensed disposal facility. Irradiated non-fuel plant components are stored on-site or processsed for shipment to a licensed disposal facility.

Hazardous Wastes Management and Past Practices

As do many large industrial facilities, BFN generates a variety of wastes that are classified as hazardous. These wastes include paint-related materials, spent solvents used for cleaning and degreasing, spent batteries, fluorescent light tubes, etc. TVA operates a Hazardous Waste Storage Facility (HWSF) in Muscle Shoals, Alabama, that holds a permit for temporary storage of hazardous wastes. The HWSF serves as a central collection point for TVA-generated hazardous wastes, and maintains contracts with waste treatment and disposal facilities. All hazardous waste generated at BFN is shipped to the HWSF for consolidation, storage, and disposal through approved and licensed facilities. BFN recycles paint solvents (primarily methyl ethyl ketone) using an on-site still. Hazardous waste generation rates for BFN average approximately 4,700 pounds per calendar year over the last five years.

Spent Fuel Management

An Independent Spent Fuel Storage Installation (ISFSI) is proposed for operation beginning in 2005. Expansion of an ISFSI can be accomplished incrementally. This technology can accommodate life-of-plant requirements regardless of DOE repository schedules or plant operation changes.

After implementation of spent fuel dry storage, sufficient capacity would be maintained in the spent fuel pools to accommodate refueling outages. Older spent fuel would be transferred to dual-purpose storage modules (i.e., metal cask or canister with overpack) for storage at the BFN ISFSI. The fuel transfer from pool storage racks to dry storage modules would be performed in the spent fuel pool. The dry storage system would be licensed for both on-site storage and off-site transportation; consequently, these dry storage systems would not require fuel to be repackaged for transport to a DOE repository.

Depending on the dry storage system design chosen for BFN, each storage module could contain up to 68 spent fuel assemblies; five of these modules would typically be loaded before each refueling outage. After loading, the dual-purpose storage module would be drained, dried, decontaminated, sealed, and then transferred by crane to the truck bay for transport to the ISFSI. Storage modules containing spent fuel would be temporarily stored at the ISFSI until a DOE spent fuel repository is available.

Surface Water Resources

BFN is located on Wheeler Reservoir at Tennessee River Mile (TRM) 294. The reservoir was created in 1936 and has an area of 67,070 acres and a volume of 1,050,000 acre-feet at the normal summer pool elevation of 556 feet (msl). Most of Wheeler Reservoir is classified by ADEM for public water supply, swimming and other whole body water-contact sports, and fish and wild life. However, the area of the reservoir immediately upstream and downstream of BFN is not classified for public water supply. Water quality is generally good and suitable for most designated uses. The one exception is a 10-mile reach of the river between Wheeler Dam and the Elk River which is on the state 303 (d) list as partially supporting its designated uses due to pH and temperature/thermal modifications caused by industrial sources and flow regulation and modification. Water temperature patterns in Wheeler Reservoir are constantly changing in response to varying meteorological and flow conditions. Natural water temperatures in the reservoir vary from around 35°F in January to near 90°F in July. Temperature patterns upstream of BFN are fully mixed during the fall, winter, and spring with weak thermal stratification from June through September.

There are 8 potable water intakes on Wheeler Reservoir withdrawing a total of approximately 124 million gallons per day (MGD) for municipal and industrial use. Wastewater discharges include 10 municipal plants discharging over 30 MGD and 17 industrial plants discharging over 2,466 MGD. Consumptive and off stream water uses do not currently result in significant use conflicts due to the large volume of reservoir water available, the high river flow rate, and the return of most of the water withdrawn. Regulatory control of withdrawal rates and NPDES permit limits for return water quality also mitigate potential conflicts. However, potential trade-offs can occur with instream water uses (e.g., instream use conflicts among aquatic life, waste assimilation, navigation, power generation, flood control, and lake levels).

Groundwater Resources

Shallow groundwater at BFN occurs within unconsolidated terrace deposits and residual soils, and along a relatively thin but highly weathered horizon at the top of bedrock. At depth, groundwater occurs exclusively in fractures and solution features of the Tuscumbia limestone and Fort Payne chert. The Tuscumbia limestone and Fort Payne chert are collectively described as the Tuscumbia-Fort Payne aquifer system which is a source of water for both wells and springs in the region. Groundwater within this aquifer system is a calcium bicarbonate type and can generally be used without extensive treatment. There is no groundwater use by BFN and site dewatering wells have been inactive since the 1980s.

Groundwater levels at the site are generally highest during the months of January through March. During September and October, water levels are usually at minimum. The Tennessee River and plant surface water features exert some control on local groundwater elevations and hydraulic gradients. The direction of groundwater movement is generally W-SW toward the Tennessee River. Within overburden soils at the site, groundwater movement is predominantly downward. Local areas of lateral flow likely occur near some streams, topographic lows, and where extensive root systems exist. Groundwater flow in the Tuscumbia limestone occurs solely in fractured and weathered zones. The orientation of fractures and solution features within the Tuscumbia is coincident with a structurally controlled joint system.

Floodplains and Flood Risk

BFN is located on the right bank of Wheeler Reservoir at TRM 294.0 in Limestone County, Alabama. The proposed project area could possibly be flooded from the Tennessee River, a small stream to the northwest of the plant site and the site drainage system. The site drainage system is broken into three areas: 1) the switchyard, 2) the main plant area, and 3) the cooling tower system. The area impacted by the construction of any of the alternatives extends from about TRM 293.0 to TRM 294.0.

The 100-year floodplain for the Tennessee River would be the area below elevation 557.3. The TVA Flood Risk Profile (FRP) elevation on the Tennessee River would also be elevation 557.3. At this location, the FRP elevation is equal to the 500-year flood elevation. The Probable Maximum Flood (PMF) design level would be 572.5 feet. A maximum flood elevation of 574 at the plant site results from a combination of the PMF and wind wave runup on a vertical wall or 575 as a result of the PMF and wind wave runup on a 3:1 grassed slope.

For the small stream to the northwest of the site and the internal site drainage system, the 100- and 500-year, and PMF flood elevations have been assessed. The maximum possible discharge for this stream is 17,200 cfs. For the switchyard drainage channel, the PMF elevation at the holding pond at the downstream end of the channel would be 574.8 and the PMF elevation at the north corner of the switchyard would be 577.8. The PMF elevation between the office and service buildings would be 566.6. In the vicinity of the radioactive waste, reactor, and diesel generator buildings, PMF elevations for all modes of plant operation would not exceed elevation 564.0. In the cooling tower system of channels there is sufficient capacity to pass the PMF and condenser water.

Flooding conditions during the term of the renewed license (up to year 2036) are expected to remain similar to current conditions. For the Tennessee River, all dams in the TVA system are assumed to be maintained and remain operational for the entire licensing period. For the small stream northwest of the plant site, significant urbanization within the 1.35 square mile drainage area is not expected to occur during the next 35 years. If complete urbanization were to occur, the 100- and 500-year flood discharges could increase as much as 2.5 times the natural discharge. The switchyard drainage channel area, the main plant area, and the cooling tower system area all have some existing impervious area within their drainage basins. Additional impervious area would increase the 100- and 500-year flood discharges by some amount, but should not cause flooding greater than that produced by the PMF event.

Terrestrial Ecology

Little native vegetation remains in the project areas because of the activities associated with the construction and operation of the existing nuclear facilities. The proposed location for the new cooling towers (i.e., the spoils hill that would be removed for Alternatives 2A and 2B) consists of old field vegetation with scattered tree species including black locust, various oaks, loblolly pine, and eastern red cedar. *Sericea lespedeza* and broomsedge are among the dominant herbs. The proposed locations for soil deposition consist of two hayfields and a fallow cotton field now vegetated by a dense thicket of blackberry, Japanese honeysuckle and *Sericea lespedeza*, with scattered saplings of black locust and eastern red cedar. No uncommon communities or otherwise sensitive vegetation occurs on or immediately adjacent to the project areas.

Aquatic Ecology

Extensive TVA sampling of the fish community in the vicinity of BFN and elsewhere in Wheeler Reservoir in recent years has collected a total of 60 species (excluding hybrids); any species known from elsewhere in the reservoir could occur in the vicinity of BFN.

Reservoir Fish Assemblage Index (RFAI) ratings are based primarily on fish community structure and function. Also considered in the rating is the percentage of the sample represented by omnivores and insectivores, overall number of fish collected, and the occurrence of fish with anomalies such as diseases, lesions, parasites, deformities, etc. Compared to other run-of-the-river reservoirs, the fish assemblage at the Wheeler mid-reservoir transition station (TRM 295.9) rated poor in 1992 and 1999, fair in 1990, 1991, 1995, and 1997, and good in 1993 and 1994. In the fall of 2000, additional (i.e., not on the regular RFAI monitoring schedule) electrofishing and gill net samples were taken at the transition station (TRM 295.9) and a newly-established sampling station for future BFN monitoring at TRM 292.5. A total of 30 fish species (excluding hybrids) was collected; the fish assemblage rated good at TRM 292.5 and fair at TRM 295.9.

Benthic (i.e., bottom-dwelling) animals common in the vicinity of BFN include Asiatic and fingernail clams, burrowing mayflies, aquatic worms, and midges in the silt-laden overbank areas. Cobble and bedrock areas found primarily in the river channel support Asiatic clams, bryozoa, sponges, caddisflies, snails, and some leeches. Thirty-eight native freshwater mussel species have been documented in Wheeler Reservoir through 1991; more recent surveys have identified up to fourteen species in the area of BFN. Introduced aquatic species known from Wheeler Reservoir include the Asiatic clam, zebra mussel, and grass carp.

Threatened and Endangered Species

No federally listed and four Alabama state-listed plant species are known from Limestone County, Alabama, in which BFN occurs. None of these state-listed plants are known to occur within five miles of the project area. In addition, field inspections of the project area reveal that suitable habitats for these or other rare plant species are not present on lands to be affected by the proposed activities.

Four state-listed animal species (two of which are also federally listed) are known from Limestone County, but none of them are reported within five miles of BFN. Three of these species have no suitable habitat at BFN; there is a limited amount of habitat at BFN for the fourth species but its quality is considered marginal.

Five federally endangered aquatic species are known to occur in the vicinity of BFN. However, their preferred types of habitat do not exist at or downstream of BFN, and it is very unlikely that populations of these species exist in Wheeler Reservoir at or downstream of BFN.

Wetlands

Wetland resources in Alabama have suffered a marked decline as the result of channelization of major streams and the clearing of wetlands for agricultural and other purposes. The extensive

areas of bottomland forested wetlands that occurred in the major stream bottoms prior to channelization and land clearing are largely absent from the landscape.

Wetlands in the vicinity of BFN are a mix of habitat types, including palustrine forested wetlands, scrub-shrub wetlands, and emergent wetlands associated with the mainstem of the Tennessee River/Wheeler Reservoir.

Wetlands in the general project area were identified using United States Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) maps and topographic maps. A determination of areas subject to jurisdiction by the United States Army Corps of Engineers (USACE) under Section 404 of the Clean Water Act (CWA) on the site was made by TVA wetland biologists pursuant to the regulatory program administered by the USACE. Wetland field surveys indicate that while there are small areas of wetland within the boundaries of BFN, there are no wetlands in the immediate project area. This includes both the area proposed for construction of the new cooling towers, and the spoil disposal area.

Socioeconomic Conditions

Limestone County has experienced rapid growth over the last few decades, with population increasing faster than in the labor market area, the state, or the nation. The population of the county, according to the 2000 Census of Population, is 65,676, an increase of 21.3% since 1990, and 57.5% since 1970. This growth pattern is likely to continue for the next several years, with the population of the county reaching more than 80,000 by 2015, about the time the current BFN licenses expire.

Minority population in Limestone County and in the labor market area is a smaller share of the total than in the state or the nation.

Unemployment in Limestone County and in the labor market area was low in 2000, 3.3% in the county and 3.9% in the labor market area, below both the state and national averages. The number of jobs in the county has grown rapidly, more than doubling since 1970. This growth is expected to continue, reaching about 41,000 in the county by the time the current BFN licenses expire and close to 58,000 by the time a 20-year extension would expire. The county is more dependent on jobs in manufacturing, government, and farming than is the labor market area, the state, or the nation, and less dependent on trade and services employment.

Per capita income in Limestone County in 1999 was just below 75% of the national average, while in the labor market area it was almost 86% of the national average. Poverty levels in the county and the labor market area are below the state average. The county poverty level is about the same as the national average, but the labor market area level is slightly lower.

Transportation, including Electric Power Transmission

The site is located approximately 10 miles southwest of Athens in Northern Alabama in Limestone County and is located just south of U. S. Highway 72, which runs from South Pittsburg, Tennessee, west to Memphis, Tennessee. The primary traffic generator in the vicinity of the site is the nuclear plant. BFN currently averages a daily site population of approximately 1,200 persons. The population currently peaks at approximately 2,000 persons during outages,

which occur every 24 months for approximately 2 months (per unit). Current truck deliveries are minimal (less than 10 per week) and include hydrogen, oxygen, and nitrogen trucks, chemical trucks and occasional gasoline and diesel fuel deliveries during peak months. Rural residences located along the county roads that provide access to the site are also traffic generators in the area. TVA estimates approximately 1,600 vehicles per day on Shaw Road, Browns Ferry Road, and Nuclear Plant Road.

Although direct rail access does not serve BFN, a spur track and unloading area is located off the CSX mainline in Tanner, Alabama, approximately 8 miles east of BFN. TVA leased this small parcel of land from CSX and used it for offloading during original construction of the plant. This area is currently planned to be used for future off-site removal of dry cask spent fuel storage canisters. There is also a short railroad spur at the plant that runs into the turbine building for short transport into the plant. There are no plans to use it for Unit 1 refurbishment or regular plant operations.

BFN is located downstream from Guntersville Lock and upstream from Wheeler Lock at TRM 294. Traffic on the Tennessee River near BFN includes both commercial and recreational vessels. The locks and channels are more than adequate in handling river traffic. Both Guntersville Lock and Wheeler Lock are operating below their utilization capacity. BFN has a qualified barge facility near the northwest corner of the site. The facility is used several times per year and requires a temporary crane. Future upgrading is planned and a temporary crane will no longer be required. An upgraded barge facility could eventually be used to transport spent fuel canisters offsite for disposal in a national repository.

BFN is connected into the TVA system network by seven 500-kV lines. One line is to Madison substation, two to Trinity substation, one line each to the West Point, Maury, and Union substations, and one line to the Limestone 500-kV Substation. Any three lines excluding more than one Trinity line can transmit the entire station output into the TVA system network. Startup power is from the 500-kV system network, but auxiliary power is available through the two common service station transformers that are fed from two 161-kV lines supplying the 161-kV switchyard, one line each from the Athens and Trinity substations.

Soil and Land Uses

Limestone County is part of the Highland Rim section of the Interior Low Pleateaus physiographic province. It is comprised of three physiographic subdivisions: The Limestone Valleys, the Plateau, and the Alluvial Plains. The Limestone Valleys include the southeastern part of the county. The Alluvial Plains include the nearly level to undulating first bottoms and stream terraces along the Tennessee and Elk Rivers. BFN is located in the Limestone Valleys and Alluvial Plains. The soils which develop in these areas are inherently productive for growing crops. There are about 279,229 acres of soils in the county classified as prime farmland and/or statewide important farmland. These are soils which have the chemical and physical properties to economically sustain high yields of crop production. Most of the soil on the BFN site was disturbed when the plant was constructed and is no longer considered as prime farmland. The entire site is classified as urban built-up land.

BFN is located in an agricultural area, surrounded by cropland planted with cotton. About 66.8% of the total acreage in the county is used for agriculture, the highest in Alabama. Limestone County is ranked first in Alabama for the most cotton grown. Agriculture is, and will continue to

be, a major economic component in the county. The remainder of the acreage in the county is used for forest (23.9%), water (7%), and urban/built-up land (2%).

The current trend in population growth will promote a larger portion of the land area to become urbanized. Population trends show an increase by 17.7% from 1980 to 1990, another increase of 17% from 1990 to 1998, and predictions from the Equifax Decision Systems project another increase of 6.6% by 2005. These trends are attributable to the increased employment opportunity in the county as well as in nearby Huntsville and Decatur.

Visual Resources

BFN is located off of County Road 25 (Nuclear Plant Road) approximately twelve miles south of Athens, Alabama. The site is surrounded to the north and east by rural countryside. It includes open pasturelands, scattered farmsteads, few residents, and little industry within several miles. The terrain is gently rolling with open views to higher elevations to the north. Little traffic is seen along the roadway except at plant shift changes and during deliveries. The south and west side of the plant site abuts Wheeler Reservoir, which is a wide expanse of open river used for an array of recreational purposes.

There are no homes within foreground viewing distance to the north and east. However, there is a small residential development to the northwest, across Wheeler Reservoir southwest, and Mallard Creek public use area that has partial views of the plant site. The views from the homes northwest off of County Road 25 are of the existing mechanical draft cooling towers (approximately 60 feet in height), a portion of the 500-kV switchyard and the turbine and reactor building. A berm, graded during the initial construction of the plant site and containing approximately 3.3 million cubic yards of earth, lies adjacent to the hot and cool water channels and blocks views of the northern and eastern plant areas. The homes to the southwest and from the Mallard Creek area have views of the off gas stack, the cooling towers, and the turbine and reactor building. These views may be somewhat obscured in the early morning hours, particularly in the fall and winter, as heavy fogs rise from the warmer waters of the reservoir.

Recreation

Approximately 3.5 miles upstream of BFN is Round Island Recreation Area developed and operated by TVA. It features facilities for camping, swimming, picnicking and boat launching. The reservoir in the vicinity of the plant site is moderately utilized by recreational boaters and fishermen. Two managed areas occur within three miles of the BFN site, Swan Creek State Wildlife Management Area and Mallard-Fox Creek State Wildlife Management Area. These areas are owned by TVA and presently managed by the Alabama Department of Conservation.

Cultural Resources

TVA Cultural Resources staff considered the nature of the undertaking and determined that the project had the potential to affect historic properties should those be present in the area. The area of potential effects (APE) for archaeological resources was determined as the three areas designated as soil disposal or spoil pile locations. The APE for historic structures was determined as those areas from which the disposal locations would be visible.

A Phase I survey was conducted at the three disposal site/spoil pile locations. This survey identified two historic properties. The survey of Area 1 (see Figure ES-1) identified a prehistoric archaeological site with an Early to Middle Woodland occupation. This site is considered potentially eligible for listing in the National Register of Historic Places. Cox Cemetery was identified in Area 2. This cemetery was relocated during the initial construction of the BFN. No historic properties were identified in Area 3.

Environmental Noise

The addition and replacement of cooling towers have the potential to change the noise environment within about a mile of their location. Within this radius there has been a significant increase in residential development since the original construction of the plant. The sensitive noise receptors are in Paradise Shores adjacent to the cooling towers to the northwest and the Lakeview community across the river. Potential noise effects evaluated include hearing loss, speech interference, annoyance, and increased awareness of the intruding noise. During present operations, cooling tower noise is audible in the closest portions of Paradise Shores but not in Lakeview or other residential locations around the plant.

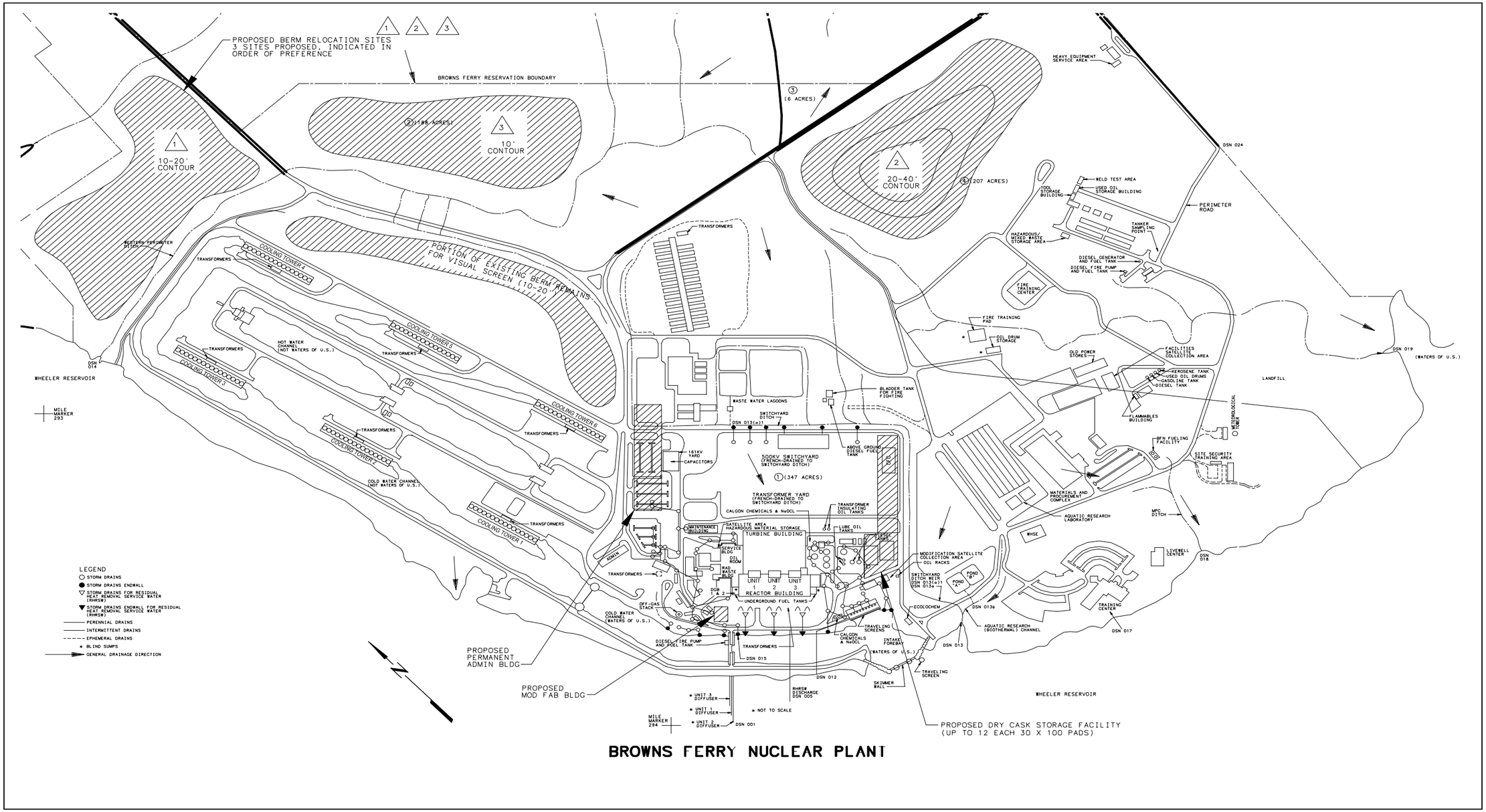
Public and Occupational Safety & Health (Non-Radiological)

The TVA nuclear work force has achieved recordable injury rates that are among the lowest in the utility industry. Operation and construction (i.e., refurbishment and restoration) activities are required to meet or exceed federal regulatory requirements for safety design and inspection, including OSHA regulations. These standards and requirements also apply to TVA contractors and vendors, which are monitored to ensure compliance.

The TVAN Safety and Health Manual contains requirements designed to assure that management administers a strong safety program. BFN has a Fire Protection Plan which is applicable to all activities which could affect the life or health of TVA employees or the public, the probability or severity of potential fires throughout the plant, or the ability to maintain safe plant shutdown, or limit radioactive release to the environment in case of fire. In accordance with state and federal regulations, BFN has developed a Spill Prevention, Control, and Countermeasure Plan that includes Hazardous Materials Response Team assignments and responsibilities, best management practices for controlling and managing oil and chemical storage, and contingency plans in the event of an accidental spill. TVA has also concluded that operation of BFN has not resulted, and is not likely to result, in adverse human health effects as a consequence of the presence of microorganisms associated with cooling towers and thermal discharges.

TVA's standard for siting new transmission lines has the effect of minimizing public exposures to electric and magnetic fields during their operation. TVA's design also ensures that the transmission lines exceed National Electric Safety Code requirements regarding shock hazards.

Figure ES-1
Location of Areas for Spoils Deposition



Radiological Impacts

At BFN, occupational radiation doses (to site workers) are consistent with current industry trends for this reactor type (BWR) and worker radiation exposures are controlled to be significantly less than regulatory limits. Similarly, controlled releases of radioactive emissions during normal operations result in radiation doses to the public that are small relative to doses from natural radioactivity. TVA has conducted a Radiological Environmental Monitoring Program (REMP) since 1973 to assess the impact of BFN operations on the surrounding environs and the general public. Data collected via the REMP demonstrate that the small amounts of radiological effluents released to the environment due to the operation of BFN have had no measurable impact on the environs surrounding BFN, and that estimated doses to the maximum exposed member of the public are typically only a small fraction of applicable limits.

BFN has a Radiological Emergency Plan (REP) which provides protective measures for TVA personnel and protects the health and safety of the public in the event of a radiological emergency resulting from an accident at the plant. This plan fulfills federal regulatory requirements and was developed in accordance with the NRC and Federal Emergency Management Agency (FEMA) guidance. Specific implementing procedures ensure that accidents are properly evaluated, rapid notifications are made, and assessment and protective actions are performed. In conjunction with the REP, State Radiological Emergency Plans have been developed to provide integrated response actions of Federal, State and local governments to any emergency caused by an incident at BFN. The REP is also designed to be implemented in a variety of non-radiological emergencies such as chemical spills, toxic gas releases, fires, plant operational problems, natural events, etc., which may pose a threat to the safe operation of the plant and have a potential impact offsite.

Postulated accidents for which the NRC has determined the probability is sufficient to warrant specific inclusion in design basis analyses are documented in the Updated Final Safety Analysis Report (UFSAR). BFN has also completed a systematic and comprehensive analysis of the potential accidents that can occur at the plant, referred to as a Probabilistic Safety Assessment (PSA), which incorporates both system reliability and human intervention. Extremely unlikely (and therefore not part of the design basis), but potentially more severe accidents are also considered via an analysis of Severe Accident Mitigation Alternatives (SAMA).

Decommissioning Impacts

TVA is required to complete decommissioning of the plant within a maximum of 60 years after permanent cessation of operations. To decommission a nuclear power plant, the radioactive material on the site must be reduced to levels that would permit termination of the NRC license; this involves removing the spent nuclear fuel, dismantling any systems or components containing activation products, and cleaning up or dismantling contaminated materials. All activated materials generally have to be removed from the facility and shipped to a waste processing, storage, or disposal facility. Contaminated materials may either be cleaned of contamination on-site, or the contaminated sections may be cut off and removed (leaving most of the component intact in the facility), or they may be removed and shipped to a waste processing, storage or disposal facility.

S.4 ENVIRONMENTAL CONSEQUENCES

Air Resources

For any of the Alternatives, potential and cumulative impacts on local climate and meteorology are expected to be less than the assessment results in the TVA Environmental Statement of the early 1970s. Conservative plume modeling and conservative operating assumptions that were used in the original EIS gave results that encompass (bound) the Alternative 2 options for increased cooling tower capacity because actual cooling tower operations have been and are expected to occur only in the warmer months, generally limited to summer. This is much less time than the 29% annual use assumed in the original EIS.

Based on operating experience, impacts on ambient air quality are all expected to be smaller than the magnitudes given in the original EIS, with the exception of carbon monoxide. Emissions and ambient concentrations for carbon monoxide were about two orders of magnitude too small compared to amounts reported during actual operations. However, the ambient air quality standard for this pollutant is still five orders of magnitude larger than this revised estimate, so the impact is considered negligible. The original EIS's assumption of maximum operation in the helper mode 22% of the time was applied to Alternative 2 with its increased cooling tower capacity options. (The 7% closed mode included in the EIS was not quantified because operation in this mode is now known to be impractical.) In this updated assessment, particulate emissions in the form of drift from the towers would be about 22 pounds/hr compared to an emissions standard for fine particulates of 45 pounds/hr. Total annual emissions would be about 21 tons/yr compared to the 100 tons/yr in the original EIS. Construction and modification impacts on air quality during refurbishment of Unit 1 also would be minor and transitory.

Geologic Setting

Construction of additional water cooling capacity under any of the alternatives considered should result in no significant impacts to the geologic resources and hazards. The changes to crustal loading caused by excavation and movement of materials and the construction of new structures should have negligible effects on the seismicity of the area. The local geology and character of local seismicity would not be impacted by continued operation of BFN.

Solid Wastes Management and Past Practices

Continued operation of BFN Units 2 and 3 through the license extension period should not result in generation of additional volumes of general plant trash which exceed the levels currently generated annually. If Unit 1 is restarted, the amount of general plant trash would be expected to increase in proportion to the increase in site population required for the recovery effort. In addition, there would be additional trash generated as a part of construction activities, but this amount would be significantly less than that generated by construction of a new facility. Once operational, the amount of trash generated would be similar to the other operating units, and the overall amount generated would increase slightly due to the small increase in permanent plant staff necessary to operate three units.

BFN would continue to maintain the license to operate the on-site construction/demolition (C/D) landfill through the duration of the extended BFN operating licenses. In the event Unit 1 is restarted, the on-site C/D landfill has the space and capacity to handle the small amount of additional wastes associated with construction activities. Should the on-site facility prove inadequate, there is sufficient alternative capacity in surrounding off-site C/D landfills.

Generation rates for low level radioactive waste would not be expected to exceed existing rates as a result of extension of the BFN licenses. Should Unit 1 be restarted, generation rates for low level radioactive wastes would be expected to increase during construction activities due to additional asbestos removal operations and the normal increases associated with nuclear construction activities. Once operational, the generation rates for this type of waste activity would increase in proportion to the additional operational activity associated with three unit operation. BFN has provisions in place to either store or ship for processing and disposal the volumes of material generated. Existing storage and disposal facilities have adequate capacity to handle the volumes of material expected to be generated during the extended life of BFN with either two unit or three unit operation.

Hazardous Wastes Management and Past Practices

Generation of hazardous waste would not be expected to increase for BFN as a result of license extension. Existing processes for managing these wastes within TVA would be expected to continue, and capacities for existing disposal and treatment facilities should be adequate to handle the relatively small volumes of material generated. Over the past 15 years, BFN has significantly reduced the generation of hazardous wastes through a combination of source reduction and product substitution. These ongoing waste reduction efforts would be expected to further reduce the number of waste streams and the volumes of waste generated at BFN.

Construction activities associated with Unit 1 restart would temporarily increase rates of hazardous waste generation due to the increased use of solvents and paint related materials necessary for refurbishment. The existing TVA process for management of this type of waste is adequate to handle the expected increase. Once operational, hazardous waste generated as a result of operation of Unit 1 would be within the normal year to year variation currently experienced.

Spent Fuel Management

Environmental consequences of additional spent fuel management resulting from license extension of either two or three BFN units would be minimal. The additional spent fuel which would accrue during the license extension period would be stored in the spent fuel pool or a dry storage system approved by NRC. Compared with license renewal of only Units 2 and 3, the addition of Unit 1 would simply increase the number of storage casks needed and the required size of the ISFSI. Subsequently, BFN spent fuel would be transferred to the DOE in accordance with the Nuclear Waste Policy Act of 1982 and subsequent amendments.

Surface Water Resources

Under Alternative 1, no significant construction impacts are expected. Best management practices and construction control measures would be employed to control surface runoff and contain potential pollutants. All waste materials will be handled and disposed in accordance with regulatory requirements. There would be no significant changes in current operational impacts. Regulatory requirements will control potential adverse impacts from plant discharges and operations. Thermal impacts from continued operation of Units 2 and 3 will remain within the levels evaluated during the original EIS. No additional thermal impacts to water temperature, reservoir stratification, sediment transport, scouring, dissolved oxygen concentrations, or eutrophication are expected.

Under Alternatives 2A, 2B, 2C, and 2D, potential construction and operational impacts are similar. Construction impacts are expected to be temporary and insignificant using best management practices (BMPs) and pollution control measures. The restart of Unit 1 would require upgrading the cooling tower system and increased flow rates from a maximum flow of approximately 2,312 MGD for Units 2 and 3 to approximately 3,468 MGD with three units operating. The discharge temperature of the cooling system water will be essentially the same for three-unit operation, due to the proportional increase in cooling water flow. However, the total amount of heat added to the river and the water temperatures at the edge of the mixing zone would increase with three units operating. Modeling analyses using historical data indicate that the maximum discharge temperature and the temperature rise between intake and discharge will remain within regulatory limits. Use of the cooling towers would increase, and on rare occasions when the cooling towers are unable to meet the thermal limits, the plant would be derated to remain in compliance. The implications of the thermal effects on reservoir water temperatures, dissolved oxygen concentrations, and eutrophication were also modeled. The results suggest that Alternatives 2A, 2B, 2C, and 2D should have insignificant effects on reservoir stratification, dissolved oxygen concentrations, eutrophication, sediment transport, and scouring.

Groundwater Resources

There are no adverse impacts to groundwater resources associated with Alternative 1. Activities potentially affecting groundwater resources would include foundation treatment, excavation, and grading associated with Alternative 2 facilities. Excavations which penetrate the water table may require temporary construction dewatering. Any groundwater drawdown impacts associated with plant construction dewatering would be temporary and of negligible magnitude due to the limited excavation depths, the relatively short duration of facility construction, and the distance of neighboring wells.

Excavation and grading associated with construction of the proposed facilities would result in permanent displacement of shallow soils above the water table (e.g., the proposed berm relocation sites). However, the long-term impact of these activities on groundwater resources would be negligible for all facility configurations given the limited depth and area of disturbance. Although permanent local impacts to groundwater levels and movement might be experienced from foundation treatment, the long-term impacts of these activities on groundwater resources would be negligible for the proposed cooling tower configurations given the limited area of disturbance. Potential contaminant releases (e.g., fuels, oils, and solvents) during construction activities would be averted by careful handling and proper disposal of potential contaminants

according to BMP guidelines. No adverse impacts to groundwater resources are anticipated from operation and maintenance of new facilities associated with Alternative 2 or the other alternatives.

Floodplains and Flood Risk

The floodplains and flood risk assessment involves ensuring that facilities would be sited to provide a reasonable level of protection from flooding. In doing this, the requirements of Executive Order (EO) 11988 (Floodplain Management) are taken into account. Due to the nature of this facility, it is necessary to evaluate the flood risk associated with the Probable Maximum Flood (PMF) elevations for all alternatives.

Under Alternative 1, all existing and proposed facilities are, or would be, located outside the limits of the 100- and 500-year floodplains. Therefore, the project would be consistent with EO 11988. All safety-related structures are protected against all flood conditions and would not be endangered by the PMF. The proposed dry cask storage facility and permanent administration building would be located on ground above the PMF elevation based on site topography dated 1989. The proposed Modifications Fabrication Building would be located on ground below the PMF elevation, but the site would be raised or the building would be floodproofed consistent with other facilities of this nature on the plant site. Based on site topography, the proposed mechanical draft cooling tower would be located above elevation 570.

During the license renewal period (up to year 2036), the 100- and 500-year flood, and PMF elevations for the Tennessee River would not be expected to change as stated in Section 3.8 of the SEIS. Although the 100- and 500-year flood flows for the small stream to the northwest of the plant site and the site drainage system could increase by as much as 2.5 times what they are now, these flows would not adversely impact existing or proposed development because they would be significantly lower than the PMF flows, and these channels can handle PMF flows without flooding the plant.

Anticipated flood impacts for Alternatives 2A, 2B, 2C, and 2D would be the same as those listed for Alternative 1, except for potential PMF flooding impacts to the new cooling tower(s). Equipment within the cooling towers that could be damaged by floodwaters would be located above or floodproofed to the PMF elevation, as required. The construction of these towers would involve the relocation of material to one of three potential spoil areas. These areas are located outside the limits of the 100-year floodplain which would be consistent with EO 11988.

Terrestrial Ecology

With respect to botanical aspects of Terrestrial Ecology, impacts are anticipated to be the same under all alternatives. No uncommon communities or otherwise significant vegetation types are known from the vicinity and impacts to this resource are anticipated to be insignificant.

Likewise, impacts to terrestrial animal communities would be similar under all alternatives. Due to previous levels of disturbance at the site during construction and operation of existing facilities, little suitable habitat of wildlife exists on site. No populations of rare or uncommon animals exist at the project site. Adoption of the proposed alternatives would not result in adverse impacts to uncommon animals or their habitats.

Aquatic Ecology

If Unit 1 is not returned to operation, but Units 2 and 3 are relicensed under Alternative 1, the total maximum two-unit intake volume, even with past plant modifications that increased Condenser Circulating (i.e., cooling) Water (CCW) flow, would be within the bounds of previously-assessed intake volumes at which fish impingement and entrainment of fish eggs and larvae were determined to not adversely impact Wheeler Reservoir fish populations. With the return of Unit 1 to operation under Alternative 2, the total CCW flow would increase by about ten percent. This increased CCW intake volume would potentially result in increased impingement of adult fish and entrainment of fish eggs and larvae, but is not expected to result in significant impacts to fish populations of Wheeler Reservoir.

TVA will confirm the expected levels of impingement and entrainment by monitoring under current 2-unit operation and following return of Unit 1 to service. TVA's Vital Signs monitoring program will also continue to assess aquatic ecological communities in Wheeler Reservoir. Although not expected, if based on these monitoring studies it is determined that increased impingement and entrainment are resulting in unacceptable environmental impacts, TVA would assess the technologies, operational meaures, and restoration measures that could be undertaken to remedy this, and institute appropriate measures in consultation with appropriate federal and Alabama agencies.

Thermal impacts to aquatic life would be insignificant under any of the proposed action alternatives because the maximum discharge temperature will remain within approved regulatory limits. With implementation of BMPs and other specialized measures as needed to prevent entry of pollutants into surface waters, impacts to aquatic life resulting from construction of new facilities would be insignificant.

Threatened and Endangered Species

For threatened and endangered plants, the impacts are anticipated to be the same under all 5 Action Alternatives. No rare (listed) plants are known from the vicinity and no impacts to this resource are anticipated. No threatened or endangered aquatic animals are presently known from the potentially affected area, and no impacts to this resource are anticipated. Four state-listed terrestrial animal species (two of which are also federally listed) are known from Limestone County, but none of them are reported within five miles of BFN. Adoption of any of the proposed alternatives would have no effect on threatened or endangered terrestrial animals or their habitats.

Wetlands

No wetlands occur on any portion of the sites proposed for construction and excavation or disposal of spoil materials. Therefore, there would be no impacts or effects upon wetlands by activities proposed under any of the alternatives.

Socioeconomic Conditions

Discontinuing Plant Operation (upon Expiration of Current Licenses)

Discontinuing operations would require that the plant begin the decommissioning process. There would be some loss of jobs as the plant went into the process, followed by further loss at the end of the decommissioning period. In addition to these direct losses of income and employment, there would be additional indirect income losses as a result of decreased spending associated with the direct job losses. However, the number of jobs lost would be roughly one percent of the labor force of Limestone County and only a small fraction of the labor force in the labor market area. Impacts to community services and housing and to local government revenues would be small. No disproportionate impacts to disadvantaged populations in the local area are expected.

Alternative 1

Under Alternative 1, there would be no significant change in operating employment levels, payroll, or other plant-related expenditures. There would be some construction activity associated with construction of the cooling tower (part of the previously reviewed EPU of BFN Units 2 and 3), modifications/fabrication building, and spent fuel dry cask storage facility, requiring a small number of workers (less than 100 at peak) for a brief period of time. However, impacts to employment and income would be small and temporary.

There would be no important impacts to community services and housing and to local government revenues. No disproportionate impacts to disadvantaged populations in the local area are expected.

Alternative 2

Under any of the variations of Alternative 2, construction activities would result in important impacts on population, employment, and income over a time span of about 5.5 years. The total number of workers involved in the construction phase would peak at about 3,000, although not all of these are likely to be located at the plant site. Operation of Unit 1 in addition to current operation of Units 2 and 3 would require an increase in employment of about 150 permanent workers. This would be a small addition to the local economy.

Construction would result in some short-term strain on community services, including police and emergency services. Schools and the housing market likely would experience short-term strains. These impacts, however, would be scattered throughout the labor market area, not just in Limestone County. The increase in permanent employment associated with operation of Unit 1 in addition to the Units 2 and 3 could have a temporary impact on the local housing market and housing prices. However, the operations impacts would be small. Local government revenues would increase as a result of increases in the in-lieu-of-tax payments by TVA. No disproportionate impacts to disadvantaged populations are expected.

Transportation

Alternative 1 will result in no impacts to the traffic generated by the plant because it would remain at the existing level. However, background traffic growth is expected to continue between

now and when the renewed licenses expire. Assuming 15% growth per decade, traffic on the county roads would increase to approximately 2,600 vehicles per day.

Additional traffic would be generated due to refurbishment of Unit 1, and there would be impacts to state and county roads in the vicinity of the site. The Action Alternatives 2A, 2B, 2C, and 2D will have additional traffic generated in the form of operation and construction workforce employee travel and construction and operational material deliveries. During the refurbishment period the workforce rises to peak levels of 3,055; assuming an average ridership of 1.6 persons per vehicle, and one trip in and out each day, about 3,820 vehicles will be added to the road network due to daily commuters during this peak construction period. The average daily traffic on Shaw Road, Nuclear Plant Road, and Browns Ferry Road would increase from the current 1,600 to about 2,900 vehicles per day, which represents a temporary (but not unacceptable) decrease in the level of service. This decrease in level of service from LOS C to LOS D would result in traffic flow conditions that could be tolerated for short periods of time. In this instance, such conditions could occur at shift changes twice during the day and last up to one hour. The county roads are in good condition for access and will be adequate to support the traffic requirements during both construction and operation; however, construction periods are temporary and peak forces only last for approximately six months. There will be some delay turning onto County Road 25 from the plant due to traffic congestion at shift changes and leaving multiple exits simultaneously. Over a long period of time, there is a natural progression to improve the quality of the local roadway network and it can be assumed that the roadway network would be improved in the normal course of events. U.S. Highways 31 and 72 would not be significantly affected.

TVA has completed a transmission study as recently as June 2000 for BFN which assessed the ability of the offsite power system to meet NRC requirements for electric power systems. This study included a 5-year look-ahead to the summer 2005 peak system load of 33,775 megawatts (MW), and assumed BFN Units 2 and 3 were generating at full power with a per-unit power uprate to 1,155 MW gross. The study examined both load flow and transient stability in response to a number of postulated system alignments, contingencies and design basis accident conditions. It was concluded that all the cases studied meet the BFN minimum voltage and design requirements.

TVA has analyzed the transmission line condition and loading in the vicinity of the BFN site, and has determined that restart of Unit 1 at EPU would require additional 500-kV circuit breakers to be installed in the existing 500 kV switchyard, and several 161-kV transmission lines are projected to become overloaded due to single contingency events. Line uprates (i.e., retensioning or increasing tower height or adding towers as necessary to maintain height clearances of conductors which warm and sag under higher power loading), reconductoring (i.e., increasing conductor size), the addition of a second 500-161kV transformer bank at the Madison 500kV substation, or other solutions would be required to correct these overloads. A Static Var Compensator and Capacitors would also be needed for regulating system voltage. These upgrades and equipment additions involve existing facilities with available spaces; any associated environmental impacts would be minimal. There would be no need to obtain new Right of Ways or construction of new transmission lines under any of the alternatives.

The alternatives considered in this SEIS have no impacts on railroads, river transport, or pipelines.

Soil and Land Uses

Activities associated with license renewal and operation of Units 2 and 3 at extended power uprate would have no impact on soils or land use on the plant site. Potential impacts to site soils and land use associated with refurbishing Unit 1 and license renewal for all 3 units, including construction of the additional cooling towers, dry cask storage facility, new administration building, and new modifications/fabrication building, would be insignificant. These construction activities would be located on previously disturbed soils and in built-up areas. Facilities for construction workers would be temporary and at completion of the project the land would revert to prior use.

Operational impacts of any of these activities on land use in the surrounding areas would be insignificant. Current trends in local land use are toward development of more land for residential and commercial use. This is a result of population growth averaging 17% per decade. Any growth associated with either of these proposed activities would be minimal compared to current trends. Existing power line easements are sufficient, no new transmission lines are proposed as part of this license renewal process.

Visual Resources

Impacts under the No Action Alternative would be insignificant. The plant site would remain in its current state and would remain visually unchanged. Under Alternative 1, minor visual impacts would include additional plumes seen by area residents and motorists along adjacent roadways. Alternative 2A will introduce two new cooling towers in the landscape, similar to those that exist now. Alternative 2B, however, will provide two cooling towers that will contrast vertically to the existing towers. Alternative 2C, demolishing the four existing Ecodyne cooling towers, constructing 5 new linear mechanical draft cooling towers and increasing the size of the existing Balcke-Durr cooling tower by 25%, would add to the number of linear elements seen across the plant site. Alternative 2D is the construction of a sixth mechanical draft cooling tower in the currently vacant position (4) where a tower that was destroyed by an accidental fire in 1986, has never been replaced. This addition of a sixth cooling tower differs from that proposed for Alternative 1 (see above) in that the tower would be somewhat larger than the recently replaced 16-cell linear mechanical draft cooling tower 3. The visual impact of Alternative 2D would essentially be the same as that for Alternative 1 since a single mechanical cooling tower of a similar design (but slightly shorter length) would otherwise have been built in the same location for the EPU project. Alternatives 1 and 2D would have the least visual impact for both plant workers, visitors, and motorists along County Road 25 under the Action Alternatives.

Recreation

There are no recreation facilities impacted by either alternative. Under either of the alternatives, there would be insignificant affects on recreation resources, facilities and activities.

Cultural Resources

TVA determined that the project had the potential to affect historic properties within the three areas designated as soil disposal or spoil pile locations. The Area of Potential Effect (APE) for historic structures was determined as those areas from which the disposal locations would be visible. A Phase I cultural resource survey was conducted to identify sites within this APE.

The archaeological survey identified one archaeological site near disposal Area 1 (see Figure ES-1). This site is marked on BFN drawings and it is expected that it would be avoided by any future activities. If avoidance is not possible, or should any future plans result in potential adverse impacts to the site, a Phase II archaeological survey would be required. Cox Cemetery, located near disposal Area 2, would also be avoided. No historic structures were identified within the APE. In consultation with the Alabama State Historic Preservation Office (SHPO), it was determined that no historic properties will be affected by Alternatives 1 and 2 under the commitments that all sites identified during the Phase I survey will be avoided.

Environmental Noise

Routine construction noise from the action alternatives would have an insignificant effect during the duration of construction activities. Some cooling tower and building construction noise would be noticeable above background at times, but it would take place during daylight hours and for a relatively short time period. The highest noise levels during construction would come from the site preparation and foundation work for additional cooling towers. Alternatives 2A and 2B would require two additional towers. Alternative 2C would involve replacement construction of four large towers and the addition of one large tower extending over a period of three to four years. Alternative 2D would require a single additional tower. These heavy construction phases require the largest and most equipment to be in operation, but they are expected to be completed in about three months per tower. The following construction phases of erection and finishing do not require as large or as many pieces of equipment.

The incremental increases in operational noise from the cooling towers for Alternatives 1, 2A, 2B, and 2D are insignificant. These are about a 1 dBA increase over current operational noise. This increase might not be detectable by most of the nearest residents, but it has the potential for a 1 to 2% increase in annoyance. The incremental increase for Alternative 2C is likely to be noticed and has the potential for about a 4% increase in annoyance. None of the alternatives has the potential for causing hearing loss or speech interference.

Although Alternative 2C has the potential to cause an operational noise increase greater than 3dBA, it would be an insignificant effect. The maximum potential effect of Alternative 2C is decreased for several reasons. First, frequently, less than all of the towers are operating; second, the towers operated an average of 17 days per year over the past five years; and third, the cooling tower noise is low frequency and continuous. Also, the towers operate during the hottest part of the summer when residential air-conditioning is used and windows are closed, eliminating any potential noise increase from inside the residences.

Public and Occupational Safety & Health (Non-Radiological)

The site Safety and Health Program will not be impacted or affected by license renewal and continuing to operate Units 2 and 3 for 20 years after the current licenses expire. If Unit 1 recovery and license renewal/extended operation is added to continuing operation of Units 2 and 3, there is still no change to the Safety and Health Program. However, during the construction/modification work in recovering Unit 1 injury rates would be expected to be higher than during periods of operation.

Radiological Impacts

Future occupational radiation exposures from continuing either two-unit or three-unit operation at Extended Power Uprate (EPU) power levels have been analyzed based on extrapolations from past and present data; it was concluded that worker radiation exposures will continue to be significantly less than the limits established by federal regulation. The average annual dose to workers and and the average annual dose per operated reactor will remain consistent with current BWR industry trends. The estimated cancer risk increase associated with the occupational dose forecast for either operational Alternative is bounded by the projected doses for license renewal analyzed in NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants."

TVA does not anticipate any significant changes to the radioactive effluent releases or exposures to the public from continuing two-unit BFN operations through completion of the license renewal period. EPU is projected to increase effluent releases proportionately, as would the addition of Unit 1. However, the refined calculated doses are a small fraction of the applicable radiological dose limits and the total exposures to the public from 3-unit operation at EPU are expected to remain a small fraction of the regulatory dose limits.

The design basis accidents addressed in the BFN UFSAR are independent of the age of the plant and are the same for each unit. Therefore, the extension of the operating lifetime of the plant from 40 to 60 years will not impact the analysis of these accidents. EPU to 120% of the originally licensed maximum thermal power level will affect accident analysis because the power level influences the amount of radioactive isotopes available for release; however, all radioactive releases are projected to remain well within regulatory limits.

Extension of plant life from 40 to 60 years will also proportionately impact the ability of safety related equipment to withstand the effects of accidents; this is because of age-related effects of continuing operational conditions (temperature, humidity, radiation, etc.). However, the BFN equipment qualification program ensures that safety-related equipment will remain qualified to operate as designed in its intended environment so as to perform its intended function. As part of this program, any equipment that cannot withstand the full 60-year life of the plant will be replaced on a predetermined maintenance schedule.

License extension with either two- or three-unit operation would be accommodated as it has in the past by the BFN Radiological Emergency Plan. Based on the BFN SAMA analysis and SAMA analyses completed to date at other nuclear plants similar to BFN, it is not anticipated that either Alternative 1 or Alternative 2 would result in justifying significant modifications.

Decommissioning Impacts

If the decision is made to extend operation of only Units 2 and 3, decommissioning would probably not be initiated for Unit 1 until cessation of all site power operations. Instead, Unit 1 would likely remain in its current non-operable status until any renewed licenses expire or a subsequent decision is made to recover and restart the unit. If Unit 1 is restarted, Unit 1 would join Units 2 and 3 in extended operation for an additional 20 years past expiration of the current licenses. Therefore, under either Action Alternative, decommissioning would be delayed by the 20-year license renewal period, providing an opportunity for decommissioning technology (including more advanced robotics) and the licensing framework to evolve and mature. In addition, it becomes more likely that a permanent spent fuel repository would be available prior to completion of decommissioning.

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2.0 ALTERNATIVES INCLUDING THE PROPOSED ACTION

The objective of this Supplemental Environmental Impact Statement (SEIS) is to provide information to the public and Tennessee Valley Authority (TVA) decision makers describing the environmental consequences of providing future baseload generation capacity by maximizing utilization of the existing power production facilities at the Browns Ferry Nuclear Plant (BFN) site. This would involve license renewal and extended operation of the units. Reasonable alternatives and related actions are also addressed. Reasonable alternatives range from ceasing operation altogether at BFN (when the current operating licenses expire) to extending operation of all three units. The decision as to how much generating capacity would be continued will take into account environmental considerations together with economic and technical aspects of the project. This decision would be documented in a Record of Decision (ROD) which would be prepared after the issuance of the Final Supplemental Environmental Impact Statement (FSEIS) and TVA's Board of Directors makes the decision.

The current (2001) facilities at BFN are shown in Figures 2.0-1 and 2.0-2. Figure 2.0-1 is a plan view of the site, and Figure 2.0-2 is a close-up view of the central power plant. These current facilities form the reference point or "baseline" from which the alternatives in this SEIS may be described as potential changes.

The No Action Alternative is described in Section 2.1. The processes that were followed to identify and screen the other alternatives evaluated in this SEIS are presented in Section 2.2. Additional actions that are common to all action alternatives are defined in Section 2.3. The Proposed Action Alternatives are described in Section 2.4 and summarized in Section 2.5. The environmental consequences of the No Action and Action Alternatives are compared in Section 2.6. A comparison of the costs is presented in Section 2.7, and TVA's Preferred Alternative is described in Section 2.8. References for this chapter are listed in Section 2.9.

2.1 Description of the No Action Alternative

The No Action Alternative would result from a decision to not extend operation of the BFN units. Since it currently appears economically infeasible to recover Unit 1 without license renewal, such a decision would effectively terminate any further consideration of restarting that unit at this time. Operation of Units 2 and 3 would cease upon expiration of their operating licenses in 2014 and 2016, respectively, and the plant would then be required to choose a decommissioning option.

Operation of Units 2 and 3 during their existing license terms is addressed in the plant's original EIS from which this EIS tiers: *Final Environmental Statement, Browns Ferry Nuclear Plant Units 1, 2, and 3* (TVA, 1972). That EIS continues to adequately identify the environmental impacts of operating the BFN units until their existing licenses expire. The other relevant NEPA reviews, identified in Section 1.5.3 of this SEIS, identify the changes that have occurred in unit operation since the original EIS and the environmental impacts associated with those changes. The discussion of the Action Alternatives in this SEIS describes current unit operations.

Figure 2.0-1
Current Facilities at BFN

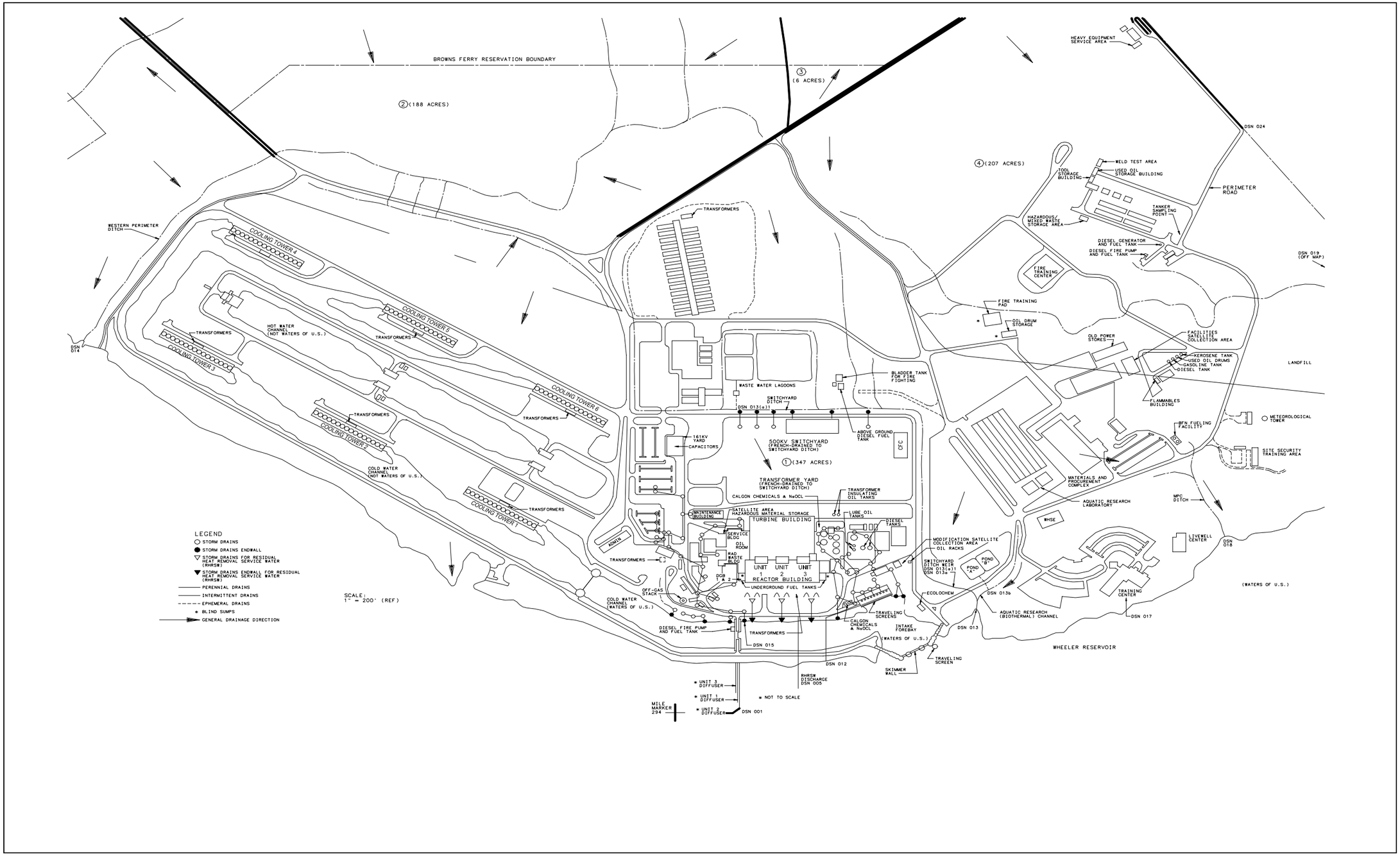
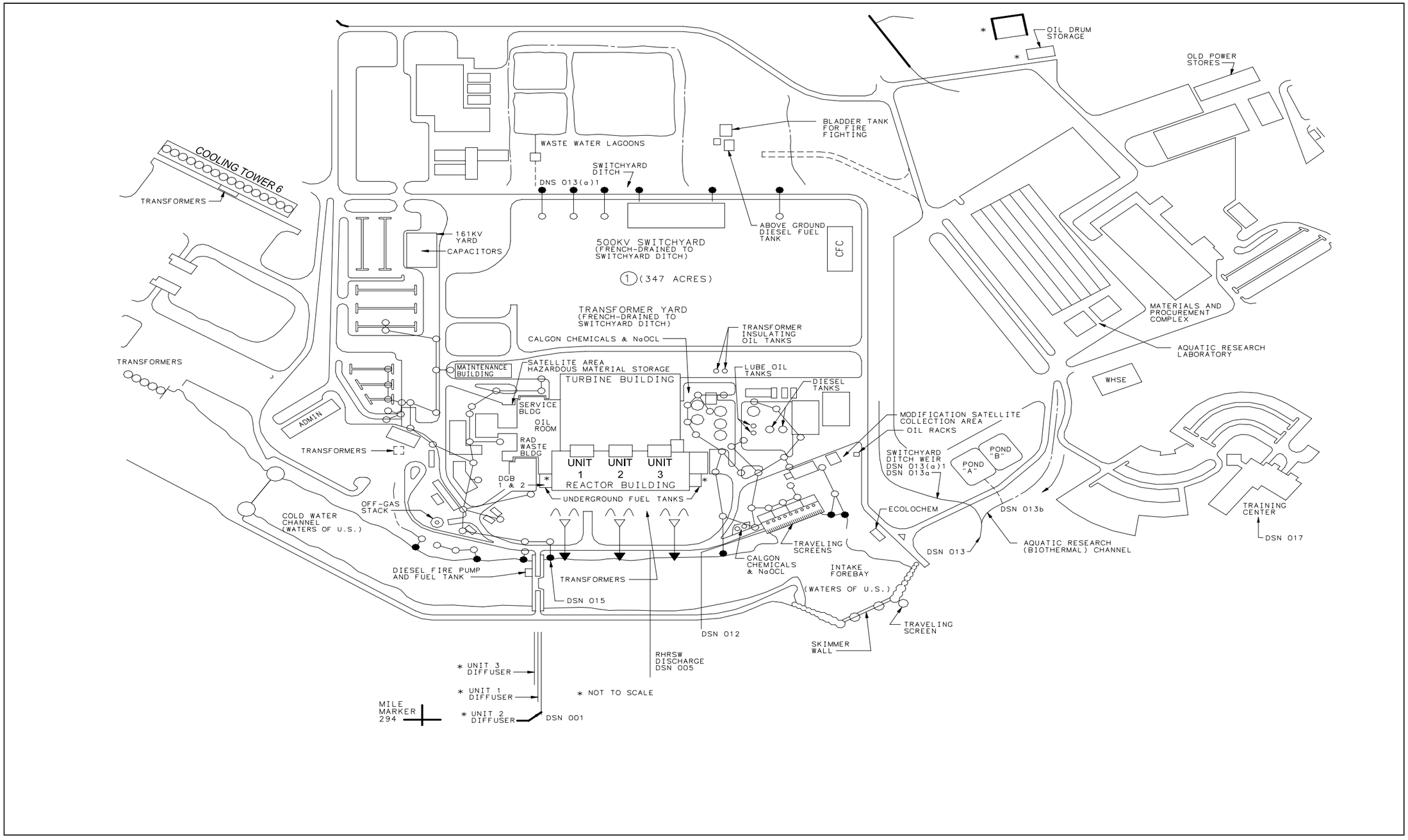


Figure 2.0-2
Current Facilities (Details) at BFN



In the event that TVA chooses to not seek an extension of the unit operating licenses or to restart BFN Unit 1, the baseload generation that could have been provided by these actions would, presumably, be provided by one of the other generation options identified in TVA's integrated resource plan (IRP) portfolio of options. Those options and their associated environmental impacts have been generally described in the *Energy Vision 2020* EIS. Prior to proposing and implementing one of those options, additional environmental analyses would be conducted. Although some of these generating options may be capable of providing the baseload generation that would result from the Action Alternatives described in this SEIS, they would not maximize the use of existing BFN assets. As addressed in *Energy Vision 2020*, most of these IRP options would likely result in more significant environmental impacts than the BFN Action Alternatives, especially those involving construction of new fossil-fuel fired generating facilities on greenfield sites. Additionally, as discussed in this SEIS, the Action Alternatives here, particularly Alternative 1, are considered more cost effective than other IRP options. It is for these reasons that the No Action Alternative has not been identified as preferable by TVA.

2.2 Screening of Action Alternatives

Except for maximizing use of BFN's assets, feasible Action Alternatives for meeting TVA's purpose and need include the entire portfolio of actions recommended in *Energy Vision 2020*. These actions include, as detailed in Section 1.4.2, various supply-side actions (e.g., constructing new power plants, purchasing and exercising call options, purchasing power from independent power producers, renewable energy, improving the existing hydroelectric generating system, converting Bellefonte Nuclear Plant to an alternative fuel); and customer service alternatives (e.g., demand-side management, beneficial electrification). The environmental impacts of these projects and actions are documented in *Energy Vision 2020* or in other environmental reviews completed prior to decisions to implement them.

Chapter 1 pointed out that some of these alternatives did not deliver the power promised, and that some alternatives pose unacceptable technical and financial risk in TVA's efforts to ensure that sufficient power is available to meet customer needs. In fact, over reliance on options purchase agreements (which have yielded mixed performance to date) and spot market purchases during periods of high electricity use could lead to failure to meet demands. Many utilities across the country did not plan for sufficient margin of production and could not meet the demands of their customers on several occasions during recent summers at any cost. Even when it is possible to purchase energy (electricity) on the spot market from other utility systems, this does not avoid the environmental impacts associated with energy generation. The impacts associated with the generation used to produce the purchased electricity would still occur. It is likely that spot market energy would be supplied by coal-fired generation because this is the generation that tends to swing with load or changes in demand (nuclear generation is normally baseloaded; hydro and natural-gas fired generation (combustion turbines) typically is reserved for use during peak periods). (Natural-gas fired combined cycle plants as they increase in number may change this generation profile over time.) Coal-fired and, to a lesser extent, natural-gas fired generation has more significant environmental impacts than nuclear generation (for example: air quality). The environmental impacts associated with spot market purchases have been addressed in *Energy Vision 2020*.

Converting one or more BFN units to fossil-fired could theoretically make maximum non-nuclear use of BFN facilities, but is probably not practicable for a number of reasons. The steam turbines

and condensate systems in a boiling water reactor (BWR) are radioactively contaminated and not designed for the steam temperatures and pressures that maximize efficiency in fossil-fired boilers. Mixing types of generation (e.g., keeping Unit 2 or 3 reactors operating while feeding the Unit 1 turbine-generator from a fossil-fired boiler) is even less likely because it would require very expensive "hardening" of steam lines and other equipment that could conceivably be accident initiators. Currently there may not be enough unused space at the BFN site to cost-effectively add large new boilers, pipelines, coal yards, etc. Therefore, conversion is not considered to be a reasonable alternative for this SEIS.

Continuing operation of BFN, as proposed in this SEIS, would further enhance the flexibility that is an inherent part of the Energy Vision IRP portfolio, and would provide TVA with an important and powerful tool for minimizing future risks, managing costs, and ensuring the delivery of low cost reliable power to its customers for many years to come.

2.2.1 Proposed Action Alternatives for this SEIS

Two alternatives are fully consistent with the stated project objectives and the updated cost comparison of alternatives previously evaluated in *Energy Vision 2020*.

ALTERNATIVE 1 – RELICENSING OF UNITS 2 AND 3

Alternative 1 is to continue to operate Units 2 and 3 for an additional 20-year period beyond the expiration dates of the current licenses. The current operating license expiration dates are 2014 for Unit 2 and 2016 for Unit 3. Units 2 and 3 would be operated at up to the Extended Power Uprate (EPU) level of 120% of their originally licensed power levels. The current Unit 1 operating license expires in 2013. If this occurs, Unit 1 would probably either have its license renewed (with the condition that any future proposal to restart the unit would be approved by the Nuclear Regulatory Commission) or the licenses for Units 2 and 3 would have to be modified to include interconnecting Unit 1 equipment as necessary. Unit 1 would continue in its current non-operable status until either the renewed license expires or a subsequent decision is made to recover and restart the unit.

The reason for the above licensing options to accommodate a non-operating Unit 1 is that a decision to not renew the operating license for Unit 1 would require it to enter a chosen decommissioning mode while Units 2 and 3 (with which it is heavily interconnected, including safety systems) are operable or operating. Both TVA and NRC would be cautious about mixing operation with decommissioning of same-site interconnected units. The facilities and components affected by implementation of Alternative 1 are shown in Figures 2.2-1 and 2.2-2; these are the same as Figures 2.0-1 and 2.0-2 except that they include an additional cooling tower, the proposed dry cask storage facility, and a proposed modifications/fabrication building.

Figure 2.2-1
Facilities Associated with Alternative 1

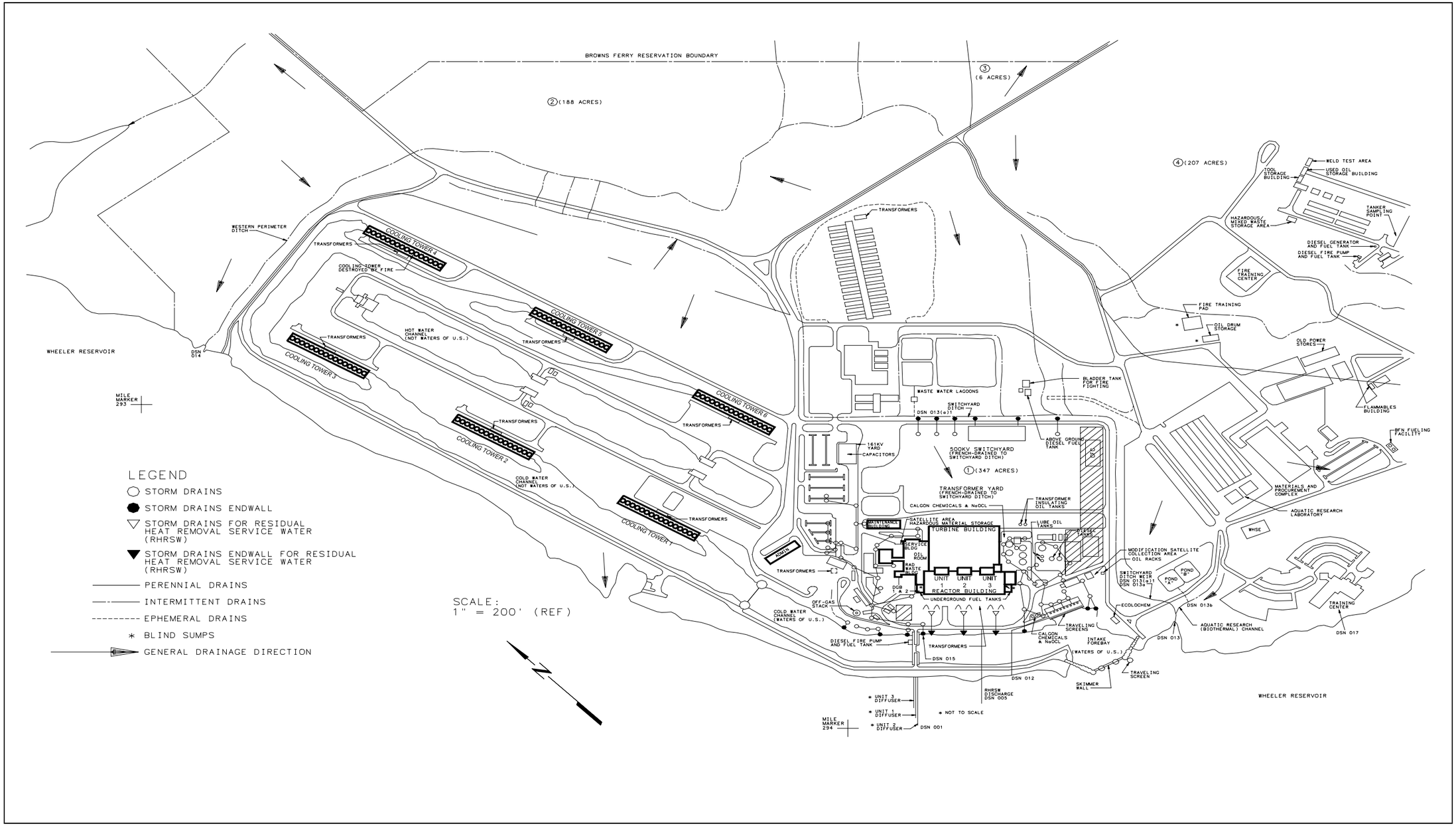
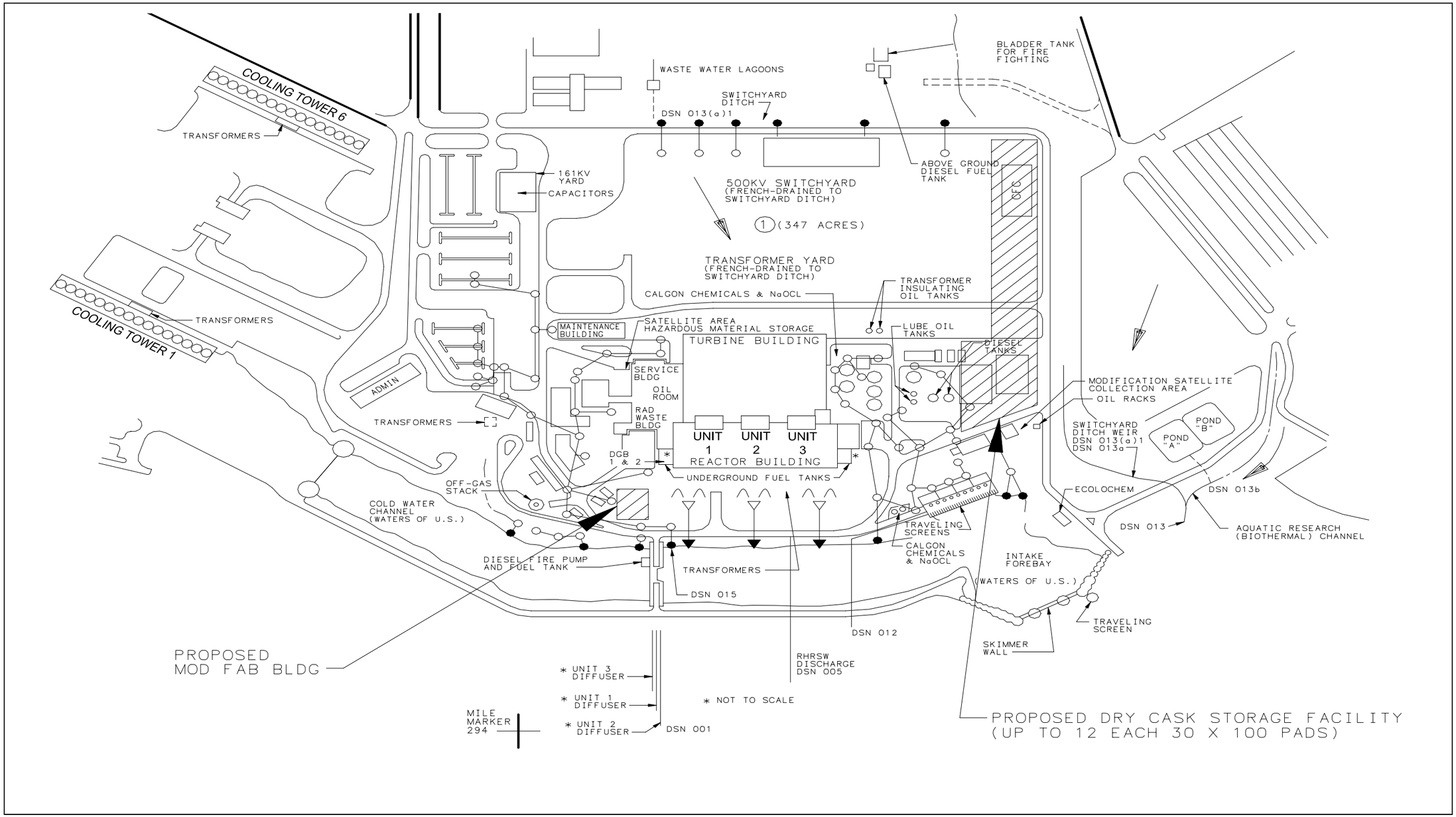


Figure 2.2-2
Details Associated with Alternative 1



ALTERNATIVE 2 - REFURBISHMENT AND RESTART OF UNIT 1 WITH RELICENSING OF ALL UNITS

Alternative 2 is to add refurbishment and restart of Unit 1 to Alternative 1, i.e., extended operation of all three BFN units. Unit 1 would be restarted at the EPU level. Although renewal of the current Unit 1 operating license would allow an additional 20 years of operation after the current license expires in 2013, restart of Unit 1 could occur as early as 2007, if the decision is made to restart the unit and recovery efforts were initiated soon after this SEIS is completed. The central facilities and components (except cooling towers) affected by implementation of Alternative 2 are shown in Figure 2.2-3.

Table 2.2.1-1 below quantifies the additional power that would be generated by each unit as a function of the Extended Power Uprate (EPU) modifications and the alternatives described in this FSEIS.

Table 2.2.1-1 Summary of Power Levels (in net megawatts electric)

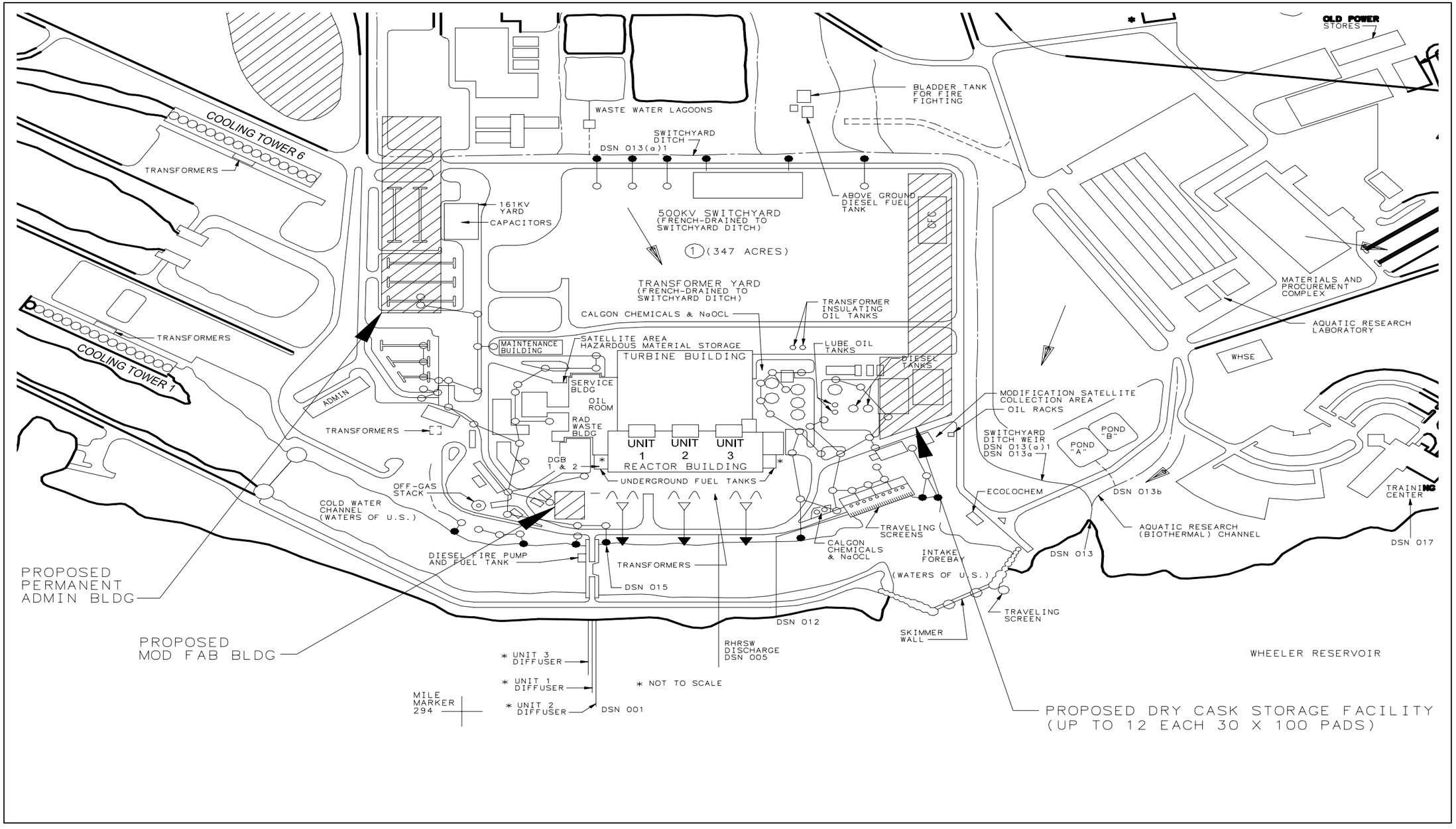
UNIT NOS.	CURRENT (prior to EPU)	AFTER EPU (Completion Date)	ALTERNATIVE 1 (begins 2013)	ALTERNATIVE 2 (begins 2013)
Unit 1	[not operable]	[not operable]	[not operable]	1280
Unit 2	1164	1280 (April ’05)	1280	1280
Unit 3	1164	1280 (April ’04)	1280	1280
Total	2328	2560	2560	3840
Increase above current	(N/A)	232	232	1512

2.2.2 Associated Condenser Circulating Water Flow Rates

The BFN units are normally cooled by pumping water from Wheeler Reservoir into the turbine-generator condensers and discharging it back to the reservoir via large submerged diffuser pipes that are perforated to maximize uniform mixing into the flowstream. This straight-through flow path is known as “open cycle” or “open mode” operation. Through various gates, this cooling water can also be directed through cooling towers to reduce its temperature as necessary to comply with environmental regulations. This flow path is known as the “helper mode.”

The physical capability also exists to recycle the cooling water from the cooling towers directly back to the intake structure without being discharged to the reservoir; this is known as the “closed mode” of operation. However, when operating in this mode in the past, BFN has experienced difficulties in keeping intake cooling water temperatures below limits during the summer months. This often resulted in forcing the plant to reduce power output during high demand periods. In addition, closed mode operation reduced plant reliability considerably because it increased vulnerability to sudden cooling tower performance degradation caused by equipment failures or changes in wind direction. BFN has not operated in this mode since restart of Units 2 and 3, and currently has no procedures for it; doing so would require some instrumentation and control circuitry refurbishment.

Figure 2.2-3
Facilities Associated with Alternative 2



For all three units operating simultaneously in the open mode, the total BFN intake flow rate, consisting of the condenser circulating (i.e., cooling) water (CCW) intake flow rate (with all 3 CCW pumps per unit) plus various smaller intake flow rates to plant auxiliaries, originally was expected to total 1,980,000 gallons per minute (GPM). This is 2,851.2 million gallons per day (MGD), which when combined with miscellaneous other minor effluent flows became the 2,855 MGD in the application TVA submitted for the National Pollutant Discharge Elimination System (NPDES) Permit of July 10, 1984.

In recent years, BFN has operated with only Units 2 and 3, but due to a combination of system upgrades and improved flow calibrations the measured total per-unit CCW flow rate in the open mode (with 3 condenser circulating water pumps per unit) has increased. For example, the condensers were re-tubed with stainless steel tubing having a larger internal diameter and decreased flow resistance, which increased flow approximately 6%. The most recent total intake flow reported to the Alabama Department of Environmental Management (ADEM) in the monthly Discharge Monitoring Report is 2,312.1 MGD (approximately 800,000 GPM per unit). With the return of Unit 1 (which will also be re-tubed), the total intake flow would then become approximately 3,468 MGD, which represents an increase over the previous high reported number (2,855) of 21.5%. However, based on extensive recent experience in measuring flows and observing changes due to various modifications, maintenance, and measurement methods and techniques, TVA believes that only about 10% of this represents a real increase in flow; the remainder is due to either changes in flow measuring methods and techniques or differences in how the original values were reported.

2.2.3 Associated Cooling Tower Impacts and Alternatives

ALTERNATIVE 1: COOLING TOWER IMPACTS

During peak hot weather periods, full-load operation of BFN Units 2 and 3 generally requires all five of the mechanical draft cooling towers to be running in order to meet condenser circulating (cooling) water maximum allowable temperature requirements for discharge to the river. Since there is currently little spare cooling capacity to accommodate any additional heat load that would be associated with the power uprate, TVA plans to erect a sixth mechanical draft cooling tower as part of the BFN EPU project (See Figures 2.2-4 and 2.2-5). This was addressed in the Environmental Assessment that TVA prepared for the EPU proposal. The design would most likely be similar to the recently replaced cooling tower number 3 and would be located on the site of the old cooling tower number 4 which was destroyed by fire in 1986 and never replaced (TVA, 2001).

Figure 2.2-4 Location of Sixth Cooling Tower for Alternative 1

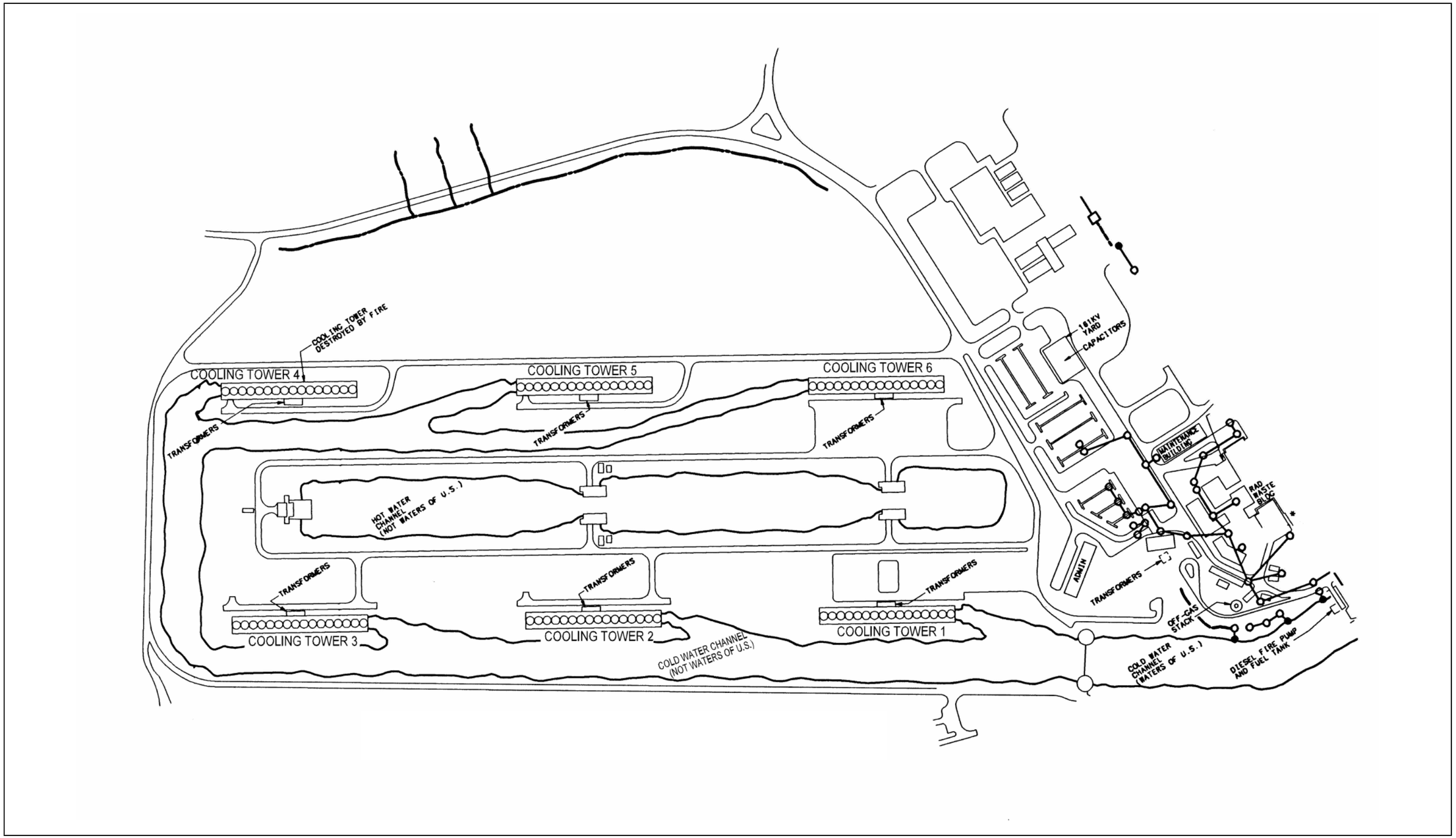
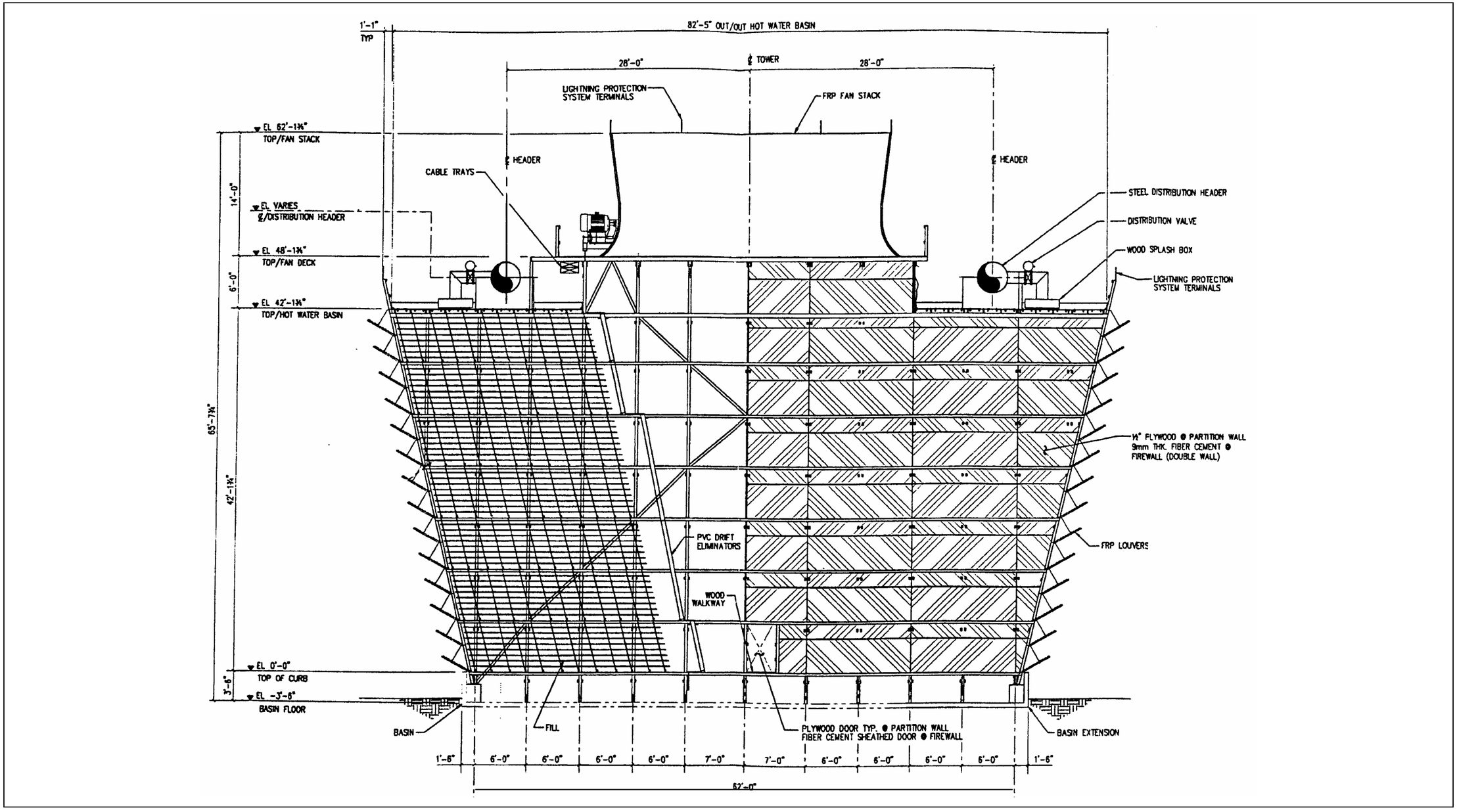


Figure 2.2-5 Diagram of Typical Mechanical Draft Cooling Tower



ALTERNATIVE 2: COOLING TOWER IMPACTS

Restarting Unit 1 would require additional cooling tower capacity beyond that currently envisioned for Units 2 and 3 with EPU. The additional cooling capacity required could be obtained by a combination of constructing new cooling towers, refurbishing the old original cooling towers, or even dismantling and replacing one or more of the original cooling towers with an updated and more efficient design. The environmental impacts of refurbishing or replacing the original towers are minimal. Installation of additional cooling towers could involve movement of a soil berm created during construction of the existing towers. This 70-foot high berm, located northeast of the tower complex, is the preferred location for some cooling tower configurations. The following sub-alternatives are evaluated in the SEIS to bound the additional cooling tower capacity that could be required.

ALTERNATIVE 2A: ADDITIONAL LINEAR MECHANICAL DRAFT COOLING TOWERS OPTION

Alternative 2A is to add two new linear mechanical draft cooling towers (see Figure 2.2-6 for location) which are very nearly identical to the recently replaced cooling tower 3. The two new towers would be in addition to the six that would be functional for operation of Units 2 and 3 at EPU, making a total of eight very similar cooling towers. Installing these new towers would require removal of most of a large existing hill or mound created by excavation of drainage canals associated with construction of the original six cooling towers. As shown in Figure 2.2-7, the displaced spoils would be deposited in three currently vacant regions of the site. The remainder of the hill or mound adjacent to the new towers would be reduced in height to ensure that wind from any direction is unimpeded in flowing across any of the towers, old or new. This will also overcome the shielding effect of the existing hill that contributes to interference between towers (i.e., effluent from one tower being entrained into the intake of another tower).

ALTERNATIVE 2B: ADDITIONAL ROUND MECHANICAL DRAFT OR MODIFIED HYPERBOLIC COOLING TOWER OPTION

Alternative 2B is similar to Alternative 2A, except that the two new cooling towers would be some type other than the current linear mechanical draft cooling towers, such as round mechanical draft or modified hyperbolic design. Approximately the same volume of spoils would be displaced as for Alternative 2A, and the footprint of the new towers would be located similarly to Alternative 2A, but would be somewhat different in size and shape (see Figure 2.2-8). Other characteristics would be different, such as noise and effluent appearance. The type of cooling tower chosen is primarily an economic decision, into which must be factored initial capital costs, operating and maintenance expenses, and the percentage of time the tower would be operating during power usage peaks and off-peak periods.

Figure 2.2-6 Location of Cooling Towers for Alternative 2A

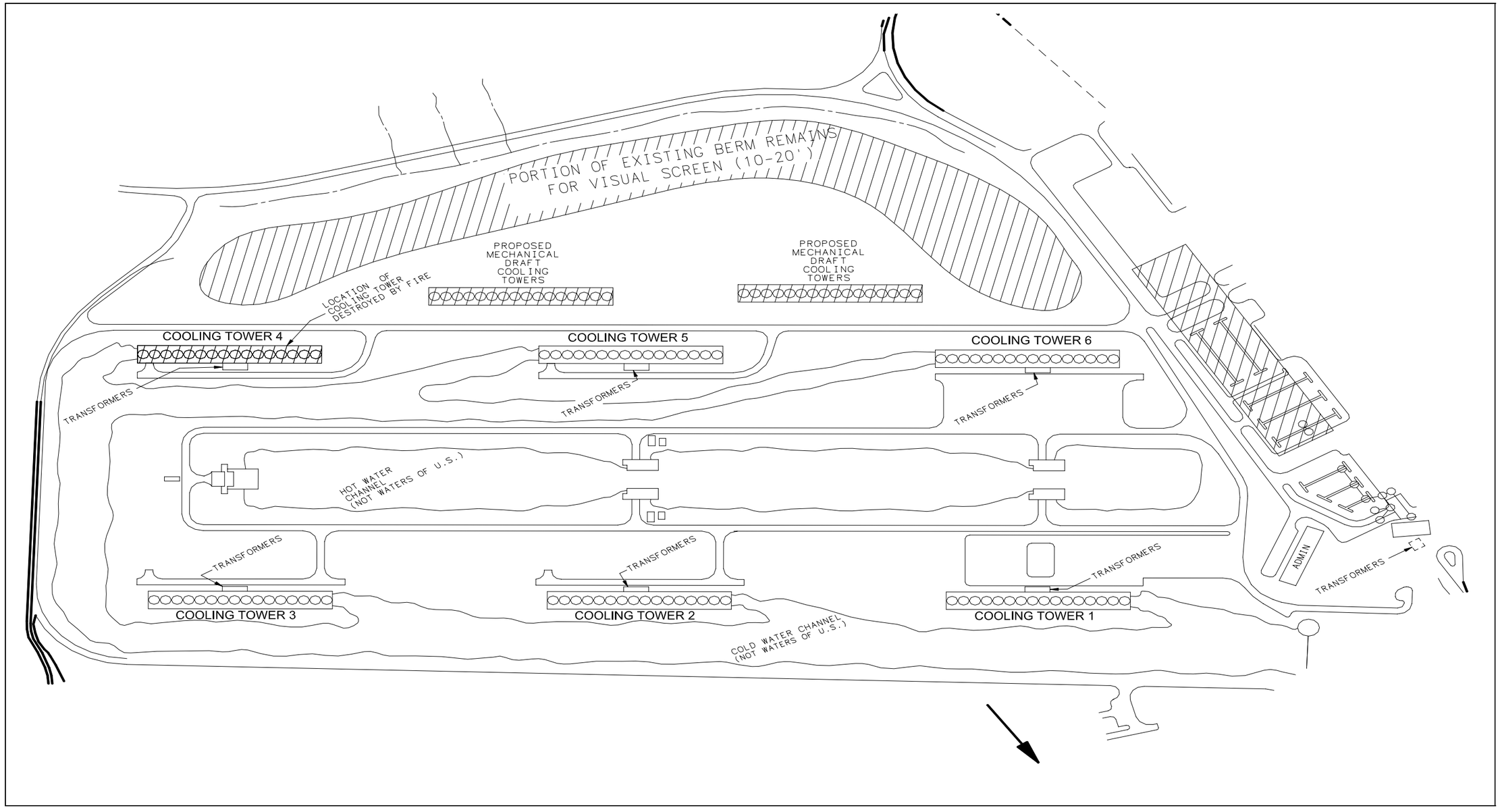


Figure 2.2-7
Location of Areas for Spoils Deposition

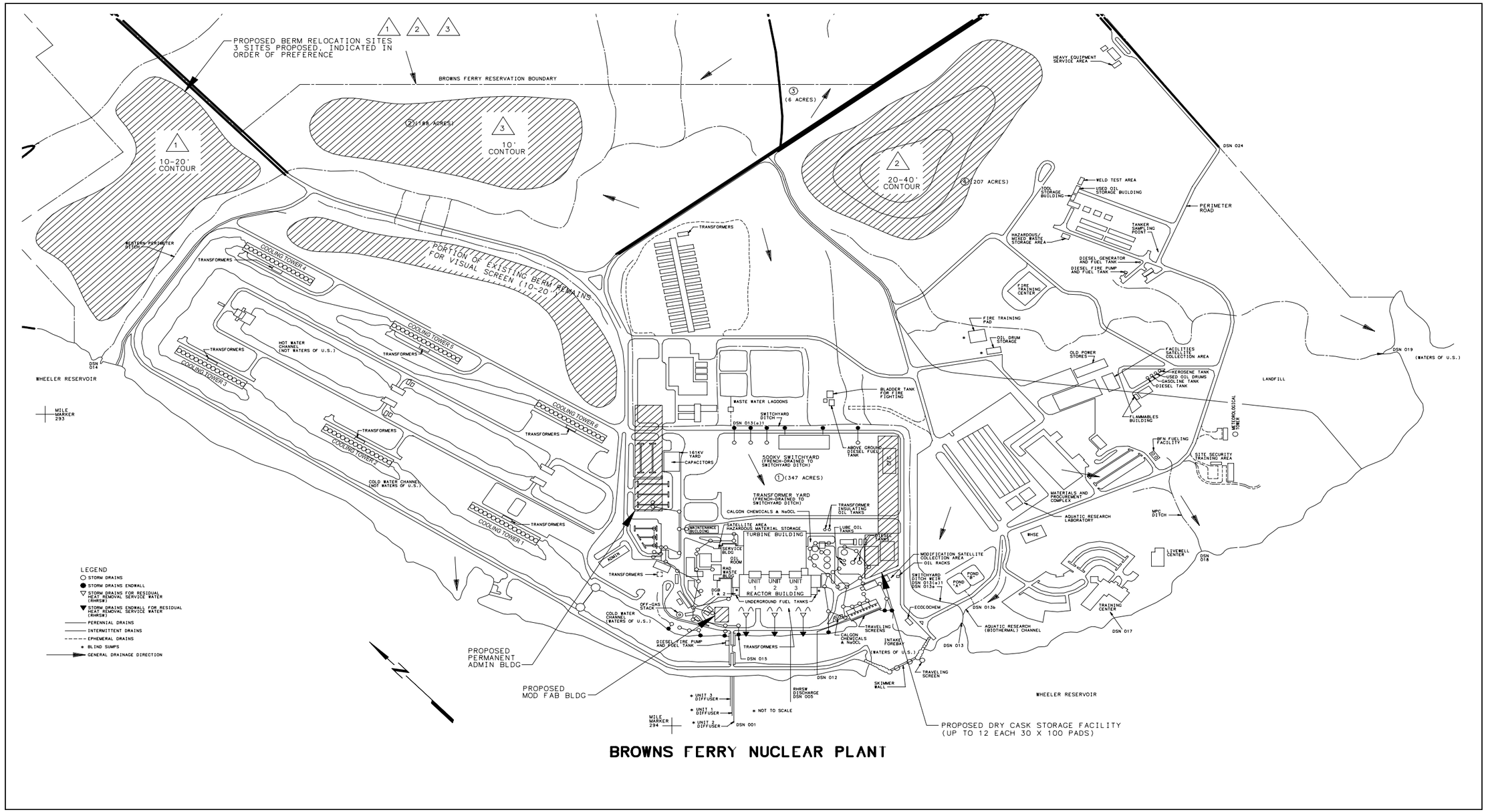
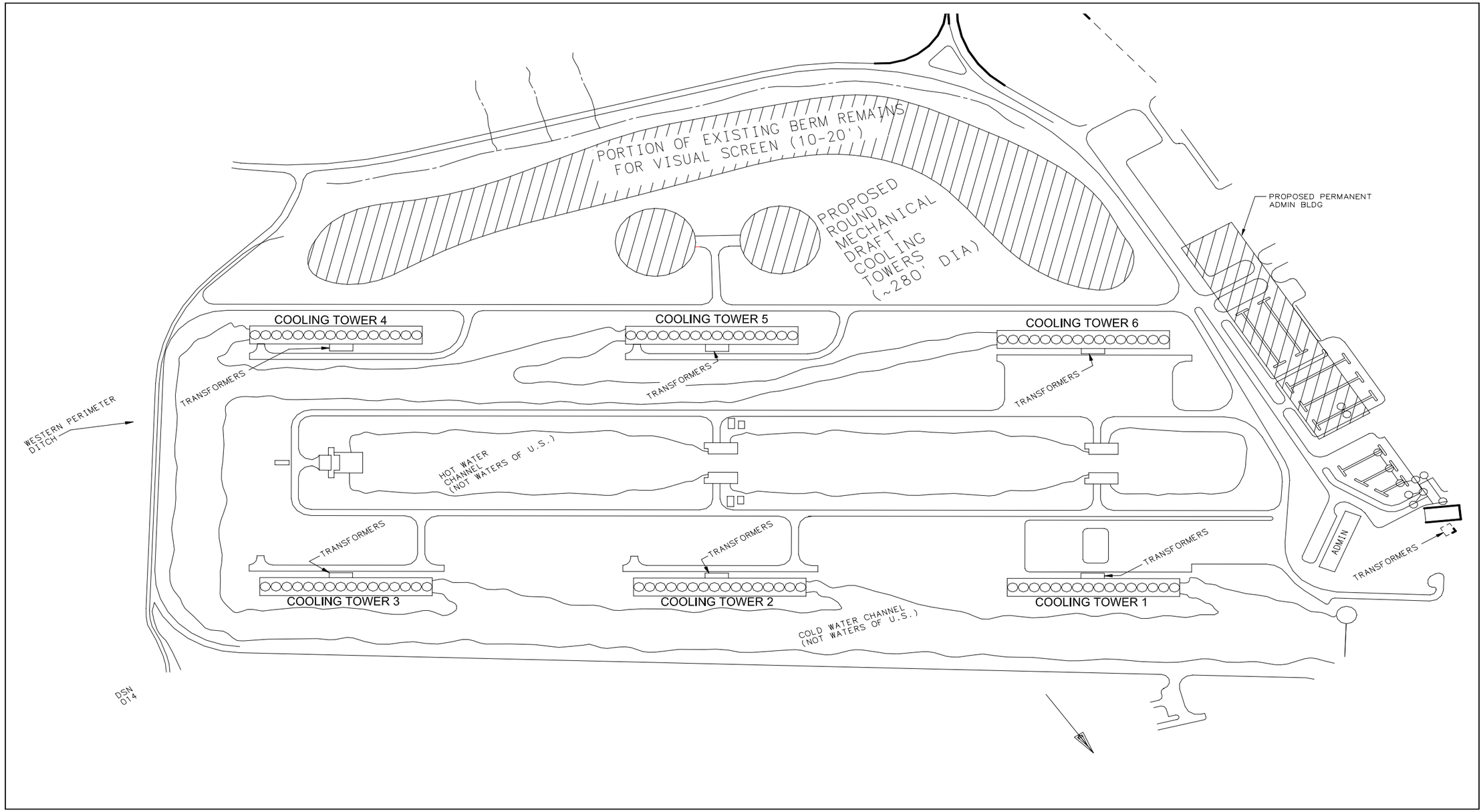


Figure 2.2-8
Location of Cooling Towers for Alternative 2B



ALTERNATIVE 2C: ENLARGED LINEAR MECHANICAL DRAFT COOLING TOWERS OPTION

Alternative 2C is to construct 5 new linear mechanical draft cooling towers and to increase the size of the existing Balcke-Durr cooling tower (tower 3) by 25%. This would be accomplished by demolishing the four existing Ecodyne towers (towers 1, 2, 5, and 6) and replacing them with new and larger linear mechanical draft cooling towers in their approximate locations and in the currently vacant cooling tower location (tower 4), and also by adding cells to cooling tower 3. This alternative would not require removal of a significant portion of the spoils hill adjacent to the cooling towers, but could involve lowering the height of the hill by several feet to decrease wind resistance. Lowering the hill height could be accomplished by recontouring or spoils removal or a combination of the two. Figure 2.2-9 shows the approximate location and footprint of the enlarged cooling towers for Alternative 2C.

ALTERNATIVE 2D: RESTORATION OF SINGLE LINEAR MECHANICAL DRAFT COOLING TOWER

Alternative 2D is to construct a single 20-cell linear mechanical draft cooling tower in the currently vacant position (tower 4) where a tower that was destroyed by an accidental fire in 1986 has never been replaced. This addition of a sixth cooling tower differs from that proposed for Alternative 1 (see above) in that the tower would be somewhat larger than the recently replaced 16-cell linear mechanical draft cooling tower 3. Other characteristics such as general size, appearance, operating sound and emissions, etc., are very similar to or proportionately larger than those of cooling tower 3. This alternative would not require removal of any of the spoils hill adjacent to the cooling towers, but could involve lowering the height of the hill by several feet to decrease wind resistance. Lowering the hill height could be accomplished by recontouring or spoils removal or a combination of the two. Figure 2.2-10 shows the approximate location and footprint of the enlarged cooling tower for Alternative 2D.

Since Alternative 2D does not add as much heat removal capacity as Alternatives 2A, 2B or 2C, the probability of having to de-rate the operating units to meet NPDES discharge temperature limits would increase during summer periods of unusually hot weather.

Figure 2.2-9
Location of Cooling Towers for Alternative 2C

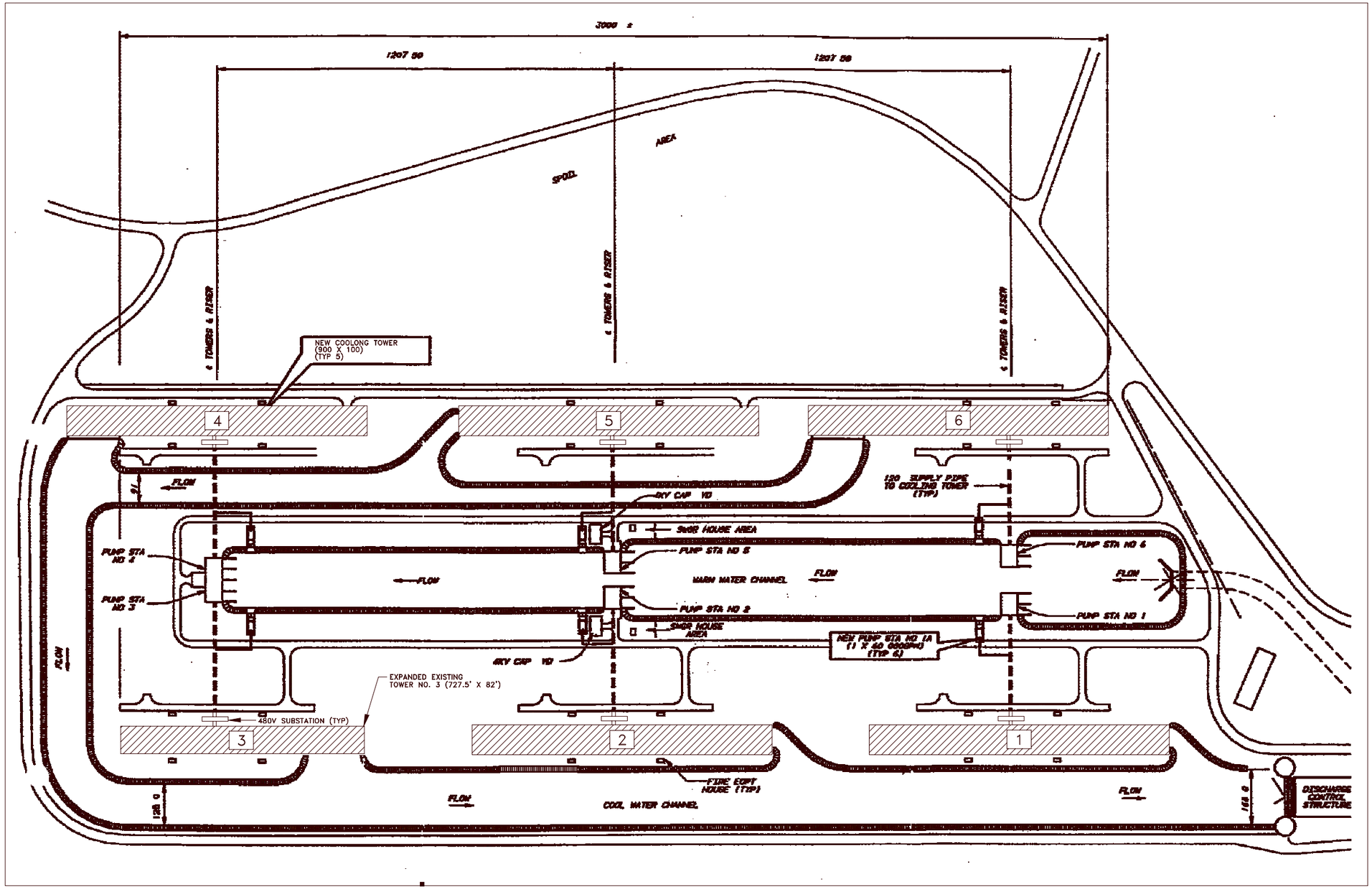
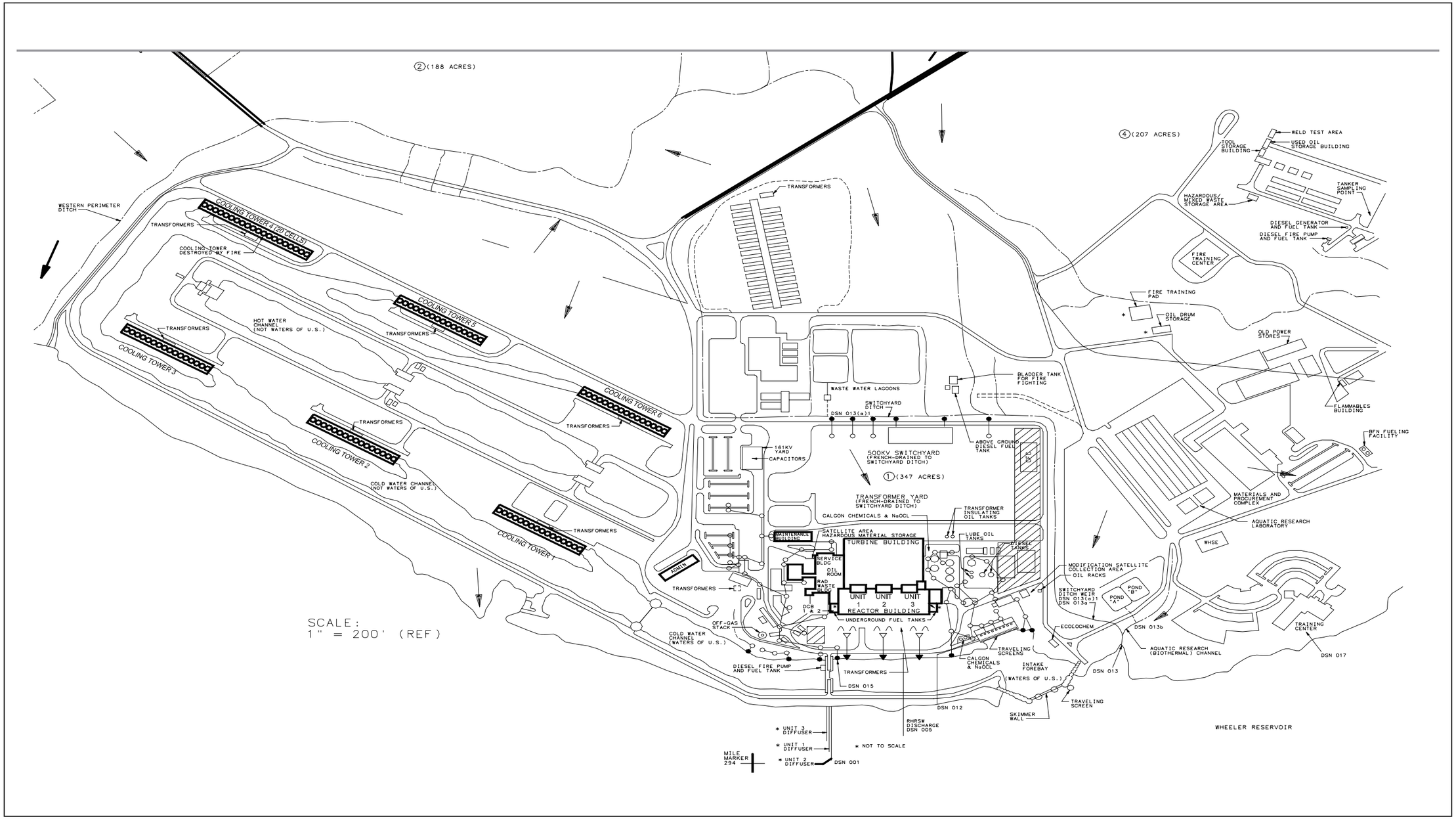


Figure 2.2-10
Location of Cooling Towers for Alternative 2D



ALL ALTERNATIVES: MINIMIZATION OF COOLING TOWER IMPACTS

The primary purpose of cooling towers is to allow BFN to operate during periods of high river temperature in compliance with the NPDES permit limitations which are designed to ensure the protection of a balanced, indigenous population of shellfish, fish and wildlife in Wheeler Reservoir. The cooling towers accomplish this by limiting the temperature of the cooling water returned to the reservoir. In accordance with provisions of section 316 of the Clean Water Act (CWA), BFN currently operates under a permitted thermal limitation set by the ADEM in 1984 which allows thermal discharges up to 90°F (24-hour average), 93°F (1-hour average) with a maximum temperature rise of 10°F. A three-phase biological monitoring program conducted from 1985-1997 evaluated the effect of the thermal discharge on selected species and total standing stocks of fish in Wheeler Reservoir. Baxter and Buchanan (1998) reported results of this work to the State of Alabama as a part of the NPDES permit renewal application, permit number AL0022080, submitted in September 1999. Both the final report and additional analyses submitted with the permit application and request for renewal of the existing permit concluded that the operations of BFN under the current thermal limitations has not had a significant impact on the aquatic community of Wheeler Reservoir, or the specific aquatic species studied.

In addition to BFN specific studies, monitoring initiated in Wheeler Reservoir in 1992 as part of TVA's Vital Signs (VS) Monitoring Program (Dycus and Meinert, 1993) provided an additional measure of quality and health of the ecological community in the vicinity of BFN. The status of existing aquatic communities in Wheeler Reservoir is biennially assessed utilizing three indices, the Reservoir Fish Assemblage Index (RFAI), the Benthic Index of Biotic Integrity (BIBI), and the Sport Fishing Index (SFI). Results since 1992 indicate that the resident ecological community in the vicinity of BFN has been and continues to be of good quality, with no indications of adverse impacts as a result of BFN operation.

For purposes of this SEIS, the cooling tower configurations described above in Alternatives 2A, 2B, and 2C represent the maximum potential change in terms of the number and size of required additional towers. In contrast, Alternative 2D represents the minimum expected additional cooling tower capacity required. The analyses presented in Chapter 4 assume that temperature limits in the current BFN NPDES permit are unchanged and continue to be met for all alternatives via increased cooling tower capacity or de-rating power operation during periods of extreme weather, or both with these alternative configurations.

However, based on ongoing monitoring of the aquatic community in Wheeler Reservoir and hydrothermal characteristics of the reservoir, it may be feasible to provide a reduced amount of additional cooling tower capacity and/or cooling tower operation in an environmentally acceptable manner. The capital and operations & maintenance (O&M) expenses associated with providing additional cooling tower capacity and operation can be very large. If sufficient margin exists in the assimilative capacity of the reservoir to safely discharge a higher level of heat during peak temperature events, opportunities may exist to allow more efficient and cost effective operation of BFN to supply reliable power to TVA customers, while yet effectively protecting aquatic resources. The feasibility of such opportunities requires a detailed evaluation of temperatures, overall water quality, and biological responses in Wheeler Reservoir.

As part of this SEIS, TVA used computational fluid dynamics (CFD) models to assess the potential impact of a reduced amount of additional cooling capacity on water temperatures in the immediate vicinity of BFN. The CFD models were fully three-dimensional and included the full

width and depth of the reservoir, the plant intake skimmer wall, and the plant discharge diffusers. The models covered roughly a 3 mile reach of the reservoir, from about 1.5 miles upstream of the plant to 1.5 miles downstream of the plant. The models included steady flow and incorporated the effects of turbulent mixing, reservoir stratification, and fluid buoyancy. The models were calibrated using data from field measurements to allow predictions of water velocity and water temperature throughout the solution domain (TVA, 2002; Alden, 2002).

Two models were used in the CFD evaluations: a "coarse" version with about 270,000 computational nodes, and a "fine" version with about 2 million nodes. The coarse model was used to identify a range of approaches that potentially may safely allow a reduced amount of additional cooling capacity. The fine model was then used to explore a select few of the approaches in detail. The model simulations were performed for a worst case condition derived from water temperature records spanning years 1969 through 2000. The worst case condition contained the highest observed water temperature in the bottom of Wheeler Reservoir immediately upstream of BFN, and included operation of the plant at full power with three units at EPU.

For these conditions and the approaches considered, the CFD evaluations showed that for cooling capacities less than that of Alternative 2D, BFN may not, without other action, be able to satisfy the requirements for instream water temperature specified in the current NPDES permit. These results confirm what TVA predictions show from other models that are used for long-term simulations of the plant. The ramification is that, during occasional peak temperature events in the summer, and for three units at EPU, BFN would likely need to reduce generation to comply with the current NPDES requirements. This is true even for the capacity of the cooling system of Alternative 2D. However, as discussed in section 2.7 *Comparison of Costs Between Alternatives*, evaluation of the projected amounts and levels of de-rate associated with Alternative 2D has shown that this sub-alternative has the highest net present value and monetary internal rate of return when considering initial construction cost, operating power consumption, and the associated de-rates. If the effect of reduced generation creates future problems for operation of the plant, power system, or river system, TVA may need to revisit the balance between the cooling capacity of BFN and any available margin for waste heat in Wheeler Reservoir. In the event that TVA would choose to do so in the future, a proposal to provide additional cooling tower capacity or request a change in the applicable standard would undergo environmental review through both the NEPA and NPDES permitting processes, as appropriate.

2.2.4 Spent Fuel Storage Options

BFN has been producing power, and consequently, spent nuclear fuel for almost three decades. Considering the Department of Energy's (DOE) delay in receiving utility spent fuel and assuming current operating conditions, BFN Unit 3 is projected to require additional spent fuel storage before November 2005. Thus, spent fuel storage expansion is required significantly before license extension or feasible implementation dates for three-unit operation. In addition, the storage expansion technology proposed for BFN is dry storage, which readily accommodates incremental expansion for increased storage requirements. BFN's proposed plans for a dry storage facility include sufficient expansion room to accommodate uncertainty in the DOE schedule for a national repository and additional storage required for license extension and three unit operation.

In response to the Nuclear Waste Policy Act of 1982 and subsequent amendments, DOE was required to develop a deep, mined geological repository for high-level waste and spent nuclear fuel. The repository was to begin receiving utility spent fuel by January 31, 1998, and based on DOE's last published Acceptance Priority Ranking (DOE/RW0457), was to begin receiving TVA's spent nuclear fuel during the fifth year of repository operation. However, the repository is now at least 12 years behind schedule. BFN is currently storing spent fuel in three spent fuel pools which were each re-racked to a capacity of 3,471 spent fuel assemblies. As a result of the DOE repository delay, Unit 3 is expected to lose full core off-load capability in November 2005.

TVA projects that BFN must increase spent fuel storage capacity by 2005 to avoid impacting plant availability, regardless of license extension or the operations alternative chosen. TVA would utilize the NRC's General License to store spent fuel at an independent spent fuel storage installation (ISFSI). A General License is an option available to all 10 CFR 50 power licensees to store spent fuel outside of the spent fuel pool at an ISFSI. The General License requires use of a fuel storage system that has been previously approved by NRC as demonstrated by issuance of a Certificate of Compliance in accordance with 10 CFR Part 72, Subpart L.

To accommodate the spent fuel storage expansion, TVA has evaluated alternatives to extend the effective life of the BFN spent fuel pools as well as alternatives for additional spent fuel storage capacity. Alternatives considered to extend pool life were fuel rod consolidation and increasing storage rack capacity. Alternatives evaluated for additional spent fuel storage capacity included dry storage modules, building an additional spent fuel pool, and transshipment of spent fuel to another TVA or private storage facility for temporary storage. None of these alternatives appear to be environmentally advantageous compared to the dry cask storage alternative.

Fuel rod consolidation requires disassembly of the fuel bundles; placing fuel rods in a close packed consolidation canister, compacting the skeleton materials and placing them in a separate canister and disposing of inserts (e.g., control rods, burnable poison, thimble plugs). The amount of storage increase depends on compaction ratios and arrangements that can be made for storing and/or disposing of skeleton materials and fuel inserts. This option is currently not acceptable for receipt as a standard fuel package at a DOE repository, such as Yucca Mountain, and some utilities have already elected to repackage the individual rods back into spacer grids. Also, there is no standard process for rod consolidation currently available for use in the nuclear industry, and there is no practical shipping cask to receive and store consolidated fuel rods for eventual shipment.

Increasing storage rack capacity can be accomplished by re-racking the fuel pool or adding racks in peripheral spaces around the pool. Re-racking adds additional storage spaces when the replacement racks have a higher cell density (closer array). In order to effectively utilize the highest density racks, credit for fuel burnup must be applied to the criticality analysis. However, these options do not significantly increase storage capacity and therefore they only provide a short delay in the eventual need for a larger storage option. Also, refueling risks would be increased by doing these modifications simultaneously with normal plant refueling operations.

Building an additional spent fuel pool was determined to be significantly more expensive than the other options. Also, moving a large quantity of fuel from existing pools to a new pool is very expensive and time consuming because it requires use of a special shipping cask (which is filled and lifted above the existing pool, decontaminated, then moved to where it can enter the new pool to be emptied).

Transshipment within TVA is not currently a viable option because there is not adequate space available at any of the TVA licensed facilities. In addition, this option would involve significant transport expense. Transshipment to a private fuel storage facility is not currently an option because no such facility exists, but it is also projected to be very expensive in terms of both storage costs and transport costs. Furthermore, private fuel storage may only be temporary (20 years or so); afterwards the spent fuel might have to be returned to TVA if a permanent repository or reprocessing facility is not available.

The BFN ISFSI would result in aboveground storage of spent fuel in dual-purpose metal (non-canister) casks or modular metal canisters with concrete overpacks. These dual-purpose storage modules are licensed by NRC for both storage and transportation of spent nuclear fuel. In addition to being the most economical option, there are several other reasons why dry storage is the most viable alternative. Dry spent fuel storage is a proven technology that is already in use at 18 U. S. nuclear power plants, and additional ISFSIs are in various stages of completion at other sites. The NRC and the utility industry project that dry storage will be in use at more than 55 reactors by the time the BFN ISFSI would be completed. Secondly, dry storage in dual-purpose storage modules minimizes BFN efforts in preparing fuel for shipment when a DOE repository is available. Lastly, procurement of additional storage modules can be accomplished incrementally (i.e., the size can be expanded as needed). Current BFN dry storage plans would provide adequate space for future ISFSI expansion sufficient to assure storage capacity for all action alternatives (i.e., license extension for two- or three-unit operation at EPU) as well as additional delays in the DOE spent fuel repository. Therefore, this technology would assure life-of-plant capability regardless of DOE schedules or plant operations changes.

As a result of these evaluations, the preferred method for assuring adequate spent fuel storage capacity at BFN is dry storage (i.e., an ISFSI).

2.2.5 Decommissioning Options

Under all of the alternatives (No Action and the Action Alternatives), TVA would eventually have to decommission the plant at the end of the units' operating licenses. Decommissioning decisions and actions would have to be made sooner under the No Action Alternative than under the Action Alternatives. When a decommissioning option is proposed in the future, appropriate environmental reviews would be conducted. Because decommissioning is common across all of the alternatives for this SEIS, a general description of decommissioning is provided. TVA currently has no preference among decommissioning options and is not proposing one now.

To decommission a nuclear power plant, the radioactive material on the site must be reduced to levels that would permit termination of the NRC license. This involves removing the spent fuel (the fuel that has been in the reactor vessel), dismantling any systems or components containing activation products (such as the reactor vessel and primary loop), and cleaning up or dismantling contaminated materials. All activated materials generally have to be removed from the facility and shipped to a waste processing, storage or disposal facility. Contaminated materials may either be cleaned of contamination onsite, or the contaminated sections may be cut off and removed (leaving most of the component intact in the facility), or they may be removed and shipped to a waste processing, storage or disposal facility. The licensee decides how to decontaminate material, and the decision is usually based on the amount of contamination, the ease with which it can be removed, and the cost to remove the contamination versus the cost to ship the entire structure or component to a waste-disposal site.

The NRC has evaluated the environmental impacts of three general methods for decommissioning nuclear power facilities: DECON, SAFSTOR, and ENTOMB (see below for definitions). The licensee (TVA) will decide how to decommission the BFN site, but NRC regulations currently state that decommissioning must be completed within 60 years of permanent cessation of operations. The choice of decommissioning options is strongly influenced by potential uncertainties in low-level waste disposal costs and by concerns over the future availability of low-level waste sites.

For the DECON option, the equipment, structures, and portions of the facility and site that contain radioactive contaminants are removed or decontaminated to a level that permits termination of the license shortly after cessation of operations. The DECON option calls for prompt removal of radioactive material to permit restricted or unrestricted access. The advantages of DECON include the following:

- facility license is terminated quickly, and the facility and site become available for other purposes,
- availability of the operating reactor work force that is highly knowledgeable about the facility,
- elimination of the need for long-term security, maintenance, and surveillance of the facility, which would be required for the other decommissioning alternatives,
- greater certainty about the availability of low-level waste facilities that would be willing to accept the low-level radioactive waste, and
- lower estimated costs compared to the alternative of SAFSTOR, largely as a result of future price escalation because most activities that occur during DECON would also occur during the SAFSTOR period, only at a later date. (It is anticipated that the later the date for completion of the decommissioning, the greater the cost.) Some of these increases may well be offset by technological advances during the SAFSTOR period.

The disadvantages of DECON include the following:

- higher worker and public doses (because there is less benefit from radioactive decay such as would occur in the SAFSTOR option),
- a larger potential commitment of disposal-site space than for the SAFSTOR option, and
- the potential for complications if spent fuel must remain on the site until a Federal repository for spent fuel becomes available.

For the SAFSTOR option, the facility is placed in a safe stable condition and maintained in that state until it is subsequently decontaminated and dismantled to levels that permit license termination. During SAFSTOR, a facility is left intact, but the fuel has been removed from the reactor vessel, and radioactive liquids have been drained from systems and components and then processed. Radioactive decay occurs during the SAFSTOR period, thus reducing the quantity of contaminated and radioactive material that must be disposed of during decontamination and dismantlement. The benefits of SAFSTOR include the following:

- a substantial reduction in radioactivity as a result of the radioactive decay that results during the storage period,
- a reduction in worker dose (as compared to the DECON alternative),
- a reduction in public exposure because of fewer shipments of radioactive material to the low-level waste site (as compared to the DECON alternative),
- a potential reduction in the amount of waste disposal space required (as compared to the DECON alternative),
- lower cost during the years immediately following permanent cessation of operations,

- a storage period compatible with the need to store spent fuel onsite, and
- more time to benefit from growth in the decommissioning trust fund.

Disadvantages of SAFSTOR include the following:

- shortage of personnel familiar with the facility at the time of deferred dismantlement and decontamination,
- site unavailable for alternate uses during the extended storage period,
- uncertainties regarding the availability and costs of low-level radioactive waste sites in the future,
- continuing need for maintenance, security, and surveillance, and
- higher total cost for the subsequent decontamination and dismantlement period (assuming typical price escalation during the time the facility is stored), but this will be offset to some extent by reduced disposal volumes resulting from radioactive decay.

For the ENTOMB option, radioactive structures, systems, and components are encased in a structurally long-lived substance, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level that permits termination of the license. The benefits of the ENTOMB process are primarily related to the following:

- reduced amount of work in encasing the facility in a structurally long-lived substance, and
- reducing the worker dose resulting from decontaminating and dismantling the facility.
- In addition, public exposure from waste transported to the low-level waste site would be minimized.

The ENTOMB option may have a relatively low cost.

Disadvantages of ENTOMB include the following:

- Because most power reactors will have radionuclides in concentrations exceeding the limits for unrestricted use even after 100 years, this option may not be feasible under the current regulations. (This option might be acceptable for reactor facilities that can demonstrate that radionuclide levels will decay to levels that will allow restricted use of the site.)
- Although three small demonstration reactors have been entombed, currently no licensees have proposed the ENTOMB option for any of the power reactors undergoing decommissioning.

Discontinuing operation of BFN at the end of the existing licenses and initiation of decommissioning would likely allow some other commercial or industrial use of part of the BFN site in the future. This would ameliorate to some extent the socioeconomic impacts of loss of employment at BFN. This might include use of the site for electric power generation. Such uses are not reasonably foreseeable at this time and any such future use would require its own environmental review.

2.3 Description of Actions Common to All Action Alternatives

2.3.1 Extended Power Uprate

Following completion of an Environmental Assessment (TVA, 2001), the TVA Board approved the EPU project for BFN Units 2 and 3 on April 18, 2001. Using engineering methodology developed by General Electric and approved by the NRC, this project will allow the BFN units to achieve an estimated 10% increase (i.e., 116 more megawatts per unit) in electrical power generation. Both Units 2 and 3 are scheduled to be operating with the increased generation in early 2005. Therefore, for purposes of this SEIS, EPU is assumed to be in place as part of the current baseline for proposed actions to relicense Units 2 and 3. If Unit 1 is recovered and restarted, it would also be operated at EPU conditions and the environmental consequences of this are addressed in the SEIS.

Similar to EPU for BFN Units 2 and 3, EPU of Unit 1 would allow operation at 120% of its originally licensed reactor thermal power level (i.e., 120% of 3,293 Megawatt thermal (MWt) is 3,952 MWt). For EPU, however, preliminary evaluations indicate that, due to generator limitations of no more than 1,280 Megawatt electrical (MWe), the BFN reactors will be operated at slightly less than the full 120% thermal power increase. As for Units 2 and 3, affected Unit 1 plant systems would be further analyzed to determine what modifications would be required to support changes in system operating parameters. Plant equipment, such as the main turbine and associated pumps and valves, will likely require modifications to accommodate the increased power generation, but any such modifications would occur within the plant site and are expected to have no or only minimal environmental impacts.

Also similar to the EPU project for Units 2 and 3, a new Unit 1 operating philosophy would be established whereby reactor power would be adjusted as seasonal changes in river temperature affect the overall efficiency of the turbine to maintain generator output at its present maximum allowable level (approximately 1,280 MWe) throughout the year. This new approach means that at times during the year, reactor steam and feedwater flow could approach levels of 120-122% of the original operating basis. To accommodate the increased reactor steam and feedwater flow and to accommodate the increased heat rejected, the following modifications to plant equipment are expected to be necessary; their exact nature would be determined after more detailed engineering evaluations are completed.

- modifications to the high pressure turbine steam path,
- modifications to the reactor feed pump turbines,
- installation of higher horsepower condensate pump motors,
- modifications to the condensate demineralizer system,
- installation of new heater drain valves,
- increased cooling tower capacity, and
- possibly some miscellaneous safety system setpoint changes.

As was documented in the Environmental Assessment for EPU on Units 2 and 3, minor impacts would occur with implementation of Unit 1 EPU compared to restarting Unit 1 without EPU. Some of the plant modifications required to implement the EPU, and the construction activities associated with cooling tower capacity expansion, may result in the generation of small amounts

of hazardous and solid wastes. BFN currently has in place the necessary procedures and contracts for proper disposal of both types of wastes. The capacity of the BFN landfill and the local landfills is adequate to accommodate the additional solid waste.

The increased thermal power proposed for EPU will result in an increase of approximately 2.3 degrees in the temperature of the circulating water leaving the main condenser (for each operating unit) from that currently experienced. This increase in discharge temperature will result in increased cooling tower usage during summer periods to maintain compliance with the discharge limitations. Cumulative impacts to aquatic communities by operation of all three units at uprated power levels are addressed in Chapter 4. No changes are expected to be required to the plant intake system or to the individual unit intake flow rates as a result of the EPU project. However, as previously noted, due to various equipment and system upgrades and improved calibrations since initial operation of the BFN units, the total amount of water withdrawn from the river for three unit operation would no longer remain within the levels evaluated during the original EIS analysis. Therefore, the potential impact of increased total intake flow on the reservoir is addressed in Chapter 4

As compared to past three-unit operations, potential radiological effects from operation of BFN Units 1, 2, and 3 under EPU will not significantly change the maximum projected annual dose or cumulative dose over time to the public resulting from plant radioactive effluents. Radiological doses for extended power uprate conditions will be well below the regulatory limits and should have no effect on human health.

An amendment to the operating licenses for the BFN units from the NRC would be required before EPU can be implemented.

2.3.2 Dry Cask Storage Facility

Even without license extension or Unit 1 restart, BFN requires expansion of spent fuel storage capacity as a result of DOE's delay in receiving utility spent fuel. The site's spent fuel pools are slowly being filled, and as noted in section 2.2.4, Unit 3 will lose full core off-load capability in November 2005. In response, BFN is planning to implement new spent fuel storage capacity during 2005 in order to avoid impacting Unit 3 availability.

Dry Cask Storage at BFN consists of building a secured fenced-in concrete storage pad in phases or sections. The current dry cask storage schedule calls for being able to begin storing fuel in 2005. Putting EPU on a fast track is not expected to impact the current dry cask storage completion schedule. This project would be required with or without EPU, license renewal, or Unit 1 recovery, but there is a strong linkage in that the size requirement for the total pad storage area is directly a function of all three. The pad is being designed to be large enough to accommodate all known requirements, and would be kept functional as a back-up even if the Yucca Mountain or some other DOE repository begins operation.

Concrete for pad construction would most likely be trucked in, rather than building a batch plant on site, because there is probably not enough volume to justify a dedicated facility. There is a nearby batch plant in Athens. (Even with a site batch plant, however, the concrete ingredients (sand, gravel, cement) would still have to be trucked in.) The pad sections would need about 60 concrete truckloads each, or about 360 truck trips for Phases 1 and 2. Phase 3 would involve 180 truck trips, but it may not be completed until 15 years later (2020). It is possible that the access

road around the river side of the plant may first have to be "hardened" where it passes over underground pipes, which could add approximately 100 truck trips. The trucks have wide tires to minimize ground loading. Building the pad sections for Phases 1 and 2 would involve approximately 20 workers for one month, near the end of 2003 or the beginning of 2004.

Each pad section would be on the order of 40 feet wide by 120 feet long by 3 feet thick, with each pad section separated by approximately 20 feet. Some amount of soil underneath would probably first be removed and then "re-engineered" (re-formulated and then re-installed and compacted). The underlayment and concrete composition of the pad sections are carefully controlled to meet seismic and energy absorption design requirements; such that tip over of a storage cask can be safely accommodated.

2.3.3 Modifications Fabrication Building

The location for the new dry cask storage facility (Figure 2.2-3) would require tearing down the existing Modifications Fabrication Building. However, the old building would not have to be displaced until approximately 2008, which is expected to be well after the new Modifications Fabrication Building would be operational. Although the primary motivation for erecting a new Modifications Fabrication Building is to make room for the new dry cask storage facility, initially it would be used for Unit 1 recovery. In fact, a decision to recover Unit 1 would essentially require work to begin on the new Modifications Fabrication Building almost immediately. The new building would be completed and occupied within 12 to 18 months after a decision is made to pursue Unit 1 recovery. Compared to the existing Modifications Fabrication Building, this new building would be larger and more flexible in the number and kind of activities it can house.

The new Modifications Fabrication Building would be designed as light commercial grade construction. It would be largely prefabricated, involving delivery of prefabricated items, concrete, and other construction materials. Construction of this new building would involve no more than 8 or so truckloads of concrete, 6 to 8 gravel truckloads, and less than 4 truckloads of various other building materials (one of construction steel, 3 for items such as sheetrock, electrical, plumbing, etc.). The number of workers would peak at 12, but no more than 8 would normally be on site simultaneously.

2.4 Description of Actions Specific to Associated Alternatives

2.4.1 Extended Operation of Units 2 and 3

Concurrent with development of this SEIS, initial work scoping and screening of plant components requiring aging management reviews has begun to better determine the feasibility of license renewal for the BFN units. No operational changes or physical work will be performed under the License Renewal process. If the need for any hardware changes, document processes or procedure changes is identified, the changes will be performed and controlled under the appropriate change process.

The work, being largely analytical in nature, will be done primarily by TVA's Nuclear Engineering staff in Chattanooga, with on-site support at BFN. The total staffing is projected to peak at 30 full-time equivalent (FTE) individuals in April of 2002, and thereafter gradually reduce to about 10 FTE in the final year (2005). At any given time, approximately two-thirds of the assigned staff will be Chattanooga and one-third at the site.

BFN is one of several U. S. nuclear plants that have initiated programs to explore the feasibility of license renewal, and some of those programs are much further along than their counterpart efforts at TVA. In fact, as of March 2002, ten utilities have already submitted applications and four of them (Calvert Cliffs Units 1 and 2, Oconee Units 1, 2, and 3, and Arkansas Nuclear One, Unit 1, and Hatch Units 1 and 2) have already been reviewed and approved by the NRC. Using this large body of experience, the following projections can be made regarding the anticipated results of comparable efforts at BFN.

License Renewal of BFN Units 2 and 3 for a 20-year period of extended operation beyond the current operating license expiration dates is not expected to require any replacement of equipment beyond possibly some electrical cables which undergo normal aging at ambient environment conditions. Nor is it expected that any major refurbishment of equipment would be necessary outside of what is already periodically scheduled for normal wear. The only equipment additions that might possibly result from the license renewal effort are those associated with modifications originating from Severe Accident Mitigation Alternatives (SAMA) (i.e., beyond design basis accidents) analyses. Experience to date at other nuclear plants indicates that changes resulting from SAMA analyses are few and relatively minor in nature.

As explained earlier, continued operation of Units 2 and 3 with renewed licenses would be at EPU levels. No transmission facility modifications or additions would be required to extend operation of BFN Units 2 and 3.

2.4.2 Extended Operation of Units 2 and 3 Plus Recovery and Restart of Unit 1

This alternative is the same as that for Extended Operation of Units 2 and 3, except that recovery and restart of Unit 1 is also completed; probably, but not necessarily, prior to expiration of its current operating license in 2013. In any event, the environmental impact of recovering, restarting and operating Unit 1, while Units 2 and 3 are continuing to operate, is analyzed in this SEIS. Operation of any and all BFN units would be at EPU levels.

In order to better understand what would be involved in recovering and restarting Unit 1, the following historical perspective is provided on past problems encountered at BFN and the experience gained in correcting those problems and recovering and restarting Units 2 and 3.

Units 1 and 3 were voluntarily shut down by TVA in March 1985, because of questions about the primary containment isolation leak rate testing for Unit 1 and reactor water level instrumentation for Unit 3. Unit 2 was in a refueling outage at that time. These specific concerns for Units 1 and 3 were resolved, but during this 3-unit shutdown, an expanded approach to resolving questions about the environmental qualification of electrical equipment resulted in extending the outages. Additional questions and concerns were subsequently raised about the overall adequacy of TVA's nuclear program, and BFN Units 2 and 3 remained shutdown until adequate corrective actions

were defined and completed to address the root causes of TVA's nuclear program problems. The corrective actions included both managerial improvements and plant hardware changes.

The managerial improvements included organizational changes compatible with corporate level restructuring, improved management control and involvement, revised conduct of design control, and programs to ensure employee confidence. Particularly noteworthy were the design control improvements that addressed a number of problems that had resulted from inadequately analyzed or documented design control and poor coordination between the engineering design and the modification process. The Design Baseline Verification Program was instrumental in re-establishing confidence and continuity between the current design and actual ("as-built") field configuration.

Special programs were defined and carried out to resolve a number of plant hardware issues for Units 2 and 3, including environmental qualification of electrical equipment, seismic design basis adequacy of suspended components, fire protection compliance with current industry standards, adequacy of past welding practices and installed welds, primary system pressure boundary susceptibility to intergranular stress corrosion cracking, safety-related instrument sensing line installation (i.e., slope, separation, material, fabrication, etc.), piping wall loss due to erosion-corrosion, safety-related qualification of past and present piece part procurements, and capability of electrical switchgear to mitigate safe shutdown design basis events. These programs resulted in a large number of plant modifications to improve nuclear safety, which were delineated in the Nuclear Performance Plan, Volume III (Browns Ferry); (TVA, 1988).

Unit 2 recovery was accomplished and the unit was restarted on May 24, 1991. In a letter to NRC dated July 10, 1991 (TVA, 1991), TVA proposed the overall regulatory framework for the restart of Units 1 and 3, which was based largely on the work experience of recovering and restarting Unit 2. This letter reiterated the commitment that TVA would not restart BFN Units 1 and 3 without prior NRC approval, and summarized the programmatic and equipment issues and programs requiring satisfactory resolution prior to startup.

Unit 3 was subsequently restarted on November 19, 1995, but as described in *Energy Vision 2020*, the decision was made to not proceed with recovery efforts on Unit 1 because the economic climate had changed, the projected costs and cost uncertainties were large, and there were other more cost-effective means available at that time to meet baseload power demands. Since *Energy Vision 2020* was issued, the overall performance of TVA's nuclear plants has improved dramatically in terms of both production costs and power availability/capacity factor, and relative cost benefit compared to other candidate sources of bulk power.

No substantial ecological impacts were associated with recovery of Units 2 and 3. Site worker population was temporarily increased to a peak of approximately 4,500, requiring placement of temporary office trailers (which were removed after the units were restarted) and increased load on the waste water treatment plant. At the conclusion of the recovery work, some other older existing temporary office buildings were also removed. The large influx of personnel also temporarily impacted local roads and facilities such as schools, and a new off-site office building was constructed in Athens for some of the workers.

No substantial non-radioactive waste was generated as a result of recovery of Units 2 and 3, although at the conclusion of the work, one site temporary office building was demolished and placed in the site land fill. Radioactively contaminated waste generated during the recovery work was shipped to the permanent low-level waste repository in Barnwell, South Carolina; these

materials (predominantly steel and other fabricated metals) resulted from control rod drive changeout, reactor recirculation piping replacement, cleanout of miscellaneous parts and pieces stored in the spent fuel pool, and various C-zone activities (booties, gloves, tape, rags, etc.). It is anticipated that recovery and restart of Unit 1 would have similar environmental consequences.

2.4.2.1 Restart of Unit 1

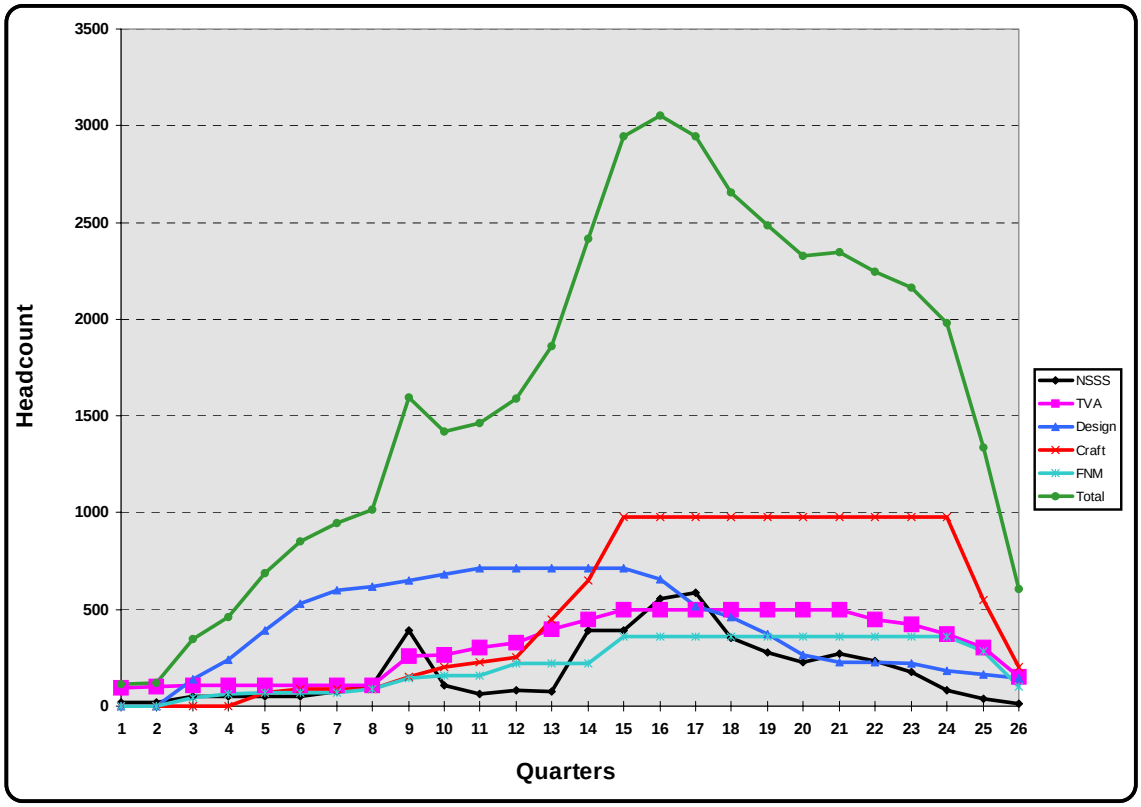
Recovery of Unit 1 for restart would be a substantial operation involving a large workforce over a time span of 5.5 years. The total number of workers (crafts, field supervisors, engineers, and managers) would peak at approximately 3,000, but some of these would remain at their parent company offices and not be re-located to the BFN site. Figure 2.4-2 illustrates how the BFN Unit 1 recovery staffing head count changes over the life of the project. As is typical with large projects, the total number of workers climbs to a peak and then begins to decrease as recovery efforts near completion. If Unit 1 is fully recovered the projected increase in permanent BFN staff required to maintain and operate the unit is 150 individuals.

The Unit 1 recovery project may be described chronologically in terms of the following phases, each with some overlap: planning (including worker facilities); engineering reanalysis; construction/modifications; turnover to operations and testing of restored systems, and commercial operation. Some of the planning and reanalysis work has already been initiated to support this SEIS and to better define the cost estimate.

To a large degree, the work involved in recovering Unit 1 is similar to the work scope previously experienced in recovering Units 2 and 3. As previously described, considerable reanalysis was involved in updating the Unit 2 and Unit 3 design basis to current standards and re-establishing consistency between design control drawings and actual installed equipment configuration. Similarly, a large amount of this same work for BFN Unit 1 recovery would be analytical in nature and would result in changes to drawings and other design basis documentation. It would also likely result in a large number of modifications and equipment changes internal to the plant, but the impact on the air, land, and water environment surrounding the facility is expected to be negligible.

In addition to the plant changes, which would be confirmed by the reanalysis, based on both the experience from recovery of Units 2 and 3 and the known equipment status of Unit 1, the planned Unit 1 work also includes a number of specific equipment additions, replacements and refurbishments. Equipment additions or changes include such things as Hydrogen Water Chemistry system, Control Rod Drive seismic restraints, 416/480V Shutdown Transformer and Control Bay Vent Board feed, Condenser Circulating Water Debris Filter, Site Sewer System augmentation, back-up Post-Accident Auxiliary Power System sequencing logic, Auxiliary Decay Heat Removal System connections, Balance-of-Plant Battery Load re-allocation cables, Auxiliary Trip Unit Inverters and Power Supply. The only environmental impacts associated with these additions or changes would be transportation into the site of material or equipment and eventual disposal via maintenance or decommissioning. Additional cooling tower capacity is a possible exception and is addressed separately under each specific Alternative 2 subsection.

Figure 2.4-2 Browns Ferry Unit 1 Recovery Staffing Plan



Notes to Figure 2.4-2:
NSSS = Personnel from the Nuclear Steam Supply System (i.e., reactor) vendor, General Electric.
TVA = Tennessee Valley Authority employees assigned to the project.
Design = Design contract personnel, typically from a large architectural engineering firm.
Craft = Predominantly local construction trades craftspersons (electricians, boilermakers, carpenters, etc.)
FNM = Field Non-Manual personnel such as craft supervisors, foremen, work planners, etc.
Time Scale = Calendar quarters, showing both gradual increase prior to start and gradual decrease during completion of pre-operational testing.

For equipment replacements, an added consideration is the disposal of the original items, which in some cases might involve decontamination and/or eventual shipment to a low-level radioactive waste facility. Some highly radioactive waste items may remain on site until a repository for high-level radioactive waste (such as the one at Yucca Mountain, Nevada) becomes available. Most often there will be some minor amount of scrap fabricated steel components and housings, electrical and piping connections, etc., requiring disposition. Equipment replacement primarily addresses obsolete items, but it can also include replacement of items scavenged for operation and/or maintenance of Units 2 and 3 such as feedwater heater level control components.

Refurbishments may result in producing other materials requiring disposal besides scrap metal, such as decontamination chemicals used to reduce thin-film radioactivity in piping and equipment and thereby limit worker radiation exposure.

Table 2.4-1 lists some of the major hardware impacts associated with Unit 1 recovery, together with any disposal considerations involved.

Table 2.4-1 Hardware Impacts Associated with Unit 1 Recovery	
Physical Change	**Disposal Consideration**
[1]Pipe replacement	scrap steel (some contaminated)
Piping hangars and supports	scrap steel (some contaminated)
[2]Control Rod Drive (CRD) replacement	contaminated scrap steel (from drywell)
[3]CRD Hydraulic Control Unit refurbishment	scrap metal
RHR pump impeller replacement	contaminated scrap steel
RHR Service Water pipe loop replacement	scrap steel
Possible Rx Vessel Internals repair/replace.	scrap metal (low level radioactive waste)
Possible Shroud Head Bolt replacement	contaminated scrap steel
Turbine Generator refurbishment	contaminated misc. maintenance materials
Miscellaneous valve replacements	scrap steel (some contaminated)
Generator Field upgrade	misc. wiring & conductor supports
Ampacity Study cable replacements	scrap cable (some abandoned in place)
Shutdown Buswork Cabling upgrade	scrap cable
Bus Tie Board/Cooling Tower cable replace.	scrap cable
Inter-Unit DG Bus Tie cable replacement	scrap cable
Chemical decontamination of piping	mixed chemical waste
Low Power Range Monitor upgrade	scrap contaminated cables and connectors
Power Range Neutron Monitor upgrade	scrap detectors (low level radioactive waste)
High Pressure Coolant Injection upgrade	scrap instruments & controls, piping & hangars
Traveling In-core Probe logic upgrade	scrap switches & controls (possibly contaminated)
Control Rod Blade (possible) changeout	scrap metal components (high level rad waste)
Feedwater Nozzle Thermal Monitor upgrade	contaminated scrap steel, wiring & connectors
Feedwater Control upgrade to digital	scrap instruments & controls
Rx Fdwtr Pump min. flow valve replacement	contaminated scrap steel and connectors
Refueling bridge control replacement	scrap instruments & controls
Recirculation Flow Control upgrade to digital	scrap instruments & controls
ECCS Suction Strainer replacement	contaminated scrap steel
Main Steam Ruggedness upgrades	scrap steel

Table 2.4-1 (continued) Hardware Impacts Associated with Unit 1 Recovery	
Physical Change	**Disposal Consideration**
Main Steam Tunnel cooling system upgrade	misc. scrap equipment (potentially contaminated)
Moisture Separator Level Control upgrade	misc. scrap equipment (potentially contaminated)
Electrohydraulic Control electronics upgrade	scrap instruments & controls
Possible Main Bank Transformer replacement	scrap steel and conductors (mineral oil insulated)
4kV Breaker replacement (new Siemens units)	scrap steel and conductors
Load Sequence Timer replacement	scrap controls
Load Shed Logic upgrade	scrap controls
Generator Breaker upgrade	scrap steel and conductors

[1]Pipe replacement involves those portions of various plant systems which are susceptible to inter-granular stress corrosion cracking, including the suction, discharge, risers, and ring header of the reactor recirculation piping; reactor water clean-up system (RWCU); core spray system; and residual heat removal (RHR) system. Included in this effort is re-routing of the RWCU piping to allow the RWCU pumps to operate at lower temperatures.
[2]CRD replacement scope includes replacement of the existing 185 Boiling Water Reactor (BWR)-4 drives with new upgraded BWR-6 drives.
[3]For the CRD Hydraulic Control Unit refurbishment, the scram valves and scram pilot valves will need to have rubber parts replaced because of shelf life considerations and some accumulators will need to be replaced due to pitting corrosion.

2.4.2.2 New Administration Building

Unit 1 is adjacent to buildings that house plant personnel. Operation of Unit 1, especially with the hydrogen injection water chemistry process currently employed in Units 2 and 3, would result in plant personnel dose rates which would be higher than that which could reasonably be achieved by relocating plant operating staff offices. Therefore, construction of a new Administration (office) Building located further from Unit 1 is being considered as a possible means of minimizing dose to site workers at BFN.

A decision to recover Unit 1 would require work to begin on a new Administration (office) Building almost immediately (Figure 2.2-3). The new office building would be required to house existing plant staff so that space could be freed up in the existing office buildings to house the incoming Unit 1 team. The new office building would be expected to be completed and occupied within 12 to 18 months after a decision is made to pursue Unit 1 recovery. After completion of Unit 1 recovery, the existing (old) office buildings would be kept for use during outages. The new office building would house almost all site office staff, approximately 514 individuals.

The new two-story office building would consist of light commercial grade construction, and would be largely prefabricated, involving delivery of prefabricated items, concrete and other construction materials. The new office building would require 40 or so truckloads of concrete, 30 to 40 gravel truckloads, less than 20 truckloads of various other building materials (5 of

construction steel, 15 for items such as sheetrock, electrical, plumbing, etc.). The number of workers would peak at 60, but no more than 40 would normally ever be on site simultaneously.

2.4.2.3 Power Transmission System Impacts

TVA has analyzed the transmission line condition and loading in the vicinity of the BFN site, and has determined that restart of Unit 1 at EPU would require additional 500-kV circuit breakers to be installed in the existing 500 kV switchyard, and several 161-kV transmission lines are projected to become overloaded due to single contingency events. Line uprates (i.e., retensioning or increasing tower height or adding towers as necessary to maintain height clearances of conductors which warm and sag under higher power loading), reconductoring (i.e., increasing conductor size), the addition of a second 500-161kV transformer bank at the Madison 500kV substation, or other solutions would be required to correct these overloads. A Static Var Compensator and Capacitors will also be needed for regulating system voltage. These upgrades and equipment additions involve existing facilities with available spaces; any associated environmental impacts would be minimal. There would be no need to obtain new right of ways or construction of new transmission lines under any of the alternatives.

2.5 Summary of Proposed Alternatives

Table 2.5-1 summarizes key aspects of the BFN units proposed for life extension in this SEIS.

Table 2.5-1 Summary of BFN Unit Attributes

Attribute	Description
Type of Generation	Nuclear Power
Type of Operation	Base Load (Continuous)
Service Mode	one month refueling outage every two years
Reactor Thermal Power	3952 MWt per unit (with EPU)
Electrical Generation	generator limited to 1280 MWe per unit
Number and Type of Units	3 GE BWR 4 Units w/Mark I Containment
Current Operating License Expiration Dates	2013, 2014, 2016 for Units 1,2,3
Renewed Operating License Expiration Dates	2033, 2034, 2036 for Units 1,2,3
No. of Site Employees (Normal/Outage)	1200/2000
Reactor Fuel Consumption	336 fuel bundles per refueling (with EPU and HEU)
Diesel Fuel Consumption[1]	380,500 gallons per year
Cooling Water Intake Source	Wheeler Reservoir (Tennessee River)
Cooling Water Intake Flow	700,000 gpm per unit
Unit 1 Recovery/Restart	
Expected Capital Cost for Recovery	$1.35 B
Peak Recovery Workforce	3,055
No. of Additional Permanent Employees	150

[1]Note: This same fuel oil is used in all site diesel engines and in the auxiliary steam boilers.

2.6 Comparison of Environmental Consequences

The following summarizes the potential impacts of the Action Alternatives across the various environmental resources. They rely on or benchmark from the environmental conditions that exist under the No Action Alternative, and are as described in the Chapter 3 Affected Environment section of this SEIS. Operation of BFN Units 2 and 3 only until the current licenses expire - which is the No Action Alternative here - is encompassed by and discussed in the plant's original EIS that this document supplements. The impacts of the No Action Alternative are therefore not further discussed in this document except where new information or refinement of the earlier analyses warrants and appears for comparison purposes with the potential impacts of the Action Alternatives.

2.6.1 Comparison by Resource

AIR RESOURCES

Potential impacts on local climate and meteorology are expected to be less than the assessment results in the original EIS. Conservative plume modeling and conservative operating assumptions that were used then gave results that encompass the Alternative 2 options for increased cooling tower capacity because actual cooling tower operations have been and would be expected to occur only in the warmer months, generally limited to summer, and for much less time than the 29% assumed in the original EIS.

Based on operating experience, impacts on ambient air quality are all expected to be smaller than the magnitudes provided in the original EIS, with the exception of carbon monoxide. Emissions and ambient concentrations for carbon monoxide were about two orders of magnitude too small compared to amounts reported during actual operations. However, the ambient air quality standard for this pollutant is still five orders of magnitude larger than this revised estimate, so the impact is still considered negligible. The original EIS assumed maximum operation of the cooling towers in the helper mode 22% of the time. This assumption has been compared to Alternative 2 with its increased cooling towers capacity options for purposes of this SEIS. (The 7% closed mode analysis included in the original EIS has not been similarly refined because operation in this mode is now known to be impractical.) In this updated assessment, particulate emissions in the form of drift from the towers would be about 22 pounds per hour compared to an emissions standard for fine particulates of 45 pounds per hour. Total annual emissions would be about 21 tons per year compared to the 100 tons per year that was the estimate in the original EIS. Construction and modification impacts on air quality during the refurbishment period would be minor and transitory.

GEOLOGIC SETTING

Construction of additional water cooling capacity under any of the alternatives considered should result in no significant impacts to the geologic resources and hazards. The changes to crustal loading caused by excavation and movement of materials and the construction of new structures are expected to have negligible effects on the seismicity of the area.

The local geology and character of local seismicity would not be impacted by continued operation of BFN.

SOLID WASTES MANAGEMENT AND PAST PRACTICES

Continued operation of BFN through the license extension period should not result in generation of additional volumes of general plant trash which exceed the levels currently generated. If Unit 1 is restarted, the amount of general plant trash would be expected to increase in proportion to the increase in site population required for the recovery effort. In addition, there would be additional trash generated as a part of construction activities, but this amount would be significantly less than that generated by construction of a new facility. Once operational, the amount of trash generated would be similar to the other operating units, and the overall amount generated would increase slightly due to the small increase in permanent plant staff necessary to operate three units.

BFN will continue to maintain the license to operate the onsite construction/demolition (C/D) landfill through the duration of the extended BFN operating licenses. In the event Unit 1 is restarted, the onsite C/D landfill has the space and capacity to handle the small amount of additional wastes associated with construction activities. Should the onsite facility prove inadequate, there is sufficient alternative capacity in surrounding off-site C/D landfills.

Generation rates for low level radioactive waste would not be expected to exceed existing rates as a result of extension of the BFN licenses. Should Unit 1 be restarted, generation rates would be expected to increase during construction activities due to additional asbestos removal operations and the normal increases associated with nuclear construction activities. Once operational, the generation rates for this type of waste activity would increase in proportion to the additional operational activity associated with three unit operation. BFN has provisions in place to either store or ship for processing and disposal the volumes of material generated. Existing storage and disposal facilities have adequate capacity to handle the volumes of material expected to be generated during the extended life of BFN with either two-unit or three-unit operation.

HAZARDOUS WASTES MANAGEMENT AND PAST PRACTICES

Generation of hazardous waste would not be expected to increase for BFN as a result of license extension. Existing processes for managing these wastes within TVA would be expected to continue, and capacities for existing disposal and treatment facilities should be adequate to handle the relatively small volumes of material generated. Over the past 15 years, BFN has significantly reduced the generation of hazardous wastes through a combination of source reduction and product substitution. These ongoing waste reduction efforts would be expected to further reduce the number of waste streams and the volumes of waste generated at BFN.

Construction activities associated with Unit 1 restart would temporarily increase rates of hazardous waste generation due to the increased use of solvents and paint related materials necessary for refurbishment. The existing TVA process for management of this type of waste is adequate to handle the expected increase. Once operational, hazardous waste generated as a result of operation of Unit 1 would be within the normal year to year variation currently experienced.

SPENT FUEL MANAGEMENT

Environmental consequences of additional spent fuel management resulting from license extension of either two or three BFN units would be minimal. The additional spent fuel would be stored in the spent fuel pool or a dry storage system approved by NRC. Compared with license renewal of only Units 2 and 3, the addition of Unit 1 would just increase the number of storage casks needed and the required size of the proposed ISFSI. Subsequently, all BFN spent fuel would be transferred to the DOE in accordance with the Nuclear Waste Policy Act of 1982 and subsequent amendments.

SURFACE WATER RESOURCES

Under Alternative 1, no significant construction impacts are expected. Best Management Practices (BMPs) and construction control measures would be employed to control surface runoff, contain potential pollutants, and dispose of all waste materials in accordance with regulatory requirements. There would be no significant change in current operational impacts. Regulatory requirements would continue to control potential adverse impacts from plant discharges and operations. Thermal impacts from continued operation of Units 2 and 3 would remain within the levels evaluated during the original EIS. No additional thermal impacts to water temperature, reservoir stratification, sediment transport, scouring, dissolved oxygen concentrations, or eutrophication are expected.

Under Alternatives 2A, 2B, and 2C, potential construction and operational impacts are similar; and those for Alternative 2D are slightly less than the other sub-alternatives and similar to those described for Alternative 1. Construction impacts are expected to be temporary and insignificant using BMPs and pollution control measures. The restart of Unit 1 will require upgrading the cooling tower system and increased flow rates from a maximum flow of approximately 2,300 MGD for Units 2 and 3 to approximately 3,450 MGD with three units operating. The discharge temperature of the cooling system water will be essentially the same for three-unit operation, due to the proportional increase in cooling water flow. However, the total amount of heat added to the river and the water temperatures at the edge of the mixing zone would increase with three units operating. With the additional cooling tower capacity installed, modeling analyses using historical data indicate that the maximum discharge temperature and the temperature rise between intake and discharge would remain within regulatory limits that are formulated to protect aquatic life and ecosystems. Use of the cooling towers would increase, however, and on occasion when the cooling towers are unable to meet the thermal limits, the plant may have to be de-rated to remain in compliance. The implications of the thermal effects on reservoir water temperatures, dissolved oxygen concentrations, and eutrophication were also modeled. The results suggest that Alternatives 2A, 2B, 2C, and 2D should have insignificant effects on reservoir stratification, dissolved oxygen concentrations, eutrophication, sediment transport, and scouring.

GROUNDWATER RESOURCES

There are no adverse impacts to groundwater resources associated with the Alternative 1 upgrade scenario. Activities potentially affecting groundwater resources would include foundation treatment, excavation, and grading associated with Alternative 2 facilities. Excavations which penetrate the water table may require temporary construction dewatering. Any groundwater drawdown impacts associated with plant construction dewatering would be temporary and of negligible magnitude due to the limited excavation depths, the relatively short duration of facility construction, and the distance of neighboring wells.

Excavation and grading associated with construction of the proposed facilities would result in

permanent displacement of shallow soils above the water table (e.g., the proposed berm relocation sites). However, the long-term impact of these activities on groundwater resources would be negligible for all facility configurations given the limited depth and area of disturbance. Although permanent local impacts to groundwater levels and movement might be experienced from foundation treatment, the long-term impacts of these activities on groundwater resources would be negligible for the proposed cooling tower configurations given the limited area of disturbance. Potential contaminant releases (e.g., fuels, oils, and solvents), during construction activities, would be averted by careful handling and proper disposal of potential contaminants according to BMP guidelines. No adverse impacts to groundwater resources are anticipated from operation and maintenance of new facilities associated with Alternative 2 for the project. No adverse groundwater use impacts are anticipated from any of the identified alternatives.

FLOODPLAINS AND FLOOD RISK

The floodplains and flood risk assessment involves ensuring that facilities would be sited to provide a reasonable level of protection from flooding. In doing this, the requirements of Executive Order (EO) 11988 (Floodplain Management) would be fulfilled. Due to the nature of this facility, it is necessary to evaluate the flood risk associated with the Probable Maximum Flood (PMF) elevations for all alternatives.

Under Alternative 1, all existing and proposed facilities are, or would be, located outside the limits of the 100- and 500-year floodplains. Therefore, the project would be consistent with EO 11988. All safety-related structures are protected against all flood conditions and would not be endangered by the PMF. The proposed dry cask storage facility and permanent administration building would be located on ground above the PMF elevation based on site topography dated 1989. The proposed Modifications Fabrication Building would be located on ground below the PMF elevation, but the site would be raised or the building would be flood proofed consistent with other facilities of this nature on the plant site. Based on site topography, the proposed mechanical draft cooling tower would be located above elevation 570. All equipment within the cooling tower that could be damaged by floodwaters would be located above or flood proofed to the PMF elevation, as required.

During the license renewal period (up to year 2036), the 100- and 500-year flood, and PMF elevations for the Tennessee River would not be expected to change as stated in Section 3.8. Although the 100- and 500-year flood flows for the small stream to the northwest of the plant site and the site drainage system could increase by as much as 2.5 times what they are now, these flows would not adversely impact existing or proposed development because they would be significantly lower than the PMF flows, and these channels can handle PMF flows without flooding the plant.

All anticipated flood impacts for Alternatives 2A, 2B, 2C, and 2D would be the same as those listed for Alternative 1, except for potential PMF flooding impacts to the new cooling tower(s). However, all equipment within the cooling towers that could be damaged by floodwaters would be located above or flood proofed to the PMF elevation, as required. The construction of these towers would involve the relocation of material to one of three potential spoil areas. These areas are all located outside the limits of the 100-year floodplain which would be consistent with EO 11988.

TERRESTRIAL ECOLOGY

With respect to botanical aspects of Terrestrial Ecology, impacts are anticipated to be the same under all alternatives. No uncommon communities or otherwise significant vegetation types are known from the vicinity and impacts to this resource are anticipated to be insignificant.

Likewise, impacts to terrestrial animal communities would be similar under all alternatives. Due to previous levels of disturbance at the site during construction and operation of existing facilities, little suitable habitat of wildlife exists on site. No populations of rare or uncommon animals exist at the project site. Adoption of the proposed alternatives would not result in adverse impacts to uncommon animals or their habitats.

AQUATIC ECOLOGY

If Unit 1 is not returned to operation, but Units 2 and 3 are relicensed under Alternative 1, the total maximum two-unit intake volume, even with past plant modifications that increased CCW flow, would be within the bounds of previously-assessed intake volumes at which fish impingement and entrainment of fish eggs and larvae were determined to not adversely impact Wheeler Reservoir fish populations. With the return of Unit 1 to operation under Alternative 2, the total CCW flow would increase by about 10 percent. This increased CCW intake volume would potentially result in increased impingement of adult fish and entrainment of fish eggs and larvae but is not expected to result in significant impacts to fish populations of Wheeler Reservoir.

TVA will confirm the expected levels of impingement and entrainment by monitoring under current 2 unit operation and following return of Unit 1 to service. TVA's Vital Signs monitoring program will also continue to assess aquatic ecological communities in Wheeler Reservoir. Although not expected, if based on these monitoring studies it is determined that increased impingement and entrainment are resulting in unacceptable environmental impacts, TVA would assess the technologies, operational measures, and restoration measures that could be undertaken to remedy this and institute appropriate measures in consultation with appropriate federal and Alabama agencies.

THREATENED AND ENDANGERED SPECIES

For threatened and endangered (T&E) plants, impacts are anticipated to be the same under all alternatives. No rare plants are known from the vicinity, and no impacts to this resource are anticipated. No threatened or endangered aquatic species were found within the area affected by construction or operational changes at BFN as proposed herein. There are no populations of threatened or endangered terrestrial animals or suitable habitat for these species at or near the project site. Adoption of the proposed alternatives would not result in direct or cumulative impacts to threatened or endangered terrestrial animals or their habitats.

WETLANDS

No wetlands occur on any portion of the sites proposed for construction and excavation or disposal of spoil materials. Therefore there would be no impacts or effects upon wetlands in the proposed project area.

SOCIOECONOMIC CONDITIONS

No Action Alternative

Under the No Action Alternative, discontinuing unit operation when the existing licenses are scheduled to expire would require that TVA choose a decommissioning option and begin plant decommissioning. There would be some loss of jobs if this occurs compared to existing employment levels and additional employment losses when decommissioning was completed. In addition to the direct losses in income and employment that would result there would also be additional income losses in the form of decreased spending in the area by BFN employees. However, the number of jobs lost would only be approximately one percent of the labor force in Limestone County and only a small fraction of the labor force in the entire labor market area. Any resulting impacts to community services and housing from reduced local government revenues would be small and there would be no disproportionate impacts to disadvantaged populations in the area.

Alternative 1

Under Alternative 1, there would be no significant change in operating employment levels, payroll, or other plant-related expenditures. There would be some construction activity, requiring a small number of workers for a brief period of time. However, impacts to employment and income would be small and temporary.

There would be no noticeable affect on community services and housing and local government revenues because of the small and temporary increase in the number of additional workers. No disproportionate impacts to disadvantaged populations in the local area are expected.

Alternative 2

Under any of the variations of Alternative 2, construction activities would have noticeable effects on population, employment, and income over a time span of about 5.5 years. The total number of workers involved in the construction phase would peak at about 3,000, although not all of these are likely to be located at the plant site. Operation of Unit 1, in addition to current operation of Units 2 and 3, would require an increase in employment of about 150 permanent workers. This would be a small addition to the local economy.

Construction would result in some short-term strain on community services, including police and emergency services. Schools and the housing market likely would experience short-term strains. These impacts, however, would be scattered throughout the labor market area, not just in Limestone County. The increase in permanent employment associated with operation of Unit 1 in addition to the Units 2 and 3 could have a temporary impact on the local housing market and housing prices. However, the operations impacts would be small. Local government revenues would increase as a result of increases in the in lieu of tax payments by TVA. No disproportionate impacts to disadvantaged populations are expected.

TRANSPORTATION

Alternative 1 would result in no new impacts to the transportation system. The other action alternatives would have additional traffic generated in the form of operation and construction workforce employee travel and construction and operational material deliveries. The county roads are in good condition for access and would be adequate to support the traffic requirements during both construction and operation; however, construction periods are temporary and peak

forces only last for several months. There would be some delay turning onto County Road 25 from the plant due to traffic congestion at shift changes and leaving multiple exits simultaneously. Over a long period of time, there is a natural progression to improve the quality of the local roadway network and any such improvements may help address this potential impact. Therefore, as traffic increases over time, it is reasonable to assume that there will be some improvement in the transportation infrastructure.

SOIL AND LAND USES

Activities associated with license renewal for operation of Units 2 and 3 at EPU would have no impact on soils or land use on the plant site. Potential impacts to site soils and land use associated with refurbishing Unit 1 and license renewal for all 3 units would be insignificant. These construction activities would be located on previously disturbed soils and in built-up areas. Facilities for construction workers would be temporary and at completion of project the land would revert to prior use.

Operational impacts of any of these activities on land use in the surrounding areas would be insignificant. Current trends in local land use are toward development of more land for residential and commercial use. This is a result of population growth averaging 17% per decade. Any growth associated with either of these proposed activities would be minimal compared to current trends. Existing power line easements are sufficient, no new transmission lines are proposed as part of this license renewal action.

VISUAL RESOURCES

Impacts under the No Action Alternative would be insignificant. Under Alternative 1, minor visual impacts would include additional cooling tower plumes seen by area residents and occasionally some additional lighting due to very infrequent night operations may affect night sky brightness. Alternative 2A would introduce two new cooling towers in the landscape, similar to those that exist now. Alternative 2B, however, would provide two cooling towers that would contrast vertically to the existing towers. Alternative 2C, demolishing the four existing Ecodyne cooling towers, constructing 5 new linear mechanical draft cooling towers, and increasing the size of the existing Balcke-Durr cooling tower by 25%, would add to the number of linear elements seen across the plant site. Alternative 2D is the construction of one 20-cell mechanical cell draft cooling tower to replace the one previously in position 4 that had previously burned down and was not replaced. For this alternative a slightly larger (longer) cooling tower (20-cell vs. 16 cell) would be constructed in lieu of the one earlier committed to in the environmental assessment for EPU of Units 2 and 3. The visual impact of this Alternative 2D would essentially be the same as that for Alternative 1 since a single mechanical cooling tower of a similar design (but slightly shorter length) would otherwise have been built in the same location for the EPU project.

Of the Action Alternatives, Alternatives 1 and 2D would have the least visual impact for plant workers, visitors, and motorists along County Road 25.

RECREATION

There are no recreation facilities impacted by Alternative 1 or 2. Under either of the alternatives, there would be insignificant affects on recreation resources, facilities and activities.

CULTURAL RESOURCES

TVA Cultural Resources staff determined that the project had the potential to affect historic properties within the three areas designated as soil disposal or spoil pile locations. The Area of Potential Effect (APE) for historic structures was determined as those areas from which the disposal locations would be visible. A Phase I cultural resource survey was conducted to identify sites within this APE.

The archaeological survey identified one archaeological site near disposal Area 1 (see Figure 2.2-7). The site is marked on BFN drawings and it is expected that it will be avoided by any future activities. If avoidance is not possible, or should any future plans result in potential adverse impacts to the site, a Phase II archaeological survey will be required. Cox Cemetery, located near disposal Area 2, would be avoided. No historic structures were identified within the APE. In consultation with the Alabama State Historic Preservation Office (SHPO), it was determined that no historic properties would be affected by Alternatives 1 and 2 under the commitments that all sites identified during the Phase I survey would be avoided.

ENVIRONMENTAL NOISE

Routine construction noise from the action alternatives would have an insignificant effect for the duration of construction activities. Some cooling tower and building construction noise would be noticeable above background at times, but it would take place during daylight hours and for a relatively short time period. The highest noise levels during construction would come from the site preparation and foundation work for the two additional cooling towers in alternatives 2A and 2B. These heavy construction phases require the largest and most equipment to be in operation, but they are expected to be completed in about three months. The following construction phases of erection and finishing do not require as large or as many pieces of equipment.

The potential construction noise from refurbishing Unit 1 in preparation for restart is also insignificant because the overwhelming majority of the work would be done inside the generation building and containment structure.

The incremental increases in operational noise from the cooling towers for Alternatives 1, 2A, 2B, and 2D are insignificant. These are about a 1 Decibel, A-weighted (dBA) increase over current operational noise. This increase might not be detectable by most of the nearest residents, but it has the potential for a 1 to 2% increase in annoyance. The incremental increase for Alternative 2C without mitigation is likely to be noticed and has the potential for about a 4% increase in annoyed people. None of the alternatives has the potential for causing hearing loss or speech interference.

The maximum potential effect of Alternative 2C is decreased for several reasons. First, frequently less than all of the towers are operating; second, the towers operated an average of only 17 days per year over the past five years; and third, the cooling tower noise is low frequency and continuous when they are operating, and such noise is considered less objectionable by most people than high frequency, intermittent noise. Also, the towers operate during the hottest part of the summer when residential air-conditioning is used and windows are closed, eliminating any potential noise increase from inside the residences. Although Alternative 2C has the potential to cause a noise increase greater than 3 dBA, this is considered an insignificant effect for these reasons.

PUBLIC AND OCCUPATIONAL SAFETY & HEALTH

The site Safety and Health Program would not be impacted or affected by license renewal and continuing to operate Units 2 and 3 for 20 years after the current licenses expire. If Unit 1 recovery and license renewal/extended operation is added to continuing operation of Units 2 and 3, there is still no change to the Safety and Health Program. However, during the construction/modification work in recovering Unit 1, injury rates would be expected to be approximately 20% higher than during periods of operation.

RADIOLOGICAL IMPACTS

Future occupational radiation exposures from continuing either two-unit or three-unit operation at EPU power levels have been analyzed based on extrapolations from past and present data. It was concluded that worker radiation exposures would continue to be significantly less than the limits established by federal regulation. The average annual dose to workers and the average annual dose per operated reactor would remain consistent with current BWR industry trends. The estimated cancer risk increase associated with the occupational dose forecast for either Action Alternative is bounded by the projected doses for license renewal analyzed in NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants."

TVA does not anticipate any significant changes to the radioactive effluent releases or exposures to the public from continuing two-unit BFN operations through completion of the license renewal period. EPU is projected to increase effluent releases proportionately, as would the addition of Unit 1. However, revised calculated doses are a small fraction of the applicable radiological dose limits and the total exposures to the public from 3-unit operation at EPU are expected to remain a small fraction of the regulatory dose limits.

The design basis accidents addressed in the BFN Updated Final Safety Analysis Report (UFSAR) are independent of the age of the plant and are the same for each unit. Therefore, the extension of the operating lifetime of the plant from 40 to 60 years would not impact the analysis of these accidents. EPU will affect accident analysis because the power level influences the amount of radioactive isotopes available for release; however, all radioactive releases are projected to remain well within regulatory limits.

Extension of plant life from 40 to 60 years would also proportionately impact the ability of safety related equipment to withstand the effects of accidents. This is because of age-related effects of continuing operational conditions (temperature, humidity, radiation, etc.). However, the BFN equipment qualification program ensures that all safety-related equipment will remain qualified to operate as designed in its intended environment so as to perform its intended function. As part of this program, any equipment that cannot withstand the full 60-year life of the plant would be replaced on a predetermined maintenance schedule.

License extension with either two or three-unit operation would be accommodated as it has in the past by the BFN Radiological Emergency Plan. The SAMA analysis for BFN, included as Appendix A of this SEIS, addresses restart of Unit 1 and operation of all three units at EPU; and therefore, addresses both Alternatives 1 and 2. Based on the existing BFN SAMA analysis and SAMA analyses completed to date at other nuclear plants similar to BFN, it is not anticipated that either Alternative 1 or Alternative 2 would result in justifying significant modifications.

DECOMMISSIONING IMPACTS

If the decision is made to extend operation of only Units 2 and 3, decommissioning would probably not be initiated for Unit 1 until cessation of all site power operations. Instead, Unit 1 would likely remain in its current non-operable status until any renewed licenses expire or a subsequent decision is made to recover and restart the unit. If Unit 1 is restarted, Unit 1 would join Units 2 and 3 in extended operation for an additional 20 years past expiration of the current licenses. Therefore, under either Action Alternative, decommissioning would be delayed by the 20-year license renewal period, providing an opportunity for decommissioning technology (including more advanced robotics) and the licensing framework to evolve and mature. In addition, it becomes more likely that a permanent spent fuel repository would be available prior to completion of decommissioning.

2.6.2 Comparison by Alternative

Table 2.6-1 summarizes the impacts of constructing and operating each alternative and sub-alternatives evaluated in this SEIS.

Table 2.6-1 Summary of Environmental Impacts for BFN License Renewal SEIS Action Alternatives

Environmental Resource	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Air Resources	***Construction:*** No significant impacts anticipated. BMPs include wetting ground surfaces to reduce fugitive dust, and maintaining trucks and equipment for efficient fuel consumption. ***Operation:*** Expected operation of six cooling towers is bounded by analyses in the original EIS. Other emissions are likewise bounded or (such as CO) are well below regulatory limits. No significant impacts are anticipated.	***Construction:*** No significant impacts anticipated. BMPs include wetting ground surfaces to reduce fugitive dust, and maintaining trucks and equipment for efficient fuel consumption. ***Operation:*** Expected operation of eight cooling towers is bounded by analyses in the original EIS. Other emissions are likewise bounded or (such as CO) are well below regulatory limits. No significant impacts are anticipated.	***Construction:*** No significant impacts anticipated. BMPs include wetting ground surfaces to reduce fugitive dust, and maintaining trucks and equipment for efficient fuel consumption. ***Operation:*** Expected operation of eight cooling towers is bounded by analyses in the original EIS. Other emissions are likewise bounded or (such as CO) are well below regulatory limits. No significant impacts are anticipated.	***Construction:*** No significant impacts anticipated. BMPs include wetting ground surfaces to reduce fugitive dust, and maintaining trucks and equipment for efficient fuel consumption. ***Operation:*** Expected operation of six large cooling towers is bounded by analyses in the original EIS. Other emissions are likewise bounded or (such as CO) are well below regulatory limits. No significant impacts are anticipated.	***Construction:*** No significant impacts anticipated. BMPs include wetting ground surfaces to reduce fugitive dust, and maintaining trucks and equipment for efficient fuel consumption. ***Operation:*** Expected operation of six cooling towers is bounded by analyses in the original EIS. Other emissions are likewise bounded or (such as CO) are well below regulatory limits. No significant impacts are anticipated.
Geologic Setting	***Construction:*** No significant impacts anticipated. Changes to crustal loading are minor. ***Operation:*** Continued operation would have no impact on the natural seismic activity in the area.	***Construction:*** No significant impacts anticipated. Changes to crustal loading are minor. ***Operation:*** Continued operation would have no impact on the natural seismic activity in the area.	***Construction:*** No significant impacts anticipated. Changes to crustal loading are minor. ***Operation:*** Continued operation would have no impact on the natural seismic activity in the area.	***Construction:*** No significant impacts anticipated. Changes to crustal loading are minor. ***Operation:*** Continued operation would have no impact on the natural seismic activity in the area.	***Construction:*** No significant impacts anticipated. Changes to crustal loading are minor. ***Operation:*** Continued operation would have no impact on the natural seismic activity in the area.

Environmental Resource	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Solid Wastes Management	***Construction:*** Onsite landfill adequate. No significant impacts are anticipated. ***Operation:*** Generation rates for wastes would not change. No significant impacts are anticipated.	***Construction:*** Onsite landfill adequate. No significant impacts are anticipated. ***Operation:*** Generation rates for wastes would increase slightly. No significant impacts are anticipated.	***Construction:*** Onsite landfill adequate. No significant impacts are anticipated. ***Operation:*** Generation rates for wastes would increase slightly. No significant impacts are anticipated.	***Construction:*** Offsite landfill would be utilized if onsite landfill not adequate. No significant impacts are anticipated. ***Operation:*** Generation rates for wastes would increase slightly. No significant impacts are anticipated.	***Construction:*** Onsite landfill adequate. No significant impacts are anticipated. ***Operation:*** *Generation rates for wastes would increase slightly. No significant impacts are anticipated.*
Hazardous Wastes and Asbestos Management	***Construction:*** Existing processes adequate for minimal quantities expected. ***Operation:*** Generation rates for wastes unchanged. No significant impacts are anticipated.	***Construction:*** Existing processes adequate for minimal quantities expected. ***Operation:*** Generation rates for wastes would increase slightly. No significant impacts are anticipated.	***Construction:*** Existing processes adequate for minimal quantities expected. ***Operation:*** Generation rates for wastes would increase slightly. No significant impacts are anticipated.	***Construction:*** Asbestos from demolished cooling towers would be deposited in a permitted landfill. ***Operation:*** Generation rates for wastes would increase slightly. No significant impacts are anticipated.	***Construction:*** *Existing processes adequate for minimal quantities expected.* ***Operation:*** *Generation rates for wastes would increase slightly. No significant impacts are anticipated.*
Spent Fuel Management	***Construction:*** No significant impacts. BMPs for building ISFSI would be followed. ***Operation:*** Experience with similar ISFSI facilities at other utilities indicates no significant impacts.	***Construction:*** No significant impacts. BMPs for building ISFSI would be followed. ***Operation:*** Experience with similar ISFSI facilities at other utilities indicates no significant impacts.	***Construction:*** No significant impacts. BMPs for building ISFSI would be followed. ***Operation:*** Experience with similar ISFSI facilities at other utilities indicates no significant impacts.	***Construction:*** No significant impacts. BMPs for building ISFSI would be followed. ***Operation:*** Experience with similar ISFSI facilities at other utilities indicates no significant impacts.	***Construction:*** *No significant impacts. BMPs for building ISFSI would be followed.* ***Operation:*** *Experience with similar ISFSI facilities at other utilities indicates no significant impacts.*

Environmental Resource	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Surface Water Resources	***Construction:*** No significant impacts; BMPs would be followed for cooling tower, ISFSI, new mod fab building. ***Operation:*** No major change from current operations; no significant impacts.	***Construction:*** No significant impacts; BMPs would be followed for cooling towers, ISFSI, new mod fab building, and new admin building. ***Operation:*** Total cooling water intake flow increased, but no significant impacts expected. Cooling tower capacity increase would ensure no significant impacts from increased heat to reservoir.	***Construction:*** No significant impacts; BMPs would be followed for cooling towers, ISFSI, new mod fab building, and new admin building. ***Operation:*** Total cooling water intake flow increased, but no significant impacts expected. Cooling tower capacity increase would ensure no significant impacts from increased heat to reservoir.	***Construction:*** No significant impacts; BMPs would be followed for cooling towers, ISFSI, new mod fab building, and new admin building. ***Operation:*** Total cooling water intake flow increased, but no significant impacts expected. Cooling tower capacity increase would ensure no significant impacts from increased heat to reservoir.	***Construction:*** No significant impacts; BMPs would be followed for cooling towers, ISFSI, new mod fab building, and new admin building. ***Operation:*** Total cooling water intake flow increased, but no significant impacts expected. Cooling tower capacity increase would ensure no significant impacts from increased heat to reservoir.
Groundwater Resources	***Construction:*** No usage, only limited local dewatering; no significant impacts. ***Operation:*** No usage; no significant impacts.	***Construction:*** No usage, only limited local dewatering; no significant impacts. ***Operation:*** No usage; no significant impacts.	***Construction:*** No usage, only limited local dewatering; no significant impacts. ***Operation:*** No usage; no significant impacts.	***Construction:*** No usage, only limited local dewatering; no significant impacts. ***Operation:*** No usage; no significant impacts.	***Construction:*** No usage, only limited local dewatering; no significant impacts. ***Operation:*** No usage; no significant impacts.

Environmental Resource	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Floodplains and Flood Risk	***Construction:*** None within 500-year floodplain; any new features within PMF would be flood-proofed. No significant impacts. ***Operation:*** Site drainage can handle PMF flows. No significant impacts.	***Construction:*** None within 500-year floodplain; any new features within PMF would be flood-proofed. Spoils relocation outside 100-year floodplain. No significant impacts. ***Operation:*** Site drainage can handle PMF flows. No significant impacts.	***Construction:*** None within 500-year floodplain; any new features within PMF would be flood-proofed. Spoils relocation outside 100-year floodplain. No significant impacts. ***Operation:*** Site drainage can handle PMF flows. No significant impacts.	***Construction:*** None within 500-year floodplain; any new features within PMF would be flood-proofed. All cooling tower equipment would be above or flood proofed to PMF. No significant impacts. ***Operation:*** Site drainage can handle PMF flows. No significant impacts.	***Construction:*** None within 500-year floodplain; any new features within PMF would be flood-proofed. All cooling tower equipment would be above or flood proofed to PMF. No significant impacts. ***Operation:*** Site drainage can handle PMF flows. No significant impacts
Terrestrial Ecology	***Construction:*** Actions impact only areas already disturbed. No significant impacts. ***Operation:*** Impacted lands presently utilized. No significant impacts.	***Construction:*** Actions impact only areas already disturbed. Spoils relocation does not impact sensitive areas. No significant impacts. ***Operation:*** Impacted lands presently utilized. No significant impacts.	***Construction:*** Actions impact only areas already disturbed. Spoils relocation does not impact sensitive areas. No significant impacts. ***Operation:*** Impacted lands presently utilized. No significant impacts.	***Construction:*** Actions impact only areas already disturbed. No significant impacts. ***Operation:*** Impacted lands presently utilized. No significant impacts.	***Construction:*** Actions impact only areas already disturbed. No significant impacts. ***Operation:*** Impacted lands presently utilized. No significant impacts

Environmental Resource	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Aquatic Ecology	***Construction:*** BMPs would control siltation. No significant impacts. ***Operation:*** Intake flows and discharge temperature limits unchanged. No significant impacts.	***Construction:*** BMPs would control siltation. No significant impacts. ***Operation:*** Total intake flow increased, potential entrainment/impinge-ment increase expected. No significant impacts expected; would be confirmed by aquatic monitoring. Increased cooling tower capacity would ensure discharge temperatures are within permitted limits. No significant thermal impact.	***Construction:*** BMPs would control siltation. No significant impacts. ***Operation:*** Total intake flow increased, potential entrainment/impinge-ment increase expected. No significant impacts expected; would be confirmed by aquatic monitoring. Increased cooling tower capacity would ensure discharge temperatures are within permitted limits. No significant thermal impact.	***Construction:*** BMPs would control siltation. No significant impacts. ***Operation:*** Total intake flow increased, potential entrainment/impinge-ment increase expected. No significant impacts expected; would be confirmed by aquatic monitoring. Increased cooling tower capacity would ensure discharge temperatures are within permitted limits. No significant thermal impact.	***Construction:*** BMPs would control siltation. No significant impacts. *Operation*: Total intake flow increased, potential entrainment/impinge-ment increase expected. No significant impacts expected; would be confirmed by aquatic monitoring. Increased cooling tower capacity would ensure discharge temperatures are within permitted limits. No significant thermal impact.
Threatened and Endangered Species	***Construction/Operation:*** None on or affected by actions. No effects.	***Construction/Operation:*** None on or affected by actions. No effects.	***Construction/Operation:*** None on or affected by actions. No effects.	***Construction/Operation:*** None on or affected by actions. No effects.	***Construction/Operation:*** None on or affected by actions. No effects.
Wetlands	***Construction/Operation:*** None on or adjacent to site. No significant impacts.	***Construction/Operation:*** None on or adjacent to site. No significant impacts.	***Construction/Operation:*** None on or adjacent to site. No significant impacts.	***Construction/Operation:*** None on or adjacent to site. No significant impacts.	***Construction/Operation:*** None on or adjacent to site. No significant impacts.

Environmental Resource	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Socioeconomic Conditions	***Construction:*** Temporary small influx of workers. No significant negative impacts. ***Operation:*** No increase in permanent workforce. No significant negative impacts.	***Construction:*** Temporary large influx of workers. No significant negative impacts. ***Operation:*** 12.5% increase in permanent workforce. No significant negative impacts.	***Construction:*** Temporary large influx of workers. No significant negative impacts. ***Operation:*** 12.5% increase in permanent workforce. No significant negative impacts.	***Construction:*** Temporary large influx of workers. No significant negative impacts. ***Operation:*** 12.5% increase in permanent workforce. No significant negative impacts.	***Construction:*** Temporary large influx of workers. No significant negative impacts. ***Operation:*** 12.5% increase in permanent workforce. No significant negative impacts.
Transportation	***Construction:*** Minor changes in vehicular traffic. No significant impacts. ***Operation:*** No changes in vehicular traffic anticipated. No significant impacts.	***Construction:*** Temporary 150% increase in vehicular traffic. Some transmission equipment upgrades necessary. No significant impacts. ***Operation:*** 12.5% increase in plant traffic. No significant impacts.	***Construction:*** Temporary 150% increase in vehicular traffic. Some transmission equipment upgrades necessary. No significant impacts. ***Operation:*** 12.5% increase in plant traffic. No significant impacts.	***Construction:*** Temporary 150% increase in vehicular traffic. Some transmission equipment upgrades necessary. No significant impacts. ***Operation:*** 12.5% increase in plant traffic. No significant impacts.	***Construction:*** Temporary 150% increase in vehicular traffic. Some transmission equipment upgrades necessary. No significant impacts. ***Operation:*** 12.5% increase in plant traffic. No significant impacts.
Soils and Land Uses	***Construction/Operation:*** No changes outside existing plant area. No significant impacts.	***Construction:*** All site construction on previously disturbed soils. No new transmission line ROW required. No significant impacts. ***Operation:*** Existing power line easements sufficient. No significant impacts.	***Construction:*** All site construction on previously disturbed soils. No new transmission line ROW required. No significant impacts. ***Operation:*** Existing power line easements sufficient. No significant impacts.	***Construction:*** All site construction on previously disturbed soils. No new transmission line ROW required. No significant impacts. ***Operation:*** Existing power line easements sufficient. No significant impacts.	***Construction:*** All site construction on previously disturbed soils. No new transmission line ROW required. No significant impacts. ***Operation:*** Existing power line easements sufficient. No significant impacts.

Environmental Resource	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Visual Resources	***Construction:*** Visual discord temporary. No significant impacts. ***Operation:*** Slight increase in cooling tower plumes and site lighting. No significant impact.	***Construction:*** Visual discord temporary. No significant impacts. ***Operation:*** Slight increase in visual discord due to berm removal and new towers. No significant impacts.	***Construction:*** Visual discord temporary. No significant impacts. ***Operation:*** Slight increase in visual discord due to berm removal and new towers. No significant impacts.	***Construction:*** Visual discord temporary. No significant impacts. ***Operation:*** Slight increase in visual discord due to larger cooling towers. No significant impacts.	***Construction:*** Visual discord temporary. No significant impacts. ***Operation:*** Slight increase in visual discord due to new cooling tower, plumes and site lighting. No significant impact.
Recreation	***Construction/Operation:*** All actions are on existing site; cumulative effect on nearby recreation resources minor. No significant impacts.	***Construction/Operation:*** All actions except transmission line upgrades are on existing plant site; cumulative effect on nearby recreation resources minor. No significant impacts.	***Construction/Operation:*** All actions except transmission line upgrades are on existing plant site; cumulative effect on nearby recreation resources minor. No significant impacts.	***Construction/Operation:*** All actions except transmission line upgrades are on existing plant site; cumulative effect on nearby recreation resources minor. No significant impacts.	***Construction/Operation:*** All actions except transmission line upgrades are on existing plant site; cumulative effect on nearby recreation resources minor. No significant impacts
Cultural Resources	***Construction/Operation:*** Cemeteries and potential archaeological sites would be avoided. No impacts are anticipated.	***Construction/Operation:*** Cemeteries and potential archaeological sites would be avoided. No impacts are anticipated.	***Construction/Operation:*** Cemeteries and potential archaeological sites would be avoided. No impacts are anticipated.	***Construction/Operation:*** Cemeteries and potential archaeological sites would be avoided. No impacts are anticipated.	***Construction/Operation:*** Cemeteries and potential archaeological sites would be avoided. No impacts are anticipated.
Environmental Noise	***Construction:*** No unusual activities planned. No significant impacts. ***Operation:*** Slight increase in potential annoyance due to cooling tower operation. No significant impacts.	***Construction:*** No unusual activities planned. No significant impacts. ***Operation:*** Slight increase in potential annoyance due to cooling tower operation. No significant impacts.	***Construction:*** No unusual activities planned. No significant impacts. ***Operation:*** Slight increase in potential annoyance due to cooling tower operation. No significant impacts.	***Construction:*** No unusual activities planned. No significant impacts. ***Operation:*** Cooling tower operation exceeds guideline for detectability, but no significant impacts.	*Construction*: No unusual activities planned. No significant impacts. *Operation*: Slight increase in potential annoyance due to cooling tower operation. No significant impacts.

Environmental Resource	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Public and Occupational Safety & Health	***Construction:*** Projected work not major. No significant impacts. ***Operation:*** No changes to current program anticipated. No significant impacts.	***Construction:*** Injury rates projected to be temporarily higher, but no significant impacts. ***Operation:*** No changes to current program anticipated. No significant impacts.	***Construction:*** Injury rates projected to be temporarily higher, but no significant impacts. ***Operation:*** No changes to current program anticipated. No significant impacts.	***Construction:*** Injury rates projected to be temporarily higher, but no significant impacts. ***Operation:*** No changes to current program anticipated. No significant impacts.	***Construction:*** Injury rates projected to be temporarily higher, but no significant impacts. ***Operation:*** No changes to current program anticipated. No significant impacts.
Radiological Impacts	***Construction:*** Projected work non-radiological in nature. No significant impacts. ***Operation:*** No major changes and no significant impacts.	***Construction:*** Unit 1 recovery increases site dose but still well within limits. No significant impacts. ***Operation:*** Unit 1 recovery adds to sources, but all projected doses are still well within limits. No significant impacts.	***Construction:*** Unit 1 recovery increases site dose but still well within limits. No significant impacts. ***Operation:*** Unit 1 recovery adds to sources, but all projected doses are still well within limits. No significant impacts.	***Construction:*** Unit 1 recovery increases site dose but still well within limits. No significant impacts. ***Operation:*** Unit 1 recovery adds to sources, but all projected doses are still well within limits. No significant impacts.	***Construction:*** Unit 1 recovery increases site dose but still well within limits. No significant impacts. ***Operation:*** Unit 1 recovery adds to sources, but all projected doses are still well within limits. No significant impacts.
Decommissioning	License renewal allows time for technology improvement and spent fuel repository development. No significant impacts.	License renewal allows time for technology improvement and spent fuel repository development. No significant impacts.	License renewal allows time for technology improvement and spent fuel repository development. No significant impacts.	License renewal allows time for technology improvement and spent fuel repository development. No significant impacts.	License renewal allows time for technology improvement and spent fuel repository development. No significant impacts.

2.7 Comparison of Costs Between Alternatives

TVA has developed information about the costs of renewing the licenses and preparing for extended operation of BFN Units 2 and 3. These costs were estimated based on typical industry experience for the activities and equipment involved. Since Units 2 and 3 are currently operating and no significant equipment upgrades are projected to be required in preparation for or during extended operation, total costs for Alternative 1 are relatively small. The only facilities changes associated with this Alternative are additional dry cask spent fuel storage facility capacity and a new (replacement) modifications/fabrication building. As part of the separate EPU project, the sixth mechanical draft cooling tower will also be restored.

TVA has also developed information about the costs involved in recovering BFN Unit 1, renewing the license, and preparing for extended operation of BFN Unit 1. The Unit 1 recovery costs were estimated based on TVA's previous experience in recovering and restarting BFN Units 2 and 3, including consideration of lessons learned from those recovery efforts and evaluation of issues and work scope unique to Unit 1. Unit 1 recovery work includes substantial engineering reanalysis and equipment upgrades such as new cables, new piping and pipe supports, and replacement of degraded equipment to bring Unit 1 up to the regulatory standards currently met by Units 2 and 3. Much of the license renewal work being completed for Alternative 1 is applicable to BFN Unit 1; therefore, the additional work required would be about one-third of that expended for Units 2 and 3 (rather than one-half). Changes to facilities or additions outside the power plant include those for Alternative 1 (additional dry cask spent fuel storage facility capacity [but proportionately larger for 3 units], the new modifications/fabrication building, and restoration of the sixth mechanical draft cooling tower as part of the EPU project) plus a new Administration Building and whatever additional cooling tower capacity is determined to be required.

Which cooling tower sub-alternative is most cost-effective overall depends upon several factors besides construction and operating costs, including the amount of additional cooling capacity required, the assumed limits on discharge temperature and condenser backpressure, and the accuracy of the calculational models in minimizing conservative assumptions such as those associated with river flow temperature stratification. The amount of additional cooling capacity needed is also a function of acceptable levels for de-rates which most likely would occur during hot weather extremes.

In comparison of the four cooling tower sub-alternatives, the estimated total construction and operational costs are approximately equivalent for Alternatives 2A, 2B and 2C but significantly less for Alternative 2D. Alternatives 2A and 2B have similar equipment costs, and both would require less new equipment than Alternative 2C. Alternative 2C also involves demolition costs of the existing older cooling towers. In contrast, Alternatives 2A and 2B both require removal of most of the spoils berm, adding a warm-water box conduit, and digging a new cold-water discharge channel. Alternatives 2A and 2B probably also would require refurbishment expenses for the existing older cooling towers.

Since it provides less additional cooling capacity, the projected amount of de-rates due to hot weather extremes is larger for Alternative 2D than for 2A, 2B or 2C. Nonetheless, Alternative 2D has the highest net present value and internal rate of return when considering initial construction cost, operating power consumption, and associated de-rates. The larger size of the new cooling tower for Alternative 2D would also provide flexibility for future operations.

The environmental impacts associated with all of the Action Alternatives appear to be relatively insignificant. The costs for license renewal and justifying readiness for extended operation (of either two or three units) are small compared to the cost of recovery of Unit 1. Therefore, the choice of the preferred Alternative depends in large part upon the overall cost of Unit 1 recovery. As explained in Chapter 1, TVA has completed a cost analysis and benefits comparison, which demonstrate that recovering Unit 1 for extended operation (with license renewal) is financially viable.

TVA has completed a Detailed Scoping, Estimating, and Planning (DSEP) review of the proposed recovery of Unit 1. This effort, which incorporated lessons learned from the recovery of Units 2 and 3, developed a detailed work scope, staffing plan, schedule and cost estimate for the BFN Unit 1 recovery project. It was concluded that: the Unit 1 recovery project is technically viable; the project scope is defined and set; sufficient technical resources are available to proceed at this time; and there are no risks which could prevent the project from being completed within the proposed budget and schedule.

2.8 The Preferred Alternative

TVA has not yet made a decision with respect to the BFN license renewal Alternatives identified in this SEIS. However, based on TVA's present analyses of the environmental and cost/benefit aspects involved, Alternative 2 is preferred. With this alternative, there are positive environmental effects to be gained, no significant or unacceptable environmental impacts have been identified, and the initial cost analysis and benefits comparison indicate that recovering Unit 1 for extended operation would be financially viable.

Recovering and extending operation of Unit 1 would have the beneficial environmental effect of generating a significant amount of additional electricity without generating the greenhouse gases that would be produced if that demand was instead met by fossil-fired plants.

This SEIS contains the basis for TVA's conclusion that no significant and unacceptable negative environmental impacts would result from Alternative 2. Restarting Unit 1 would increase the waste heat load to Wheeler Reservoir, but the BFN cooling tower capacity would be increased and operated as necessary to ensure that discharge temperature regulatory limits continue to be met. For reasons explained in the previous section, sub-alternative 2D is the preferred option for additional cooling tower capacity. TVA is not proposing any modification to the existing NPDES permit limitations for the plant. For those periods of unusually hot weather where the increased cooling tower capacity is not sufficient, the operating power levels will be decreased (de-rated) as necessary to maintain discharge temperatures below regulatory limits. The total cooling water flow rate would be approximately 10% higher than it had been previously with three-unit operation, but no significant adverse impacts are expected. Monitoring of aquatic biota impingement and entrainment effects during the first year of operation would help to confirm the impact evaluation and identify any unanticipated or unacceptable impacts. All personnel exposures and radioactive effluents would continue to be well within regulatory limits. The addition of a dry cask spent fuel storage facility would safely accommodate all the spent fuel that would be generated by three units with renewed operating licenses.

As explained in Chapter 1, TVA has completed a cost analysis and benefits comparison which demonstrate that recovering Unit 1 for extended operation (with license renewal) is financially

viable. However, the TVA decision on Unit 1 will of necessity take into account other relevant factors external to this SEIS, such as available financing options. The decision could be made as early as 30 days after issuance of this (Final) SEIS. It is currently expected that TVA will most likely make a decision on the proposed actions in May of 2002.

2.9 References

Baxter, D. S. and J. P. Buchanan. 1998. Browns Ferry Nuclear Plant thermal variance monitoring program final report. Tennessee Valley Authority, Resource Group, Water Management, Norris, TN. 54pp.

Dycus, D. L. and D. L. Meinert. 1993. Reservoir monitoring, monitoring and evaluation of aquatic resource health and use suitability in Tennessee Valley Authority reservoirs. Tennessee Valley Authority, Water Resources, Chattanooga, Tennessee, TVA/WM-93/15.

Lin, F. and G. E. Hecker. "3-D Numerical Model of Thermal Discharge from Browns Ferry Nuclear Plant." Alden Research Laboratory, Inc., Holden, Massachusetts, to be published 2002.

NRC 1996; 1999.

Smith, B T. and P. N. Hopping. "2001 Hydrothermal Survey for Browns Ferry Nuclear Plant." Report No. WR202-4-67-134, Tennessee Valley Authority, River System Operations & Environment, River Operations, to be published 2002.

Tennessee Valley Authority. 2001. Finding of No Significant Impact - Environmental Assessment Browns Ferry Nuclear Plant - Extended Power Uprate for Units 2 and 3, March 15, 2001.

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3.0 AFFECTED ENVIRONMENT

The existing environmental conditions at the Browns Ferry Nuclear Plant (BFN) site that would be affected by the proposed alternatives are described in this chapter. Since the current operating licenses for Units 1, 2, and 3 do not expire until 2013, 2014, and 2016, respectively, but work on recovering Unit 1 or constructing a dry cask storage facility for spent fuel could begin as early as 2002, the affected environment addresses projected changes between 2002 and 2016.

In accordance with Council on Environmental Quality regulations, the affected environment is "interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment," (40 CFR 1508.14). The descriptions of the affected environment provide bases for understanding the direct, indirect, and (where applicable) the cumulative effects of the alternatives. The affected environment text is subdivided by subject area and includes human interaction aspects as well as descriptions of the physical and biological topics. Existing environmental conditions are also representative of the conditions that are expected to exist under the No Action Alternative, which is to operate Units 2 and 3 only until the end of their existing licenses.

3.1 Air Resources

3.1.1 Climate and Meteorology

The local climate and meteorology of the BFN site is characterized in the TVA BFN Environmental Statement, Volume 2, Section 3.3, which was prepared in the early 1970s. More extensive information and detailed data summaries, especially for on-site meteorological data, can be found in Section 2.3 of the Final Safety Analysis Report (FSAR). Among minor climate variations that have been observed during the past century was a trend of decreasing average temperatures from the 1930s and 1940s to the 1970s that was followed by the current warming trend. This warming trend is expected to continue through the renewed license period. However, the conditions for the 1879-1958 period of temperature data presented in the original Environmental Statement are expected to be representative of these near future conditions that will extend well into the 2030s. Other climate and meteorology variables are also not expected to change significantly in that time frame.

3.1.2 Ambient Air Quality

National Ambient Air Quality Standards establish concentration limits in the outside air for six pollutants: particulate matter, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead. These standards are designed to protect public health and welfare. With one exception, the standards are essentially unchanged from those considered in the TVA Environmental Statement of the early 1970s. The standard for hydrocarbons in effect at that time was later rescinded and a standard for ozone was implemented. An area where any air quality standard is violated is designated as a nonattainment area for that pollutant, and emissions of that pollutant from new or

expanding sources are carefully controlled. There are no nonattainment areas near the BFN site, which is located in Limestone County, Alabama. Although Huntsville, Alabama, in adjacent Madison County is currently in attainment of the one-hour ozone standard and the particulates standard, United States Environmental Protection Agency (EPA) promulgated new, more restrictive standards for ozone and particulate matter in July 1997. These new standards, including an eight-hour standard for ozone that would supersede the old one-hour standard, have been challenged in the courts and are unlikely to be implemented until after the year 2003, if they withstand legal challenge. Full implementation of the new standards is expected to take place over a period of several years. However, it is anticipated that Madison County and possibly some surrounding counties will face significant air quality compliance problems for ozone and particulate matter.

In addition, Prevention of Significant Deterioration (PSD) regulations that restrict emissions and any significant reduction in ambient air quality include protection of national parks and wilderness areas that are designated PSD Class I air quality areas. A new or expanding major air pollutant source is required to estimate potential impact of its emissions on the air quality of any nearby Class I area, as specified by the State or local air regulatory agency, with input from the Federal Land Manager(s) having jurisdiction over the given Class I area(s). The closest PSD Class I area is the Sipsey Wilderness Area about 28 miles (45 kilometers) southwest of BFN.

3.1.3 Existing Air Emission Sources

Sources of non-radiological air pollutants at BFN include the mechanical draft cooling towers, the auxiliary steam boilers for heating and other uses, the diesel-powered auxiliary (emergency) generators, and miscellaneous other small sources such as fuel storage facilities. The cooling towers, auxiliary boilers, and diesel generators and associated estimated emissions are discussed in the TVA Environmental Statement, Volume 1, Section 2.5.

In Volume 1, Section 2.5, of the original Environmental Impact Statement (EIS), potential emissions and ambient air quality impacts are discussed. However, these earlier analyses only considered emissions from four of the eight diesel generators at the site. The emission estimates from the eight diesel generators should have been twice the emission estimates used in the original EIS. However, this does not change the expected impacts on air resources analyzed in the original EIS because those impacts are still enveloped by the combination of the auxiliary boilers and the diesel generators that was assessed. The auxiliary boilers were evaluated for the maximum possible fuel consumption, and the expected actual maximum annual operation was stated to be less than half the level that was assessed.

Actual emissions are much smaller than those estimated in the original EIS, with one exception. There is an inconsistency in the estimated emissions and ambient concentration for carbon monoxide in Section 2.5 in comparison to the magnitudes for the other pollutants calculated there and the relative magnitudes for the actual annual emissions reported during 1996-1999. Apparently, the carbon monoxide emissions and ambient concentrations presented in Section 2.5 are about two orders of magnitude too small. However, the ambient air quality standard is still about five orders of magnitude larger than the revised estimate. Thus, the impact of carbon monoxide emissions is still considered negligible, consistent with the conclusion in Section 2.5, Volume 1, of the original EIS.

Though generation of carbon dioxide (CO_2) at a nuclear facility is very minor compared to that of a fossil-fueled plant, the auxiliary boilers, emergency diesel generators, diesel-driven pumps, motorized vehicles, etc., collectively produce approximately 4,250 tons of carbon dioxide per year at BFN.

Potential impact on ambient air quality from operation of the cooling towers is associated with particulates emitted as part of the drift losses. Conservative estimated emissions of particulates are presented in Section 2.5, Volume 1, of the original EIS. Associated assumptions included closed mode operation for 7% of the time, helper mode operation for 22% of the time, and a conservative drift loss rate of 0.1%. Actual operating experience under the thermal regulations in effect, the reservoir conditions, and the plant's cooling requirements has shown that closed mode operation of the cooling towers has been unnecessary and is not expected to be done in the future. Cooling tower operation is conducted only in the warmer months of the year. During the last six years, Units 2 and 3 have both been back in service and the greatest amount of time that cooling tower operation has been required has been about 8% of a year.

The Plant operates under the air quality permit category of a minor source of air pollutants as approved by the State of Alabama air regulatory agency, Alabama Department of Environmental Management (ADEM).

3.1.4 Air Quality During Refurbishment

Air quality conditions are expected to remain about the same as now during the refurbishment period, with the exception of possible regulatory constraints that may develop in association with the eventual implementation of the new EPA standards on ozone and particulates.

3.2 Geologic Setting

3.2.1 Local and Regional Geology

The local and regional geology are described in section 3.3 of the original EIS.

3.2.2 Geologic Structure and Faulting

The BFN area is underlain by flat-lying, underformed limestone of the Mississippian age. The site lies on the southeastern flank of the Nashville structural dome where it merges into the foreland slope of the Appalachian geosyncline. The Nashville dome controls the regional geologic structure, and the regional dip is a degree or less to the southeast. During its history, this immediate region has been one of little deformation. Major folds and faults are entirely absent. No active faults showing recent surface displacement are known within a 200-mile radius of the site. The nearest known ancient fault is in Lawrence County, Alabama, 16.5 miles to the west-southwest from the BFN site. This fault is one of three apparently related near-vertical faults that cut Mississippian bedrock and have vertical displacements that vary from 0 to 60 feet (BFN UFSAR).

3.2.3 Seismicity

Significant centers of seismic activity are considered to be regions that have produced large earthquakes (magnitude greater than 6.0) in historical time. For BFN the nearest examples of such seismic source zones include the New Madrid Seismic Zone in the central Mississippi Valley in the vicinity of New Madrid, Missouri and the Charleston Seismic Zone near Charleston, South Carolina. BFN is approximately 200 miles from the New Madrid Seismic Zone and approximately 400 miles from the Charleston Seismic Zone. Both of these seismic zones have produced one or more earthquakes that caused damageover a wide area.

The December 7, 2001, magnitude 3.8/3.9 earthquake that occurred west of Scottsboro, Alabama was not associated with a seismic source zone that has generated large earthquakes in historical time. The earthquake's epicenter was about 50 miles from BFN and 17 miles from TVA's unfinished Bellefonte Nuclear Plant site located approximately six miles northeast of Scottsboro. The event was not felt nor noticed in any way at Browns Ferry. BFN staff confirmed that the seismic instruments were operable and that the seismic alarm, set at 0.01 G., did not activate.

The earthquake was not "felt" at Bellefonte. However, TVA staff in the control room did hear a rumble that sounded like something heavy being dragged along the roof. It seemed to last approximately 5 to 6 seconds. No books fell from shelves, nor did any objects topple. Inspections of the site the evening of the earthquake and the following morning revealed no damage and nothing out of place. Bellefonte does not have a seismic instrument.

The December 7, 2001 earthquake occurred in the Southern Appalachian Seismic Zone as defined by Bollinger (1973). The largest earthquake known to have occurred within this zone occurred in Giles County, Virginia in 1897 with a magnitude of approximately 5.8.

Earthquakes of the size (3.8 magnitude) that occurred near Scottsboro, Alabama on December 7, 2001, could be expected to occur somewhere within the southern Appalachians about once every three years (Bollinger, et al, 1989). The southern Appalachian seismic zone extends from central Alabama to western Virginia, and therefore, most earthquakes occurring in this zone are much farther from BFN than the recent one near Scottsboro. Two aftershocks were associated with the Scottsboro earthquake (both quite small), and it appears the aftershock sequence ended in less than a month.

As shown by the U.S. Geological Survey's 1996 national seismic hazard maps, BFN is located in a region of low seismic hazard. Although infrequent, small earthquakes (magnitude less than 4.0) are likely to continue to occur in the area around BFN. However, earthquakes of this size, even if much closer to BFN than the December 7, 2001 earthquake, produce ground motions that are considerably smaller than those for which the plant is designed and thus pose no threat to plant safety.

3.3 Solid Wastes Management and Past Practices

Solid wastes generated in conjunction with operation of BFN can be subdivided into four general categories:

1. General plant trash consisting of paper, metals, garbage and other items;
2. Construction and demolition debris associated with site activities;
3. Low Level radioactive solid wastes which consists of spent resins, and dry active waste (DAW) (contaminated protective clothing, paper, rags, glassware, and trash); and
4. Hazardous Wastes as defined under the Resource Conservation and Recovery Act (RCRA).

All of these solid wastes are managed in accordance with applicable Nuclear Regulatory Commission (NRC), State, and Federal environmental regulations, and disposed in approved and licensed disposal facilities.

3.3.1 General Plant Trash

General plant trash collected as part of routine plant operation activities is managed through a TVA wide contract with a licensed waste disposal company. Waste material is collected in dumpsters and transported to a State licensed regional landfill permitted to accept Subtitle D waste materials from Limestone County. At the current time, Alabama has greater than ten years of remaining landfill capacity. Generation rates for this type of material are currently approximately 50 tons per month. BFN has an active recycling program that segregates and recycles scrap metal, cardboard, paper, batteries, and aluminum cans at approved State and local recycling facilities.

3.3.2 Construction/Demolition Debris

BFN operates a State permitted Construction/Demolition (C/D) landfill (Permit Number 42-02) within the confines of the BFN site. This landfill is permitted to accept non-hazardous, non-radioactive solid wastes including scrap lumber, bricks, sandblast grit, crushed metal drums, glass, wiring, non-asbestos insulation, roofing materials, building siding, scrap metal, concrete with reinforcing steel and similar construction and demolition wastes at an average daily volume of five tons per day from the BFN site. The landfill is approximately 7.7 acres in size. The generation rate for this type of material over the past two years is approximately 0.04 tons per day. The C/D landfill permit is issued for five-year permit cycles, with the current permit set to expire in May 2005.

3.3.3 Low-Level Radioactive Waste

Spent resins are packaged, de-watered and temporarily stored on-site in concrete storage modules until they are shipped for burial offsite in a licensed disposal facility. DAW is collected within the plant, and transported to a waste processor for volume reduction and subsequent shipment to a licensed disposal repository, such as the Envirocare of Utah, Inc. burial facility. Irradiated non-fuel plant components are stored on-site or processed for shipment to a licensed disposal facility. Generation rates for these types of materials are approximately 30-40 cubic meters per month.

3.4 Hazardous Wastes Management and Past Practices

As is the case with any large industrial facility, BFN generates a variety of wastes that are classified as hazardous under RCRA. These wastes include paint related materials, spent solvents used for cleaning and degreasing, as well as Universal Wastes such as spent batteries, fluorescent light tubes etc. TVA operates a Hazardous Waste Storage Facility (HWSF) in Muscle Shoals that holds a RCRA Part B permit for temporary storage of hazardous wastes. The HWSF serves as a central collection point for TVA-generated hazardous wastes, and maintains contracts with waste treatment and disposal facilities through TVA's Environmental Restricted Awards Process. All hazardous waste generated at BFN is shipped to the HWSF for consolidation, storage, and disposal through approved and licensed facilities. BFN recycles paint solvents (primarily Methyl Ethyl Ketone) using an on-site still. Universal wastes are collected for recycling and shipped to recycling firms listed on the ERAL. Hazardous waste generation rates for BFN average approximately 3,400 pounds per calendar year. While not a hazardous waste as defined in the RCRA regulations, Used Oil is also generated at BFN as a result of maintenance activities on plant equipment. All used oil is collected, stored on site, and shipped to an approved recycling center for energy recovery.

3.5 Spent Fuel Management

A 20-year extension of the BFN operating licenses including three-unit operation would impact spent fuel management in the quantity of spent fuel storage required. As described in section 2.3, a BFN Independent Spent Fuel Storage Installation (ISFSI) is proposed for operation beginning 2005. Expansion of an ISFSI can be accomplished incrementally, provided adequate space is allotted in the initial design. This technology can accommodate life-of-plant requirements regardless of Department of Energy (DOE) repository schedules or plant operation changes.

After implementation of spent fuel dry storage, sufficient capacity would be maintained in the spent fuel pool to accommodate refueling outages. Older spent fuel would be transferred to dual-purpose storage modules (i.e., metal cask or canister with overpack) for storage at the BFN ISFSI. The fuel transfer from pool storage racks to dry storage modules would be performed in the spent fuel pool. The dry storage system would be licensed for both on-site storage in accordance with 10 CFR 72 and off-site transportation in accordance with 10 CFR 71. Consequently, these dry storage systems do not require fuel to be repackaged for transport to a DOE repository.

Depending on the dry storage system design chosen for BFN, each storage module could contain up to 68 spent fuel assemblies. Assuming a storage module design with a 68-fuel assembly capacity, five modules would typically be loaded before each refueling outage. After loading, the dual-purpose storage module would be drained, dried, decontaminated, sealed, and then transferred by crane to the truck bay for transport to the ISFSI site. The storage module containing spent fuel would be temporarily stored at the ISFSI until a DOE spent fuel repository is available.

Appropriate dual-purpose system components used for fuel storage would also be used for fuel transportation to the DOE repository. Preparation for transport varies depending on design of the dry storage system chosen. Transport preparation typically includes testing of the storage module seal integrity, then addition of impact limiters for metal (non-canister) systems or addition of a transport overpack and impact limiters if modular systems are used. These operations can be

completed either at the ISFSI site, provided an appropriate crane system is available, or at a specially constructed transfer facility. The only part of a dry storage module that would remain on site after shipment to DOE is the storage overpack (if a modular canister design is used).

3.6 Surface Water Resources

3.6.1 Wheeler Reservoir Description

BFN is located on Wheeler Reservoir at Tennessee River Mile (TRM) 294. The reservoir extends from Guntersville Dam at TRM 349 to Wheeler Dam at TRM 274.9. The drainage area upstream of Wheeler Dam is 29,590 square miles. The reservoir was created in 1936 as one of the first major dam projects on the Tennessee River for flood control, power generation, and navigation. Wheeler has a normal summer elevation of 556 feet (mean sea level) msl and a minimum water elevation of 550 feet. The lake usually reaches summer elevation by April 15. Fall drawdown, in anticipation of winter rains, usually begins around August 1. At summer pool elevation, the reservoir has an area of 67,070 acres, a volume of 1,050,000 acre-feet, a mean depth of 15.7 feet, and a hydraulic residence time of 10.6 days.

Rainfall in the area averages 57 inches per year, with March being the wettest month at 6.6 inches, and October the driest month at 3.3 inches. The average monthly air temperature ranges from 39°F in January to 79°F in July with an annual mean of about 60°F. Average unregulated streamflow at the dam is 49,800 cubic feet per second (cfs) or 1.7 cfs per square mile of drainage area. Historically, the dissolved oxygen concentration of reservoir releases ranges from about 11 milligrams per liter (mg/L) in late January to 6 mg/L in early July with an annual average of 8 mg/L. The release water temperature ranges from about 43°F in January to 84°F in July with an annual average of 68°F. Most of Wheeler Reservoir is classified by ADEM for public water supply, swimming and other whole body water-contact sports, and fish and wild life. The area of the reservoir immediately upstream and downstream of BFN is classified for swimming and other whole body water-contact sports and fish and wild life. Reservoir water quality is generally good and suitable for most designated uses. The one exception is a ten-mile reach of the river between Wheeler Dam and the Elk River which is on the state 303 (d) list as partially supporting its designated uses due to pH and temperature/thermal modifications caused by industrial sources and flow regulation and modification. Table 3.6-1 summarizes general water quality conditions in Wheeler Reservoir using 1990 through 1998 data available from EPA STORET.

Table 3.6-1 Summary of Wheeler Reservoir Water Quality[a]						
Parameter	**Units**	**Number Samples**	**Mean**	**Standard Division**	**Maximum**	**Minimum**
Turbidity	NTU	63	8.91	11.07	75.0	1.2
Secchi Depth	meters	305	1.06	0.39	2.5	0.2
Total Alkalinity	mg/L	462	58.13	8.74	112	15
Dissolved Oxygen	mg/L	6542	7.42	1.98	16.8	0.1
Temperature	°F	6537	78.66	8.39	91.9	43.6
BOD_5	mg/L	2334	2.39	1.36	11.0	0.1
Total Suspended Solids	mg/L	2669	6.38	5.05	130	1
Fecal Coliform	100ml	168	159.6	556.8	6200	0
Organic Nitrogen	mg/L	166	0.26	0.27	1.3	0.02
NH_3+NH_4 Nitrogen	mg/L	613	0.058	0.068	0.88	0.01
NO_2+NO_3 Nitrogen	mg/L	622	0.30	0.32	3.8	0.01
Total Phosphorus	mg/L	624	0.056	0.11	1.8	0.002
Total Organic Carbon	mg/L	144	2.35	1.06	5.9	0.2

[a]EPA STORET data collected by ADEM, EPA Region IV, and TVA from 1990 through 1998.

3.6.2 Water Quality

Using conventional classification methods, Wheeler Reservoir would be considered eutrophic (Higgins and Kim, 1981). TVA 1999 Vital Signs Monitoring rated the overall ecological condition of the reservoir as fair (TVA, 2000). The 1999 rating was lower than previous years, primarily due to less than normal rainfall. Much of the summer of 1999 was characterized by low flows that increased reservoir retention time, algal production, and dissolved oxygen depletion. Dissolved oxygen concentrations of less than 2.0 mg/L occurred during summer thermal stratification at two of the four sampling sites; at times comprising up to 25% of the water column and 75% of the bottom length. There were no swimming advisories on Wheeler Reservoir in 1999. Fecal coliform bacteria in samples collected at five swimming beaches and four boat ramps were within the State of Alabama guidelines for water contact.

3.6.3 Temperature

Water temperature patterns in Wheeler Reservoir are constantly changing in response to varying meteorological and flow conditions. Important heat transfer variables include air temperature, relative humidity, wind speed, solar radiation, evaporation, advection, and convection. Reservoir flow rates and geometry are also key factors. For a detailed discussion of hydrothermal conditions in Wheeler Reservoir see TVA, 1983.

BFN is located in a region of expanding reservoir cross section. Upstream riverine conditions change to deep channel and expansive overbank just upstream of BFN. Downstream, the reservoir is deep and wide. River flows depend on discharges from upstream Guntersville Dam and downstream Wheeler Dam. Travel times from BFN to Wheeler Dam range from three days to two weeks, depending on river flows.

The current temperature limits for the BFN thermal discharge, obtained via Section 316(a) of the Clean Water Act, include two parameters--the maximum temperature downstream of the plant, and the maximum temperature rise from upstream to downstream of the plant. These limits must be met at the edges of a mixing zone with the following dimensions: 1) a maximum length of 2,400 feet downstream of the diffusers; 2) a maximum width of 2,000 feet; and 3) a maximum length of 150 feet upstream of the diffusers to the top of the diffuser pipes and extends to the bottom downstream of the diffusers. Downstream river temperature measurements are obtained by three permanent monitoring stations located in a line across the reservoir at approximate river mile 293.45. Upstream river temperature measurements are obtained by a permanent monitoring station located in the main channel at about river mile 297.8. The maximum temperature downstream of the plant includes a 1-hour average limit and a 24-hour average limit. The one-hour average limit is 93°F (33.9°C) and the 24-hour average limit is 90°F (32.2°C). The maximum temperature rise includes only a 24-hour average limit, which is 10 Fahrenheit degrees (5.6 Celsius degrees). Historical data shows that it is possible for the 24-hour average upstream (i.e., ambient) water temperature to exceed 90°F. To allow plant operation under these conditions, if the upstream 24-hour temperature exceeds 90°F, the 24-hour downstream temperature may equal, but not exceed, the upstream value. That is, the temperature rise must be zero or less. As ambient temperature increases, this type of operation is acceptable until the 1-hour average limit of 93°F is obtained.

Natural water temperatures in the reservoir vary from around 35°F in January to near 90°F in July. Monthly changes of 15 to 20°F are common in the spring and fall. Meteorological conditions can cause temperatures throughout the reservoir to change 5°F in ten days. Daily variations due to solar heating can cause 1 to 2°F changes during fully mixed conditions and up to 3 to 5°F changes in the surface layer down to five feet.

Temperature patterns upstream of BFN are fully mixed during the fall, winter, and spring with weak thermal stratification from June through September. Temperatures in the overbank near BFN are similar to those in the main channel except that the overbank areas are more responsive to changing meteorological conditions. Spatial differences, overbank to main channel, caused by wind and flow mixing can cause 1 to 3°F differences on an hourly basis. In the lower portion of the reservoir weak thermal stratification can result in a 5°F difference from surface to bottom.

3.6.4 Water Intakes and Wastewater Discharges

Tables 3.6-2 and 3.6-3 list the potable water supply intakes and wastewater discharges on Wheeler Reservoir (ADEM, 2001). There are eight water intakes withdrawing approximately 124 million gallons per day (MGD) for municipal and industrial use. Wastewater discharges include ten municipal plants discharging over 30 MGD and 17 industrial plants discharging over 2,466 MGD.

3.6.5 Water Use Conflicts

Consumptive and off-stream water uses have not resulted in significant use conflicts due to the large volume of reservoir water available, the high river flow rate, and the return of most of the water withdrawn. Regulatory control of withdrawal rates and National Pollutant Discharge Elimination System (NPDES) permit limits for return water quality also mitigate potential conflicts. Potential trade-offs can occur with instream water uses, however (e.g., instream use conflicts among aquatic life, waste assimilation, navigation, power generation, flood control, and lake levels). These potential conflicts are addressed by historic operating procedures, legal requirements, and regulatory procedures.

Table 3.6-2 Potable Water Intakes on Wheeler Reservoir

Name	Intake Location	Population Served	Daily Use (MGD)
Municipal			
West Morgan - East Lawrence Counties	TRM 286.5	24,000	4.0
Decatur Utilities	TRM 306.0	64,500	27.2
Huntsville Utilities	TRM 319.4	199.500	16.5
Huntsville Utilities (South Plant)	TRM 334.2	199,500	8.5
Northeast Morgan County Water Authority	TRM 334.7	17,529	0.9
Industrial			
Redstone Arsenal - Plant 2	TRM 330.2	19,940	11.3
Redstone Arsenal - Plant 1	TRM 323.9	1,240	0.7
International Paper Co. (Courtland)	TRM 282.4	2,500	55.0

Table 3.6-3 Wastewater Discharges on Wheeler Reservoir		
Name	**Location**	**Flow (MGD)**
Municipal		
Decatur Dry Creek	Dry Branch Mile 0.6 at TRM 302.8	18.5
Huntsville West Area	TRM 318.5	11.1
Priceville WWTP	TRM 311.5	0.2
Cotaco School	Cotaco Creek Mile 2 at TRM 319.2	N/A
Crosscreek Subdivision	TRM 317	N/A
Lawson Trailer Park Lagoon	TRM 303.1	N/A
Reid School	TRM 298	N/A
Sherbrooke Utilities Inc.	Dry Creek Mile 1 at TRM 328.5	N/A
Tanner High School	TRM 301	N/A
Union Grove Junior High School	Shoal Creek Mile 2.1 at TRM 347	N/A
Industrial		
Saint Gobain Indust. Ceramics	TRM 335.1	1.2
Tru-Line Manufacturing	Flint Creek Mile 3 at TRM 308.4	N/A
General Electric Co.	TRM 307.1	0.3
Goodyear Tire & Rubber	TRM 305.9	N/A
Decatur Transit	TRM 302	N/A
Nova Chemicals	Dry Branch Mile 0.2 at TRM 302.8	N/A
3M Corporation	Bakers Creek Mile 0.1 at TRM 301.2	16.0
Air Products & Chemicals	Bakers Creek Mile 1 at TRM 301.2	N/A
BP Amoco Chemical	Bakers Creek Mile 0.1 at TRM 301.2	4.5
Cerestar USA – Decatur	Bakers Creek Mile 0.4 at TRM 301.2	1.3
Daikin America	Bakers Creek Mile 0.5 at TRM 301.2	1.5
Diamond Wood Treaters	Bakers Creek Mile 1 at TRM 301.2	N/A
Solutia Inc.	Bakers Creek Mile 0.9 at TRM 301.2	115.0
Solvay Advanced Polymers	Bakers Creek Mile 0.4 at TRM 301.2	N/A
City of Decatur/Morgan Co.	Trinity Branch Mile 2.4 at TRM 295.9	N/A
Trico Steel Co.	Trinity Branch Mile 2.4 at TRM 295.9	1.0
TVA BFN	TRM 294.4	2325.0*

* The discharge from BFN is cooling water, not Municipal or Industrial wastewater.

3.7 Groundwater Resources

3.7.1 Groundwater Occurrence

Shallow groundwater at BFN occurs within unconsolidated terrace deposits and residual soils, and along a relatively thin but highly weathered horizon (epikarst zone) at the top of bedrock. At depth, groundwater occurs exclusively in fractures and solution features of the Tuscumbia limestone and Fort Payne chert. The Tuscumbia limestone and Fort Payne chert are collectively

described as the Tuscumbia-Fort Payne aquifer system. This aquifer system is the most important water-bearing unit in the site vicinity from a regional perspective since it is a source of water for both wells and springs in the area.

Recharge to the shallow groundwater system at the plant site is derived primarily from precipitation. Regional water balance studies (Zurawski, 1978) show that approximately 10 to 13 inches of this precipitation enters groundwater storage. A total of 18 monitoring wells have been installed at the BFN site since 1980 and groundwater level measurements were initially monitored on a monthly basis.

Groundwater levels at the site are generally highest during the months of January through March. During September and October, water levels are usually at a minimum. Correlation between water levels in site wells and neighboring surface waters indicates that the Tennessee River and plant water channels exert some control on local groundwater elevations and hydraulic gradients. The direction of groundwater movement is generally W-SW toward the Tennessee River. Exceptions to this directional flux occur at the plant site during dewatering operations that can reverse gradient conditions, in the vicinity of leaking water lines serving the site, in areas of topographic highs/lows, and in the vicinity of the Low-Level Radioactive Waste (LLRW) storage facility where more complex movement exists.

Within overburden soils at the site, groundwater movement is predominantly downward. Local areas of lateral flow likely occur near some streams, topographic lows, and where extensive root systems exist. Based on 15 undisturbed soil samples, Boggs (1982) determined that the saturated hydraulic conductivity of site soils in the vicinity of the LLRW storage facility averages 3.7E-08 feet per second. Water supply wells developed within such low permeability soils are primarily of limited capacity. Based on aquifer testing in a similar setting (Julian, et al., 1993) the cherty gravel horizon near bedrock (epikarst) can be significantly transmissive. Measured transmissivity values by Julian, et al. (1993) suggest horizontal hydraulic conductivity values that are from one to two orders of magnitude greater than those measured in the shallow Tuscumbia limestone. Observations of groundwater levels during early site borings (TVA, 1972) also suggest that groundwater within the epikarst zone and Tuscumbia-Fort Payne aquifer might be confined.

Groundwater flow in the Tuscumbia limestone occurs solely in fractured and weathered zones. The orientation of fractures and solution features within the Tuscumbia is coincident with a structurally controlled joint system (i.e., along strike and dip). Studies by Julian, et al. (1993) indicate that the transmissivities of bedrock fractures and solution features in the Tuscumbia may decrease with depth. However, the interconnectivity of these features is equally important. Although fractured, the silty, siliceous nature of the Fort Payne chert inhibits the development of solution features. Therefore, the average permeability of the Fort Payne at the site is expected to be less than that of the Tuscumbia limestone.

There are two sets of on-site lagoons at BFN.

Wastewater Lagoons. There is a series of three interconnected lagoons located north of the switchyard that are used to provide secondary treatment for the plant's sanitary wastewater. The lagoons were constructed using compacted clay and possess no synthetic linings. There is no monitoring of lagoon influent. However, effluent is discharged under the plant NPDES permit (DSN 013a(1)) that is monitored for flow, pH, BOD5, TSS, and fecal coliform. There are no groundwater monitoring wells installed in the vicinity of these lagoons.

Sedimentation Ponds. There are two sedimentation ponds (Ponds A & B) located east of the plant and adjacent to the end of the central perimeter (switchyard) drainage ditch. These ponds are both lined with Hypalon Synthetic liners. The ponds receive reject water from the Ecolochem Reverse Osmosis process used to generate demineralized water for the plant, water discharged from the Diesel Generator building sumps, and water from the Water Intake Building sump. Discharge from Pond A, the larger of the two ponds, is permitted under an NPDES permit (DSN 013b). The pond is released on a batch basis as needed, and the outfall is monitored for flow, pH, TSS and Oil and Grease under the terms of the NPDES permit. Pond B has no outfall. When it fills, effluent from Pond B is manually pumped to Pond A and released through the permitted outfall. Piping and valves are provided to allow flexibility in filling either of the ponds. There are no groundwater monitoring wells installed in the vicinity of these ponds. Although an original plant bedrock monitoring well (well 7) was located about 100 feet southwest of pond A (between the pond and the river), it was destroyed when the Ecolochem building was constructed.

3.7.2 Groundwater Use

The Tuscumbia-Fort Payne aquifer system provides volumes of water sufficient for domestic supplies and some municipal and industrial supplies in the region. Groundwater in this aquifer system is a calcium bicarbonate type and can generally be used without extensive treatment. Public groundwater supplies within a 50-mile radius of BFN were previously identified by TVA (TVA, 1972). An off-site well survey was conducted in May 1995 to identify groundwater supplies within a two-mile radius of the BFN site and this information is provided by TVA (1999). The closest known public groundwater supply (Limestone County Water System, Well G-1) resides approximately two-miles north of BFN (ADEM, 2001). There is no groundwater use by BFN, and site dewatering wells have been inactive since the 1980s.

3.8 Floodplains and Flood Risk

The BFN plant site is located on the right bank of Wheeler Reservoir at Tennessee River mile (TRM) 294.0 in Limestone County, Alabama. The affected project area could possibly be flooded from the Tennessee River, a small stream to the northwest of the plant site and the site drainage system. The site drainage system is broken into three areas: 1) the switchyard, 2) the main plant area, and 3) the cooling tower system. The area impacted by the construction of any of the alternatives extends from about Tennessee River mile 293.0 to mile 294.0.

3.8.1 Current Conditions

The 100-year floodplain for the Tennessee River would be the area below elevation 557.3. The TVA Flood Risk Profile (FRP) elevation on the Tennessee River would also be elevation 557.3. The FRP is used to control residential and commercial development on TVA lands. At this location, the FRP elevation is equal to the 500-year flood elevation. Results of studies completed in 1981 give an estimated Probable Maximum Flood (PMF) level of 570 at the BFN site, or 2.5 feet lower than that provided in Appendix 2.4A of the FSAR. However, the PMF design value of 572.5 feet will continue to be used with the 2.5 feet difference as a design margin. Consequent wave run-up above the flood level would be 1.7 feet on a vertical wall and 2.7 feet on a 3:1 grassed slope. A

maximum flood elevation of 574 at the plant site results from a combination of the PMF and wind wave run-up on a vertical wall or 575 as a result of the PMF and wind wave run-up on a 3:1 grassed slope.

For the small stream to the northwest of the site and the internal site drainage system, the 100- and 500-year flood elevations have not been determined. No PMF elevations have been computed for the small stream northwest of the plant; however, the maximum possible discharge is 17,200 cfs. For the switchyard drainage channel, the PMF elevation at the holding pond at the downstream end of the channel would be 574.8 and the PMF elevation at the north corner of the switchyard would be 577.8. The PMF elevation between the office and service buildings would be 566.6. In the vicinity of the radioactive waste, reactor, and diesel generator buildings, PMF elevations for all modes of plant operation would not exceed elevation 564.0. In the cooling tower system of channels there is sufficient capacity to pass the PMF and condenser water (Reference: FSAR).

3.8.2 Anticipated Future Conditions

Flooding conditions during the term of the renewed license (up to year 2036) are expected to remain similar to current conditions. For the Tennessee River, all dams in the TVA system are assumed to be maintained and remain operational for the entire licensing period. Existing procedures used for determining the 100- and 500-year flood levels on the Tennessee River are currently being reviewed; however, no major changes are expected to the adopted flood elevations as listed above. In addition, urbanization within the 27,130 square mile drainage area upstream of BFN would not be expected to significantly increase the 100- and 500-year floods. The computation of PMF levels is based on adopted standards and procedures, and no changes to these procedures are expected within the licensing period. If there were a change in these procedures, or if a major flood event occurred during the licensing period, a reevaluation could be necessary.

In regard to the small stream to the northwest of the plant site and the site drainage system, total development of a small drainage basin will increase the 100- and 500-year flood discharges from a small amount up to 2.5 times the natural discharge from the basin, depending on the amount of impervious area associated with the development. For the small stream northwest of the plant site, significant development within the 1.35 square mile drainage area is not expected to occur during the next 35 years. If total development were to occur, the 100- and 500-year flood discharges could increase as much as 2.5 times the natural discharge, as stated above. The switchyard drainage channel area, the main plant area, and the cooling tower system area all have some existing impervious area within their drainage basins. Additional impervious area would increase the 100- and 500-year flood discharges by some amount, but should not cause flooding greater than that produced by the PMF event.

3.9 Terrestrial Ecology

3.9.1 Vegetation

BFN is located within the Highland Rim section of the Interior Low Plateau Physiographic Province as described by Fenneman (1938). Botanically, the project site occurs within the Mississippian Plateau section of the Western Mesophytic Forest Region as recognized by Braun (1950). In this region of northern Alabama, native forest communities generally consist of mixed oak forests varying composition in relation to topography and soils. Historically, upland forests in the project area were characterized by mixtures of southern red oak, black oak, post oak and white oak with dogwood commonly present in the understory. The clearing of forested lands for agriculture has converted many of these forest communities to early successional habitats, allowing representative native plant communities to become replaced by introduced plant species.

The area in and around the BFN has been heavily impacted and altered as a result of the construction and operation of the existing facilities. Field inspections of the areas associated with the proposed action reveal that little native vegetation remains. The proposed location for the new cooling towers consists of old field vegetation with scattered tree species including black locust, various oaks, loblolly pine, and eastern red cedar. *Sericea lespedeza* and broomsedge are among the dominant herbs. The proposed locations for soil deposition (required for the construction of the new cooling towers) consist of two hayfields and a fallow cotton field now vegetated by a dense thicket of blackberry, Japanese honeysuckle and *Sericea lespedeza*, with scattered saplings of black locust and eastern red cedar. No uncommon communities or otherwise sensitive vegetation occurs on or immediately adjacent to the project areas.

3.9.2 Wildlife

The Tennessee River and surrounding terrestrial habitats offer suitable habitat to a wide variety of wildlife species. The river is used extensively by a variety of waterfowl and wading bird species. Wheeler Wildlife Refuge, located upstream from BFN is one of the southern-most wintering areas for ducks and geese in the southeast. In suitable terrestrial habitats, wildlife such as white-tailed deer, coyote, eastern cotton-tailed rabbit and opossum are fairly abundant in the vicinity. Most habitats in the vicinity are used by a many species of mammals, birds, amphibians and reptiles. Numerous caves are reported from Limestone County. These sensitive habitats provide habitat for numerous cave-dwelling species of animals, mostly bats, amphibians and numerous species of invertebrates.

Extensive agricultural practices prior to the construction of the BFN and construction of the existing facility have led to a decrease in the overall diversity of habitats within the project area. Limited available wildlife habitat existing at the nuclear plant site includes early successional, old field habitats, with scattered trees and agricultural fields. Wildlife species most commonly observed in the project area include those species that are less sensitive to human disturbance and are common in the region. Common bird species include song sparrow, eastern meadowlark, eastern bluebird, northern mockingbird, and American robin. Amphibians such as spring peeper

and upland chorus frogs are common in the area. Small mammals such as hispid cotton rat, least shrew, and meadow voles may be found in these habitats.

3.9.3 Introduced Species

As described in section 3.9.1, the lands of the BFN site have been heavily impacted and altered as a result of the construction and operation of the existing facilities. As a result of these disturbances, native plant communities have been converted to early successional habitats characterized by introduced (non-native) plant species such as *Sericea lespedeza*, Japanese honeysuckle and multiflora rose. Introduced plant species have the potential to impact terrestrial ecology resources through reductions in native biological diversity because of their potential for rapid establishment and spread in disturbed habitats, and their tendency to displace native vegetation (Tennessee Exotic Plant Council, 1996).

The densities of introduced plant species and the habitats in which they occur on the project lands are characteristic of such disturbed sites in the region. Various native (i.e., indigenous) plants occur in the area; however, no intact native plant communities exist on the lands to be disturbed by the proposed action.

Due to the lack of complexity of habitats and the presence of the facility, several non-native species of wildlife exists on the project lands. Species such as European house sparrow and European starling are common on the site.

3.9.4 Managed Areas and Ecologically Significant Sites

A review of the TVA Regional Natural Heritage database indicates that there are no Managed Areas or Ecologically Significant Sites on or adjacent to the proposed project site. However, two Managed Areas are known to occur within three miles of the BFN. These areas have been recognized and are protected, to varying degrees, because they contain unique natural resources, scenic values, or public use opportunities. The following paragraphs offer brief descriptions of each area including primary use and available facilities.

SWAN CREEK STATE WILDLIFE MANAGEMENT AREA

This wildlife management area includes over 3,000 acres of land and over 5,000 acres of water surrounded by numerous industrial facilities. Wooded lands and grassy pastures, occasionally interrupted by railroad tracks and transmission lines, provide one of the most important waterfowl management areas in the state of Alabama. Although the primary management focus is for waterfowl and small game hunting, this area is becoming increasingly important for migrating bird species. In addition, the area is increasingly utilized by bird watchers and other outdoor enthusiasts. These lands are owned by TVA and presently managed by the Alabama Department of Conservation (ADC).

MALLARD-FOX CREEK STATE WILDLIFE MANAGEMENT AREA

Encompassing approximately 700 acres of land and 1,700 acres of water, this wildlife management area is primarily utilized for small game hunting. Although the majority of these acres are owned by TVA, the ADC manages these lands for public use.

3.10 Aquatic Ecology

3.10.1 Fish

TVA has conducted extensive sampling of the fish community in the vicinity of BFN and elsewhere in Wheeler Reservoir in recent years, both in monitoring programs conducted specifically for BFN (Baxter and Buchanan, 1998), and as part of TVA's Reservoir Monitoring Program (Dycus and Baker, 2000). A total of 60 species (excluding hybrids) has been collected in recent years by various sampling methods (Table 3.10-1).

Cove rotenone samples were collected annually from 1969 through 1997 as a component of the TVA environmental monitoring program for BFN, to provide a database on the fish community in the vicinity of BFN, and later to serve as a part of the thermal variance monitoring program. In more recent samples, 52 species were collected in 1995; 45 species in 1996; and 43 species in 1997. Annual standing stock estimates were 105,655 fish/hectare (ha) and 683 kilograms per hectare (kg/ha) in 1995 and decreased to 11,713 fish/ha and 366 kg/ha in 1996, then increased to 24,497 fish/ha and 489 kg/ha in 1997. As usual, forage fish were numerically dominant in samples, and also dominated biomass estimates in 1995 and 1996, but rough fish were highest in biomass in 1997. Gizzard shad exhibited the highest biomass during all three years, followed by threadfin shad in 1995 and smallmouth buffalo in 1996 and 1997 (Baxter and Buchanan, 1998).

TVA began a program to systematically monitor the ecological conditions of its reservoirs in 1990. Previously, reservoir studies had been confined to assessments to meet specific needs as they arose. Reservoir (and stream) monitoring programs were combined with TVA's fish tissue and bacteriological studies to form an integrated Vital Signs Monitoring program. Vital signs monitoring activities focus on:

1. Physical/chemical characteristics of waters;
2. Physical/chemical characteristics of sediments;
3. Benthic macroinvertebrate community sampling; and
4. Fish assemblage sampling.

Fish are included in aquatic monitoring programs because they are important to the aquatic food chain and because they have a long life-cycle, which allows them to reflect conditions over time. Fish are also important to the public for aesthetic, recreational, and commercial reasons (Dycus and Baker, 2000).

Fish samples were taken in three areas of Wheeler Reservoir from 1990 through 1995, and again in 1997 and 1999 as part of TVA's Reservoir Vital Signs monitoring program. Areas sampled included the forebay (area of the reservoir nearest the dam), a mid-reservoir transition station in the vicinity of TRM 295.9, an upper-reservoir inflow station at TRM 348, and the Elk River Embayment. Although any fish species known from elsewhere in the reservoir could occur in the

vicinity of BFN, results of sampling at the transition station are presented here because they are more representative of fish communities in the vicinity of BFN.

Reservoir Fish Assemblage Index (RFAI) ratings are based primarily on fish community structure and function. Also considered in the rating are the percentage of the sample represented by omnivores and insectivores, overall number of fish collected, and the occurrence of fish with anomalies such as diseases, lesions, parasites, deformities, etc. Compared to other run-of-the-river reservoirs, the fish assemblage at the Guntersville mid-reservoir station (TRM 295.9) rated poor in 1992 and 1999, fair in 1990, 1991, 1995, and 1997, and good in 1993 and 1994. In the fall of 2000, additional (i.e., not on the regular RFAI monitoring schedule) electrofishing and gill net samples were taken at the transition station (TRM 295.9) and a newly-established sampling station for future BFN monitoring at TRM 292.5. A total of 30 fish species (excluding hybrids) was collected; the fish assemblage rated good at TRM 292.5 and fair at TRM 295.9 (Table 3.10-1) (Dycus and Baker, 2001).

Table 3.10-1 Fish Species Collected in the Vicinity of BFN by TVA During BFN Monitoring and Reservoir Monitoring Activities, 1995-2000

Common Name	Fall 2000 Gill Net and Electrofishing TRM 292.5	Fall 2000 Gill Net and Electrofishing TRM 295.9	Cove Rotenone 1995-1997	Fall 1999 Gill Net and Electrofishing TRM 295.9
Chestnut lamprey	-	-	x	-
Spotted gar	-	x	x	-
Longnose gar	-	-	x	-
Bowfin	-	-	x	-
Skipjack herring	x	x	x	x
Gizzard shad	x	x	x	x
Threadfin shad	x	x	x	x
Central stoneroller	-	-	x	-
Grass carp	-	x	-	-
Spotfin shiner	-	-	x	-
Steelcolor shiner	-	-	x	-
Common carp	-	x	x	x
Striped shiner	-	-	x	-
Silver chub	-	-	x	-
Golden shiner	-	-	x	-
Emerald shiner	x	x	x	-
Ghost shiner	-	-	x	-
Mimic shiner	-	-	x	-
Bullhead minnow	-	-	x	-
Northern hog sucker	x	x	x	-
Smallmouth buffalo	x	x	x	x
Bigmouth buffalo	-	-	x	-
Spotted sucker	x	x	x	x
Silver redhorse	-	-	x	-
River redhorse	x	x	-	-
Black redhorse	x	-	-	-
Golden redhorse	-	-	x	x

Table 3.10-1 Fish Species Collected in the Vicinity of BFN by TVA During BFN Monitoring and Reservoir Monitoring Activities, 1995-2000

Common Name	Fall 2000 Gill Net and Electrofishing TRM 292.5	Fall 2000 Gill Net and Electrofishing TRM 295.9	Cove Rotenone 1995-1997	Fall 1999 Gill Net and Electrofishing TRM 295.9
Shorthead redhorse	-	-	x	-
Black bullhead	-	-	x	-
Yellow bullhead	-	-	x	-
Brown bullhead	-	-	x	-
Blue catfish	x	x	x	x
Channel catfish	x	x	x	x
Flathead catfish	x	x	x	x
Blackstripe topminnow	-	-	x	-
Blackspotted topminnow	-	-	x	-
Western mosquitofish	-	-	x	-
Brook silverside	x	-	x	-
Inland silverside	-	-	x	-
White bass	x	x	x	x
Yellow bass	x	x	x	x
Hybrid striped x white bass	-	x	-	x
Striped bass	x	-	-	x
Redbreast sunfish	-	-	x	-
Green sunfish	-	-	x	-
Warmouth	-	x	x	-
Orangespotted sunfish	-	-	x	-
Bluegill	x	x	x	x
Longear sunfish	x	-	x	-
Redear sunfish	x	x	x	x
Hybrid sunfish	-	-	x	-
Smallmouth bass	x	x	x	-
Spotted bass	x	x	x	x
Largemouth bass	x	x	x	x
White crappie	-	-	x	-
Black crappie	-	-	x	-
Stripetail darter	-	-	x	-
Yellow perch	-	x	x	x
Logperch	x	x	x	-
River darter	-	-	x	-
Sauger	x	x	x	x
Freshwater drum	x	x	x	x

3.10.2 Benthic Organisms

As mentioned, BFN is located on Wheeler Reservoir, which TVA classifies as a Run-of-river reservoir. Run-of-river reservoirs typically have short water retention times (one to two weeks) and little winter drawdown. Benthic habitats in the reservoir range from deposits of finely divided silts to river channel cobble and bedrock. The most extensive benthic habitat is composed of fine-grained brown silt, which is deposited both in the old river channel and on the former overbank areas. The overbank areas, on either side of the old river channel, are far more extensive than the channel and are the most productive (TVA, 1972). These overbanks, located directly across from BFN, extend approximately two miles downstream. The overbanks support communities of Asiatic and fingernail clams, burrowing mayflies, aquatic worms, and midges. Cobble and bedrock areas, found primarily in the old channel, support Asiatic clams, bryozoa, sponges, caddisflies, snails, and some leeches. The Asiatic clam is nonindigenous to North America and is common in the Tennessee River system.

TVA began a program entitled Vital Signs monitoring to systematically monitor the ecological condition of its reservoirs in 1990. Benthic macroinvertebrates are included in Vital Signs monitoring because of their importance to the aquatic food chain, and because they have limited capability of movement, thereby preventing them from avoiding undesirable conditions. Since 1995, Vital Signs samples have been collected in the late fall/winter (November - December). Depending on reservoir size, as many as three stations are sampled (i.e., inflow, transition, and forebay).

Benthic macroinvertebrate Vital Signs monitoring data are analyzed using metrics. The number of metrics has varied through the sample years as reservoir benthic analysis has been fine-tuned. The most recent analysis is comprised of nine metrics: taxa richness, EPT taxa, long-lived taxa, non-chironomid and oligochaete density, percent oligochaete, dominance, zero samples, non-chironomid and oligochaete taxa, and chironomid density. The number derived for each metric is totaled and the score is applied to a range of values that identify the overall condition of the benthic community (i.e., very poor, poor, fair, good, or excellent).

BFN is located a short distance downstream from the Vital Signs transition station on Wheeler Reservoir (TRM 295.5). The transition station is the zone considered to be between riverine (the inflow station) and impoundment habitats (the forebay station). Benthic community scores at the transition station ranged from “excellent” in 1994 to “good” in 1995 and “excellent” again in 1997 and 1999 (Dycus and Baker, 2000).

In addition to Vital Signs benthic macroinvertebrate monitoring, benthic community sampling in support of BFN thermal variance monitoring was begun in the fall of 2000 (and will continue at least for the term of the current permit cycle - five years). Station locations are TRM 296 and TRM 292, upstream and downstream of the BFN diffusers respectively. An analysis of the 2000 sample year data indicated the benthic community above BFN diffusers was in “excellent” condition and the community below the diffusers was in “good” condition (Dycus and Baker, 2001).

Freshwater mussel fauna are not assessed as part of TVA’s Vital Signs program; however, they are excellent indicators of water quality due to their sessile nature and inability to avoid perturbations impacting water quality. Mussels feed on microorganisms (protozoans, bacteria, diatoms) and organic particles suspended in the water that are brought into the body via siphon action and consumed.

Thirty-eight freshwater mussel species had been documented in Wheeler Reservoir through 1991 (Ahlstedt and McDonough, 1992). Twelve species were identified in the vicinity of BFN during a 1982 survey for a proposed barge facility (Henson and Pryor, 1982). Most recently, Alabama Fish and Game identified 14 species upstream of BFN and 12 species downstream (Jeffrey T. Garner, Alabama Game and Fish Division Malacologist, personal communication, 2001). A listing of these species appears in Table 3.10-2.

Table 3.10-2 Mussel Species Collected by Alabama Game and Fish Division Near Browns Ferry Nuclear Plant in 1999

Common Name	Scientific Name
TRM 292, October 13-14, 1999	
Washboard	*Megalonaias nervosa*
Pink heelsplitter	*Potamilus alatus*
Threehorn wartyback	*Obliquaria reflexa*
Mapleleaf	*Quadrula*
Threeridge	*Amblema plicata*
Pimpleback	*Quadrula pustulosa*
Elephantear	*Elliptio crassidens*
Flat floater	*Anodonta suborbiculata*
Ebonyshell	*Fusconaia ebena*
Fragile papershell	*Leptodea fragilis*
Giant floater	*Pyganondon grandis*
Pistolgrip*	*Tritogonia verrucosa*
TRM 298, August 17 and October 20, 1999	
Washboard	*Megalonaias nervosa*
Pink heelsplitter	*Potamilus alatus*
Pimpleback	*Quadrula pustulosa*
Threehorn wartyback	*Obliquaria reflexa*
Threeridge	*Amblema plicata*
Elephantear	*Elliptio crassidens*
White heelsplitter	*Lasmigona complanata*
Pistolgrip	*Tritogonia verrucosa*
Purple waryback	*Cyclonaias tuberculata*
Mapleleaf	*Quadrula*
Butterfly*	*Ellipsaria lineolata*
Giant floater*	*Pyganodon grandis*
Pink papershell*	*Potamilus ohiensis*
Flat floater*	*Anodonta suborbiculata*

* = collected as dead shells

3.10.3 Introduced Species

A nonindigenous water flea, *Daphnia lumholtzi*, has been documented throughout the Tennessee River system (Tyler Baker, TVA biologist, personal communication, 2001). It is therefore expected to occur in Wheeler Reservoir.

Asiatic clam and zebra mussel populations that exist within Wheeler Reservoir would not be prone to exacerbation or extirpation due to BFN's thermal discharge. Thermal discharge limits permitted by ADEM would not exceed thermal thresholds of both organisms. Asiatic clams cannot survive extreme ambient water temperatures less than 36°F (2.2°C) and greater than 95°F (35°C). Thermal tolerance of Zebra mussels is 32°F to 98.6°F (Nalepa and Schloesser,1993). Potential biofouling by zebra mussels would actually be reduced by thermal addition as mortality of 60 percent was reported by Nalepa and Schloesser, (1993) at 89.6°F. BFN treats their raw water intake biannually with molluscide to control biofouling by Asiatic clams and zebra mussels. In addition, biweekly Raw water samples are analyzed during April through October for zebra mussel veligers as an early warning for potential biofouling.

Grass carp have been introduced to reservoirs in the TVA system, both by individuals seeking to control heavy infestations of aquatic vegetation, and by TVA in Guntersville Reservoir. Grass carp have not been collected in high numbers; they were not included in cove rotenone samples taken through 1997, and have been taken infrequently in reservoir monitoring gill net and electrofishing samples (Table 3-10.1).

3.10.4 Entrainment and Impingement of Fish and Shellfish, Heat Shock

Fish eggs and larvae entrained in cooling water may suffer mortality from one or more physical effects of passage through the plant. Consequently, in conjunction with the construction of BFN, TVA investigated the preoperational characteristics and dynamics of the annual Ichthyoplankton populations in Wheeler Reservoir (TVA, 1978a). This investigation was continued through the initiation of commercial operation in 1974, and data from 1971-1977 were reported (TVA, 1978b); 1978 and 1979 data were also reported (TVA, 1980). The larval fish populations were consistently dominated (80-98%) by clupeids (shad). Total annual percent fish entrainment increased over the four-year study period from 1.0 to 11.7% of the total number estimated passing the plant. Other significant taxa comprising greater than one percent of the total number of larval fish collected were catastomids (suckers), cyprinids (minnows and carp), sciaenids (drum), and percichthyids (white and yellow basses). The three families of fish with the highest estimated entrainment during three-unit operation at BFN in 1977 were Clupeidae (12.1%), Catostomidae (4.5%) and Sciaenidae (6.1%).

Four species of fish (threadfin shad, gizzard shad, freshwater drum, and skipjack herring) represented 95% of the total fish impinged at BFN. No species other than these four comprised greater than 1% of total fish impinged (TVA, 1980).

TVA's Vital Signs monitoring program (TVA 2000) reported no obvious decline in the fish and benthic macroinvertebrate communities in Wheeler Reservoir and there is a balanced indigenous fish community.

Response of fish and other aquatic life to elevated temperatures found in power plant discharges can range from acute, which includes immediate disability and death; to chronic or low level, which may include physiological or behavioral responses such as changes in spawning, migration, or feed behaviors. Since the discharge diffusers at BFN are located such that fish do not become trapped in areas of elevated temperatures, acute impacts are highly unlikely. TVA studies have documented that thermal releases from BFN have not had a significant impact on the aquatic community of Wheeler Reservoir (TVA, 1983, Baxter and Buchanan, 1998).

3.10.5 Microbiological Organisms

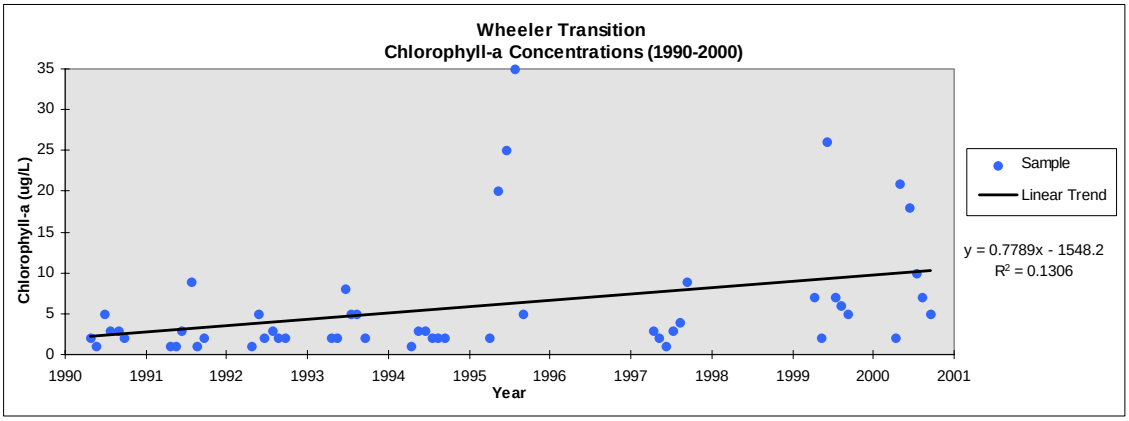
Plankton surveys were conducted during BFN preoperational monitoring in the early 1970s and have been a component of many BFN aquatic community surveys since then. The earliest phytoplankton surveys for Wheeler Reservoir found the assemblage to be quite diverse. As many as 27 Chrysophyta, 52 Chlorophyta, and 17 Cyanophyta taxa have been documented (TVA, 1977). Early zooplankton surveys documented a diverse assemblage as well, with 32 Dladocera, 24 Copepoda, and 47 Rotifera taxa represented (TVA, 1977). More recently, algal dynamics surveys were conducted in 1989 during plant shutdown and again in 1991 when the plant was operational as part of the approved BFN thermal variance monitoring program (Lowery and Poppe, 1992). The objective of this activity was to determine the effect the BFN thermal discharges would have on the phytoplankton community in Wheeler Reservoir. The study was initiated as a result of recommendations made during the operational monitoring reporting process for BFN.

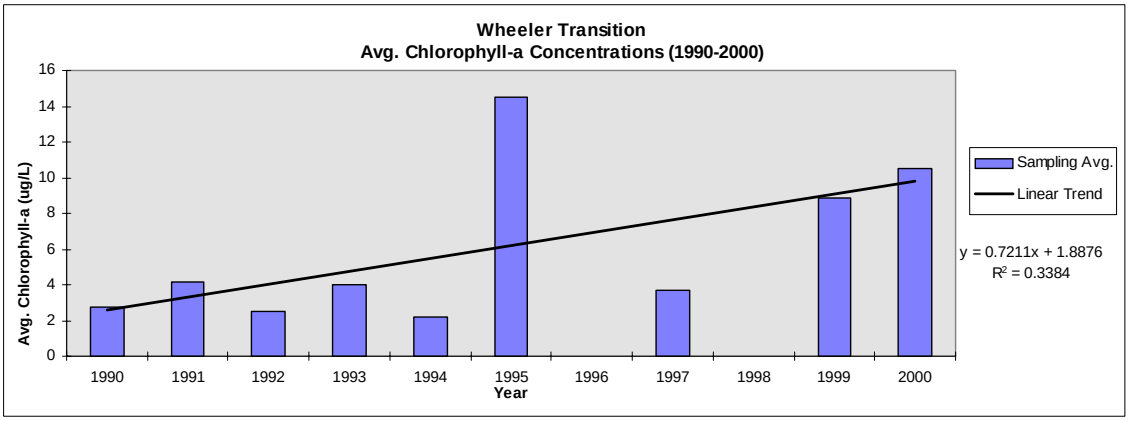
The validity of preoperational and operational BFN algal surveys conducted in the 1970s has been brought into question with advancements in reservoir limnology during the past 18 to 20 years. Considerable research and monitoring, conducted by TVA and others to evaluate phytoplankton/nutrient interactions in reservoirs has found that several factors must be considered to determine cause/effect relationships in reservoirs. These factors include flow-through conditions, overbank/embayment areas, residence time, zonation, and placement of point and non-point pollution sources (Lowery and Poppe, 1992). Erroneous results can occur when using annual “snapshot” surveys to analyze algal communities in reservoirs.

BFN preoperational and operational monitoring collections were typically conducted on an annual basis – once per summer. Vital Signs monitoring is conducted on a monthly schedule, April through September. Plankton data gathered during Vital Signs monitoring is believed to be more reliable. According to Lowery and Poppe (1992), the importance in sampling monthly lays in the fact that algal division rates are such that several generations can be missed in less frequent sampling and hence the chances for observing “boom or bust” situations increase as sampling frequency decreases. Unfortunately, abnormally high densities observed during operational monitoring may have been nothing more than chance collections, during peak densities just as lower numbers in other years may have been underestimates (Lowery and Poppe, 1992). If BFN is having a stimulatory or depressing effect on the plankton community in the near field, numbers should be significantly increased or decreased downstream of the plant in at least some habitats as compared to similar habitats. Examination of the 1989 and 1992 samples and the Vital Signs monitoring network data (far field) showed no consistent changes in either the near field or downstream (Lowery and Poppe, 1992). The only consistent observation that could be made from the 1989 and 1991 surveys and the Vital Signs monitoring data was that plankton communities vary on a daily basis regardless of location or habitat type.

Chlorophyll *a* is a simple, long-standing, and well-accepted measurement for estimating algal biomass, algal productivity, and trophic condition of a lake or reservoir (Carlson, 1977). Generally, lower chlorophyll concentrations in the oligotrophic range are thought to be indicative of good water quality conditions, and high chlorophyll concentrations are usually considered indicative of cultural eutrophication (Dycus and Baker, 2000). Average chlorophyll a concentrations (µg/L) recorded from Wheeler Reservoir's transition station between 1992 and 1999 are illustrated in Figure 3.10-1. Wheeler Reservoir's chlorophyll levels at the transition station, in the vicinity of BFN, received a "fair" rating in 1992 and 1994, a "good" rating in 1993, 1997, and 1999, and a "poor" rating in 1995 (TVA, 1993, 1994, 1995, 1996, 1998, Dycus and Baker, 2000). Low flow conditions in 1995 are believed to have allowed for longer water retention times in the reservoir contributing to increased algal production and a substantially lower score. For a detailed explanation of how chlorophyll a concentrations are translated into a rating, see Dycus and Baker (2000).

Figure 3.10-1 Chlorophyll *a* Concentrations from Wheeler Reservoir Transition Station, Vital Signs Monitoring 1990-2000





3.11 Threatened and Endangered Species

3.11.1 Animal

A review of TVA Regional Natural Heritage databases indicates that four federally- or state-listed species of animals are reported from Limestone County (Table 3.11-1). No listed species are reported within five miles of the BFN.

Table 3.11-1 Rare Terrestrial Animal Species Known from Limestone County, Alabama

Common Name	Scientific Name	Federal Status	State Status
Gray Bat	*(Myotis grisescens)*	Endangered	Protected
Indiana Bat	*(Myotis sodalis)*	Endangered	Protected
Tennessee Cave Salamander	*(Gyrinophilus palleucus)*	none	Protected
Appalachian Bewick's Wren	*(Thryomanes bewickii altus)*	none	Protected

Federally listed endangered gray and Indiana bats are reported from caves along the Elk River. Gray bats are monitored at these caves annually by ADC Biologists. Gray bat populations appear to be stable at these sites. Indiana bats have not been reported from these caves in recent years. Although there are no suitable habitats for gray or Indiana bats on the BFN, gray bats likely forage along the Tennessee River adjacent to the project area.

State-listed Tennessee cave salamanders and Appalachian Bewick's wren have been reported from northern portions of Limestone County. No caves are known from the project area; therefore, no suitable habitat for Tennessee cave salamanders exists on the site. Appalachian Bewick's wren prefers nesting in hedgerows or slash piles in early successional habitat. Limited amounts of this habitat exist on the site; however, the quality of this habitat is considered marginal.

3.11.2 Aquatic

Five federally listed endangered aquatic species are known to occur in the vicinity of BFN. The rough pigtoe (*Pleurobema plenum*) and the pink mucket (*Lampsilis abrupta*) are freshwater mussels that historically occurred in silt-free, stable gravel and cobble habitats in large river habitats throughout the Tennessee River system (Parmalee and Bogan, 1998). These species are now extremely rare and are primarily found in unimpounded tributary rivers and in the more riverine reaches of the largely impounded mainstream Tennessee River. In Wheeler Reservoir, most of the surviving large river habitat occurs upstream of BFN. All recent records of these two species are from upstream of BFN (Ahlstedt and McDonough, 1993; Colaw and Carroll, 1982; El-Ashry and Lesene, 1979; Jeffrey T. Garner - State Malacologist - Alabama Game and Fish Division, personal communication 1998 and 2001; Gooch, et al., 1979; Henson and Pryor, 1982; TVA Regional Natural Heritage Database, 2001; Yokely, 1998). It is very unlikely that populations of these species exist in Wheeler Reservoir downstream of BFN (Koch, 1999).

Two aquatic snails, restricted to streams entering Wheeler Reservoir in Limestone County, Alabama, were recently listed as endangered by the U. S. Fish and Wildlife Service. The armored snail (*Pyrgulopsis pachyta*) and the slender campeloma (*Campeloma decampi*), as well as the

previously listed Anthony's river snail (*Leptoxis* [=*Athearnia*] *anthonyi*), are restricted to tributary creeks to Wheeler Reservoir, located upstream from BFN. No evidence exists to suggest that populations of these species exist in Wheeler Reservoir downstream of BFN.

Other federally-listed species, such as the orange-footed pimpleback mussel (*Plethobasus cooperianusi*), the cracking pearly mussel (*Hemistena lata*), the fine-rayed pigtoe mussel (*Fusconaia cuneolus*), the shiny pigtoe mussel (*F. cor*), Snail darter (*Percina tanasi*), the slackwater darter (*Etheostoma boshungi*), the boulder darter(*E. wapiti*), and the Alabama blind cave shrimp (*Palaemonias alabamae*) are known to occur in the general North Alabama area (i.e., Limestone, Lawrence, and Morgan Counties, Alabama). None of these species are presently known to exist within the area affected by the proposed actions.

3.11.3 Plants

A review of the TVA Regional Natural Heritage database indicates that no federally listed and five Alabama state-listed plant species are known from Limestone County, Alabama (Table 3.11-2). A more detailed review of TVA Heritage records indicates that none of these species, or any other rare plant species known from adjacent counties, are known to occur within five miles of the project area. In addition, field inspections of the project area reveal that suitable habitats for these or other rare plant species are not present on lands to be affected by the proposed activities.

Table 3.11-2 Rare Plant Species Known from Limestone County, Alabama

Common Name	Scientific Name	Federal Status	State Status†
Duck River bladderpod	*Lesquerella densipila*	none	NOST
Snow wreath	*Neviusia alabamensis*	none	NOST
Sweetflag	*Acorus calmus*	none	NOST
Toadshade*	*Trillium sessile*	none	NOST
Waterweed	*Elodea canadensis*	none	NOST

† NOST - Alabama Natural Heritage Program does not assign status codes to state-listed species; this designation indicates the species is tracked by the Alabama Natural Heritage Program due to its rarity in the state.

* This common name is often applied to more than one member of this genus.

3.12 Wetlands

Wetland resources in Alabama have suffered a marked decline as the result of channelization of major streams and the clearing of wetlands for agricultural and other purposes. Past land-use changes and stream channelization have resulted in the reduction of total wetland acreage, changes in wetland types, and diminished ecological integrity of many of the remaining wetlands throughout the region. Channelized streams result in less frequent flooding and allow rapid runoff and drainage of the floodplain and adjacent areas. The extensive areas of bottomland forested wetlands that occurred in the major stream bottoms prior to channelization and land clearing are largely absent from the landscape. Overall, Alabama sustained a net loss of 42,000 acres out of 2.7 million acres between 1974 and 1983. The greatest losses were due to the conversion of forested wetlands to non-wetland or other wetland types (Heffner, et al., 1994). Since 1983 wetland losses have

slowed, although urbanization and impacts associated with transportation construction projects still impact wetlands in the state (Flynn, 2001).

WETLANDS IN THE PROJECT AREA

Wetlands in the vicinity of BFN are a mix of habitat types, including palustrine forested wetlands, scrub-shrub wetlands, and emergent wetlands associated with the mainstream of the Tennessee River/Wheeler Reservoir. These areas occur primarily along embayments of the main channel. There are also wetlands associated with various tributary streams in the project area, including Douglas Branch, Poplar Creek, Dry Creek, and Round Island Creek. Wetlands in these areas are generally confined to narrow strips of forested or scrub-shrub wetlands along the stream channel and many have been reduced both in extent and function due to clearing and channelization associated with agricultural activities.

National Wetland Inventory (NWI) maps indicate small areas of palustrine emergent and scrub-shrub wetlands occur within the boundaries of BFN, and in the areas proposed for disposal of spoil materials associated with construction. A field survey verified the presence of a palustrine emergent wetland within the boundaries of an excavated unnamed stream channel draining agricultural fields at the northeast boundary of the plant boundary. This area is within the plant boundaries, but not within the areas proposed for disturbance. Vegetation consists of soft rush (*Juncus effusus*), blunt spike rush (*Eleocharis obtusa*), and fescue (*Festuca* spp.). The NWI also indicates a palustrine emergent/scrub-shrub wetland in low-lying agricultural area in the northeast boundary of the plant, in an area proposed for spoil disposal. However, a field survey indicated that this area has been excavated and cleared by agricultural activities to the extent that wetland characteristics are absent from this area.

3.13 Socioeconomic Conditions

3.13.1 Demography

Estimated 2000 population in Limestone County is 65,676, an increase of 21.3% since 1990 and 57.5% since 1970. This growth is much faster than the LMA, the state, or the nation. The LMA includes Colbert and Lauderdale Counties (Florence Metropolitan Area), Lawrence County, Madison County (Huntsville), and Morgan County (Decatur). Total population in the LMA in 2000 was 631,193, an increase of 13.5% since 1990 and 40.1% since 1970, higher than the state and slightly higher than the national growth rate.

The population of Limestone County is projected to reach more than 80,000 by 2015, with a labor market population of over 748,000 at that time. These projections are based on a continuation of growth rates experienced over the last three decades, except for Colbert County, which is projected to continue the growth turnaround experienced since 1990.

Table 3.13-1 Population and Population Projections						
	1970	**1980**	**1990**	**2000**	**2010**	**2015**
Limestone Co.	41,699	46,005	54,135	65,676	74,831	80,762
Colbert Co.	49,632	54,519	51,666	54,984	58,515	60,365
Lauderdale Co.	68,111	80,546	79,661	87,966	95,133	98,799
Lawrence Co.	27,281	30,170	31,513	34,803	37,405	38,881
Madison Co.	186,540	196,966	238,912	276,700	313,143	335,444
Morgan Co.	77,306	90,231	100,043	111,064	126,346	134,093
LMA	450,569	498,437	555,930	631,193	705,373	748,344
Alabama (000)	3,444.4	3,894.0	4,040.4	4,447.1	4,816.5	5,014.0
U. S. (000)	203,302.0	226,545.8	248,790.9	281,421.9	311,318.1	328,413.3

Source: Historical data from U. S. Department of Commerce, Bureau of the Census. Projections by TVA.

Table 3.13-2 Population Growth Rates				
	1970-2000	**1990-2000**	**2000-2010**	**2000-2015**
Limestone Co.	57.5	21.3	13.9	23.0
Colbert Co.	10.8	6.4	6.4	9.8
Lauderdale Co.	29.2	10.4	8.1	12.3
Lawrence Co.	27.6	10.4	7.5	11.7
Madison Co.	48.3	15.8	13.2	21.2
Morgan Co.	43.7	11.0	13.8	20.7
LMA	40.1	13.5	11.8	18.6
Alabama (000)	29.1	10.1	8.3	12.7
U. S. (000)	38.4	13.1	10.6	16.7

3.13.2 Economic Conditions

Limestone County had a total labor force of 29,524 persons on average during 2000, while the labor force in the LMA was almost 316,000. The unemployment rate in the LMA was 3.9%, below the state average and slightly below the national average. Limestone County, itself, had a lower rate of unemployment, 3.3%, well below the state average. These rates of unemployment meant that almost 1,000 persons in Limestone County and over 12,000 in the LMA were unemployed.

Table 3.13-3 Labor Force and Unemployment, 2000			
	Civilian Labor Force	Number Unemployed	Unemployment Rate
Limestone Co.	29,524	971	3.3
Colbert Co.	25,531	1,606	6.3
Lauderdale Co.	41,381	2,258	5.5
Lawrence Co.	16,703	906	5.4
Madison Co.	145,450	4,101	2.8
Morgan Co.	57,195	2,338	4.1
LMA	315,784	12,180	3.9
Alabama	2,154,273	99,092	4.6
U. S. (000)	140,863	5,655	4.0

Source: Alabama Department of Industrial Relations, Employment Security Division, and U. S. Department of Labor, Bureau of Labor Statistics.

The number of jobs in Limestone County has more than doubled since 1970, reaching a total of 29,035 jobs in 1999. This 1999 level is 6.8% higher than in 1990. Growth since 1970 has been faster than the LMA, the state, and the nation. However, since 1990 the rate of growth was much slower than the LMA, the state, or the nation. On the other hand, as discussed above, population grew faster since 1990 as well as over the longer term. This suggests that over the last several years, Limestone County has become more of a bedroom community to Huntsville as its growth has continued to spread toward the west.

The LMA grew more slowly from 1990 to 1999 than did the state and the nation, although it grew more rapidly than either during the overall time period since 1970.

Limestone County is more dependent on manufacturing, government, and farm employment than the LMA, the state, or the nation and less dependent on trade and services employment. The LMA has an industrial distribution similar to that of the state as a whole, although it is slightly more dependent on manufacturing. The state as well as the LMA is more dependent on manufacturing and less on trade and services employment than is the nation as a whole.

Based on the population projected above and on the TVA forecasts of employment for the TVA Power Service Area, employment in Limestone County is expected to be around 41,000 at the time of current license expiration, and close to 58,000 by the time a 20-year license extension would expire. The LMA is projected to exceed 434,000 jobs and 535,000 jobs, respectively, by these dates.

Table 3.13-4 Total Employment (Full-time and Part-time), by Place of Work						
	1970	1980	1990	1999	Percent Change, 1970-99	Percent Change, 1990-99
Limestone Co.	14,056	18,300	27,188	29,035	106.6	6.8
Colbert Co.	25,045	29,775	28,594	29,039	15.9	1.6
Lauderdale Co.	20,518	29,126	36,579	42,978	109.5	17.5
Lawrence Co.	7,289	8,905	11,445	12,102	66.0	5.7
Madison Co.	93,110	108,507	165,710	192,297	106.5	16.0
Morgan Co.	34,144	42,699	54,151	64,397	88.6	18.9
LMA	194,162	237,312	323,667	369,848	90.5	14.3
Alabama	1,412,924	1,735,999	2,061,914	2,409,612	70.5	16.9
U. S. (000)	91,281.6	114,231.2	139,426.9	163,757.9	79.4	17.5

Source: U. S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Information System.

Table 3.13-5 Projected Total Employment, 2015 and 2035					
	1999	2015	2035	Percent Change, 1999-2015	Percent Change, 1999-2035
Limestone Co.	29,035	41,469	58,013	42.8	99.8
Colbert Co.	29,039	32,294	36,931	11.2	27.2
Lauderdale Co.	42,978	51,879	61,519	20.7	43.1
Lawrence Co.	12,102	19,047	23,497	57.4	94.2
Madison Co.	192,297	215,961	262,638	12.3	36.3
Morgan Co.	64,397	73,470	93,004	14.1	44.4
LMA	369,848	434,120	535,602	17.4	44.8

Source: Projections by TVA.

Table 3.13-6 Percent Distribution by Industry Employment (Full-time and Part-time), by Place of Work, 1999						
	Total	Farm	Manufac-turing	Trade and Services	Govern-ment	Other
Limestone Co.	29,035	7.7	22.4	37.6	20.3	12.1
Colbert Co.	29,039	3.3	15.7	42.6	20.4	18.0
Lauderdale Co.	42,978	5.1	16.8	48.1	16.9	13.1
Lawrence Co.	12,102	16.4	21.1	29.8	14.0	18.7
Madison Co.	192,297	1.7	15.4	51.6	19.3	12.0
Morgan Co.	64,397	3.2	23.6	43.6	11.8	17.8
LMA	369,848	3.4	17.8	47.3	17.7	13.8
Alabama	2,409,612	3.5	15.7	47.2	16.0	17.6
U. S.	163,757.9	3.2	11.8	52.5	13.6	18.9

Note: Percentages may not add to 100 due to rounding.
Source: U. S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Information System.

Per capita income in both Limestone County and the LMA declined relative to the state and the nation between 1989 and 1999. In 1989, per capita income in Limestone County was 79.3% of the national average, but in 1999 the percentage had declined to 74.6%; in the meantime, the state had grown slightly relative to the nation. In a similar pattern, per capita income in the LMA was 90.6% of the national average in 1989, but only 85.8% in 1999. None of the counties in the LMA had average income above the national average in 1999, although Madison County did in 1989. Both Madison and Morgan Counties had average incomes higher than the state average in 1999, as well as in 1989.

Table 3.13-7 Per Capita Personal Income

	Per Capita Personal Income, 1989	Per Capita Personal Income, 1999	Percent of Nation, 1989	Percent of Nation 1999
Limestone Co.	14,714	21,294	79.3	74.6
Colbert Co.	14,260	22,550	76.8	79.0
Lauderdale Co.	14,587	21,036	78.6	73.7
Lawrence Co.	11,952	20,691	64.4	72.5
Madison Co.	19,223	27,049	103.5	94.8
Morgan Co.	16,858	24,585	90.8	86.1
LMA	16,812	24,498	90.6	85.8
Alabama	14,899	22,972	80.2	80.5
U. S.	18,566	28,546	100.0	100.0

Source: U. S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Information System.

3.13.3 Community Services and Housing

Limestone County is a fast-growing county and a part of the Huntsville metropolitan area. As such, it has experienced relatively fast growth in housing and in the provision of government and other local services. It is also adjacent to the central metropolitan counties of Madison (Huntsville), Morgan (Decatur), and Lauderdale (Florence). These counties have well-developed community services and housing markets. Schools, fire and police protection, and medical services have all been exposed to growth and change in their communities in recent years, as have the local housing markets.

3.13.4 Environmental Justice

Minority population in Limestone County and in the LMA is a smaller share of the total than in the state or the nation. Limestone County has a minority population of 11,534, some 17.6% of the total, while the LMA has a minority population of 139,362, some 22.1% of the total. Poverty levels in both Limestone County and in the LMA as a whole are below the state average. For the LMA as a whole, the poverty rate is also lower than the national average, while the rate in Limestone County is about the same as the national average.

Table 3.13-8 Minority Population, 2000, and Percent Below Poverty Level, 1997				
	Total Population	Minority Population	Percent Minority	Percent Below Poverty Level
Limestone Co.	65,676	11,534	17.6	13.5
Colbert Co.	54,984	10,514	19.1	13.5
Lauderdale Co.	87,966	10,726	12.2	13.3
Lawrence Co.	34,803	7,904	22.7	15.7
Madison Co.	276,700	80,204	29.0	11.0
Morgan Co.	111,064	18,480	16.6	11.4
LMA	631,193	139,362	22.1	12.1
Alabama	4,447,100	1,321,281	29.7	16.2
U. S.	281,421,906	86,869,132	30.9	13.3

Source: U. S. Bureau of the Census.

BFN is located in Census Tract 211, not far from Census Tract 204.01. According to the 2000 Census of Population, 35.0% of the population in Tract 211 and only 8.6% of the population in Tract 204.01 is minority.

3.14 Transportation

3.14.1 Highways and Roads

The site is located approximately ten miles southwest of Athens in northern Alabama in Limestone County and is located just south of U. S. Highway 72, which runs from South Pittsburg, Tennessee, west to Memphis, Tennessee. The site is directly accessible from County Road 25. County Road 25 (Shaw Road) intersects U. S. Highway 72 approximately six miles north of the site. County Road 25 (Nuclear Plant Road) also intersects U. S. Highway 31 approximately nine miles east of the site. U. S. Highway 31 intersects U. S. Highway 72 northeast of the site. Browns Ferry Road to County Road 25 just east of the site provides a more direct route to the site from Athens. U. S. Highway 72 and U. S. Highway 31 are both high quality four-lane routes with good lane widths, alignments, turning lanes, and speed limits of 50 miles per hour (mph) through Athens and increasing away from the city. County Road 25 and Browns Ferry Road are medium quality two lane roads with level alignment, some passing zones, and speed limits of 45 mph. Direct accessibility into the plant facility off County Road 25 is good. The large diamond intersection at one entrance allows for smooth turning movements into and out of the plant. Another access road into the plant commonly used by contractors utilizes a traffic light at the intersection with Nuclear Plant Road.

The primary traffic generator in the vicinity of the site is the nuclear plant. BFN currently averages a daily site population of approximately 1,200 persons. The population currently peaks at approximately 2,000 persons during outages, which occur every 24 months (per unit) for approximately two months. Current truck deliveries are minimal (less than ten per week) and include hydrogen trucks, Calgon water chemistry trucks, and occasional diesel fuel deliveries during peak months. Rural residences located along the county roads that provide access to the site are also traffic generators in the area.

Figure 3.14-1 shows a map of the local road network for the area. The latest available 1998 Average Daily Traffic (ADT) counts in close proximity to the site indicate approximately 13,440 vehicles per day (vpd) on U. S. Highway 72 north of the site and 16,260 vpd on U. S. Highway 31 south of U. S. Highway 72. There are no available traffic counts on the county roads; however, TVA estimates approximately 1,600 vpd on Shaw Road, Browns Ferry Road, and Nuclear Plant Road.

3.14.2 Railroads

Direct rail access does not serve BFN. A railway spur track and unloading area is located off the CSX mainline which runs north and south in Tanner, Alabama, approximately eight miles east of BFN. TVA leased this small parcel of land from CSX (Louisville and Nashville Railroad) and used it for offloading during construction of the plant; however, TVA has not used this area for offloading and transporting materials to the plant since then. After offloading, heavy items were transported on heavy trucks via a "hardened" pathway to the site that included shallow fords through creek beds along the way. At the site itself a short railroad spur runs into the turbine building for transport into the plant.

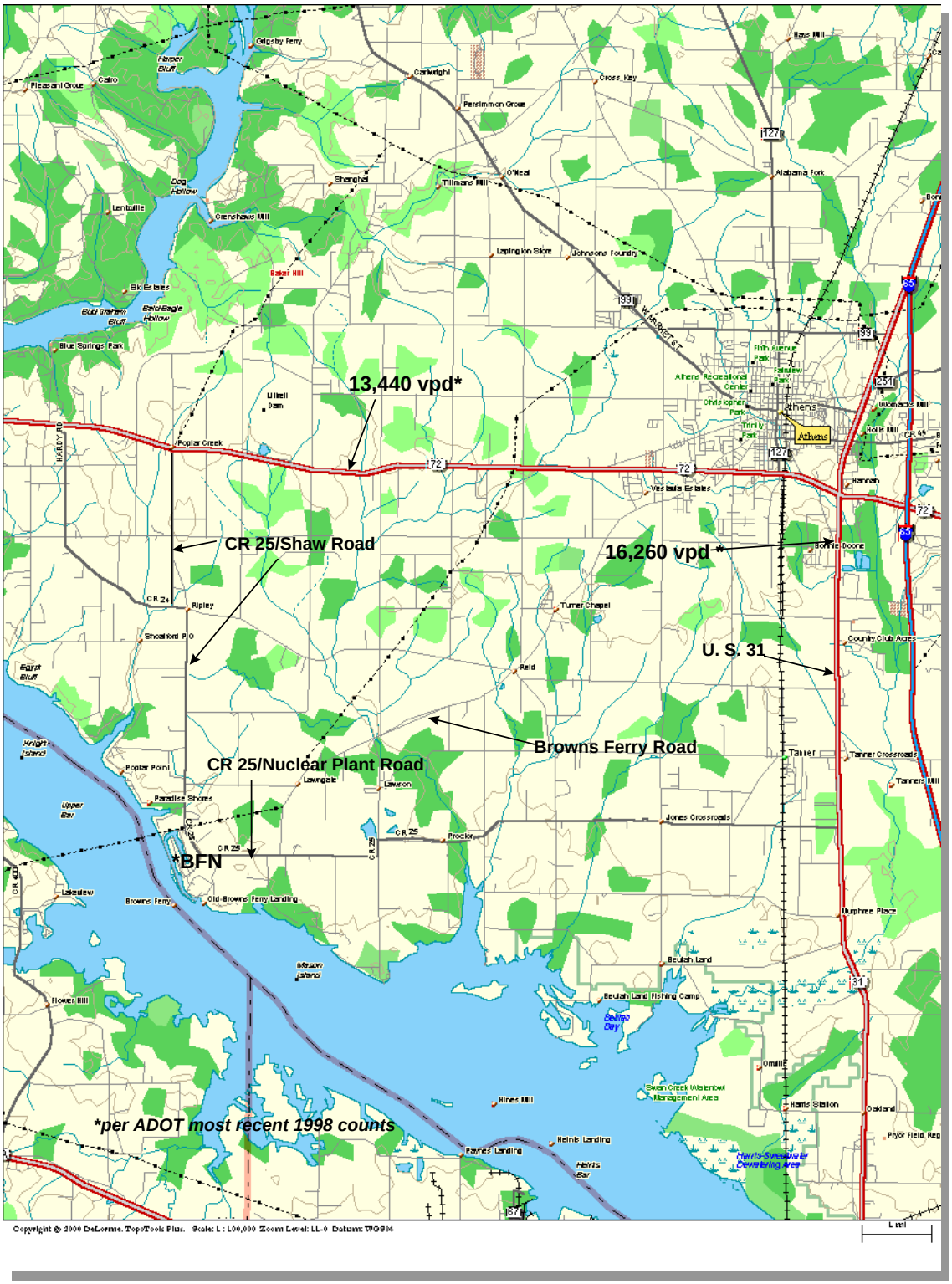
The railroad spur track and unloading area is currently planned for future removal off site of dry cask spent fuel storage canisters. There are no plans to use it for Unit 1 refurbishment or regular plant operations.

3.14.3 River Transport

BFN is located along the Tennessee River at approximately TRM 294. Guntersville Lock and Dam are located 55 miles upstream from the site and Wheeler Lock and Dam are located 20 miles downstream from the site. Traffic on the Tennessee River near BFN includes both commercial and recreational vessels. The locks and channels are more than adequate in handling river traffic. Both Guntersville Lock and Wheeler Lock are operating below their utilization capacity.

BFN has a qualified barge facility near the northwest corner of the site. Currently it consists of barge tie points and a wide ramp going down into the water. The ramp was used during initial plant construction for very heavy loads such as reactor vessels. The barge facility is currently used several times per year, but each usage requires a temporary crane. The roadbed from the plant to the barge facility is "hardened" for heavy loads. Future work is contemplated to upgrade the barge facility by stabilizing the riverbank and installing anchoring cells and a permanent dock (so that the facility will no longer require use of a temporary crane). An upgraded barge facility could eventually be used to transport spent fuel canisters offsite for disposal in a national repository. The barge facility would likely be used for some heavy items during Unit 1 refurbishment; however, this upgrade is independent of any decision on refurbishing Unit 1. Appropriate environmental analyses would be done if TVA decides to propose upgrading the barge facility.

Figure 3.14-1 Local Road Network for BFN



3.14.4 Pipelines

Three pipelines pass within five miles of the center of the BFN plant site. One is an eight-inch line carrying xylene at a maximum pressure of 175 pounds per square inch (psi); it runs north and south and passes about 2.4 miles east of the plant. The other two carry natural gas in a common right-of-way about 3.8 miles south-southwest of the plant. They run generally east-west. One line is eight-inch and the other 12-inch and both have a maximum pressure of 600 psi.

The only pipeline crossing the BFN site boundary is a ten-inch potable water line from the Athens Water District. There are no plans to install or connect to any pipelines in the foreseeable future.

3.14.5 Transmission Lines

The BFN is connected into the TVA system network by seven 500-Kilovolt (kV) lines. One line is to Madison substation, two to Trinity substation, one line each to the West Point, Maury, and Union substations, and one line to the Limestone 500-kV Substation. Any three lines excluding more than one Trinity line can transmit the entire station output into the TVA system network.

Normal station power is from the unit station service transformers connected between the generator breaker and main transformer of each unit. Startup power is from the TVA 500-kV system network through the 500- to 20.7-kV main and 20.7- to 4.16-kV unit station service transformers. Auxiliary power is available through the two common station service transformers that are fed from two 161-kV lines supplying the 161-kV switchyard, one line each from the Athens and Trinity substations.

3.15 Soil and Land Uses

3.15.1 BFN Environs

Limestone County is part of the Highland Rim section of the Interior Low Plateaus physiographic province. It is comprised of three physiographic subdivisions: The Limestone Valleys, the Plateau, and the Alluvial Plains. The Limestone Valleys, locally called the red lands, include the southeastern part of the county. The Alluvial Plains include the nearly level to undulating first bottoms and stream terraces along the Tennessee and Elk Rivers. BFN is located in the Limestone Valleys and Alluvial Plains (USDA, 1953).

The soils that have developed in the Limestone Valleys and Alluvial Plains are inherently productive for growing crops. Those that developed from high-grade limestone originally contained a relatively high quantity of organic matter, and the depth of soil over bedrock is 15 to 20 feet in most places. Drainage is good and the acidity is moderate. The alluvial soils are fairly well supplied with lime, organic matter, and plant materials, which provide fertility needed to obtain high crop yields (USDA, 1953).

There are about 279,229 acres (73.5%) of soils in the county classified as prime and/or statewide important farmland (USDA-NRCS, 1979). These are soils that have the chemical and physical properties to economically sustain high yields of crop production.

Soils comprising the majority of the region immediately surrounding the BFN and including the site are Abernathy, Cumberland, and Decatur soils. Phases of these soils that occur on slopes less than 6% are classified as prime farmland. The Abernathy soils have developed from colluvial material washed from surrounding soils of high-grade limestone. This well-drained soil occupies mainly basins or depressions. The Cumberland soils are located on the river and stream banks and have developed from alluvium material washed from soils underlain by limestone and to a small extent by shale and sandstone. This soil is well adapted to cultivated crops because of its fertility and physical characteristics. The Decatur soils have developed from residual material weathered from high-grade limestone of the Tuscumbia formation. It is well suited for cropping and is one of the most extensively cropped soils in the county. (USDA, 1953).

Most of the soil on the BFN site was disturbed when the plant was constructed and is no longer considered as prime farmland. The entire site is classified as urban built-up land.

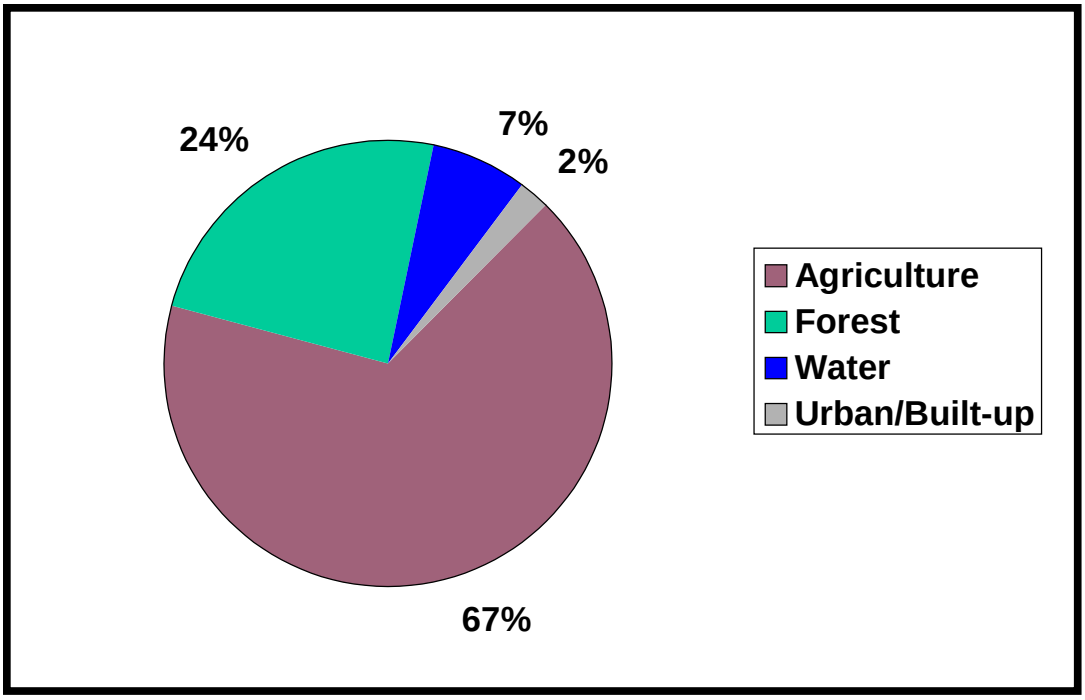
3.15.2 Past and Existing Land Uses (Including Offsite)

BFN is located in an agricultural area, surrounded by cropland planted with cotton. About 66.8% of the total acreage in the county is used for agriculture, the highest in Alabama (Figure 3.15-1). There are an estimated 78,900 acres (23.9%) of land in forest. The majority of the forestland is located in the northern two-thirds of the county. Trends show that land used for forest has been declining since the early sixties. During the sixties, thousands of acres were cleared for agriculture and other land uses associated with population growth (Limestone County Comprehensive Plan, 1985). Cropland has increased from 166,841 acres in 1987 to 181,292 acres in 1997 (USDA-NRCS).

Limestone County is ranked first in Alabama for the most cotton grown. In 1999, 69,200 acres of cotton were harvested, a total production yield of 79,000 bales. There were 6,400 acres of corn harvested, 16,500 acres of soybeans, 10,000 acres of wheat, and 24,000 acres of hay. Agriculture Census data for the county lists crop production cash receipts at $31,614,000. Livestock and poultry receipts were $21,905,000. Agriculture is, and will continue to be, a major economic component in the county.

From the 1994 EPA land use database (Figure 3.15-1), only about 2% of the county is urban built-up land. The current trend in population growth will promote a larger amount of land to become urbanized. Population growth for Limestone County from 1980 to 1990 was 17.7%. Athens City had a population increase of 17% from 1990 to 1998. These trends are attributable to the increased employment opportunity in the county as well as in nearby Huntsville and Decatur. During the last part of the 1980's, unprecedented growth in industrial employment occurred in each of the four outlying counties. Madison County also added thousands of new manufacturing jobs, but the change was most noticeable in the predominantly rural counties, such as Limestone. This trend in Limestone County suggests that a new era of economic development has already begun. Most of the residential development is occurring in the eastern portion of the county in the Capshaw French Mill area. There is also a significant number of new dwellings in the Browns Ferry Road area. It is expected that the majority of residential growth will occur around the City of Athens and the Elkmont Village area (Limestone County Comprehensive Plan, 1985). Development of commercial property is rapidly occurring in the area of intersection of U. S. Highway 72 and U. S. 65 and along the U. S. Highway 72 corridor to Huntsville.

Figure 3.15-1 Land Use in Limestone County



Source: EPA 1994

3.15.3 Land Use Planning and Controls

Limestone County, as part of Top of Alabama Regional Council of Governments, developed a Comprehensive Plan in 1985 to cover the period to year 2000 (Limestone County Comprehensive Plan, 1985). The vision of the Plan includes goals for land use, community facilities, transportation, and a capital improvements program and budget. The Plan has not been updated, but the same vision is reflected in the "Vision 2000, Strategic Agenda" document prepared by the Limestone County Vision 2000 Quality Council in March 2000.

The goal of the Land Use Plan was to achieve a balance among various land uses to accommodate a diversity of total life styles which will fulfill the requirements of county residents. The Plan has three objectives. The first is to promote a variety of housing types and a high level of efficiency in residential development patterns. The second is to promote the spatial distribution of various land uses that will result in a compatible relationship of land use activities. The third objective is to provide land for a wide variety of employment opportunities for the residents. The implementation of these objectives would provide utilities, services, and transportation to achieve the desired land use developments.

3.16 Visual Resources

The physical, biological, and cultural features seen in the landscape give a geographic area its distinct visual character and sense of place. Varied combinations of these elements make the visual resources of an area identifiable and unique. Scenic integrity indicates the degree of intactness, unity, or wholeness of the visible landscape. Aesthetic considerations include scenic beauty, scale, contrast, harmony, color, density, noise, and other qualities that affect the sense of place. Views of the affected landscape are described in terms of foreground, middleground, and background distances. Foreground is considered the area within a half-mile of the observer where details of objects are easily distinguished in the landscape. Middleground is the zone between foreground and background, normally between a mile and four miles from the observer. The objects may be distinguishable, but their details are weak and they tend to merge into larger patterns. Background is the distant part of the landscape, where objects are not normally discernible unless they are especially large and standing alone. Details are generally not visible and colors are lighter.

BFN is located off of County Road 25 (Nuclear Plant Road) approximately twelve miles south of Athens, Alabama. The site is surrounded to the north and east by rural countryside. It includes open pasturelands, scattered farmsteads, few residents, and little industry within several miles. The terrain is gently rolling with open views to higher elevations to the north. Little traffic is seen along the roadway except at plant shift changes and during deliveries. The south and west side of the plant site abuts Wheeler Reservoir, which is a wide expanse of open river used for an array of recreational purposes. Elevations across the plant site and in the surrounding areas rise gradually from 558 feet above sea level at the north shore of Wheeler Lake to around 800 feet above sea level ten miles north in the vicinity of Athens. The average elevation of the plant site is 575 feet above sea level. Scenic integrity is moderate, contrasting occasionally with homes that have lake views from across the river.

Access to the plant site is from Browns Ferry Road to County Road 25 from State Route (SR) 72 in Athens. The 600-foot high off gas stack comes into view over existing tree lines while traveling along Browns Ferry Road. Closer to the plant site, near County Road 25, the plant site comes into view. The site has remarkable contrast to the mostly rural countryside that surrounds it. From this viewpoint, clusters of transmission lines and associated steel pole and tower structures can be seen in the foreground and near middleground. These features identify the power plant and its associated architecture and infrastructure as predominately industrial facilities with little transition from rural countryside.

There are no homes within foreground viewing distance to the north and east. However, there is a small residential development to the northwest, across Wheeler Reservoir southwest, and Mallard Creek public use area that has partial views of the plant site. The views from the homes northwest off of County Road 25 are of the existing mechanical draft cooling towers (approximately 60 feet in height), a portion of the 500-kV switchyard and the turbine and reactor building. A berm, graded during the initial construction of the plant site and containing approximately 3.3 million cubic yards of earth, lies adjacent to the hot and cool water channels and blocks views of the northern and eastern plant areas. The homes to the southwest and from the Mallard Creek area have views of the off gas stack, the cooling towers, and the turbine and reactor building. These views may be somewhat obscured in the early morning hours, particularly in the fall and winter, as heavy fogs rise from the warmer waters of the lake.

3.17 Recreation

There are no developed public recreation facilities located at the BFN site. Located directly across the Tennessee River from the site is Mallard Creek Recreation Area. This is a TVA-developed and operated area. It includes camping, picnicking, swimming beach, and a boat launch area. Approximately 3.5 miles upstream of BFN is Round Island Recreation Area, also developed and operated by TVA. It features facilities for camping, swimming, picnicking and boat launching. The reservoir in the vicinity of the plant site is moderately utilized by recreational boaters and fishermen.

Two managed areas are known to occur within three miles of the site. These areas have been recognized and are protected, to varying degrees, because they contain unique natural resources, scenic values, or public use opportunities. These areas are owned by TVA and presently managed by the ADC.

SWAN CREEK STATE WILDLIFE MANAGEMENT AREA

This wildlife management area includes over 3,000 acres of land and over 5,000 acres of water surrounded by numerous industrial facilities. Wooded lands and grassy pastures, occasionally interrupted by railroad tracts and transmission lines, provide one of the most important waterfowl management areas in the state of Alabama. Although the primary management focus is for waterfowl and small game hunting, this area is becoming increasingly important for migrating bird species. In addition, the area is increasingly utilized by bird watchers and other outdoor enthusiasts.

MALLARD-FOX CREEK STATE WILDLIFE MANAGEMENT AREA

Encompassing approximately 700 acres of land and 1,700 acres of water this wildlife management area is primarily utilized for small game hunting.

3.18 Cultural Resources

3.18.1 Archeological Resources

HISTORIC BACKGROUND OF THE PROJECT AREA

Prehistoric Period

Archaeological research has indicated prehistoric human occupation in north central Alabama has occurred from the Paleo-Indian to the Mississippian period. Archaeological periods are based on changing settlement and land use patterns and artifact styles. In Alabama, prehistoric chronology is divided into five broad time periods: Paleo-Indian, Archaic, Gulf Formational, Woodland, and Mississippian (Walthall, 1980; McNutt and Weaver, 1985). Each of these broad periods is further broken down into sub-periods (generally Early, Middle, and Late), which are also based on artifact styles and settlement patterns. Smaller time periods, known as “Phases,” are representative of distinctive sets of artifacts.

The Paleo-Indian period (12000-8500 B.C.) represents the first human occupation of the area. The settlement and land use pattern of this period was dominated by highly mobile bands of hunter/gatherers. Following the Paleo-Indian period, the Archaic period (8500-1200 B.C.) continued to represent a hunter/gatherer lifestyle. An increase in social complexity and the appearance of horticulture characterized the later part of the period. The settlement pattern during this period is characterized by spring and summer campsites situated along river ways that exploit riverine resources and dispersed fall and winter campsites in the adjacent uplands. It is during the Gulf Formational Period (1200-400 B.C.) when pottery first appears in north central Alabama. The Early Gulf Formational Period is a transitional period from the Late Archaic during which there is a continuance of Archaic Period settlement patterns but there are also influences from the Gulf Coastal area to the south. The Gulf Formational period in the lower Tennessee Valley begins with the Middle Gulf Formational period and is associated with Wheeler series, fiber-tempered pottery. The Late Gulf Formational Phase is associated with Alexander series, fiber- and sand-tempered pottery, and correlates with Early Woodland Period cultures elsewhere. Increased social complexity, reliance on horticulture and agriculture, and a continuation and fluorescence of ceramic technology characterize the Woodland Period (600 B.C. - 1000 A.D.). The increased importance of horticulture is associated with a less mobile lifestyle as suggested by semi-permanent structures. Residential base camps were located on flood plains and alluvial terraces with specialized procurement sites in the adjoining uplands. The Middle Woodland Period is classified by various Colbert and Copena components. The Late Woodland is associated with the Flint River and Baytown cultures. The Mississippian Period (900-1700 A.D.), the last prehistoric period in north central Mississippi, is associated with the pinnacle of social complexity in the Southeastern United States. In north central Alabama this period is characterized by permanent settlements, maize agriculture, and chiefdom level societies.

Historic Period

The Historic Period is represented by the settlement of Europeans, Euro-Americans, and African-Americans in the region and the subsequent removal of Native American tribes. The first recorded European encounter with Native American groups in northern Mississippi by Europeans was Hernado de Soto's expedition in 1540. Continued expeditions into the area by French, Spanish and English traders and explorers occurred during the 16th, 17th, and 18th centuries. Clashes between the native Creeks and Europeans continued through the 18th century. By the early 19th century, the Creeks were defeated by Jackson and forced to surrender their lands and leave the area. The first permanent Euro-American settlements occurred in the early 19th century and the area was predominately occupied by Euro-Americans and African-Americans. Subsistence and cotton farming characterized the region from the Antebellum period to the early 20th century. Industrialization and urbanization has characterized the region in the late 20th century.

TVA is mandated, under the National Historic Preservation Act (NHPA) of 1966, to protect significant archaeological resources and historic structures located on land affected by TVA undertakings. NHPA Section 106 [16 U.S.C. 470f] requires Federal agencies prior to taking action that implements an undertaking to:

1) Take into account the effects of their undertaking on historic properties; and
2) Afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment regarding such undertaking.

The State Historic Preservation Office (SHPO) serves as a proxy to the ACHP and consultation has been initiated with the Tennessee SHPO concerning the project alternatives and any potential affect to historic properties.

The determination that an action is an undertaking does not require knowledge that historic properties are present. An agency determines that a given proposal is an undertaking based solely on that proposal's inherent ability to directly or indirectly affect historic properties. The area of potential effects (APE) for an undertaking is usually defined for archaeological resources as any area where facilities would be situated and for historic structures as any area from which those facilities would be visible.

At the initiation of this proposal, TVA Cultural Resources staff considered the nature of the undertaking and determined that the project had the potential to affect historic properties should those be present in the area. The APE for archaeological resources was determined as the three areas designated as soil disposal or spoil pile locations. The APE for historic structures was determined as those areas from which the disposal locations would be visible.

A Phase I survey was conducted at the three disposal site/spoil pile locations. This survey identified two historic properties. The survey of Area 1 (see Figure 2.2-7) identified a prehistoric archaeological site with an Early to Middle Woodland occupation. This site is considered potentially eligible for listing in the National Register of Historic Places. Cox Cemetery was identified in Area 2. This cemetery was relocated during the initial construction of the BFN. No historic properties were identified in Area 3.

3.18.2 Historical Structures

An architectural survey was conducted within the visual APE of the proposed project area. No historic structures were identified.

3.19 Environmental Noise

3.19.1 Introduction

Areas that are potentially affected by environmental noise from typical industrial operations are usually within a mile radius of the noise source(s). Sometimes effected areas can reach to two miles under special conditions that are favorable to outdoor sound propagation. This evaluation is primarily concerned with the potential environmental noise effects of the addition and replacement of cooling towers in Alternative 2. Although there are only a couple of residences within the one-mile radius of the center of the main-plant building, there are many residences within a mile of the cooling tower area. Also, within two miles is the Lakeview Community across the river. The open path across water is favorable to sound propagation toward Lakeview. The following sections present a more detailed description of the potentially affected areas; the regulations, standards, and guidelines concerning environmental noise; the possible effects that environmental noise might have on people; and the current noise environment in the area.

3.19.2 Potentially Affected Areas

As anticipated, there has been substantial change in the character of some of the areas surrounding BFN subsequent to the release of the original EIS. Generally, the number of residences and population along the waterfront have increased and the industrial activity on and along the river has also increased.

Upstream and adjacent to the BFN property are new developments of waterfront homes. (Pointe Westmoreland and Lookingbill subdivisions). There are about 40 residences along approximately 4,400 feet of riverfront. The nearest house is within 100 feet of the BFN property line on the east side. These residences are more than a mile from the closest cooling towers 1 and 6, and there is a small hill and the main plant in between this residential area and the cooling towers. Also, there are no favorable conditions for sound propagation in this direction. For these reasons, this residential area is not considered sensitive to environmental noise.

Downstream and adjacent to the BFN property and adjacent to cooling tower area is an older waterfront community, Paradise Shores. This area had few residences in-place when the plant was built, and it is currently a mix of year-around and recreational homes. There are about 100 residences within one mile of the closest cooling towers, and some are as close as 1,500 feet. Paradise Shores is a medium to high density suburban area. This is an area that could be sensitive to environmental noise.

The Lakeview Community is across the river and approximately 8,500 feet from the center of the cooling tower area. It is primarily year-around homes with a few recreation residences. Most of these were built after BFN was constructed. As mentioned in the Introduction, this area could be sensitive to environmental noise because of the favorable sound propagation characteristics across water.

The areas northeast of BFN are still agricultural as they were when the plant was built. There are no residential developments within a mile of the cooling tower, and these areas are not considered sensitive to environmental noise.

3.19.3 Noise Regulations, Ordinances, Guidelines, and Other Useful Criteria

Generally, environmental noise regulations, ordinances, guidelines, and other criteria are set for two reasons. First, to protect the existing residents from the potential impact of new noise sources; and second, to protect new residents from the existing noise sources. The guidelines from the U. S. EPA found in its "levels" document (EPA, 1974) and most municipal noise ordinances (Gatley, 1979) address the first reason. Also, the Federal Interagency Committee on Noise (FICON, 1992) recommends using potential noise impact analysis as a criterion in possible mitigation of sensitive areas when siting airports. Whereas, guidelines from the U. S. Department of Housing and Urban Development (HUD, 1983) and the Federal Interagency Committee on Urban Noise (FICUN), a predecessor to Federal Interagency Committee on Noise (FICON), (FICUN, 1980) concentrate on the second reason to protect new residents from moving into an incompatible noise environment.

The guideline from EPA recommends an average annual equivalent sound level day/night (DNL) of 55 dBA to protect the health and well being of the public with an adequate margin of safety. Guidelines and recommendations from HUD and FICUN also use DNL as their measurement metric and give tables of compatible use categories based on the existing DNL levels. For example, both HUD and FICUN use 65 DNL as their upper limit for acceptable residential development without added noise reduction construction. FICON also uses DNL as its metric.

There are no Federal, State of Alabama, or local municipal noise standards, regulations, or ordinances that apply to the action alternatives evaluated in this SEIS.

TVA uses the EPA guideline of 55 dBA DNL as a design goal when feasible if the nearest receptor is residential, and the equivalent sound level (L_{eq}) of 60 dBA at the property line in industrial and commercial areas. In addition, TVA uses the FICON (FICON, 1992) recommendation that a 3 dB increase indicates possible impact and the need for further analysis when the background DNL is 60 dBA or less. These guidelines were developed and published since the original BFN EIS. At that time, TVA used the HUD guideline of 65 dBA DNL (HUD, 1971) as normally acceptable for adjacent residential areas.

3.19.4 Potential Effects of Environmental Noise

3.19.4.1 Hearing Loss

Exposure to high noise and sound levels can cause hearing loss. The Occupational Safety and Health Administration (OSHA) regulates noise exposure in the workplace and EPA gives guidance for exposure to environmental noise to prevent hearing loss. For environmental noise, EPA recommends an average annual exposure limit of 70 dBA equivalent sound level for 24 hours [$L_{eq}(24)$] over 40 years to prevent hearing loss (EPA, 1974). The Occupational Safety and Health

Administration (OSHA) exposure standard is 90 dBA for eight-hour exposure over a working lifetime (OSHA, 1984).

3.19.4.2 Annoyance and Complaints

Along with the physical, hearing loss response from exposure to prolonged, high levels of environmental noise, there can be annoyance and complaints from the disturbance of social and personal activities caused by moderate levels of environmental noise exposure. Noise can interfere with communications, relaxation and sleep, and concentration. In the FICON analysis of noise effects, annoyance was identified as the summary of the general adverse reactions that people have to noise. Specifically, it states that the best measure of this adverse response is the percentage of the effected population that is characterized as "highly annoyed" as a function of DNL (FICON, 1992). FICON recommends using the updated "Schultz curve" to define the relationship between highly annoyed and DNL. The Schultz curve relationship was originally recommended by EPA in its 1982 guidance document (EPA, 1982), and it was updated by the U. S. Air Force Armstrong Laboratory (FICON, 1992). The updated relationship is:

$$\% \text{ Highly Annoyed} = \frac{100}{1 + e^{[11.13 - 0.141(\text{DNL})]}} \qquad \textbf{Eq. 3.19-1}$$

This relationship is shown in Table 3.19-1 in tabular form below.

Table 3.19-1 Percentage Highly Annoyed Based on DNL

DNL, dBA	40	45	50	55	60	65	70	75	80	85	90
Percent Highly Annoyed	0.4	0.8	2	3	6	12	22	36	54	70	83

The discussion in the FICON document goes on to state that complaints are not an absolute measure of the impact of environmental noise on a community. It explains that annoyance can exist without complaints and the converse is also possible.

3.19.4.3 Communication Interference

Sentence intelligibility is one method of determining communication interference when background or intruding noise is broad spectrum. This is usually the case when there are multiple noise sources. In the EPA "levels" document (EPA, 1974), it estimates that there is 99% sentence intelligibility for normal voice communications when the background noise is 54 dBA or less and 100% at 45 dBA or less. This correlates very well with another presentation found in Harris (Harris, 1991) that shows that "just-reliable" normal voice communication can occur at background noise levels as high as 58 dBA when the speaker and listener are one meter apart.

Typical residential construction provides about 20 dB of noise reduction from the outside to the inside with the windows closed. This is factored into the FICUN category of "compatible" at 65 dBA DNL to give an indoor level of 45 dBA or less (FICUN, 1980) in the minimal or moderate noise exposure zones. A 20 dB noise reduction for residential construction also falls within the range of noise reduction given by EPA (EPA, 1974). The HUD guidelines state that common

building construction will make the indoor noise environment acceptable when the DNL is 65 dBA or less. In higher noise exposure zones, residential structures need to be constructed with higher noise reduction to prevent potential communication interference.

3.19.5 Current Noise Environment

The current noise environment is different than prior to the construction and operation of BFN. Since that time, the residential population adjacent to BFN has grown (see section 3.19.2), the industrial park about two miles upstream and across the river has expanded, and barge traffic has increased. All of these have some effect on the noise environment. The background noise measurements presented in the original BFN EIS are not applicable to the action alternatives evaluated in this SEIS. The environmental noise evaluation of these action alternatives is concerned with the potential effects of additional cooling tower(s) and the replacement of the current cooling towers which operate during the peak of the summer. The original background noise was measured in November, 1971. A 24-hour background noise survey was conducted June 11-12, 2001, in the Paradise Shores and Lakeview communities. The survey location at Paradise Shores was about 1,500 feet from cooling tower 3 along its major axis. In Lakeview, the survey location was in a vacant lot in the center of the community. The 15 hour daytime (0700-2200) average noise was 45.7 dBA, and the nine hour nighttime average was 43.1 dBA at Paradise Shores and 44.1 dBA and 38.7 dBA at Lakeview. Predominant noise sources were typical of suburban life, and included traffic, lawn mowing, home air-conditioning units, and children. At night, insects, frogs, air-conditioning, and traffic were dominant, although Lakeview had less traffic because of a posted restriction.

A daytime noise survey of three of the current operating cooling towers was conducted July 30, 2001. Towers 2, 3, and 5 were operating, and these are the towers closest to Paradise Shores. The noise from the towers was audible at 1,500 feet in the Paradise Shores area, but it was not audible in the Lakeview Community. Measurements were taken at the same location in Paradise Shores as the background measurements, and another set of measurements was taken at 520 feet off the northwest end of tower 3 inline with the Paradise Shores measurement location. The total noise in Paradise Shores was 45.8 dBA, and at 520 feet it was 47.6 dBA. Based on the 520-foot measurements, the calculated intruding noise from the cooling towers at the 1,500-foot location in Paradise Shores is 38.4 dBA. By adding this calculated intruding noise to the daytime background noise level measured in June, the calculated total noise level is 46.4 dBA, which is similar to the total noise measurement of 45.8 dBA. The operation of towers 1 and 6 would cause a negligible increase, less than 1 dB to the total noise in Paradise Shores because the towers are an additional 1,800 feet away and partially blocked by other towers. Also, operating a cooling tower of similar design at the number 4 tower location would add about 3 dBA to the intruding noise and about 1 dBA to the total noise Leq (24 hrs.) in Paradise Shores to 47 dBA.

Noise from the three operating cooling towers was not detectable in the Lakeview Community on the day of the survey. The calculated intruding noise from the current towers would be 38 dBA based on measured data taken broadside to the towers on July 30. This intruding noise is about 6 dBA less than the daytime background noise level taken in June.

These measured and calculated noise levels, along with the number of operating days of the cooling towers, can be used to calculate the average annual DNL. In the past five years when both BFN units 2 and 3 operated, the cooling towers ran an average of 17 days per year. The range of operating days was from 7 to 27 during this time and included 12-hour start-up and 12-hour

shutdown periods. The measured and calculated intruding noise at Paradise Shores, 1,500 feet from the current cooling towers, is about 42 dBA, and the 24-hour and average annual DNLs are 52 and 50 dBA, respectively. At the Lakeview Community across the river, the intruding noise from the cooling towers is not detectable, but the calculated intruding noise is 38 dBA and the 24-hour and average annual DNLs are 48 and 46 dBA, respectively. The maximum average annual DNL for the largest number of operating days, 27, is 50 dBA at Paradise Shores, and 46 dBA at Lakeview. These levels assume that all cooling towers operated the entire periods. Frequently, fewer towers operated which makes these calculated levels the maximum. Table 3.19-2 presents the current noise levels at Paradise Shores and Lakeview communities.

Table 3.19-2 Current Noise Environment*

Location	Background Leq (24 hrs.)	Total Leq (24 hrs.)	DNL 24 hrs	Average Annual DNL 17 days op.	Ave. Annual DNL 27 days op.
Paradise Shores	45	47	52	50	50
Lakeview	43	44**	48**	46**	46**

*All data are dBA.
**Noise from current operating cooling towers was not detectable; these are calculated values.

3.20 Public and Occupational Safety & Health (Non-Radiological)

3.20.1 Site Safety and Health Plan

The TVA nuclear work force has achieved recordable injury rates that are among the lowest in the utility industry. Employees are required to be trained in the safe handling of chemicals that they use in the work environment. Additionally, numerous other safety-related training courses are conducted to respond to OSHA requirements for workers. Operation and construction (i.e., refurbishment and restoration) activities are required to meet or exceed Federal regulatory requirements for safety design, inspection and OSHA regulations. BFN has a 24-hour fire and rescue staff that is Certified Emergency Medical Technicians (EMTs). Emergency medical response procedures are outlined in various Rad/Chem and Emergency Preparedness procedures. Professional medical treatment and testing is available on site with a permanent medical staff that includes a physician. The TVAN Safety and Health Manual contains requirements designed to assure that management administers a strong safety program.

Included in the Safety and Health Manual are provisions for:

Personal protective equipment use,
Safety training requirements for workers,
Accident reporting and investigative requirements,
Hazard communication and right to know,
Heat stress management,
Confined spaces,
Electrical work practices,
Use of chemicals,
Industrial hygiene,
Lead and asbestos abatement,
Fall protection, and
Job safety planning

Employees are trained in applicable safety procedures and methods prior to the start of work at the facility.

3.20.2 TVA's Employee Safety Program

There exists the potential for workers to be exposed to health and safety hazards while constructing and operating the facilities. Construction activities are conducted in accordance with OSHA Construction Industry Standards (29 CFR 1926). All other activities are conducted in accordance with OSHA General Industry Standards (29 CFR 1910) and OSHA Federal Safety and Health Program Requirements (29 CFR 1960). These standards establish practices, chemical and physical exposure limits, and equipment specifications to preserve employees' health and safety. Standards and requirements also apply to TVA contractors and vendors. Contractor operations are monitored to ensure operations are conducted in a safe and healthful manner and that they meet contract requirements.

The TVA Hazard Communication Program ensures that Material Safety Data Sheets (MSDSs) are available and appropriate labels are visible to employees for all products to which they might be exposed in the course of their workday.

TVA's Safety and Occupational Hygiene Program is designed to help the agency conduct its operations in a manner which protects the safety and health of employees. The Safety and Occupational Hygiene Program, headed by a Designated Agency Safety and Health Official (DASHO), defines the activities necessary to prevent on-the-job accidents and occupational illnesses and diseases. This program is implemented by a joint effort among TVA's managers, labor organizations, and employees with guidance and assistance from the DASHO and a professional staff. The program's highlights include:

Workplace Standards - Standards, work rules, and other practices developed by regulatory agencies and by TVA provide employees direction on safe work practices and working conditions.

Job Safety Planning - All jobs undertaken are planned by those involved in sufficient detail to ensure that hazards are identified and eliminated or controlled to an acceptable level.

Training - Each organization provides for job training to improve the safety knowledge and skills of employees and enable them to perform their jobs in a safe and healthful manner.

Employee Involvement - TVA's success in protecting people and property from accidental harm depends on the involvement of all employees in its safety program. Employees are actively involved in the development and implementation of workplace standards and other program activities to minimize unsafe acts and conditions through participation on safety and health committees and through interaction with management and fellow employees.

Workplace Inspection Monitoring and Audits - Workplaces are regularly inspected and monitored to ensure that they meet regulatory and agency requirements. Regular audits assess the effectiveness of inspection and monitoring programs as well as activities to prevent accidents and illnesses. These audits provide the feedback necessary to ensure control of workplace hazards and keep efforts focused on continuous improvement.

Accident Reporting and Investigation - All accidents are reported and investigated by management. Investigations address the following elements:

- Root causes are identified,
- Corrective action to prevent future accidents is recommended,
- Accident data is analyzed for trends to help direct future safety program efforts, and
- Information is shared throughout TVA to support the accident prevention efforts to other organizations.

3.20.3 Fire Protection

BFN has a Fire Protection Plan which is applicable to all activities at or related to BFN which could affect the life or health of TVA employees or the public, the probability or severity of potential fires throughout the plant, or the ability to maintain safe plant shutdown, or limit radioactive release to the environment in case of fire. To assure that the program functions properly and to meet the requirements of 10 CFR 50.48, a Fire Protection Plan has been developed for BFN. The Fire Protection Plan is incorporated into the UFSAR by reference as recommended in NRC Generic Letter 86-10. This document is the sole source for fire protection program commitments at BFN. The Fire Protection Plan contains the current fire protection commitments that affect the Fire Protection Program. The Fire Protection Plan is revised, as required, to reflect all new commitments that affect the BFN Fire Protection Program.

The objectives of the Fire Protection Plan are achieved through the integration of fire protection into the design, construction, operation, and maintenance of the plant and equipment; by fire prevention techniques; and by providing appropriate fire detection and suppression features and fire rated compartmentation. This is known as a defense-in-depth concept, which employs multiple levels of safety measures to attain the required high degree of safety. In addition, the defense-in-depth approach includes the proper administrative controls necessary to maintain program integrity.

The BFN fire protection systems are designed to provide automatic fire protection for known hazardous areas where it is practical to do so, to provide adequate warning of fire in hazardous areas where automatic protection is not feasible, to provide adequate manually-actuated fire protection systems for the entire plant and yard areas (i.e., hose stations, hydrants, etc.), and to ensure the maintenance of divisional integrity of safety-related systems to the extent that the

capability for safe shutdown of the reactors is assured during and after a fire. The common parts of the BFN fire protection systems are the high pressure water subsystem (supplies sprinkler/spray systems and fire hose stations), the low pressure carbon dioxide subsystems (used in plant areas with flammable oil and electrical hazards), the fire detection/annunciation and protective action initiation systems, and the compartmentation and fire retardant systems.

Fire prevention is an important part of the overall BFN Fire Protection Plan. The primary objective of the fire protection activities is to prevent fire from occurring. The plant fire prevention program consists of identification, evaluation, and control of fire hazards. Administrative controls have been established to control both combustibles and ignition sources to the greatest extent possible. Procedures have been established to minimize fire hazards and fire protection impairments in areas containing structures, systems, and components important to safety and to maintain the performance of the fire protection systems and personnel. NFPA guidelines have been used as a basis for these procedures.

Effective handling of fire emergencies is an important aspect of the BFN defense-in-depth Fire Protection Program. This is accomplished by the provision of a trained and qualified emergency response organization, the fire safety awareness of all plant employees, a comprehensive pre-fire plan, safe shutdown procedures, and the ability of the operations personnel to perform such procedures.

3.20.4 Electric and Magnetic Fields

TVA recognizes there is public concern about whether any adverse health effects are caused by electric and magnetic fields (EMF) that result from generation, transmission, distribution, and use of electricity. Many scientific research efforts and other studies examining the potential health and other effects of EMF have been and are being done. TVA is aware of, and ensures that it stays aware of, published research and study results, and directly supports some of the research and study efforts.

Studies, interpretations, and research to date are not conclusive about potential associations between electric or magnetic fields and possible health impacts. A few studies have been interpreted by some as suggesting a weak statistical relationship between magnetic or electric fields and some form of rare cancer. However, equal numbers of similar studies show no association. The present weight of this type of evidence does not allow any conclusion and does not indicate a cause and effect relationship between fields and health effects. No laboratory research has found such a cause and effect adverse health impact from EMF, and no concept of how these fields could cause health effects has achieved scientific consensus.

TVA's standard for siting new transmission lines has the effect of minimizing public exposures to EMF during their operation.

3.20.5 Shock Hazards

Shock hazards are produced mainly through direct contact with conductors and have effects ranging from a mild tingling sensation to death (NRC, 1991). The transmission line towers associated with the BFN Plant are designed to preclude direct public access to the conductors. However, secondary shock currents are produced when persons contact capacitively charged objects (such as vehicles parked near a transmission line) or magnetically linked metallic structures (such as fences near a transmission line). Shock intensity depends on the strength of the electric field, the size and location of the object, and the ground insulation. Design criteria that limit hazards from steady state currents are based on the National Electrical Safety Code (NESC), which requires that transmission lines are designed to limit the short-circuit current to ground produced from the largest anticipated vehicle to less than 5 milliamperes (NRC, 1991). TVA's design ensures that the transmission lines meet the requirement given in NESC (TVA, 1994b). Therefore, the impact of shock hazards and EMF exposure are minimal, as a result of operation of the BFN Plant.

3.20.6 Airborne Pathogenic Microorganisms

Some thermophilic microorganisms associated with cooling towers and thermal discharges can have deleterious impacts on human health. These microorganisms include the enteric pathogens *Salmonella* sp. and *Shigella* sp., as well as *Pseudomonas aeruginosa* and thermophilic fungi. Methods of testing for these microorganisms are known and their presence in aquatic environments is often controllable. Other microorganisms normally present in surface water, but not as easily detected or controlled, include the bacteria *Legionella* sp. (which causes Legionnaires' disease) and the amoebae of the genera *Naegleria* and *Acanthamoeba*, which causes a rare but very serious human infection, primary aerobic meningoencephalitis (PAME) (NRC, 1991).

Legionella sp. has been found in the aerosols in the vicinity of condensers or cooling tower basins that were in the process of being cleaned. Two reported cases of infections related to *Naegleria* sp. that were associated with the cleaning of cooling towers have been reported (NRC, 1991). For this reason, utilities that identify microorganisms that are responsible for PAME in the cooling tower often require respiratory protection for workers in the vicinity of the cooling towers and condensers.

The potential health effects from *Naegleria* sp. at sites such as the BFN site, located on rivers with average flow rates less than 2,830 cubic meters per second (100,000 cubic feet per second), are a public health concern (NRC, 1991). These microorganisms occur in surface water where the risk of infection is always present. Increases in average water temperature due to weather or climatic conditions, or from the discharge of heat, may cause an increase in the levels of the microorganisms. Information obtained by TVA in discussions with the Centers for Disease Control and Prevention indicated that to contract primary amoebic meningoencephalitis from *Naegleria* sp., large doses of cyst-contaminated water must enter the nasal mucosa area. A few cases have been reported in swimmers from Texas and the Carolinas during the past few years; however, these were not associated with aerosol cysts from power plant cooling towers (TVA, 1994g). The Tennessee Department of Health was not aware of any cases for which either *Legionella* sp. or *Naegleria* sp. was associated with cooling towers in Tennessee (TVA, 1994b). TVA concludes that the operation of the BFN plant has not resulted, and is not likely to result, in adverse effects to human health as a result of the presence of these microorganisms.

3.20.7 Hazardous Chemicals

Table 3.20-1 lists the hazardous chemicals in storage for use at BFN, along with their storage location. All of the hazardous chemicals at BFN are either stored inside plant buildings, or are equipped with secondary containment to contain the chemicals in the event of a spill. None of the chemicals stored on-site exceeds the quantity limitations that would require preparation of a Risk Management Plan under 40 CFR Part 68.

In accordance with State and Federal Regulations, BFN has developed a Spill Prevention, Control and Countermeasure (SPCC) Plan that includes spill response assignments and responsibilities, best management practices for controlling and managing oil and chemical storage, and contingency plans in the event of an incident.

BFN has an on-site Hazardous Materials Response Team that is trained and certified to respond to, contain, and clean up oil and hazardous chemicals that may be released. In addition, BFN has the necessary supplies and equipment on-site to control chemical releases, and has arrangements in place for outside assistance in the event of a serious incident.

BFN maintains Material Safety Data Sheets for all hazardous chemicals on-site, and operates a Chemical Traffic Control (CTC) Program to control the use and distribution of chemicals on the site.

Implementation of the alternatives discussed in this EIS would not result in significant differences in the amounts or types of hazardous chemicals stored or used at BFN on an annual basis. All chemicals proposed for use on-site are reviewed and approved for use through the CTC program.

Table 3.20-1 Chemical Storage by Area

Drainage[a] Area	Location	Substance	Physical State	Maximum Storage[b]	Storage Vessels	Secondary Confinement: Type	Secondary Confinement: Percent of Maximum Storage Capacity
4	Hazardous Waste Storage Building	waste solvents, waste acid, and waste caustic, spent fluorescent lighting	liquid	825	drums (15)	Floor drain sump	91
1	Intake	sodium hypochlorite	liquid	5,700	tank (1)	Concrete wall and floor	>100
		Calgon H-940 (sodium bromide)	liquid	5,700	tank (1)	Concrete wall and floor	>100
		Calgon CL-50 (sodium hexametaphosphate)	liquid	1,600	tank (1)	Double-walled tank	100
		Calgon PCL-401 (anionic copolymer)	liquid	1,600	tank (1)	Double-walled tank	100
		Calgon H-300 (glutaraldehyde)	liquid		bin (1)		
		Calgon EVAC (molluscicide)		300		Plastic pan	>100
			liquid	300	bin (1)	Plastic pan	>100
1	Offgas Building	ethylene glycol	liquid	15,000	tanks (3)	Building sump	>100
1	Modifications Area						
	• Oil Rack	methyl ethyl ketone	liquid	165	drums (3)	Metal pans	>100
		mineral spirits	liquid	385	drums (7)	Metal pans	>100
		ethylene glycol	liquid	110	drums (2)	Metal pans	>100
	• Paint Shop	paints, epoxies, and resins	liquid	1,500-2,000	1- and 5-gallon cans	None	-
1	• Materials Procurement Complex (MPC-B3B (BFN-1) (MPCJ)	hydrazine (35%)	liquid	165	drums (3)	None	-
		paint thinners	liquid	770	drums (14)	None	-
		boric acid	granular	3,425 lbs.	bags (35)	Not applicable	-
1	Reactor Building	aqueous film-forming foam	liquid	900	tank (3)	Floor drain sump	>100
		sodium nitrite (30%)	liquid	5	tank (1)	Floor drain sump	>100
		sodium pentaborate (9.2%)	liquid	4,850	tank (2)	Floor drain sump	>100

Table 3.20-1 Chemical Storage by Area

Drainage[a] Area	Location	Substance	Physical State	Maximum Storage[b]	Storage Vessels	Secondary Confinement	
						Type	Percent of Maximum Storage Capacity
4	Mixed Waste Storage Area	waste solvents, waste acids, and waste caustic, waste lead paint chips	liquid solid	3,465	drums (63)	Floor drain sump	65
1	• Service Building • • Paint Room • Power Stores						
		paint	liquid	100	cans (40)	None	
		ethylene glycol	liquid	165	drums (3)	None	
		mineral spirits	liquid	660	drums (12)	None	
		thinner	liquid	330	drums (6)	None	-
		sodium nitrite	solid	360 lbs.	plastic bags or jars	Not applicable	-
	Thinner Rack (near Service Building)	thinners	liquid	330	drums (6)	None	_
1	Turbine Building	sodium hypochlorite	liquid	8,530	tank (1)	Containment diking	>100
		Calgon PCL 401 (anionic copolymer)	liquid	1550	tank (1)	dike	>100
		Calgon CL 50	liquid	4400	tank (1)	dike	>100
		Calgon EVAC	liquid	300	bin (1)	plastic pan	>100
		Calgon H-300	liquid	300	bin (1)	plastic pan	>100
		Calgon H-940	liquid	1550	tank (1)	dike	>100
		hydrazine (0.1%)	liquid	125	reservoirs (1)	Floor drain collector tank	>100
		hydrazine (35%)	liquid	55	drum (1)	Metal pan	>100
		ammonium hydroxide (50 ppm)	liquid	125	tank (1)	Floor drain collector tank	>100

[a]There are no chemicals of concern stored in drainage areas 2 and 3.
[b]Units are gallons unless otherwise stated.

3.20.8 Site Emergency Response Plan

BFN has a Radiological Emergency Plan (REP) which addresses organizational responsibilities, capabilities, actions and guidelines for TVA during a radiological emergency. However, the REP is also designed to be implemented based on a variety of situations that could potentially adversely affect the operations of a TVA nuclear plant such as BFN. In addition to radiological emergencies, these include natural events, chemical spills, toxic gas releases, fires, plant operational problems, etc., which may pose a threat to the safe operation of the plant and have a potential impact offsite. The REP is described in Section 3.21.3.

3.21 Radiological Impacts Baseline

3.21.1 Normal Operations

3.21.1.1 Occupational

Occupational radiological impacts refer to radiation dose received by individuals in the course of their employment. Section 4.3.21.1.1 contrasts the current industry and facility occupational radiation dose trends against the current limits established by federal regulation to minimize the potential health risk to individual workers. At BFN, the average annual dose to workers and the average collective worker dose per reactor are consistent with current industry trends for this type of reactor (boiling water reactor) and worker radiation exposures are controlled to be significantly less than regulatory limits.

3.21.1.2 Public

Commercial nuclear power reactors, under controlled conditions, release small amounts of radioactive materials to the environment during normal operation. These releases result in radiation doses to humans that are small relative to doses from natural radioactivity. Nuclear power plant licensees must comply with NRC regulations (e.g., 10 CFR Part 20, Appendix I to 10 CFR Part 50, 10 CFR Part 50.36a, and 40 CFR Part 190) and conditions specified in the operating license.

The BFN Off-site Dose Calculation Manual (ODCM) provides the methodology used to calculate offsite doses based on gaseous and liquid effluent releases from the plant. These releases are reported in BFN's annual radioactive effluent release report. The ODCM specifies the parameters used to calculate potential off-site doses due to radioactive liquid and gaseous effluents and to ensure compliance with the following limits:

- The concentration of radioactive liquid effluents released from the site to the unrestricted area will be limited to levels that meet regulatory requirements.
- The exposure to any individual member of the public from radioactive liquid effluents will not result in doses greater than the design objectives of 10 CFR Part 50, Appendix I.
- The exposure to any individual member of the public from radioactive gaseous effluents will not result in doses greater than the design objectives of 10 CFR Part 50, Appendix I.

- The dose to any individual member of the public from the nuclear fuel cycle will not exceed the limits in 40 CFR Part 190 and 10 CFR Part 20.
- The dose rate from radioactive gaseous effluents at any time at the site boundary will be limited to:
  (a) less than or equal to 5 mSv/yr (500 millirem per year (mrem/yr) to the whole body and less than or equal to 30 mSv/yr (3,000 mrem/yr) to the skin for noble gases, and
  (b) less than or equal to 15 mSv/yr (1,500 mrem/yr) to any organ for iodine-131 and -133, tritium, and for all radioactive materials in particulate form with half-lives greater than eight days.

BFN's recent operating experience has shown that doses from gas and liquid effluents are a small fraction of the applicable radiological dose limits.

TVA has conducted a Radiological Environmental Monitoring Program (REMP) since 1973 to assess the impact of BFN operations on the surrounding environs and the general public. The purpose of the REMP is to:

- Provide verification that radioactive material released to the environment as a result of plant operations and the ambient environmental radiation levels attributable to plant operations are within the NRC regulatory limits and the EPA environmental radiation standards in 40 CFR Part 190.
- Provide for the assessment of any measurable buildup of long-lived radionuclides in the environment.
- Monitor and evaluate ambient environmental radiation levels.
- Determine if plant operations results in any statistically significant increase in the concentration of radionuclides in the environs of the plant site.

The REMP conducted for BFN is designed to monitor the primary pathways for exposure to humans. The BFN REMP includes measurement of direct radiation levels and collection and analysis of various sample types. Monitoring for the liquid pathway includes samples of fish, shoreline sediment and water from the Tennessee River. The airborne pathway is monitored by direct sampling for air particulates and gaseous radioiodine and sampling of milk, soil, and food crops that could be affected by the deposition of airborne radionuclides.

The results from the REMP are reported in the Annual Radiological Environmental Operating Report (AREOR). The data reported in the BFN AREOR demonstrate that the small amounts of radiological effluents released to the environment due to the operation of BFN have had no measurable impact on the environs around BFN.

Estimated doses to the maximum exposed member of the public due to radiological effluent releases from BFN are calculated on an annual basis. These dose values have consistently been very low, typically only a small fraction of applicable limits. For example, the maximum calculated whole body dose for liquid releases in 1999 was 0.037 mrem/year, or 1.2% of the applicable limit (10 CFR 50 App. I, 3mrem/year). The maximum organ dose equivalent from gaseous effluents in 1999 was 0.04 mrem/year which represented 0.3% of the limit (10 CFR 50 App. I, 15 mrem/year). The calculated whole body or other organ (other than thyroid) dose was 0.12 mrem (0.5% of the 40 CFR 190 limit, 25 mrad/year) for 1999. The calculated thyroid dose was 0.082 mrem (0.1% of the 40 CFR 190 limit, 75 mrad/year) for 1999.

There are also no significant changes to the radiological effluent releases anticipated as a result of BFN operations over the current license period.

3.21.2 Facility (Design Basis) Accidents

The BFN Updated Final Safety Analysis Report (UFSAR) Chapter 14 addresses several design basis accidents such as Loss of Coolant Accident (LOCA), Main Steam Line Break (MSLB), Control Rod Drop Accident (CRDA), and Fuel Handling Accident (FHA). Since the design basis accidents are independent of the age of the plant, the extension of the lifetime operation of the plant from 40 years to 60 years will not impact the analysis of these accidents. This conclusion applies to all BFN units.

The originally licensed maximum thermal power level for the BFN units was 3293 megawatt thermal (MWt). The current analyses in Chapter 14 address BFN operation at the present 5% uprated power level of 3458 MWt. EPU at 120% of the originally licensed maximum thermal power level will affect accident analysis because the power level influences the radioactive isotope inventories and releases. The analyses will be re-performed at EPU power levels, and the plant will conform to regulatory requirements prior to implementation of EPU.

Extension of the plant life from 40 years to 60 years will impact equipment qualification (EQ) of safety related equipment. The total integrated radiation doses will generally increase by 50%. However, the BFN 10 CFR 50.49 (EQ) program will ensure that all safety related equipment will be qualified to operate in its intended environment so as to perform its intended function. Any equipment that cannot withstand the full 60-year life of the plant will be replaced on a predetermined maintenance schedule as part of the 10 CFR 50.49 program. At any time during the life of the plant, the equipment will be qualified for its environment, and will be on a regular maintenance/replacement schedule as needed. Therefore, life extension will not negatively impact the safety of the public following an accident.

3.21.3 Site Radiological Emergency Response Plan

The following discussions detail how the BFN REP fulfills Federal (10 CFR 50) and State and Local (44 CFR 350) requirements.

10 CFR PART 50 DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

The REP has been developed to provide protective measures for TVA personnel, and to protect the health and safety of the public in the event of a radiological emergency resulting from an accident at a TVA nuclear plant. This plan, which has been approved by the NRC, fulfills the requirements set forth in Part 50, Title 10 of the Code of Federal Regulations, and was developed in accordance with the NRC and Federal Emergency Management Agency (FEMA) guidance. As specified in NUREG-0654, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans in Support of Nuclear Power Plants and REG Guide 1.101, the REP provides for the following:

- Adequate measures are taken to protect employees and the public.
- Individuals having responsibilities during an accident are properly trained.
- Procedures exist to provide the capability to cope with a spectrum of accidents ranging from those of little consequence to major core melt.
- Equipment is available to detect, assess, and mitigate the consequences of such occurrences.

- Emergency action levels and procedures are established to assist in making decisions.

The REP, together with the appendices, describes the methods TVA will use to:

- Detect an emergency condition.
- Evaluate the severity of the problems and conduct environmental monitoring.
- Notify Federal, State, and local agencies of the condition.
- Activate the TVA emergency organizations.
- Evaluate the possible off-site consequences by performing dose assessments.
- Recommend protective actions for the protection of the public.
- Mitigate the consequences of the accident.
- Maintain a drill and exercise program.

Since TVA authority is limited to TVA-owned and -controlled property, State and local agencies are responsible for ordering and implementing actions offsite to protect the health and safety of the public.

Specific procedures are developed to ensure that the plan is implemented as designed. These implementing procedures are designed to ensure that accidents are properly evaluated, rapid notifications made, and assessment and protective actions performed. These procedures are compiled in the EPIPs. Site specific procedures for abnormal and emergency operation and control exist but are not included in the EPIPs. These plant-operating procedures are designed to ensure the implementation of the EPIPs.

44 CFR PART 350 REVIEW AND APPROVAL OF STATE AND LOCAL RADIOLOGICAL EMERGENCY PLANS AND PREPAREDNESS

State Radiological Emergency Plans (SREPs) have been developed to provide a guide for the response of the State Government to any emergency caused by an incident at a TVA operated Nuclear Plant. The plan also provides integrated response actions of Federal, State, and local governments to an emergency that causes, or has the potential for causing, a release of a significant amount of radioactive material into the environment. In accordance with this plan, the State, in coordination with each concerned agency, will provide timely warning and protection for those citizens who may be threatened by an accident or incident at the plant. This plan fulfills the requirements set forth in Part 350, Title 44 of the Code of Federal Regulations, and was developed in accordance with the NRC and FEMA guidance.

As specified in NUREG-0654, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans in Support of Nuclear Power Plants, the SREPs address State and local concepts of operation, organization, administration and logistics, communications, execution, authority and reference, and supporting plans. In addition, plans include annexes to provide guidelines for more specific planning and response information used to protect the public during a radiological emergency. The SREPs has been evaluated and approved by the FEMA which has the responsibility to ensure the adequacy for off-site planning.

The plan, to include annexes, describes the methods the involved agencies use relating to:

- Direction and Control,
- Alert , Warning, and Notification,
- Communications,
- Public Information and Education,
- Radiological Protection Measures for public and emergency workers, to include utilization of radiological and environmental monitoring for the assessment and minimization radiological health hazards,
- Medical and Public Health,
- Plume Exposure Emergency Planning Zone/Ingestion Pathway Zone, to include protective actions decision making for controlling the distribution and use of food and water and consumption of radio-protective drugs, and advising the agriculture community concerning livestock and farm products,
- Evacuation,
- Security,
- Reentry, Recovery, and Return,
- Radiological Emergency Response Training, and
- Exercises.

Since State and local agencies are responsible for ordering and implementing off-site actions for the protection of the health and safety of the public, county implementation procedures are also included.

3.21.4 Severe Accident Mitigation Alternatives

For purposes of this SEIS, the term "accident" refers to any unintentional event (i.e., outside normal or expected plant operations) that result in the release or potential release of radioactive material to the environment. Generally, the nuclear industry and the NRC categorize accidents as "design basis" or "severe." Design basis accidents are those for which the risk is great enough that a nuclear plant is required to be designed and constructed to prevent unacceptable accident consequences. Severe accidents are those considered too unlikely to warrant design controls.

The NRC has concluded in its generic license renewal rulemaking that unmitigated environmental impacts from severe accidents met the criteria for exclusion from requiring additional plant-specific analyses. Nonetheless, the NRC, noting that 1) ongoing regulatory programs related to severe accident mitigation have not been completed for all plants, and 2) these programs have identified plant programmatic and procedural improvements (and in a few cases, minor modifications) as cost-effective in reducing severe accident risks and consequences, elected to require that alternatives to mitigate severe accidents be considered for all plants that have not considered such alternatives. Site-specific information to be presented includes: 1) potential SAMAs; 2) benefits, costs, and net value of implementing potential SAMAs; and 3) sensitivity of analysis to changes to key underlying assumptions.

BFN has previously completed a Probabilistic Safety Assessment (PSA), which is a systematic and comprehensive analysis of the potential accidents that can occur at the plant. The PSA is a thorough description of the frequency and consequences of potential accidents; it incorporates both system reliability and human involvement in plant safety. The BFN PSA evaluates the potential for core damage during power operation (i.e., "Level I" analysis) and also includes containment failure

and radionuclide source term estimations following core damage (i.e., "Level II" analysis). It does not, however, evaluate the effects of radionuclide release to the surrounding environment (i.e., "Level III" analysis); this is an integral part of a SAMA analysis.

In response to NRC requirements, BFN has also previously completed an Individual Plant Examination (IPE) which addresses internal events, and an IPE for External Events (IPEEE) such as flood, earthquake, fires, etc. The IPE and IPEEE are less comprehensive than the current PSA, but they utilize standardized methodology which allows some degree of comparison of results between plants. Like the PSA, they involve Level I and II analyses which have been used to identify plant programmatic and procedural improvements (and in some cases, minor modifications) which are effective in reducing severe accident and risk consequences.

A SAMA analysis has been prepared for BFN that addresses operation during the 20-year license renewal period and relates the costs of potential programmatic, procedural, and physical changes to benefits associated with reducing the radiological damage to the surrounding environment (Level III). This analysis is included as Appendix A of this SEIS.

3.22 References

Alabama Agricultural Statistics Service. 1999. Alabama Agricultural Statistics 1997-1999. United States Department of Agriculture.

Alabama Department of Environmental Management. 2001. "Personal Communication with Enid Bittner, Alabama Department of Environment and Conservation, Public Groundwater Supplies Within a 2-Mile Radius of Browns Ferry Nuclear Plant," April 2001.

Alabama Department of Transportation (ADOT). Traffic Flow Maps showing 1998 Average Daily Traffic, reported by ADOT.

Baxter, D. S. and J. P. Buchanan. 1998. Browns Ferry Nuclear Plant Thermal Variance Monitoring Program - Final Report. Tennessee Valley Authority, Water Management, Environmental Compliance.

Boggs, J. Mark. 1982. "Browns Ferry Nuclear Plant Low-Level Radwaste Storage Facility Groundwater Pathway Analysis," Tennessee Valley Authority, Report No. WR28-1-67-116, October 1982.

Braun, E. L. 1950. Deciduous Forests of Eastern North American. The Blakiston Company, Philadelphia. 596 pp.

Browns Ferry Nuclear Plant (BFN), Updated Final Safety Analysis Report, Section 2.5.

Bureau of Economic Analysis. 1997. Bearfacts for 1987-1997; Limestone County, Alabama. (http://www.bea.doc.gov/bea/regional/bearfacts)

Dycus, D. L. and T. F. Baker. 2000. Aquatic Ecological Health Determinations for TVA Reservoirs - 1999. Tennessee Valley Authority, Water Management, Chattanooga.

Dycus, D. L. and T. F. Baker. 2001. Aquatic Ecological Health Determinations for TVA Reservoirs - 2000. Tennessee Valley Authority, Water Management, Chattanooga.

Edison Electric Institute (EEI). 1984. "Electric Power Plant Environmental Noise Guide."

Environmental Protection Agency. 1994. "Wheeler Lake, BASINS Core Data." (http://www.epa.gov/OST/BASINS/HUCS/06030002/)

Federal Farmland Protection Policy Act. 1981. U. S. Code of Federal Regulations Title 7, Part 567. Amended in 1984 and 1994 (7 CFR Part 658).

Federal Interagency Committee on Noise. 1992. "Federal Agency Review of Selected Airport Noise Analysis Issues."

Federal Interagency Committee on Urban Noise. 1980. "Guidelines for Considering Noise in Land Use Planning and Control."

Fenneman, N. M. 1938. Physiography of Eastern United States. McGraw-Hill Book Company, Inc., New York. 714 pp.

Gatley, W. S. 1979. "Factors Affecting the Design and Implementation of a Workable Community Noise Ordinance." ASTM Special Tech. Pub. 692. "Community Noise." American Society for Testing and Materials.

Harper, W. L. 2001. Browns Ferry Nuclear Plant—Summary of Results from Thermal Modeling Analysis. TVA Internal Memorandum.

Harris, C. M. 1991. Ed. "Handbook of Acoustical Measurement and Noise Control." McGraw-Hill, Inc.

Higgins, J. M. and Kim, B. R. 1981. "Phosphorus Retention Models for Tennessee Valley Authority Reservoirs." Water Resources Research, Vol. 17, No. 3, pp. 571-576.

Julian, H. E., S. C. Young, C. Lu, and K. E. Richter. 1993. NFERC Regional Groundwater Investigation, TVA Engineering Laboratory, Report No. WR28-1-520-191, Norris, Tennessee, April 1993.

Maceina, M. J., P. W. Bettoli, S. D. Finely, and V. J. DiCenzo. 1998. Analyses of the sauger fishery with simulated effects of a minimum size limit in the Tennessee River of Alabama. North American Journal of Fisheries Management 18: 104-113.

Nalepa, T. F., and D. Schloesser. 1993. Zebra Mussels: biology, impacts, and control. Lewis Publishers. pp. 217-225.

Oregon State University Information Services, Government Information Sharing Project. 1999. 1997 Census, Limestone County, Alabama. (http:/govinfo.library.orst.edu/)

Shiao, M. C. 2001. Browns Ferry Nuclear Plant—Model Analysis of Wheeler Reservoir for 1988. TVA Internal Memorandum.

Tennessee Department of Labor and Workforce Development. 2000. Labor Force Estimates Summary –Tennessee, Annual Average 1999.

Tennessee Valley Authority. 1972. "Browns Ferry Nuclear Plant - Final Safety Analysis Report," Tennessee Valley Authority, February 1972.

Tennessee Valley Authority. 1978a. Browns Ferry Nuclear Plant Preoperational Fisheries Resources Report. Division of Forestry, Fisheries, and Wildlife Development, Norris, Tennessee.

Tennessee Valley Authority. 1978b. Biological Effects of Intake-Browns Ferry Nuclear Plant. Volume 4: Effects of the Browns Ferry Nuclear Plant Cooling Water Intake on the Fish Populations of Wheeler Reservoir. Division of Forestry, Fisheries, and Wildlife Development, Norris, Tennessee.

Tennessee Valley Authority. 1980. Fish Entrainment and Impingement at Browns Ferry Nuclear Plant, Wheeler Reservoir, Alabama, for the Years 1978 and 1979. Division of Water Resources, Fisheries and Aquatic Ecology Branch. Norris, Tennessee.

Tennessee Valley Authority. 1983 "A Supplemental 316(a) Demonstration for Alternative Thermal Discharge Limits for Browns Ferry Nuclear Plant, Wheeler Reservoir, Alabama."

Tennessee Valley Authority. 1990 "Water Resources Issues Analysis: Wheeler Reservoir Watershed Region." TVA/WR/WQ-90/6.

Tennessee Valley Authority. 1993. "Two-Dimensional Water Quality Modeling of Wheeler Reservoir." Report No. WR28-1-3-105.

Tennessee Valley Authority. 1999. "Browns Ferry Nuclear Plant (BFN) – Units 1, 2, and 3 – Updated Final Safety Analysis Report (UFSAR), Amendment 18." Tennessee Valley Authority, November 16, 1999.

Tennessee Valley Authority. 1999. Browns Ferry Nuclear Plant - National Pollutant Discharge Elimination System Permit Number AL 0022080 - Renewal Application.

Tennessee Valley Authority. 2000. "Aquatic Ecological Health Determinations for TVA Reservoirs—1999."

Top of Alabama Regional Council of Governments. 1983. Limestone County Comprehensive Plan 1985.

Top of Alabama Regional Council of Governments. 1985. Limestone County Fiscal Analysis Study.

Transportation Research Board. 1994. "Highway Capacity Manual," Special Report 209. 3rd ed. Washington: Transportation Research Board.

U. S. Department of Agriculture. 1953. Soil Survey for Limestone County, Alabama. Soil Conservation Service.

U. S. Department of Agriculture. 1999. National STATSGO Database, Natural Resource Conservation Service. (www.ftw.nrcs.usda.gov/stat2.html).

U. S. Department of Commerce, Bureau of the Census. (www.census.gov/population/estimates/).

U. S. Department of Commerce, Bureau of the Census. (www.census.gov/hhes/www/saipe/).

U. S. Department of Commerce. 1969-1998. Bureau of Economic Analysis. Regional Economic Information System. (CD-ROM).

U. S. Department of Housing and Urban Development. 1971. "Noise Abatement and Control: Departmental Policy, Implementation Responsibilities, and Standards." Circular 1390.2.

U. S. Department of Housing and Urban Development. 1983. "Noise Assessment Guidelines." HUD-PDR-735.

U. S. Department of Labor. 1984. Occupational Safety and Health Administration. "Occupational Noise Exposure."

U. S. Environmental Protection Agency. 1974. "Information on Levels of Environmental Noise Requisite to Protect Human Public Health and Welfare with an Adequate Margin of Safety." EPA 550/9-74-004.

U. S. Environmental Protection Agency. 1982. "Guidelines for Noise Impact Analysis." EPA-550/9-82.

Vision 2000 Quality Council. 2000. Vision 2000, Strategic Agenda, Athens-Limestone County, Alabama.

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4.0 ENVIRONMENTAL CONSEQUENCES

Environmental consequences associated with the proposed alternatives are described in this chapter. Section 4.1 addresses the environmental impacts associated with the No Action Alternative which involves operation of Units 2 and 3 only until their existing license terms expire. Section 4.2 addresses the environmental impacts associated with Alternative 1, which involves operating Browns Ferry Nuclear Plant (BFN) Units 2 and 3 for an additional 20-year period beyond the expiration dates of the current licenses. Section 4.3 discusses the environmental impacts associated with Alternative 2 (A, B, C, and D), which includes the refurbishment and restart of BFN Unit 1 with the additional 20-year operation for all three units. Section 4.4 identifies possible mitigation measures. Section 4.5 discusses the irreversible adverse impacts of the proposed actions. Section 4.6 compares short-term uses of the environment with the long-term productivity enhancements that are expected from the proposed actions. Section 4.7 describes irreversible and irretrievable commitment of resources, and Section 4.8 provides a listing of the references used throughout Chapter 4.

The environmental impacts described in this chapter are based on the affected environment as described in Chapter 3 and on the information describing the proposed actions in Chapter 2. The chapter is formatted to follow the section headings used in Chapter 3. The proposed actions would be carried out in a way which meets all environmental regulations and requirements and this would help ensure that associated impacts are environmentally acceptable.

4.1 Impacts to the Environment Associated with the No Action Alternative

The No Action Alternative would result in TVA not applying for relicensing for any of the three units at BFN at this time. The current operating licenses for Units 1, 2, and 3 would be allowed to expire in 2013, 2014, and 2016, respectively. Existing environmental conditions would remain unchanged or would change through actions other than operation of Units 2 and 3 only until the current licenses expire. The original BFN EIS describes the environmental impacts associated with operating Units 1 through 3. Operation of Units 2 and 3, until the existing licenses expire, is encompassed by the analyses in the original BFN EIS. To the extent that changes affecting environmental impacts have occurred, or that there is new information relevant to environmental impacts since the release of the original EIS, this is addressed either in Chapter 3 in the description of the Affected Environment or is embedded in the discussion of the changes from existing conditions that could occur as a result of the Action Alternatives.

4.1.1 Decommissioning

Under all of the alternatives (No Action and the Action Alternatives), TVA would eventually have to propose a decommissioning option and implement it. It is not proposing a decommissioning option now. The No Action Alternative would be the earliest entry into decommissioning. Therefore, although decommissioning is common to all of the alternatives, it is discussed in the context of the No Action Alternative with references to the action alternatives where appropriate. Prior to choosing a decommissioning option, TVA would conduct appropriate environmental

analyses and reviews. General information about decommissioning is included in this SEIS to update the original BFN EIS in the interim.

Environmental issues associated with decommissioning resulting from continued plant operation during the renewal term of a license have already been discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (GEIS), NUREG-1437 (NRC 1996; 1999). The GEIS included a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues were then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required by the Nuclear Regulatory Commission (NRC), unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria of Category 1; therefore, additional plant-specific review for these issues is required. There are no Category 2 issues related to decommissioning at BFN.

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1 that are applicable to BFN Units 1, 2, and 3 decommissioning following the renewal term are listed in Table 4.1-1. For all of those issues, the NRC staff concluded in the GEIS that the impacts are SMALL, and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4.1-1 Category 1 Issues Applicable to the Decommissioning of BFN Following the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
DECOMMISSIONING	
Radiation Doses	7.3.1; 7.4
Waste Management	7.3.2; 7.4
Air Quality	7.3.3; 7.4
Water Quality	7.3.4; 7.4
Ecological Resources	7.3.5; 7.4
Socioeconomic Impacts	7.3.7; 7.4

A brief description of the NRC staff's review and the GEIS conclusions, as codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, for each of the issues follows. As indicated, the analyses in

the original EIS and those done here for the SEIS have not identified anything that leads TVA to conclude that decommissioning impacts are likely to be materially different under any of the alternatives. However, based on past experience, it is possible that decommissioning techniques would continue to be improved over time; therefore, Alternatives 1 and 2 (the Action Alternatives) could result in fewer impacts or impacts of less severity.

- Radiation doses: Based on information in the GEIS, NRC found: "Doses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 man-rem [0.01 person-Sv] caused by buildup of long-lived radionuclides during the license renewal term." TVA has not identified any significant new information during its review and evaluation that would indicate any additional radiation dose would be experienced by either the public or workers (NRC, 1990). Therefore, TVA concludes that there would be no radiation doses associated with decommissioning following license renewal beyond those discussed in the GEIS.

- Waste management: Based on information in the GEIS, NRC found: "Decommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected." TVA has not identified any significant new information relevant to environmental concerns during its review and evaluation that leads to a different conclusion. Therefore, TVA concludes that there would be no solid waste impacts associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Air quality: Based on information in the GEIS, NRC found: "Air quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term." TVA has not identified any significant new information relevant to environmental concerns during its review and evaluation that leads to a different conclusion. Therefore, TVA concludes that there would be no air quality impacts from license renewal during decommissioning beyond those discussed in the GEIS.

- Water quality: Based on information in the GEIS, NRC found: "The potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts." TVA has not identified any significant new information relevant to environmental concerns during its review and evaluation that leads to a different conclusion. Therefore, TVA concludes that there would be no water quality impacts from license renewal term during decommissioning beyond those discussed in the GEIS.

- Ecological resources: Based on information in the GEIS, NRC found: "Decommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts." TVA has not identified any significant new information relevant to environmental concerns during its review and evaluation that leads to a different conclusion. Therefore, TVA concludes that there would be no ecological resources impacts from license renewal during decommissioning beyond those discussed in the GEIS.

- Socioeconomic impacts: Based on information in the GEIS, NRC found: "Decommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth." TVA has not identified any significant new

information relevant to environmental concerns during its review and evaluation that leads to a different conclusion. Therefore, TVA concludes that there would be no socioeconomic impacts from license renewal during decommissioning beyond those discussed in the GEIS.

A number of commercial nuclear power plants are currently conducting initial decommissioning efforts, and are developing both the technology and the licensing framework that will allow better understanding of and approaches to decommissioning by others in the future.

- Technology: The decommissioning commercial nuclear power plants, in cooperation with the Electric Power Research Institute (EPRI), the Department of Energy's (DOE) National Energy Technology Laboratory (NETL), and private industry, have developed technologies which are improving the effectiveness and safety of the decommissioning process. The most significant of these technologies are in the areas of site characterization (locating and characterizing radiological contamination), decontamination, dismantlement, disposal (e.g., volume reduction), and worker safety (EPRI, 2001). Commercial robotics technology, although in its infancy, is already contributing in many of these areas.

- Licensing: The NRC, working with commercial licensees through the Nuclear Energy Institute (NEI), has and is continuing to develop a framework of rules and regulations to systematically "de-license" plants in the course of the decommissioning process (NRC, 2000a and 2000b).

In summary, choosing the No Action Alternative or any of the action alternatives would not result in foreclosing any decommissioning options, or result in any environmentally unacceptable conditions. Unlike license renewal under Alternatives 1 and 2, the No Action Alternative would not allow an additional 20-year period for decommissioning technology (including more advanced robotics) and the licensing framework to evolve and mature. Similarly, choosing the No Action Alternative would not allow an additional 20-year period to increase the likelihood that a permanent spent fuel repository would be available prior to the completion of decommissioning. The availability of a spent fuel repository would further reduce the potential for adverse environmental effects from decommissioning.

4.1.2 Power Replacement Alternatives

The range of options available to TVA as sources of replacement power, assuming a decision by the TVA Board of Directors to not seek license renewal of the BFN units, is addressed in *Energy Vision 2020*. The supply-side options include combined-cycle plants, purchasing and exercising call alternatives, purchasing power from independent power producers, developing renewable energy resources, and improving the existing hydroelectric generating systems.

Energy Vision 2020 analyzes the connection between various air pollutants and carbon dioxide emissions with fossil-fired power production, and used carbon dioxide emissions and pollutant levels as one of the measures to differentiate among TVA's energy strategies. For example, coal-based technologies emit over 200 pounds of carbon dioxide per million BTU of heat input; this is in stark contrast with nuclear power, which emits none. TVA has been an active participant in programs to minimize and/or mitigate the effects of utility emissions on global climate, such as the Climate Challenge Memorandum of Understanding signed by the Department of Energy, four utility organizations, and TVA on April 20, 1994. Consistent with these program objectives, *Energy Vision 2020* lists several potential means of lowering the carbon dioxide emitted per unit of electric energy produced by TVA, the first and foremost of which is increased production of

nuclear power. The others are (1) hydroelectric power plant modernization, (2) addition of more efficient fossil-fired plants, (3) increased use of renewables, and (4) repowering of existing coal-fired plants with more efficient energy conversion systems. However, compared with a single 1,000 megawatt nuclear unit, these other alternatives either represent a smaller collective contribution to the overall energy production mix (1 and 3), or would still remain as large sources of carbon dioxide (2 and 4). The total power increase from hydro plant modernization is approximately 750 megawatts, and the current total power from other renewable energy sources (bioenergy, solar and wind) is less than 10 megawatts. Since currently about two-thirds of TVA's total power production originates from fossil fuels and further development of new hydroelectric generation is unlikely, any change in nuclear power generation within TVA will affect the overall production of greenhouse gases.

4.1.3 Socioeconomic Impacts of Discontinuing Plant Operations at Expiration of Current Licenses

4.1.3.1 Economic Conditions

According to the analysis by the NRC (NRC Generic EIS, Section 7.3.7), there are no significant socioeconomic impacts from decommissioning, and it is considered to be a Category 1 issue, not requiring additional plant-specific analysis. Nonetheless, should BFN not be relicensed, there would be some loss of jobs as the plant went into the decommissioning process, at license expiration followed by further loss at the end of the decommissioning period. In addition to these direct losses of income and employment, the impacts would be increased by additional indirect income and employment losses in the area as a result of decreased spending due to the direct income losses. The number of jobs lost would be roughly equal to perhaps one percent of the labor force of Limestone County, but would be only a tiny fraction of the labor force in the labor market area. The NRC study (NRC Generic EIS, Section 7.3.7) concludes that, "The impact of license renewal on the socioeconomic impacts of decommissioning are of small significance. Because license renewal does not affect the socioeconomic impacts that will occur at the time of decommissioning, there is no need for the consideration of mitigation as part of the license renewal environmental review."

The need for additional storage for spent fuel will require construction of a dry cask storage facility and replacement of the Modifications Fabrication Building in a different location (see Sections 2.3.2 and 2.3.3). This will be required under any of the alternatives. However, the employment and income impacts of these actions would be small and short-term, and therefore would not be significant.

4.1.3.2 Demography

As shown in Section 3.13.1, the population of Limestone County is expected to be about 80,000 at the time of license expiration, with a labor market area population of close to 750,000. Thus, the population loss that could occur in association with this alternative would be only a small share of the total.

4.1.3.3 Community Services and Housing

Due to the small size of the population impact relative to the total population in the area, no important impacts to community services are expected. Sudden loss of this number of jobs could have a noticeable dampening effect on the housing market; however, this effect would be short-lived if the area continues to grow as expected and is likely to be small.

4.1.3.4 Local Government Revenues

Under this alternative, there would be little impact on the TVA in lieu of tax payments to the state of Alabama or to the share that the state passes on to Limestone County. As long as TVA owns the site, the book value of the property would be used in the formulas that calculate the payments. It is possible that sometime, most likely after decommissioning, ownership of the property would be conveyed to someone else. If so, TVA in lieu of tax payments would stop; however, if ownership were private there should be local tax collections based on the actual property value at that time. Most likely, by the time this might happen, the book value would be very low anyway, and therefore even this impact would be small.

The loss of jobs and income would cause a very small decrease in local sales and property tax collections. However, these would not be significant as a share of the total revenues of local governments.

4.1.3.5 Environmental Justice

TVA is not subject to the executive order requiring some federal agencies to consider environmental justice impacts. However, TVA considers such impacts in its NEPA reviews as a matter of policy. The primary impacts in the local area would be to employees at the plant and their families. Secondary impacts would be diffused throughout the area and would not be significant to any particular population group. Therefore, no disproportionate impacts to disadvantaged populations in the local area are expected.

4.2 Impacts to the Environment Associated with Alternative 1

4.2.1 Air Resources

4.2.1.1 Climate and Meteorology

Alternative 1 would not involve any potential impacts on the local climate and meteorology more severe than was assessed in the original BFN EIS. The potential for fogging and icing from operation of the cooling towers was based on conservative plume modeling and conservative assumptions for operation of the original six mechanical draft towers and should not increase with extended operation of Units 2 and 3 and operation of six mechanical draft cooling towers.

4.2.1.2 Ambient Air Quality

Alternative 1 involves the operation of Units 2 and 3 and operation of six mechanical draft cooling towers. These six towers will be configured as assessed in the original EIS. (As addressed in the environmental assessment that TVA completed for extended power uprate (EPU) for these units, TVA plans to also rebuild the other cooling tower that burned down, returning the total number of cooling towers at the site to six). The primary sources of non-radiological air pollutants are these cooling towers, three auxiliary steam boilers, and eight diesel-powered auxiliary generators. Four of the diesel generators are linked to Units 1 and 2 and four are linked to Unit 3.

In Volume 1, Section 2.5, of the original EIS, potential emissions and ambient air quality impacts are discussed. However, these earlier analyses only considered emissions from four of the eight diesel generators at the site. The emission estimates from the eight diesel generators should have been twice the emission estimates used in the original EIS. However, this does not change the expected impacts on air resources analyzed in the original EIS, because those impacts are still enveloped by the combination of the auxiliary steam boilers and the diesel generators that was assessed. The auxiliary steam boilers were evaluated for the maximum possible fuel consumption, and the expected actual maximum annual operation was stated to be less than half the level that was assessed.

Actual emissions are much smaller than those estimated in the original EIS, with one exception. There is an inconsistency in the estimated emissions and ambient concentration for carbon monoxide in Section 2.5 in comparison to the magnitudes for the other pollutants calculated there and the relative magnitudes for the actual annual emissions reported during 1996-1999. Apparently, the carbon monoxide emissions and ambient concentrations presented in Section 2.5 are about two orders of magnitude too small. However, the ambient air quality standard is still about five orders of magnitude larger than the revised estimate. Thus, the impact of carbon monoxide emissions is still considered negligible, consistent with the conclusion in Section 2.5, Volume 1, of the original EIS.

Potential impact on ambient air quality from operation of the cooling towers is associated with particulates emitted as part of the drift losses. Conservative estimated emissions of particulates are presented in Section 2.5, Volume 1, of the original EIS. Associated assumptions included closed

mode operation for 7% of the time, helper mode operation for 22% of the time, and a conservative drift loss rate of 0.1%. Actual operating experience under the thermal regulations in effect, the reservoir conditions, and the plant's cooling requirements has shown that closed mode operation of the cooling towers has been unnecessary and is not expected to be done in the future. Cooling tower operation is conducted only in the warmer months of the year. During the last six years, Units 2 and 3 have both been back in service and the greatest amount of time that cooling tower operation has been required has been about 8% of a year. Therefore, for Alternative 1, the potential impacts on ambient air quality from operation of the cooling towers remain within the analyses presented in the original EIS.

4.2.1.3 Existing Air Emission Sources

There have been no material changes in plant emission sources compared to those assessed in the original EIS. Table 4.2.1-1 below contains the emissions calculation results presented in the 1972 EIS, and Table 4.2.1-2 lists other additional emission sources.

Table 4.2.1-1 Emissions Calculation Results Presented in 1972 EIS (tons/yr)

Pollutant	Auxiliary Boilers [1]	Emergency Diesel Generators [2]	Six Mechanical Draft Cooling Towers
Particulates	20.9	0.66	100.0 [3]
Sulfur oxides	205.0	6.4	-
Carbon monoxide	0.1 [4]	0.004 [4]	-
Hydrocarbons	13.1	0.42	-
Nitrogen oxides	274.0	8.6	-

1. The 1972 EIS text states that expectations are that maximum actual operation will consume less than half the maximum possible fuel consumption used for these calculations.
2. The 1972 EIS presented numbers for four generators, but the actual number of these generators installed was eight. Therefore, the magnitudes in this column are double those shown in the 1972 EIS.
3. Operation in helper mode and summer only. This magnitude encompasses all alternatives for the cooling towers.
4. These values appear to be underestimated. The maximum annual CO emissions during the 1996-1999 period were 1.2 tons/yr for the three auxiliary boilers and 6.36 tons/yr for the eight emergency diesel generators.

Table 4.2.1-2 Additional Emission Sources			
Source	**Level of Emissions**	**Purpose**	**Time/Season**
Fuel Storage & Dispensing	Minor (THAP, VOC)	Non-radiological BFN plant fuel supply	Daily
Other Misc. Sources	Minor (PM, THAP, VOC)	Misc. BFN plant operations support	Daily/Intermittent
Construction Equipment	Minor and Intermittent (CO, CO_2, PM, NO_x, SO_x, VOC)	Refurbishment, erection of new facilities, earth moving for cooling tower options	Daily/Intermittent/ Limited Project Length(s)
Increased Work Force Traffic	Minor and Intermittent (CO, CO_2, PM, NO_x, SO_x, VOC)	Work force commuting	Daily/Intermittent

4.2.1.4 Air Quality Impacts

For Alternative 1, emissions of small amounts of fugitive dust may be associated with surface preparation and transport of concrete in mixing trucks for the construction of the proposed dry cask storage facility, and the proposed Modifications Fabrication Building. In addition, minor emissions of combustion exhaust products such as nitrogen oxides, carbon monoxide, carbon dioxide, sulfur oxides, and hydrocarbons can be expected from engines in concrete mixing trucks, other construction-related vehicles, and construction equipment. Some particulates would be emitted from a concrete batch plant in the unlikely event that one should be built instead of trucking in the concrete for the pads of the proposed dry cask storage facility. Trucks would still be used in that event to transport the concrete mixing materials to the batch plant location. Some vapors including hydrocarbons may be emitted from stored fuels and during refueling activities. All of these potential impacts on ambient air quality would be minor, intermittent and transitory during the various periods of construction. Chapter 2 provides details about these construction activities.

4.2.2 Geologic Setting

4.2.2.1 Impacts on Geology

The impacts on geology of continued operation of BFN under any of the options being considered are addressed in section 2.8-2 of the original EIS.

4.2.2.2 Impacts of Construction on Seismicity

Under some circumstances, human activities can change the ambient seismicity of an area. Four types of human activities are known to have the ability to change seismicity levels and patterns: (1) the creation of large reservoirs; (2) large underground explosions (e.g., nuclear tests); (3) the

injection (or withdrawal) of underground fluids; and (4) the excavation of mines (Gough, 1978). These activities can induce earthquakes ranging in size from micro earthquakes to earthquakes with m_b (body wave) magnitudes of six or slightly greater (Yeats, et. al. 1996).

None of these activities will be associated with Alternative 1. Therefore, no impacts are expected.

4.2.2.3 Impacts of Operation on Seismicity

Continued operation of BFN should have no impact on the natural level of seismic activity in the area.

4.2.3 Solid Wastes Management and Past Practices

4.2.3.1 General Plant Trash

Continued operation of BFN through the license extension period should not result in generation of additional volumes of general plant trash above and beyond the levels currently generated annually. Disposal of this material would continue as described in Chapter 3. As mentioned previously, landfill capacity and projections for availability of landfill space in Alabama indicate that sufficient space to accommodate this material from BFN should be available during the duration of operating under renewed licenses.

4.2.3.2 Construction/Demolition Debris

BFN would continue to maintain the license to operate the onsite C/D landfill through the duration of the extended BFN operating licenses. The volume of this type of material disposed should remain with the levels currently experienced (average of 0.04 tons per day) and would not require expansion of the existing landfill space on the site. In the unlikely event that additional materials are generated that exceed the capacity of the onsite landfill, arrangements for disposal in an alternative licensed facility would be made.

4.2.3.3 Low Level Radioactive Waste

Generation rates for this type of material would not be expected to exceed existing rates as a result of extension of the BFN licenses. BFN has provisions in place to either store or ship for processing and disposal the volumes of material generated. Existing storage and disposal facilities have adequate capacity to handle the volumes of material expected to be generated during the extended life of BFN.

4.2.4 Hazardous Wastes Management and Past Practices

As is the case for other types of waste material, annual generation of hazardous waste, universal wastes and used oil would not be expected to increase as a result of the license extensions for BFN. The existing process for managing these wastes within TVA would be expected to continue, and capacities of existing disposal and treatment facilities should be adequate to handle the relatively small volumes of material generated. In addition, ongoing waste reduction efforts would be expected to result in further reduction in the number of waste streams and the volumes of waste generated at BFN. Over the past 15 years, BFN has significantly reduced the generation of hazardous wastes through a combination of source reduction and product substitution. In CY 1987, BFN shipped over 220,000 pounds of hazardous waste for treatment/disposal. In CY 2000, BFN shipped 3,900 pounds for treatment/disposal, and over the last five years the average has been 4,700 pounds per calendar year.

4.2.5 Spent Fuel Management

Environmental consequences of additional spent fuel management resulting from license extension would be minimal. As described in sections 2.2, 2,3, and 3.5, additional spent fuel resulting from license extension would be stored in the spent fuel pool or a dry storage system approved by NRC in accordance with 10 CFR 72. Subsequently, BFN spent fuel would be transferred to the DOE in accordance with the Nuclear Waste Policy Act of 1982 and subsequent amendments. The only component of a dry storage system not transferred to DOE would be the concrete storage overpack provided a modular system is chosen. If used, this component would be disposed as part of the Independent Spent Fuel Storage Installation (ISFSI) decommissioning.

4.2.6 Surface Water Resources

4.2.6.1 Construction Effects

Under continued operation of Units 2 and 3, two additional facilities would be constructed: the dry cast storage pad and the modification fabrication building. Concrete for the pad construction would most likely be trucked in rather than building a batch plant on site. The pad sections would need about 60 concrete truckloads each, or about 360 truck trips for Phases 1 and 2. Phase 3 would involve 180 truck trips. It is possible that the access road around the river side of the plant may first have to be “hardened” where it passes over underground pipes, which could add approximately 100 truck trips. The trucks have wide tires to minimize ground loading. The new modifications fabrication building would be designed as light commercial grade construction. It would be largely prefabricated, involving deliveries of prefabricated items, concrete, and other construction materials. Construction of this new building would involve no more than eight or so truckloads of concrete, six to eight gravel truckloads, and less than four truckloads of various other building materials.

Construction activities could potentially result in adverse water quality impacts. Improper water management or storage and handling of potential contaminants could result in the runoff of pollutants to receiving streams. Erosion, sediment, and accidental spills of fuel or oil could impact streams and threaten aquatic life. However, standard safeguards would be included in the project design, construction, and operation to minimize the risk of adverse impacts. Construction activities would comply with state permit requirements for the control of potential pollutants (e.g., general

construction permit, best management practices (BMP) plan, erosion control plan, and spill prevention plan). BMPs sufficient to minimize the risk of and avoid adverse impacts will be followed for all construction activities. Site grading and soil removal would be minimized. For those areas which have grasses and other plants, clearing operations would be staged so that only land that will be developed promptly is stripped of protective vegetation; this is not applicable to the proposed dry cask storage site, which is predominantly gravel. Mulch or temporary cover would be applied whenever possible to reduce sheet erosion. Permanent vegetation, ground cover, and sodding would be installed as soon as possible after site preparation. Surface water runoff would be managed using sediment basins, silt fences, berms, or other control options. These and other similar precautions are expected to minimize potential construction impacts such that no special mitigation measures would be necessary.

4.2.6.2 Chemical Effluent Effects

Chemical treatment is provided for the Emergency Equipment Cooling Water, Raw Cooling Water, and Residual Heat Removal Service Water systems. The flow rates, chemicals, operation, and discharge concentrations are summarized in Table 4.2.6-1.

Under Alternative 1, existing chemical discharges and impacts would continue (as well as under the No Action Alternative). Discharges are regulated under the Clean Water Act (CWA) by the U.S. Environmental Protection Agency (EPA) and the Alabama Department of Environmental Management (ADEM). The National Pollutant Discharge Elimination System (NPDES) permit issued to the plant specifies the discharge standards and monitoring requirements for each discharge. The permit must be renewed every five years and this process helps ensure that no changes have been made to the facility that would alter aquatic impacts and that no unacceptable adverse impacts are occurring. Compliance with the NPDES process, other provisions of the CWA (e.g., Sections 316 (a) and (b), 401, 404), and other regulatory requirements (e.g., Federal Insecticide, Fungicide, and Rodenticide Act) should continue to ensure that potential chemical effluent effects are kept within acceptable levels.

Table 4.2.6-1 Summary of Projected Usage Rates for Chemical Effluents
EMERGENCY EQUIPMENT COOLING WATER
(EECW) SYSTEM (8,000 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM) (AT DSN001)	DISCHARGE CONC. ACTIVE (PPM) (AT DSN001)
PCL-401	Co-polymer	28.5	2.0	0.6	Continuous	0.01	0.003
CL-50	Poly phosphate	38.5	7.5	2.9	Continuous	0.04	0.016
H-940	NaBr	40	17	6.8	20 hrs/wk	NA	<0.1
NaOCl	NaOCl	10	51	5.1	20 hrs/wk	NA	<0.1
Nalco 1336	Toly-triazole (TTA)	50	2	1	Continuous	0.01	0.005
EVAC	Endothall	53	25	13.3	2/yr (72 hrs each)	<0.075	<0.04

* EECW empties to the intake forebay, mixes with the forebay water and the condenser circulating water (CCW) flow (2300 mgd) and discharges to the Tennessee River through DSN001.

RAW COOLING WATER/RAW SERVICE WATER
HIGH PRESSURE FIRE PROTECTION SYSTEMS*
(50,000 GPM TOTAL AVERAGE FLOW)

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM) (AT DSN001)	DISCHARGE CONC. ACTIVE (PPM) (AT DSN001)
PCL-401	Co-polymer	28.5	2.0	0.6	Continuous	0.07	0.02
CL-50	Poly phosphate	38.5	7.5	2.9	Continuous	0.25	0.10
H-940	NaBr	40	17	6.8	20 hrs/wk	NA	<0.1
NaOCl	NaOCl	10	51	5.1	20 hrs/wk	NA	<0.1
EVAC	Endothall	53	25	13.3	2/yr (72 hrs each)	<0.075	<0.04

*Portions of these systems empty to the intake forebay where they mix with forebay water and CCW before discharge to the Tennessee River through DSN001. The remainder discharges directly into the CCW and is discharged through DSN001.

RHRSW SYSTEM -STAGNANT TREATMENT MODE
(2,000 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM)	DISCHARGE CONC. ACTIVE (PPM)
PCL-401	Co-polymer	28.5	70	20	2/Quarter	70	20
CL-50	Poly phosphate	38.5	80	30	2/Quarter	80	30
H-940	NaBr	40	17	6.8	2/Quarter	NA	<2.0
NaOCl	NaOCl	10	51	5.1	2/Quarter	NA	<2.0
H-300	Gluter-aldehyde	45	200	90	2/Quarter	200	90

* In the stagnant treatment mode, amounts are based on flushes twice per quarter for each of 10 heat exchangers (80 flushes per year). Each flush consists of 20 minutes at < 2000 gpm. Discharge is through DSN 005.

RHRSW SYSTEM -INTERMITTENT TREATMENT MODE
(4,500 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM)	DISCHARGE CONC. ACTIVE (PPM)
PCL-401	Co-polymer	28.5	2.0	0.6	Intermittent	2.0	0.6
CL-50	Poly phosphate	38.5	7.5	2.9	Intermittent	7.5	2.9
H-940	NaBr	40	17	6.8	20 hrs/wk	NA	<2.0
NaOCl	NaOCl	10	51	5.1	20 hrs/wk	NA	<2.0
EVAC	Endothall	53	25	13.3	2/Year 72 hrs each	13.0	7.0

* In the intermittent treatment mode, amounts are based on a total duration of treatment equivalent to 120 days per year at 4500 gpm. Discharge is through DSN 005.

4.2.6.3 Thermal Effects

The assessment of thermal effects assumes that sufficient cooling tower capacity will be provided to routinely maintain the instream thermal limits as given in the current NPDES permit. If extreme hot and dry conditions should make it impossible for the cooling towers to meet the thermal limits, the plant would be de-rated to remain in compliance. Thermal impacts from continued operation of Units 2 and 3 remain within the levels evaluated during the original EIS. No additional thermal impacts to water temperature, reservoir stratification, sediment transport, scouring, dissolved oxygen concentrations, or eutrophication are expected because of continued operation of BFN.

4.2.6.4 Water Use/Water Availability

No additional water use/water availability impacts are expected from continued operation of Units 2 and 3.

4.2.6.5 Microbiological Organisms

No additional microbiological impacts are expected from continued operation of Units 2 and 3.

4.2.7 Groundwater Resources

4.2.7.1 Groundwater Occurrence

There are no environmental consequences to groundwater resources associated with Alternative 1. Effluent discharges from plant systems such as yard drains, station sumps, and sanitary wastewater would not be expected to change significantly under Alternative 1. Considering that the plant wastewater lagoons and sedimentation ponds possess clay and Hypalon liners, respectively, no impacts to groundwater resources are anticipated. The changes in pond/lagoon discharges to the river would remain within the bounding conditions established in the NPDES. These permits are

renewed every five years and this helps to ensure that no changes have been made to the facility that would alter aquatic impacts and that no significant adverse impacts have occurred.

4.2.7.2 Groundwater Use

Currently, groundwater is not used by BFN, and no groundwater use is anticipated for Alternative 1. Therefore, there would be no impacts to groundwater resources under this alternative.

4.2.8 Floodplains and Flood Risk

The floodplains and flood risk assessment involves ensuring that facilities would be sited to provide a reasonable level of protection from flooding. In doing this, the requirements of Executive Order (EO) 11988 (Floodplain Management) are considered. For non-repetitive actions, EO 11988 states that all proposed facilities should be located outside the limits of the 100-year floodplain unless alternatives are evaluated which would either identify a better option or support and document a determination of "no practicable alternative" to siting within the floodplain. If this determination can be made, adverse floodplain impacts would be minimized during design of the project. For a "critical action," facilities must be protected to the 500-year flood elevation. A "critical action" is considered to be any activity for which even a slight chance of flooding would be too great. One of the criteria used in determining if an activity is a critical action is whether essential and irreplaceable records, utilities and/or emergency services would be lost or become inoperable if flooded. Due to the nature of this facility, it is necessary to evaluate the flood risk associated with the Probable Maximum Flood (PMF) elevations for all alternatives. The PMF (see glossary) is more severe than the 500-year flood and is primarily used to conservatively evaluate dams and nuclear facilities.

Common to all of the alternatives, a dry cask storage facility, and Modifications Fabrication Building would be constructed. All existing and proposed facilities are, or would be, located outside the limits of the 100- and 500-year floodplains. Therefore, the project would be consistent with EO 11988.

All safety-related structures are protected against all flood conditions and would not be endangered by the Probable Maximum Flood (Reference: Individual Plant Examination of External Events (IPEEE). This includes potential flooding from all sources. For the small stream to the northwest of the plant site, the channel is designed with capacity sufficient to carry the PMF without flooding the plant. For the switchyard drainage channel, the switchyard is higher than the maximum water surface, preventing flow from entering the plant. In the vicinity of the radioactive waste, reactor, and diesel generator buildings, the flood elevations from the surface drainage would not exceed elevation 565.0, which is the plant grade. For the Cooling Tower System, the channels have sufficient capacity to pass the PMF runoff and condenser water without flooding the plant for any mode of plant operation. (Reference: FSAR)

The proposed dry cask storage facility would be located on ground above the PMF elevation based on site topography dated 1989. The proposed Modifications Fabrication Building would be located on ground below the PMF elevation, but the site would be raised or the building would be flood proofed consistent with other facilities of this nature on the plant site. Based on the same site topography, the proposed mechanical draft cooling tower would be located above elevation 570.

All equipment within the cooling tower that could be damaged by flood waters would be located above or flood proofed to the PMF elevation, as required.

During the license renewal period (up to year 2036), the 100- and 500-year flood, and PMF elevations for the Tennessee River would not be expected to change as stated in Section 3.8. Although the 100- and 500-year flood flows for the small stream to the northwest of the plant site and the site drainage system could increase by as much as 2.5 times what they are now as a result of total development of the drainage basin, these flows would not adversely impact existing or proposed development because they would be significantly lower than the PMF flows, and these channels can handle PMF flows without flooding the plant.

4.2.9 Terrestrial Ecology

4.2.9.1 Vegetation

No uncommon plant communities or otherwise sensitive vegetation exists on the lands to be affected under Alternative 1. With respect to vegetation, any direct, indirect or cumulative impacts to the terrestrial ecology of the region are expected to be insignificant as a result of this Alternative.

4.2.9.2 Wildlife

Under Alternative 1, the operating licenses for Units 2 and 3 at BFN would be renewed at an EPU of 120% of the original operating power levels. Because no rare or uncommon communities of animals exist on the site, the construction and operation activities associated with Alternative 1 would not result in adverse impacts to any uncommon wildlife or their habitats.

4.2.9.3 Introduced Species

Because no intact native plant communities occur on lands to be disturbed by the proposed actions, and because introduced plant species are already present in these areas, any direct, indirect, or cumulative impacts due to the establishment or spread of introduced plant species are anticipated to be insignificant as a result of the actions associated with Alternative 1.

Two introduced species, the European house sparrow and the European starling, are known to exist on the project site. These species are quite common in the project area. Alternative 1 would not result in increased population levels of introduced animal species.

4.2.9.4 Managed Areas and Ecologically Significant Sites

Because the proposed actions would occur within the lands presently utilized for the operation and maintenance of the BFN no impacts to Managed Areas or Ecologically Sensitive Sites are anticipated.

4.2.9.5 Refurbishment Impacts

Alternative 1 involves only Units 2 and 3, which are currently operating successfully without the need for significant equipment replacements. License renewal of BFN Units 2 and 3 for a 20-year period beyond the current operating license expiration dates is not expected to require any replacement of equipment beyond possibly some electrical cables which undergo normal aging at ambient environment conditions. Nor is it expected that any major refurbishment of equipment will be necessary outside of what is already periodically scheduled for normal wear.

4.2.10 Aquatic Ecology

4.2.10.1 Fish

In 1985, BFN initiated a three-phase biological monitoring program to evaluate the effects of the thermal discharge on total standing stocks and selected fish species in Wheeler Reservoir, and a sampling program to monitor total standing stocks of fish in Wheeler Reservoir. The results of this monitoring program were reported to the State of Alabama in 1998 (Baxter and Buchanan, 1998), and additional analysis of the data was provided as part of the NPDES Permit Renewal application submitted in September 1999 (TVA, 1999). Both the final report and the additional analyses concluded that the operation of BFN under the current permit limitations has not had a significant impact on the aquatic community of Wheeler Reservoir or on the specific aquatic species studied. In addition to the BFN specific studies, monitoring initiated in Wheeler Reservoir in 1990 as part of TVA's Vital Signs Monitoring Program provided an additional measure of the quality of the ecological health of the aquatic community in the vicinity of BFN (Dycus and Baker, 2000). Results since 1991 indicate no adverse impacts as a result of BFN operation.

Two species of special interest, sauger and yellow perch, were the focus of BFN thermal variance studies because both are considered coolwater species and, theoretically, more susceptible to elevated water temperature. Based on results of studies conducted from 1985 through 1992, operation of BFN had no significant adverse impact on the reproductive success of either species nor the movement of sauger past BFN. However, studies did indicate sauger spawning success was adversely impacted by overfishing in Wheeler Reservoir and drought conditions (e.g., low flows and decreased turbidity) in the Tennessee Valley during 1985 through 1988 (Maceina, et al. 1998, and Baxter and Buchanan, 1998).

No changes to the thermal discharge limitations are necessary to accommodate the EPU under Alternative 1 with extended operating periods. As noted earlier, use of the cooling towers would increase from approximately 1.8% of the time for current operations to approximately 2.3% of the

time with EPU. This increase would not result in any impacts to the aquatic community of Wheeler Reservoir. TVA plans to continue an ongoing monitoring program for at least the term of the current permit cycle (five years) to confirm that operation at the uprated power levels does not have an adverse impact on the aquatic community in the vicinity of BFN.

The thermal variance permitted under BFN's current NPDES permit of 90°F is well within the thermal tolerance levels of most reservoir fish species in Wheeler Reservoir. Annual ambient maximum temperatures rarely exceed 89°F in the main channel but often exceed this temperature in the shallow areas in embayments and coves. Mundahl (1990) reported most fishes upper temperature tolerances well exceed temperatures found in their natural habitat. As ambient temperatures rise, fish are able to increase their tolerance of high temperatures. High temperatures increase the fishes metabolic rate and induces frantic behavior which aids in the fishes ability to swim out of the thermally affected mixing zone. Therefore, if any fish happen to drift or swim into the mixing zone they have a natural ability to escape if conditions are not favorable. Larval fish do not have the ability to swim out of the mixing zone, but will drift through with minimal exposure to the elevated temperatures. Juvenile fishes (excluding sauger) possess the ability to tolerate warmer temperatures than adults (Brungs and Bernard, 1977).

The area thermally affected below BFN does not exceed upper lethal limits of sunfish (bluegill, black and white crappie), bass (largemouth, smallmouth and spotted bass), channel catfish, sauger, or gizzard shad. Their upper thermal tolerances reported by Brungs and Bernard are listed in Table 4.2.10-1. Only yellow perch and juvenile sauger could be affected below BFN's zone of thermal influence. Yellow perch, with a thermal tolerance of 32°C (89.6°F), could be affected by BFN's thermal effluent during annual extreme water temperatures. During June through September, ambient water temperatures would also exceed the upper lethal thermal limit for juvenile sauger of 30°C (86°F) Table 4.2.10-1. Baxter and Buchanan (1998) reported that sauger disperse throughout the reservoir and are not found in the vicinity of BFN during extreme ambient water temperatures.

It is unlikely that sublethal effects would occur from the proposed action. Temperatures below BFN would be within compliance of the permitted thermal variance and the increased discharge would be negligible compared to the releases from Guntersville Dam. Existing predator-prey relationships and other fish behavior patterns should not be affected by the proposed alternatives. Baxter and Buchanan (1998) reported that sauger are not attracted to the BFN thermal plume during seasonal extreme ambient water temperatures. Sauger migrated upstream past BFN during the mid-winter months to spawn in the Guntersville Tailwater and dispersed throughout the reservoir during the mid-summer months. Lowery and Poppe (1992) reported that reproductive success of sauger in Wheeler Reservoir, regardless of their distribution patterns, is not adversely affected by the thermally influenced zone of BFN discharge. All sauger examined during this study appeared to be in excellent physical condition and revealed normal gonadal development. This study also demonstrated that sauger were not concentrated near the BFN thermal discharge. Results of prior operational monitoring at BFN involving egg, larvae and juvenile fishes, do not suggest effects to these life stages from the proposed alternatives.

Table 4.2.10-1 Upper Thermal Temperature Tolerances of Juvenile and Adult Fish Found in Wheeler Reservoir

SPECIES	UPPER LIMIT JUVENILE	LOWER LIMIT JUVENILE	UPPER LIMIT ADULT	LOWER LIMIT ADULT
Black crappie	27-37°C (80.6 – 98.6°F)	3 – 15°C (37.4 – 59°F)	31 – 35°C (87.8 – 95°F)	3 – 11°C (37.4 – 51.8°F)
Bluegill	27-37°C (80.6 – 98.6°F)	3 – 15°C (37.4 – 59°F)	31 – 35°C (87.8 – 95°F)	3 – 11°C (37.4 – 51.8°F)
Common carp	31 – 41°C (87.8 – 105.8°F)			
Channel catfish	30 – 38°C (86 – 100.4°F)			0 – 6°C (32 – 42.8°F)
Emerald shiner	23 – 31°C (73.4 – 87.8°F)	2 – 5°C (35.6 – 41°F)		
Gizzard shad	34 – 36.5°C (Underyearling) (93.2 – 98.2°F)	10.8 – 20°C (Underyearling) (51.44 – 68°F)		
Golden shiner			29.5 – 34.5°C (85.1 – 94.1°F)	1.5 – 11.2°C (34.7 – 52.16°F)
Hybrid striped x white bass		39.2°C (102.5°F)		
Largemouth bass	33 – 36°C (91.4 – 96.8°F)	5 – 12°C (41 – 53.6°F)		
Sauger	27 – 30°C (80.6 – 86.0°F)			
Smallmouth bass	35°C (95°F)	2 – 10°C (35.6 – 50°F)		
Striped bass	35°C (95°F)		38°C (82.4°F)	
Threadfin shad		9°C (48.2°F)		
Walleye	29 – 31°C (84.2 – 87.8°F)	31°C (87.8°F)		
White crappie	33°C (91.4°F)			
White sucker	26 – 31°C (78.8 – 87.8°F)	2 – 6°C (35.6 – 42.8°F)		
Yellow perch		9°C (48.2°F)	21 – 32°C (69.8 – 89.6°F)	

4.2.10.2 Benthic Organisms

As identified in the EPU EA, an increase of approximately 2.3°F in the temperature of the circulating water would occur with the uprate of Units 2 and 3. This increase in discharge temperature would result in increased cooling tower usage during summer periods. However, in order to maintain compliance with the discharge limitations, discharge temperature at the diffusers

would not change appreciably (Brellenthin, 2001). Water intake velocity would not change from that which was evaluated during previous studies when all three units were in operation at BFN. Therefore, no additional impacts to benthic macroinvertebrate communities due to discharge temperatures or entrainment are expected in the vicinity of BFN as a result of extending the operating licenses for Units 2 and 3.

4.2.10.3 Introduced Species

Asiatic clam and zebra mussel populations that exist within Wheeler Reservoir would not be prone to exacerbation or extirpation due to BFN's thermal discharge. Thermal discharge limits permitted by ADEM would not exceed thermal thresholds of both organisms. Asiatic clams cannot survive extreme ambient water temperatures less than 36°F (2.2°C) and greater than 95°F (35°C). Thermal tolerance of Zebra mussels is 32°F to 98.6°F (Nalepa and Schloesser 1993). Potential biofouling by zebra mussels would actually be reduced by thermal addition as mortality of 60% was reported by Nalepa and Schloesser, (1993) at 89.6°F. BFN treats their raw water intake biannually with molluscide to control biofouling by Asiatic clams and zebra mussels. In addition, biweekly raw water samples are analyzed during April through October for zebra mussel veligers as an early warning for potential biofouling.

Grass carp abundance is not expected to be influenced by BFN operations. Introduced grass carp are normally sterile, so that their numbers can be maintained at desired levels by adjusting any future stocking rates.

Nuisance aquatic plants such as Eurasian water-milfoil (*Myriophyllum spicatum*) and hydrilla (*Hydrilla verticillata*) are established and abundant in several TVA reservoirs including some portions of Wheeler Reservoir. Because of the current abundance of Eurasian water-milfoil on Wheeler Reservoir, the potential of hydrilla to colonize large portions of Wheeler Reservoir in the near future, and published literature on these two species, they were selected to evaluate the potential impacts of thermal enrichment on aquatic plants.

Eurasian watermilfoil and hydrilla grow over a broad temperature range with maximal rates of photosynthesis or biomass accumulation reported in the 32° to 35°C range (Stanley and Naylor, 1972; Van, Haller, and Garrard, 1978; Barko and Smart, 1981; Smith and Barko, 1990). Increases in water temperatures during the growing season (late April through September) theoretically would result in the advancement of phenological events (e.g., onset of growth, flowering, fragmentation, and senescence), an increase in shoot length, and an increase in maximum plant biomass. An increase in maximum biomass of Eurasian water-milfoil might not occur because of sloughing of shoot fragments at the higher temperatures of its growth range (Barko and Smart, 1981). Small changes in temperature within the range (i.e., 0.5°F or less) predicted by the modeling studies for alternative 2 likely will not result in measurable reservoir changes in plant biomass, shoot length, or phenological events. Any effects of thermal enrichment from operation of BFN on aquatic plant populations likely would be insignificant compared to the impacts associated with annual variations in rainfall, reservoir flow, and turbidity (phytoplankton, suspended solids).

In addition, in 2001 most of the estimated 3,600 acres of submersed aquatic plants (including Eurasian water-milfoil, hydrilla, spiny-leaf naiad, coon-tail, southern naiad) in Wheeler Reservoir grew in the broad, shallow over bank habitat (TRM 296 upstream to 305) upstream of Brown's Ferry Nuclear Plant in areas that would not be impacted by thermal enrichment. During the peak

year of aquatic plant coverage on Wheeler Reservoir in 1988 when aquatic plants colonized about 9,840 acres (Burns, Bates, and Webb, 1989), only about five percent of submersed aquatic plants were in areas downstream of Brown's Ferry that potentially would have been impacted by thermal enrichment.

4.2.10.4 Entrainment and Impingement of Fish and Shellfish, Heat Shock

For the continued operation of Units 2 and 3, the volume of water withdrawn from the reservoir remains within the levels evaluated during previous studies of intake effects on fish for three-unit operation at BFN; therefore, as found in the original EIS and in subsequent operational monitoring, entrainment and impingement levels are expected to remain at insignificant levels under Alternative 1. Any increased discharge temperatures would be within the NPDES permit limits; thus, there should be no significant thermal impacts.

4.2.10.5 Microbiological Organisms

Data collected during the 1990-1991 Browns Ferry Thermal Variance monitoring study and the TVA Vital Signs monitoring program did not indicate that the operation of BFN had influenced the phytoplankton community in Wheeler Reservoir (Lowery and Poppe, 1992). Under Alternative 1, no changes to thermal discharge limitations are necessary to accommodate extension of the units' operating licenses. In addition, intake velocity and volume would remain within previously evaluated levels. Therefore, no additional impacts to the plankton communities are anticipated.

4.2.11 Threatened and Endangered Species

4.2.11.1 Animal

Adoption of Alternative 1 is expected to have no effect on federal or state listed terrestrial animal species. Little or no habitat suitable for listed species exists on the project area, and no listed species are known to be on the site.

4.2.11.2 Aquatic

Effects from Alternative 1 are not expected to impact threatened or endangered aquatic species within the area affected by construction or operational changes at BFN as proposed herein. Therefore, these proposed changes and additions to BFN would have no effect on the species listed in Section 3.11.2. No threatened or endangered aquatic animals are presently known to exist within the area potentially affected by Alternative 1; therefore, no impacts to these species are expected to result from adoption of this alternative.

4.2.11.3 Plants

Because no occurrences of rare (federal- or state-listed) plant species are known on or immediately adjacent to BFN, no effects on rare plant species are expected as a result of Alternative 1.

4.2.12 Wetlands

There would be no impacts to wetlands as the result of continuing operation of Units 2 and 3 at BFN for an additional 20 years past the expiration dates of the current operating licenses. There would be no major construction activities scheduled that would impact or affect wetlands in the plant area and construction of the proposed dry cask storage and modification fabrication facilities would not impact any wetlands.

4.2.13 Socioeconomic Conditions

4.2.13.1 Demography

As shown in Section 3.13.1, the population of Limestone County is expected to be about 80,000 at the time of license expiration, with a labor market area population of close to 750,000. Under Alternative 1, the number of construction workers is small enough (less than 100 at peak) that there would be no noticeable impact to population, and any impact would be of very short duration.

4.2.13.2 Economic Conditions

Under Alternative 1, operation of Units 2 and 3 would continue without significant change from that in effect at the end of the current licensing period. Relicensing would result in no changes in operating employment levels at the plant, in payroll, or on other plant-related expenditures. However, a new Modifications Fabrication Building and a dry cask storage facility would be constructed. These construction activities, which are discussed in Sections 2.3.2 and 2.3.3, would add a small number of workers for a brief period of time, providing a positive but very small impact to the local economy. Since operations employment would continue at about the current level, there would be no impact to the local economy from operations under this alternative, as compared to current conditions.

4.2.13.3 Community Services and Housing

Under Alternative 1, there would be no noticeable impact to community services or to housing, due to the small size of the employment impacts and to the short duration of such impacts.

4.2.13.4 Local Government Revenues

Under Alternative 1, there would be no important impact to TVA's in lieu of tax payments paid to the state or received by Limestone County. The new facilities would add a relatively small amount to the book value of the property, and therefore would slightly increase the amounts, but the difference would not be significant.

4.2.13.5 Environmental Justice

As discussed in Section 3.13.4, the disadvantaged population in the immediate area near the site is relatively small. Any negative impacts to persons living near the site would be small and would tend to be dispersed through the area. Therefore, no disproportionate impacts to disadvantaged populations are expected.

4.2.14 Transportation

4.2.14.1 Highways and Roads

In years 2014 and 2016, Units 2 and 3 operating licenses would expire. Alternative 1 involves operating these relicensed units at EPU for an additional 20 years. There would be a minor increase in construction traffic during erection of a sixth mechanical draft cooling tower, the dry cask storage facility, and the modification fabrication facility. This minor traffic increase due to construction workforce and construction deliveries and disposals would be temporary and have no significant traffic impact. Operational traffic generated by the plant would not be affected under this alternative. Current traffic generated by BFN would remain at the existing level. However, traffic growth is expected to occur over this period of time. Assuming general traffic growth occurs along with projected population growth, Average Daily Traffic (ADT) on U.S. Highway 72 will increase to approximately 16,500 vehicles per day (vpd) and ADT on U.S. Highway 31 will increase to approximately 20,000 vpd. The ADT on secondary county roads which provide access to the plant would increase to approximately 2,000 vpd.

Traffic growth will continue during the license period for 20 years following to years 2034 and 2036. During this time, traffic volumes would increase, assuming 15% growth rate per decade, to approximately 21,900 vpd on U.S. Highway 72 and 26,500 vpd on U.S. Highway 31. The county roads would increase to approximately 2,600 vpd.

Under this alternative, there would be no additional impact to the local transportation network. The percentage of vehicles on the road would remain at the current level and decrease as background traffic grows.

4.2.14.2 Railroads

Alternative 1 would result in no impacts to the railway system.

4.2.14.3 River Transport

Alternative 1 would result in no impacts to river transportation.

4.2.14.4 Pipelines

Alternative 1 would result in no impacts to pipelines.

4.2.14.5 Transmission Lines

TVA completed a transmission system study in June 2000 for BFN that assessed the ability of the offsite power system to meet NRC requirements for electric power systems. (These requirements are delineated in 10 CFR 50 Appendix A, General Design Criterion 17.) This study included a five-year look-ahead to the summer 2005 peak (net TVA peak system load of 33,775 megawatts), and assumed BFN Units 2 and 3 were generating at full power with a per-unit power uprate to 1,155 MW gross. The study examined both load flow and transient stability in response to a number of postulated system alignments, contingencies and design basis accident conditions. It was concluded that all the cases studied meet the BFN minimum voltage requirements and satisfy all General Design Criterion 17 requirements relative to safe shutdown of Units 2 and 3 in the event of a design basis accident. Therefore, no additional transmission facilities would be required.

TVA has also recently completed an interim study, excluding transient stability, fault analyses, and off-site power studies of line loading in the vicinity of BFN (with EPU) for the year 2007. This study assumed the units were uprated to 1,280 MW. No transmission lines were identified as exceeding their load limits, although several of them had small margins. TVA is continuing to assess the capabilities of its transmission system, including in the vicinity of BFN.

4.2.15 Soils and Land Uses

Impacts to soils or land use on the site as a result of activities associated with license renewal for operation of Units 2 and 3 at EPU would be insignificant. The construction of the dry cask storage facility and modifications fabrication building would occur on sites previously disturbed or housing other facilities.

4.2.16 Visual Resources

The project area, located within the BFN site, is an industrial setting within the rural countryside. Scenic integrity is moderate, with many transmission lines and associated steel tower structures traversing the countryside and into the switchyard in the plant area. The terrain is gently rolling throughout the plant site and terminates on the west side overlooking the scenic Wheeler Reservoir. Together, the natural and cultural elements provide variety and some scenic attractiveness, which forms a mosaic of rural and industrial setting. This section examines the visual and aesthetic consequences of license renewal of BFN, including construction of facilities common to all alternatives. Visual consequences are examined in terms of visual changes between the existing landscape and proposed actions, sensitivity of viewing points available to the general public, their viewing distances, and visibility of proposed changes. In this assessment, scenic attractiveness is described using the following adjectives: variety, unity, coherence, vividness, harmony, tranquility, and uniqueness. Scenic integrity indicates the degree of intactness or wholeness of the landscape character. These measures help identify changes in visual character based on commonly held perceptions of landscape beauty, and the aesthetic sense of place. The foreground, middleground, and background viewing distances were previously described in Section 3.1.16.

There are common proposed activities for all Action Alternatives 1, 2A, 2B, 2C, and 2D. These include the construction of a dry cask storage facility and a new Modifications Fabrication Building. The proposed facilities would have minor visual impacts on the industrial character of the plant site. However, adding the proposed facilities would increase the number of adversely-contrasting elements seen inside the development from the rural countryside. These incremental changes may not be individually significant, but together with other facilities, they would add to a continuous growth of structures seen in the landscape and a cumulative reduction of visual resources as seen from the countryside.

County Road 25 provides the main access route to both the plant entrances and to homes north of the site. Most views to the site will be from this area and from the homes across Wheelers Lake at Mallard Creek and Mallard Creek public use area. Increasing the number of vertical objects in the landscape would add to the visually discordant contrast between rural countryside and the industrial character of the plant site. The heights and related dimensions of the tallest existing structures in the plant site are shown in Table 4.2.16-1.

Table 4.2.16-1 Summary of Height/Size Information	
Plant Feature (Existing)	**Feature size same for each alternative**
Transmission Towers at Switchyard, Northeast of Plant Site, and crossing Wheeler Reservoir	157 feet height at switchyard; 150 feet entering plant from northeast side; 247 feet mounted on river islands crossing Wheeler reservoir
Plant Reactor/Turbine Building	Roof heights vary from 111 feet-4 inches to 155 feet
Existing Earthen Berm	70 feet, height; 3,000 feet, length
Mechanical Draft Towers (4 existing)	65 feet, height
Off Gas Stack	Nominally 600 feet, height

IMPACTS OF CONSTRUCTION

Operating relicensed Units 2 and 3 at EPU under Alternative 1 will involve minor construction site preparation of a few areas at BFN. Visible construction would include minor grading to construct building pads, new laydown areas for construction equipment and materials, temporary facilities, and trenching for new utilities. As the construction reached completion, it would be seen in the foreground by passing motorists. Scenic integrity in the area would be somewhat low during the construction process. However, the visual discord as a result of construction would be temporary, and would last until site cleanup and reclamation of disturbed areas are complete.

IMPACTS OF OPERATION

The impacts of operation under Alternative 1, while operating Units 2 and 3 at EPU, could include a small increase in the number of plumes, and potentially the duration for which they will be seen, rising from the mechanical draft cooling towers. These plumes could be observed most frequently by area residents and, depending upon atmospheric conditions, by residents much farther away from the plant site.

4.2.17 Recreation

Since the proposed action would be contained within the existing plant site, impacts for Alternative 1 would be insignificant. This includes the construction of the proposed dry cask storage and the modification fabrication facilities. No recreation facilities, resources or activities would be significantly affected.

Cumulative impacts for Alternative 1 would be insignificant. This includes the construction of the proposed dry cask storage and the modification fabrication facilities.

4.2.18 Cultural Resources

4.2.18.1 Archaeological Resources

Alternative 1 proposes to relicense Units 2 and 3 at EPU. This action would have no affect on historic properties because activities will take place within existing facilities. The construction of the proposed dry cask storage facility and Modifications Fabrication Building would not have any direct effects on historic properties. However, historic properties (one prehistoric archaeological site and one historic cemetery) have been identified at BFN. Placement of construction spoil on either of these historic properties would be an adverse effect. These two historic properties encompass small portions of disposal areas 1 and 2. By excluding these two historic properties from potential disposal areas, placement of spoil would not result in an adverse effect to historic properties. The boundaries of these two sites have been adequately demarcated on site-controlled drawings to prevent inadvertent disturbance of these sites. The Cox Cemetery, located in Area 2, would be avoided by all activities.

4.2.18.2 Historical Structures

No historic structures were identified within the visual area of potential effect. Therefore, there would be no effect on historic structures.

4.2.19 Environmental Noise

There would be no environmental noise effects from Alternative 1, the relicensing of Units 2 and 3, that are different from existing noise conditions described in Chapter 3.

Construction of the dry cask storage area and the modification fabrication building has the potential for short-term, insignificant environmental noise effects. Neither construction is a major project. The dry cast storage area consists of a light-commercial building, concrete pads, and fencing; and the modifications fabrication building is a large, light-commercial, prefabricated steel structure. Sections 2.3.2 and 2.3.3 give more details about these facilities.

Earth moving for site preparation and concrete deliveries are the two major noise sources from the construction of the dry cask storage area. The pads for Phase 1 and 2 would probably take a few months to complete, and this work would be done during normal business hours. This area is more than 4,200 feet from the closest residence and there is a small, wooded hill in between. Although concrete truck noise will be noticeable along the delivery route for a few weeks, the overall potential environmental noise effect is insignificant for this construction.

Construction of the modifications fabrication building will take a few weeks and will require about 25 to 30 truck deliveries. The proposed site of this building is tucked-in behind the main plant, and

it needs minimal site preparation. Erection of this building has no potential for environmental noise effects.

There will be no operational noise effects from Alternative 1, the relicensing of Units 2 and 3, that are different from existing noise conditions described in Chapter 3.

4.2.20 Public and Occupational Safety & Health (Non-Radiological)

The site Safety and Health Program described in Section 3.20 would not be impacted or affected by license renewal and continuing to operate Units 2 and 3 for 20 years after the current operating licenses expire in 2014 and 2016, respectively.

4.2.21 Radiological Impacts

4.2.21.1 Normal Operation

4.2.21.1.1 Occupational

Occupational radiation dose refers to radiation dose received by individuals as a course of their employment. Parameters considered for the analysis included: baseline occupational dose, projected dose increments, and an estimated cancer risk increase for the projected dose increments. The scope for Alternative 1 (see section 2.2.1) addresses units 2 and 3 EPU with an extended operating license (20 years). EPU has been addressed by a specific environmental assessment (EA). A conservative basis assumption of that EA is that the annual collective dose would increase in direct proportion to the power level. Table 4.3.21.1.B summarizes the current facility dose parameter and forecasts the EPU basis dose assumption. Alternative 1 occupational radiation dose increases are less than those analyzed for Alternative 2 (see section 4.3.21.1). The occupational radiation dose increase in cancer risk associated with the EPU is addressed in Table 4.3.21.1.D. NUREG-1437 Vol. 1 Section 4.6.3.2 postulates that the radiation dose attributable to license extension might result in a five percent increase in the calculated cancer incidence to workers, but there may be no increase. The estimated cancer risks for the proposed Alternative 1 activities are bounded by the NUREG-1437 Vol. 1 Section 4.6.3.2 assumptions.

4.2.21.1.2 Public

Current radioactive effluent releases and associated exposures from BFN operations are not expected to change in adverse ways during a 20-year renewal period. There are no significant changes to the radiological effluent releases anticipated as a result of the proposed action(s) and, therefore, the impacts to the environment or the general public are not expected to change.

4.2.21.2 Facility (Design Basis) Accidents

The design basis accidents addressed in Chapter 14 of the BFN UFSAR are independent of the age of the plant. Therefore, extension of the operating lifetime of the plant from 40 to 60 years would not change the analysis of these accidents.

4.2.21.3 Severe Accident Mitigation Alternatives

A "severe" accident is a potential accident that is considered too unlikely to warrant design controls. A Severe Accident Mitigation Alternative (SAMA) analysis assesses alternative ways of mitigating the impact of such accidents. TVA has conducted a SAMA analysis for BFN. The complete SAMA analysis may be found in Appendix A of this SEIS. The SAMA analysis addresses both Alternatives 1 and 2.

The purpose of the present analysis is to provide a consistent framework to facilitate the consideration of the potential benefit of Severe Accident Mitigation Alternatives (SAMAs) for the Browns Ferry Nuclear Plant within the context of extending the current licensing periods of Units 1, 2 and 3.

The framework developed is in the form of a cost/benefit analysis. A distinguishing feature of this cost/benefit analysis is a series of screening steps. If the projected benefit associated with a specific SAMA is found to be greater than a specific screening criterion, then the SAMA is retained for further consideration in subsequent, more realistic screening steps. SAMAs that survive all screening steps are retained for future engineering evaluation.

This assessment considers all three Browns Ferry units, each operating at 120% of their original licensed power level. Ideally, this assessment would take advantage of unit-specific Probabilistic Safety Assessments (PSAs) for each unit that reflects operation of all three units at 120% of their original licensed power level. That information is not currently available. Unit-specific PSAs are available for Units 2 and 3 that represent operation at 105% of their original licensed power level. Because of the progressive, screening nature of the SAMA evaluation, it was possible to use the available PSA information, along with engineering knowledge of the plant to form a basis for the three-unit cost/benefit analysis.

First, a baseline profile of the costs associated with severe accidents potentially arising from the current design and operation of Units 2 and 3 was formulated. Next, potential SAMAs were identified, and their impact on calculated core damage frequency and associated severe accident costs were assessed. SAMAs may consider changes to hardware, procedures, or both. Finally, SAMAs that passed cost/benefit criteria (i.e., if their estimated implementation costs are less than the anticipated savings) were retained for further consideration.

The identification of potential SAMAs for consideration started with reviewing those SAMAs that had been identified in other industry efforts, including other SAMA submittals to the NRC. In addition, potential design and/or procedural changes were identified following the review of the BFN Units 2 and 3 PSAs. These plant-specific potential alternatives were added to the generic SAMAs to complete the list of SAMAs for consideration.

The current PSAs for Units 2 and 3 were used in this evaluation. These PSAs, however, required some modification for use in evaluating the SAMAs. The current PSAs can be characterized as "level 1+" risk studies; that is, they trace the plant and operator response from a set of initiating

events to one of three scenario end states: success (no core damage), core damage with "large early release," or core damage without "large early release." This formulation is consistent with current NRC requirements and guidance for PSAs supporting risk-informed applications. For SAMA evaluations, however, additional information from the PSAs was required.

In the evaluation of SAMAs, it is required that off-site consequences (economic as well as radiation dose to the public) be estimated. A PSA that fully meets these requirements is often referred to as a "level 3" PSA. This necessitated the extension of the current models to address off-site impacts of core damage sequences. Normally, this would require the development of a model that considers the phenomena associated with the in-plant transport of post-core damage fission products (a so called "level 2" PSA). To meet this requirement, the current PSAs were modified to map core damage sequences to the "level 2" end states that were identified for the 1992 BFN IPE. Existing analyses that were done in support of the IPE allow for the characterization of the amount and timing of fission product release from the plant for core damage sequences. Off-site consequence analyses were then evaluated using the MACCS2 computer code. This approach satisfies the "level 3" requirement for the SAMA evaluation in an efficient manner.

Evaluation of the off-site impacts of the as-is design of Units 2 and 3 allowed the determination of baseline severe accident costs. The cost evaluation included the consideration of replacement power costs.

The list of SAMAs was screened to determine those potential changes that required more detailed evaluation. Over 130 potential SAMAs were identified. Those SAMAs, for example, that did not apply to the BFN design, were already implemented at BFN, or whose cost of implementation greatly exceeded the costs associated with the as-is design severe accident costs were systematically eliminated from further consideration.

The impacts on both the Unit 2 and the Unit 3 PSAs were determined for those potential SAMAs that passed the initial screening. From the original list of SAMAs, 28 "phase II" SAMAs were identified. Often it was appropriate to identify a bounding impact on the PSA that would conservatively (i.e., overestimate) the potential benefit of the SAMA. For several of the SAMAs, information from the PSA (e.g., system importance measures) were used to estimate their potential benefit. For the majority of the phase II SAMAs, however, new PSA models that incorporate individual SAMAs were developed and quantified. The cost associated with severe accidents was then evaluated for each unit assuming that the specific SAMA was fully implemented. The difference between the baseline off-site costs and the off-site costs with the SAMA implemented was determined for two different future discount rates (3% and 7%). This difference is presented as an "avoided cost."

Uncertainties in the PSA calculations were considered by identifying those SAMAs that would not be screened during the cost/benefit comparison if the benefit were to increase by a factor of three. The factor of three approximates the ratio of the 95th percentile of the core damage frequency to the mean.

Effects on avoided costs due to restart of Unit 1 were also addressed. The operation of Unit 1 would increase the calculated core damage frequency of Units 2 and 3. The units share certain equipment (e.g., diesel generators, Residual Heat Removal Service Water and Emergency Equipment Cooling Water) resulting, in selected scenarios, in decreased availability of equipment to a particular unit. Success criteria for selected systems are also impacted. Insights from the Multiple Unit PSA performed in 1995 were used to bound the effects of three-unit operation.

Implementation costs for each SAMA were estimated. The cost/benefit evaluation was based on comparing the implementation costs with the two discounted cost savings for individual SAMAs. The results of this evaluation indicated that one SAMA listed below is potentially cost beneficial. This SAMA is:

- Increase/improve DC bus shedding. This would improve DC power reliability and thus increase the time available to recover power during a station blackout event.

In addition, uncertainties in the PSA calculations were considered by identifying those SAMAs that would not be screened during the cost/benefit comparison if the benefit were to increase by a factor of three. The factor of three approximates the ration of the 95th percentile of the core damage frequency to the mean. Consideration of uncertainty alone did not result in any additional SAMAs surviving the screening process.

When a bounding analysis was used to estimate the potential impact of three-unit operation at Browns Ferry, one additional SAMA was retained:

- Provide additional DC battery capacity.

When bounding analyses were performed to estimate the impact of both uncertainty and three-unit operation on the screening process, two additional SAMAs survive the screening process:

- Use of the fire protection system as a backup source for diesel cooling.
- Develop a procedure to trip unneeded RHR/CS pumps on loss of ventilation.

It should be noted that additional engineering analyses are warranted to further consider the above SAMAs. The analysis documented in Appendix A is bounding in nature.

4.2.22 Decommissioning Impacts

As explained in Chapter 2, under this Alternative (1), decommissioning would probably not be initiated for Unit 1 while operation is extended for Units 2 and 3. Instead, Unit 1 would likely remain in its current non-operable status until any renewed licenses expire or a subsequent decision is made to recover and restart the unit.

License renewal of BFN Units 2 and 3 would provide an additional 20-year period for decommissioning technology (including more advanced robotics) and the licensing framework to evolve and mature. In addition, it becomes much more likely that a permanent spent fuel repository would be available prior to the completion of decommissioning. Consequently, in comparison with the No Action Alternative, the potential for adverse environmental effects from decommissioning could be further reduced.

4.3 Impacts to the Environment Associated with Alternative 2

4.3.1 Air Resources

4.3.1.1 Climate and Meteorology

Alternative 2 would not involve any potential impacts on the local climate and meteorology greater than was assessed in the original EIS. The potential for fogging and icing from operation of the cooling towers was based on conservative plume modeling and conservative assumptions for operation of the original six mechanical draft towers. The results given in Volume 3, Section 3.4, of the original EIS are greater than would be expected from additional cooling capacities of all variations of Alternative 2. This is because the actual operation of the cooling towers has been and would be expected to occur only in the warmer months, mainly in the summer, and for much less time than the 29% assumed in the original EIS.

4.3.1.2 Ambient Air Quality

Alternative 2 involves restart of Unit 1 and consequent operation of Units 1, 2, and 3. The impacts discussion of the auxiliary steam boilers and diesel generators for Alternative 1 also applies to Alternatives 2A, 2B, 2C, and 2D. Alternative 2A includes the addition of two new rectangular mechanical draft towers; Alternative 2B includes the addition of two round mechanical draft towers instead of rectangular towers; Alternative 2C includes enlargement of existing cooling tower number 3 by 25% and replacing the other five cooling towers with new and larger linear mechanical draft cooling towers; and Alternative 2D includes the construction of a single 20-cell linear mechanical draft cooling tower in the currently vacant position (no. 4) where a tower that was destroyed by an accidental fire in 1986 has never been replaced. The amount of condenser circulating (i.e., cooling) water (CCW) flow would be the same for Alternatives 2A, 2B, and 2C, and the same or less for Alternative 2D. Therefore, the total drift loss from the cooling towers is also expected to be the same for Alternatives 2A, 2B and 2C, and the same or less for Alternative 2D.

The CCW requirement for Alternative 1 is 3,579 cubic feet per second (cfs), which is less than the design rate of about 3,680 cfs for the original six cooling towers. The CCW requirement for each of Alternatives 2A, 2B, 2C, and 2D is 5,368 cfs. In order to estimate PM-10 emissions (particulates in the drift), TVA used this CCW value, the default drift factor of 1.7 pounds/10^3 gallons given in EPA publication AP-42, an estimated 101 parts per million (ppm) total dissolved solids (TDS) content of the intake water which was determined during a source assessment for Title V of the Clean Air Act, and a helper mode concentration factor of 1.03. The current National Ambient Air Quality standard for particulates applies to particles smaller than 10 microns. All of the particles resulting from the TDS in the drift are assumed to be at least this small, and the majority of them are expected to be smaller than the 2.5 micron criterion in a new standard that was promulgated in 1997, but was overturned by court action. Thus, the addition of cooling towers potentially changes the estimate of total particulate emissions identified in the original EIS.

In addition to the values stated above, an expected maximum operation in the helper mode was assumed to be 22% of the time. This amount of time should encompass the increase from two to three units and potentially more adverse conditions in future years than have been encountered in the last six years. It also provides direct comparison of the results with the helper mode results in the original EIS, Volume 1, Section 2.5. For Alternative 2, under any of the options, the estimated emissions would be about 22 pounds/hr compared to an emissions standard of 45 pounds/hr and total emissions would be 21.2 tons/yr compared to the 100 tons/yr stated in Section 2.5. Thus, despite the potential increase in the number of cooling towers, design change, and configuration, particulate emissions are expected to be less than the level identified in the original EIS. As discussed in Section 3.1.3, conservative assumptions about expected emissions and conservative modeling gave the large results in the original EIS**.** If the future maximum operation of the towers is no more than the eight percent maximum experienced in recent years, the total emissions would be only about 7.7 tons/yr.

4.3.1.3 Existing Air Emission Sources

All existing BFN emission sources for air pollutants are described in the original EIS. The addition of two cooling towers or modification of sizes of cooling towers would result in emissions discussed in Section 4.3.1.2. Construction sources and increased work force traffic would be somewhat more extensive for Alternative 2 than for Alternative 1, but the source types, levels, purpose, and time/season would be the same as listed in Table 4.2.1-2.

4.3.1.4 Air Quality During Refurbishment

For Alternatives 2A, 2B, 2C, and 2D, the same minor construction impacts as for Alternative 1 can be expected, and some additional impacts would be associated with the expected addition of more cooling tower capacity and Unit 1 restart work. These additional impacts may include fugitive dust from earth-moving activities required to reduce the height of the existing soil berm on the northeast side of the current set of cooling towers and to prepare the footprints for the additional cooling tower capacity and associated fuel combustion emissions from construction equipment and trucks. Emissions of small amounts of fugitive dust may be associated with surface preparation and transport of concrete in mixing trucks for the construction of the proposed dry cask storage facility, the proposed modifications fabrication building, and the proposed administration building. Minor emissions of combustion exhaust products such as nitrogen oxides, carbon monoxide, carbon dioxide, sulfur oxides, and hydrocarbons from engines in concrete mixing trucks, other construction-related vehicles, and construction equipment used in construction of the new facilities and in the Unit 1 refurbishment process can also be expected. Some vapors including hydrocarbons may be emitted from stored vehicle fuels and during refueling activities. As concluded for Alternative 1, construction-related impacts on ambient air quality for Alternative 2 would be minor, intermittent, and transitory.

4.3.2 Geologic Setting

4.3.2.1 Impacts on Geology

The impacts on geology of continued operation of BFN under any of the alternatives being considered are encompassed by the analysis in section 2.8-2 of the original EIS.

4.3.2.2 Impacts of Construction on Seismicity

Under some circumstances, human activities can change the ambient seismicity of an area. Four types of human activities are known to have the ability to change seismicity levels and patterns: (1) the creation of large reservoirs; (2) large underground explosions, e.g., nuclear tests; (3) the injection (or withdrawal) of underground fluids; and (4) the excavation of mines (Gough, 1978). These activities can induce earthquakes ranging in size from microearthquakes to earthquakes with m_b magnitudes of six or slightly greater (Yeats, et. al. 1996).

Activities (1), (2), and (4) can be associated with construction. Activities (1) and (2) would not occur at the site under Alternative 2A, 2B, 2C, or 2D. Activity (4), excavation, would occur on a relatively small scale at the site for any of the sub-alternatives of Alternative 2. Alternatives 2A, 2B, and 2C would require removal of some or all of the mound of earth located immediately north of the existing cooling towers. Alternative 2D would not likely require removal of this material. It is very unlikely that moving this material would change the crustal loading enough to trigger earthquakes. Therefore, there is essentially no possibility that any construction associated with re-licensing and refurbishment of Unit 1, including the construction of the three new facilities, would alter the natural level of seismic activity and no construction impacts are expected.

4.3.2.3 Local Geology

Continued operation of BFN and refurbishment activities, including the construction of the three new facilities, should have no impact on the natural level of seismic activity in the area.

4.3.3 Solid Wastes Management and Past Practices

4.3.3.1 General Plant Trash

In the event that Unit 1 is restarted, the amount of general plant trash would be expected to increase in proportion to the increase in site population required for the reconstruction effort. In addition, there would be additional trash generated as a part of construction activities, but this amount would be significantly less than that generated by construction of a new facility. Together this could be as much as a 30% increase over current levels during the construction period. Once operational, the amount of trash generated would be similar to the other operating units, and the overall amount

generated would increase slightly (approximately 12.5 %) from the current 50 ton per month level due to the small increase in permanent plant staff necessary to operate three units. The increase in general plant trash could be offset to some extent by implementation of recycling efforts beyond those currently in place. This would include increasing the amount of white paper, aluminum cans, and special stock paper sent to recycling, and improving recycling of waste wood. The existing contractor is capable of handling the increased volumes anticipated.

4.3.3.2 Construction/Demolition Debris

A small amount of additional C/D wastes associated with construction activities (except as discussed below) would be expected in the event that Unit 1 is restarted. This amount may be as much as twice that currently experienced (0.04 tons per day, increased to 0.08 tons per day). The on-site landfill has the space and capacity to handle the anticipated increase without expansion, and there is sufficient alternative capacity in surrounding off-site C/D landfills should the on-site facility prove inadequate. Once Unit 1 is completed, the amount of C/D waste generated as a result of three-unit operation would not be expected to increase significantly over the rates experienced for two-unit operation.

Alternative 2C (six large linear mechanical draft cooling towers) would result in generation of a large amount of construction/demolition debris and asbestos as a result of the need to remove four existing towers and modify the fifth tower to increase its size. Demolition of Towers 1, 2, 5, and 6 would result in approximately 39 to 45 dumpsters (40 cubic yards each) of fiberglass and vinyl, 60 to 70 dumpsters of asbestos, and 16 to 20 dumpsters of scrap lumber. The fiberglass and asbestos would be disposed in off-site permitted landfills, while the majority of the scrap lumber could be recycled. A minor amount of scrap metal (wires, fasteners, etc.) would also be generated and disposed through existing recycling programs. In addition, approximately 1,350 gallons of used oil would be generated as a result of removal of the fan motors and gearboxes; this material would be recycled through the existing BFN program. Discarded motors and gear boxes would also be recycled as scrap metal. Appropriate demolition notifications would be sent to the Alabama Department of Environmental Management.

4.3.3.3 Low Level Radioactive Waste

Should Unit 1 be restarted, generation rates would be expected to increase during construction activities primarily due to additional asbestos removal operations and the normal increases associated with nuclear construction activities. Once operational, the generation rates for this type of waste material would increase in proportion to the additional operational activity associated with three-unit operation. This would result in an increase to approximately 45 to 60 cubic meters per month. These increases would be expected to remain within the storage and disposal capacities of existing facilities. The existing contractor(s) is capable of handling the increased volumes anticipated.

4.3.4 Hazardous Wastes Management and Past Practices

Construction activities associated with Unit 1 restart would temporarily increase rates of hazardous waste, universal wastes and used oil generation due to the increased use of solvents and paint related materials necessary for refurbishment, and the recovery of various plant equipment. The increases anticipated could be as much as 25 to 30% over current levels of approximately 3,000 to 3,500 pounds per year. The existing TVA process for management of this type of waste is adequate to handle the expected increase. Once operational, hazardous waste generated as a result of operation of Unit 1 would be within the normal year to year variation currently experienced. The existing contractor(s) is capable of handling the increased volumes anticipated.

4.3.5 Spent Fuel Management

Environmental consequences of additional spent fuel management resulting from Unit 1 restart and license extension of the three BFN units would be minimal. As described in sections 2.2, 2.3, and 3.5, additional spent fuel resulting from license extension would be stored in the spent fuel pool or a dry storage system approved by NRC in accordance with 10 CFR 72. Subsequently, BFN spent fuel would be transferred to the DOE in accordance with the Nuclear Waste Policy Act of 1982 and subsequent amendments. The only component of a dry storage system not transferred to DOE would be the concrete storage overpack provided a modular system is chosen. If used, this component would be disposed as part of the ISFSI decommissioning. Compared with license renewal of only Units 2 and 3, the addition of Unit 1 would just increase the number of storage casks needed and the required size of the ISFSI by approximately 33%.

4.3.6 Surface Water Resources

4.3.6.1 Construction Effects

The Unit 1 upgrade, restart, and increased cooling tower capacity involves substantial construction activities. As development occurs, soil disturbances associated with access roads and other construction activities could potentially result in adverse water quality impacts. Improper water management or storage and handling of potential contaminants could result in the runoff of pollutants to receiving streams. Erosion, sediment, and accidental spills of fuel or oil could impact streams and threaten aquatic life.

Standard safeguards would be included in the project design, construction and operation to minimize the risk of adverse impacts. Construction activities would comply with state permit requirements for the control of potential impacts (e.g., general construction permit, best management practices (BMP) plan, erosion control plan, and spill prevention plan). BMPs sufficient to minimize the risk of and avoid adverse impacts would be followed for all construction activities. Site grading and soil removal would be minimized. Clearing operations would be staged so that only land that would be developed promptly is stripped of protective vegetation. Mulch or temporary cover would be applied whenever possible to reduce sheet erosion. Permanent vegetation, ground cover, and sodding would be installed as soon as possible after site preparation.

Surface water runoff would be managed to avoid adverse impacts using sediment basins, silt fences, berms, or other control options. These and other similar precautions are expected to minimize potential construction impacts such that no special mitigation measures would be necessary.

4.3.6.2 Chemical Effluent Effects

Under Alternative 2, the Emergency Equipment Cooling Water, Raw Cooling Water, and Residual Heat Removal Service Water (Intermittent Treatment Mode) systems would have increased flow rates. Conservative estimates indicate that flow would increase by up to one-third as Unit 1 is added to Units 2 and 3 (actual increases may be less due to some commonality among systems). Discharge concentrations would be similar to those shown in Table 4.2.6-1, due to proportional flow increases in the corresponding waste streams. No changes are expected in the flow, concentrations, or treatment frequencies for the Residual Heat Removal (Stagnant Treatment Mode), since the operation of this system would be the same under all sub-alternatives for Alternative 2.

Effluent discharges from other plant systems such as yard drainage, station sumps, and sewage treatment would not be expected to change significantly with the restart of Unit 1. The changes in discharges to the river would remain within the bounding conditions established in the NPDES permit, and therefore should have minimal impact either individually or cumulatively on the environment. The discharges are regulated under the Clean Water Act (CWA) by the U.S. Environmental Protection Agency and the Alabama Department of Environmental Management. The NPDES permit specifies the discharge standards and monitoring requirements for each discharge. The permit is renewed every five years and this helps to ensure that no changes have been made to the facility that would alter aquatic impacts and that no significant adverse impacts have occurred. Compliance with the NPDES process, other provisions of the CWA (e.g., Sections 316 (a) and (b), 401, 404), and other regulatory requirements are expected to adequately control potential chemical effluent effects. In general, under these regulatory programs, TVA treats wastewater effluents, collects and properly disposes potential contaminants, and undertakes pollution prevention activities that comply with regulatory requirements and minimize the risk of adverse environmental impacts.

4.3.6.3 Thermal Effects

The restart of Unit 1 will require upgrading the cooling tower system from the existing Unit 2 and 3 capacity. The following analysis assumes that sufficient cooling tower capacity would be supplied to routinely maintain the instream thermal limits in the current NPDES permit. If extreme hot and dry conditions should make it impossible for the cooling towers to meet the thermal limits, the plant would be de-rated to remain in compliance.

Under Unit 2 and 3 operation, the maximum flow rate for the once through Condenser Circulating Water system is approximately 2,312 MGD (actual annual average flow rates are slightly lower due to outages). Restarting Unit 1 will result in a maximum flow rate for all three units of approximately 3,468 MGD. No changes are expected in the plant intake system to accommodate the flow rate for all three units.

The discharge temperature of the cooling system water would be essentially the same for three-unit operation as for Units 2 and 3 operation, due to the proportional increase in cooling water flow. However, the total amount of heat added to the river and the water temperatures at the edge of mixing zone would increase with the restart of Unit 1. Table 4.3.6-1 summarizes the temperature changes based on a near-field modeling analysis of 29 years of historical data from 1969-1999 (Harper, 2001, 2002). (Years 1989 and 1990 were not included in the analysis due to missing data.) Results are also shown for 1988, one of the driest and hottest years in the period of analysis, and for 1985-1999, recent years that include warmer than normal conditions and changes in the way TVA operates the river system (TVA, 1990).

Table 4.3.6-1 Summary of Projected Thermal Effects on Water Temperatures (°F)*

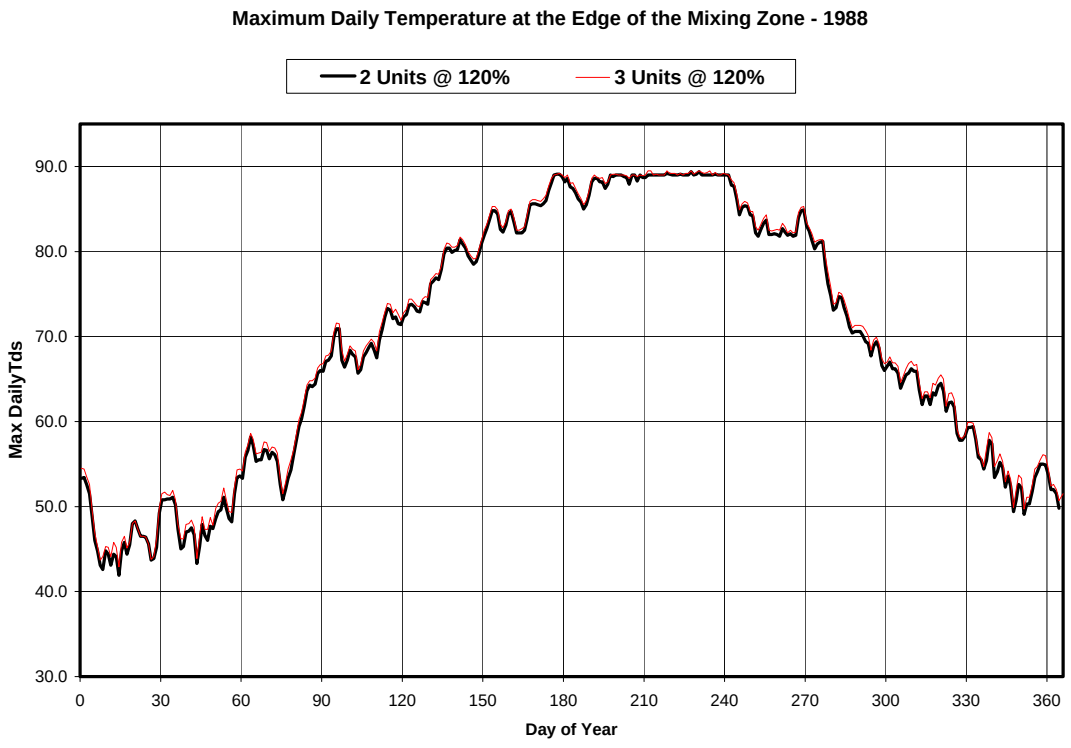
Alternative 1. Units 2 and 3 Operating								
Years	Discharge Point			Edge of Mixing Zone			Percent of Time	
	Min.	Mean	Max.	Min.	Mean	Max.	Towers	De-rate
1969-99	58.8	89.7	116.3	36.1	67.9	89.8	2.8	0.03
1985-99	59.2	90.1	115.9	36.2	68.8	89.8	4.6	0.06
1988	62.1	89.0	114.2	41.5	68.8	89.4	6.3	0.00
Alternative 2. All Three Units Operating **								
Years	Discharge Pont			Edge of Mixing Zone			Percent of Time	
	Min.	Mean	Max.	Min.	Mean	Max.	Towers	De-rate
1969-99	58.8	89.4	115.1	36.3	68.4	90.0	4.6	0.19
1985-99	59.2	89.9	115.1	37.7	69.2	90.0	6.6	0.40
1988	62.1	88.9	113.9	42.4	69.4	89.5	8.9	0.00

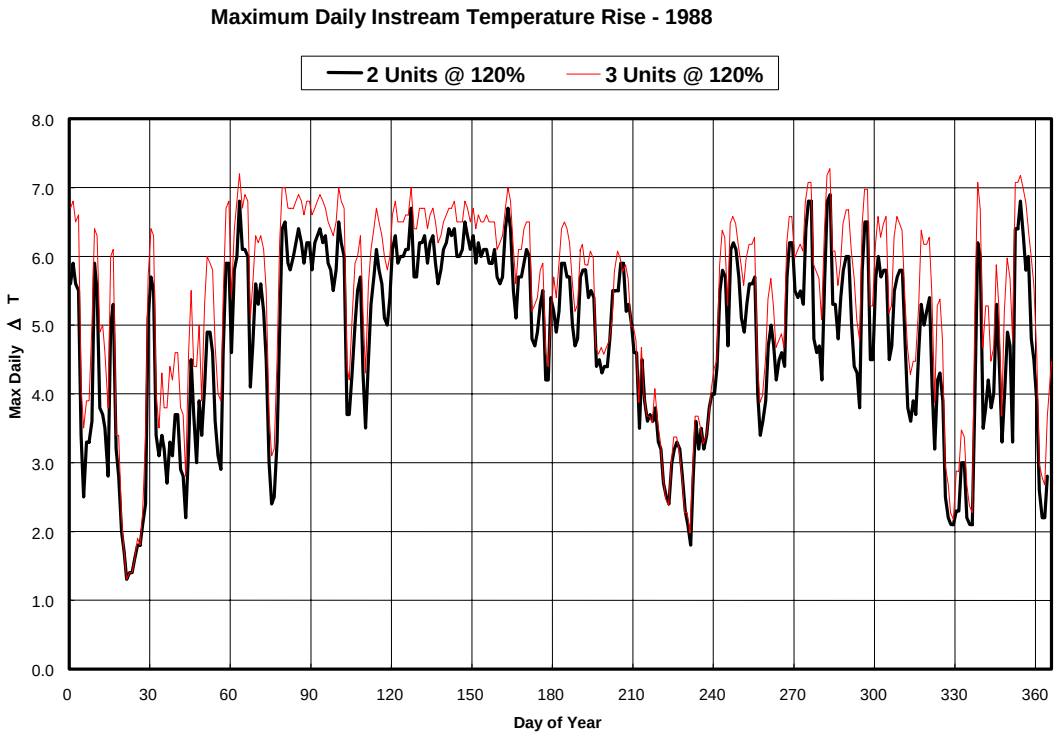
* Based on modeling analysis of hydrological and meteorological conditions for the years indicated (Harper 2001, 2002).

** Mean and minimum temperatures were essentially the same for each of the four cooling tower configurations. Maximum temperatures varied slightly (e.g., 89.8 °F to 90.0 °F during the 1969-99 simulation period). Cooling tower usage and plant de-rating also varied slightly depending on the cooling tower configuration (e.g., during 1969-99, tower usage varied from 3.9 to 4.6 percent of the time and de-rating varied from 0.06 to 0.19 percent of the time).

The mean 1969-1999 water temperature at the edge of the mixing zone increases from 67.9°F to 68.4°F as Unit 1 is added to Units 2 and 3. In 1988, the mean temperature at the edge of the mixing zone increased from 68.8°F to 69.4°F. Figure 4.3.6-1 compares the model results for 1988 under two-unit and three-unit operation. In both cases the maximum temperature at the edge of the mixing zone is maintained below 90°F with the use of cooling towers. In 1988, the instream temperature rise (i.e., between the ambient monitoring station (no. 4) upstream of the intake and downstream edge of the mixing zone) ranged from 1.2°F to 7.6°F. The potential effects of the added heat load are discussed below, based on a far-field modeling analysis.

Figure 4.3.6-1 Water Temperatures for Two-Unit and Three-Unit Operation 1988





With all three units operating, the maximum downstream temperature and temperature rise between upstream and downstream would remain within regulatory limits. Use of the cooling towers would increase, and on rare occasions when the cooling towers are unable to meet the thermal limits, the plant would have to be de-rated to remain in compliance. During the 1969-1999 simulation period, model results showed that with Units 2 and 3 operating, the cooling towers would be used 2.8% of the time and de-rating would be required approximately 0.03% of the time (i.e., de-rated 3.3 days over the 29 year period of analysis). With all three units operating, the cooling towers would be used approximately 4.6% of the time and de-rating would be required approximately 0.19% of the time (i.e., de-rated 20.8 days over the 29 year period of analysis). For the more recent period of analysis (1985-1999), cooling towers would be used approximately 6.6% of the time with de-rates occuring approximately 17.5 days over the 12-year period (1989 and 1990 are not included).

The implications of the thermal effects on reservoir water temperatures, dissolved oxygen concentrations, and eutrophication were evaluated using a far-field two dimensional reservoir model (TVA, 1993). Hydrological and meteorological conditions for 1988 (without cooling tower operation) were assessed as a potential worst-case condition for reservoir water quality (i.e., due to the low flows and warm weather). The potential reservoir effects from the restart of Unit 1 are expected to be less with the use of cooling towers and less in years of more typical hydrology and meteorology than in 1988. Results for 1988 are summarized in Table 4.3.6-2 for three reservoir locations: immediately upstream of BFN, immediately downstream of BFN, and in the reservoir forebay just upstream of Wheeler Dam.

The 1988 mean annual water temperature at the reservoir section downstream of BFN increased from 65.0^{o}F to 66.5^{o}F as Unit 1 is added to Units 2 and 3 (under the EPU operating capacity for all three units) in the modeled scenario. The mean annual water temperature at the downstream reservoir section was 66.0^{o}F for all three units operating at their initial 100% capacities. Thus, the current three-unit operation represents an increase of 0.5^{o}F over the original plant operation with all three units operating. The average daily reservoir temperature at this downstream section on the warmest day in 1988 increased from 87.1^{o}F to 89.0^{o}F as Unit 1 is added to Units 2 and 3 (under the EPU operating capacity for all three units). With all three units operating at their initial 100% capacity the water temperature on the warmest day was 88.6^{o}F. Thus, the proposed three-unit operation is predicted to result in an increase of 0.4^{o}F on the warmest day, over the original plant operation. Similar model results are shown in Table 4.3.6-2 for the upstream and reservoir forebay stations. The model results indicate potentially higher upstream and downstream temperatures due to periodic back flow conditions. The cumulative thermal impact would be insignificant, due to the small increase in reservoir temperatures, the limited effect on temperatures downstream of Wheeler Reservoir, and the lack of other major thermal discharges in the vicinity.

Table 4.3.6-2 Summary of Wheeler Reservoir Modeling Analysis for 1988*						
Parameter/Units	Upstream of BFN TRM 294		Downstream of BFN TRM 292		Reservoir Forebay TRM 275	
	Annual Mean	Max. Day	Annual Mean	Max. Day	Annual Mean	Max. Day
Temperature (°F)						
Units 2 and 3 (EPU)	64.5	87.0	65.0	87.1	63.5	85.1
All 3 Units (EPU)	65.8	88.3	66.5	89.0	64.8	86.7
All 3 Units (100%)	65.4	88.0	66.0	88.6	64.4	86.3
Difference (120%-100%)	0.4	0.3	0.5	0.4	0.4	0.4
Algal Biomass (mg/L)	**Annual Mean**	**Max. Day**	**Annual Mean**	**Max. Day**	**Annual Mean**	**Max. Day**
Units 2 and 3	1.7	4.6	1.8	4.5	1.6	3.5
All 3 Units	1.8	4.3	1.9	4.4	1.7	3.5
Difference	0.1	-0.3	0.1	-0.1	0.1	0.0
Dissolved Oxygen (mg/L)	**Annual Mean**	**Min. Day**	**Annual Mean**	**Min. Day**	**Annual Mean**	**Min. Day**
Units 2 and 3	8.8	6.3	8.7	5.8	7.9	4.3
All 3 Units	8.7	6.7	8.7	6.6	7.9	4.5
Difference	-0.1	0.4	0.0	0.8	0.0	0.2

*Based on 1988 modeled reservoir conditions for the period and location indicated (Shiao, 2001).

The 1988 mean annual dissolved oxygen and algal concentrations in the reservoir were essentially unchanged with the addition of Unit 1. On the day of lowest dissolved oxygen concentration in 1988, the model indicted a potential DO decrease of 0.2 mg/L to 0.8 mg/L at the three reservoir sections. Algal concentrations on the day of highest productivity were essentially unchanged. Cumulative impacts of thermal changes on DO and algal concentrations would be insignificant.

Based on these results and the future operation of the plant in compliance with regulatory requirements for thermal effluents, Alternative 2 is expected to have insignificant effects on reservoir stratification, dissolved oxygen concentrations, eutrophication, sediment transport, scouring, and cumulative impacts.

4.3.6.4 Water Use/Water Availability

Restart of Unit 1 is not expected to adversely affect the availability of water or water use by others, as the maximum cooling water withdrawal is approximately 5,368 cfs, compared to an annual average flow at Wheeler Dam of 49,800 cfs. With once-through cooling essentially all of the water

is returned to the river. Even during times of minimum river flow sufficient water will be available from reservoir storage for use by others.

4.3.6.5 Microbiological Organisms

There are no developed public recreation facilities located at the BFN site. Located directly across the Tennessee River from the site is Mallard Creek Recreation Area. This is a TVA-developed and operated area. It includes camping, picnicking, swimming beach, and a boat launch area. Approximately two miles upstream of BFN is Round Island Recreation Area, also developed and operated by TVA. It features facilities for camping, swimming, picnicking and boat launching. The reservoir in the vicinity of the plant site is moderately utilized by recreational boaters and fishermen.

During the 1999 TVA Vital Signs Monitoring, samples were collected at five swimming beaches and four boat ramps throughout the reservoir and analyzed for fecal coliform bacteria. All of the samples were within the State of Alabama guidelines for water contact. Since essentially no microbiological organisms will be discharged by BFN, no microbiological impacts to the reservoir or water uses are expected.

4.3.7 Groundwater Resources

4.3.7.1 Groundwater Occurrence

Activities potentially affecting groundwater resources would include foundation treatment, excavation, and grading associated with Alternative 2 facilities. These facilities might include parabolic or mechanical draft cooling towers, a Dry Cask Storage Facility, a Modifications Fabrication Building, and a permanent Administration Building. Although no groundwater use is anticipated during construction, excavations that penetrate the water table may require temporary construction dewatering. Therefore, transient impacts to groundwater resources from dewatering activities might be expected to produce localized and temporary reductions in the groundwater table. Although several water supplies are known to exist in the area, the only water supply identified close to BFN was Limestone County Water System Well G-1, more than two miles north of the proposed project site. Any groundwater drawdown impacts associated with plant construction dewatering would be temporary and of negligible magnitude due to the limited excavation depths, the relatively short duration of facility construction, and the distance of neighboring wells.

Excavation and grading associated with construction of the proposed facilities would result in permanent displacement of shallow soils above the water table. This includes the proposed berm relocation sites for sub-alternatives 2A, 2B, and 2C under Alternative 2. However, the long-term impact of these activities on groundwater resources would be negligible for all facility configurations given the limited depth and area of disturbance. The areas proposed for the mechanical draft or hyperbolic cooling towers are underlain by weathered Tuscumbia limestone and Fort Payne chert bedrock that might require foundation treatment for stabilization. Although permanent local impacts to groundwater levels and movement might be experienced from

foundation treatment, the long-term impacts of these activities on groundwater resources would be negligible for the proposed cooling tower configurations given the limited area of disturbance.

A secondary construction concern is associated with potential contaminant releases during construction activities. The potential contaminants are primarily fuels, oils, and solvents used for operation and maintenance of vehicles and equipment. However, this potential risk would be lessened by careful handling and proper disposal of potential contaminants according to BMP guidelines. Possible BMP measures include careful handling and proper disposal of contaminants according to guidelines of the BFN Spill Prevention, Control and Countermeasure Plan.

No adverse impacts to groundwater resources are anticipated from operation and maintenance of new facilities associated with Alternative 2 for the project.

Effluent discharges from plant systems such as yard drains, station sumps, and sanitary wastewater would not be expected to change significantly under Alternative 2. Considering that the plant wastewater lagoons and sedimentation ponds possess clay and Hypalon liners, respectively, no impacts to groundwater resources are anticipated. The changes in pond/lagoon discharges to the river would remain within the bounding conditions established in the NPDES. These permits are renewed every five years and this helps to ensure that no changes have been made to the facility that would alter aquatic impacts and that no significant adverse impacts have occurred.

4.3.7.2 Groundwater Use

Currently, groundwater is not used by BFN, no groundwater use is anticipated during construction, and site dewatering wells have been inactive since the 1980s. Although excavations that penetrate the water table may require temporary construction dewatering under Alternative 2, drawdowns would be temporary and of negligible magnitude to impact off-site private water supplies. No adverse groundwater use impacts are anticipated from all alternatives considered for the project.

4.3.8 Floodplains and Flood Risk

The floodplains and flood risk assessment for Alternatives 2A and 2B is the same as for Alternative 1.

Under Alternative 2A, Units 2 and 3 would be relicensed at EPU levels, Unit 1 would be refurbished, restarted, and relicensed at EPU levels, and a dry cask storage facility, Modifications Fabrication Building, permanent Administration Building, and two additional mechanical draft cooling towers would be constructed. All anticipated flood impacts would be the same as those listed for Alternative 1 except for potential PMF flooding impacts to the two new towers. The towers would be located above the PMF elevation in a new footprint. The construction of these towers would involve the relocation of material to one of three potential spoil areas. These areas are all located outside the limits of the 100-year floodplain, consistent with EO 11988.

Under Alternative 2B, Units 2 and 3 would be relicensed at EPU levels, Unit 1 would be refurbished, restarted, and relicensed at EPU levels, and a dry cask storage facility, Modifications Fabrication Building, permanent Administration Building, and two new hybrid cooling towers

would be constructed. All anticipated flood impacts would be the same as those associated with Alternative 2A.

Under Alternative 2C, Units 2 and 3 would be relicensed at EPU levels, Unit 1 would be refurbished, restarted, and relicensed at EPU levels, and a dry cask storage facility, Modifications Fabrication Building, Permanent Administration Building, and five new linear mechanical draft cooling towers would be constructed. Based on the site topography dated 1989, the proposed mechanical draft cooling towers would be located at the existing cooling tower footprints above elevation 570. All equipment within the cooling towers that could be damaged by floodwaters would be located above or flood proofed to the PMF elevation, as required. The construction of these towers would also involve the relocation of material to one of three potential spoil areas. These areas are all located outside the limits of the 100-year floodplain, consistent with EO 11988.

Under Alternative 2D, Units 2 and 3 would be relicensed at EPU levels, Unit 1 would be refurbished, restarted, and relicensed at EPU levels, and a dry cask storage facility, Modifications Fabrication Building, permanent Administrative Building, and one new 20-cell mechanical draft cooling tower would be constructed. All anticipated flood impacts would be the same as those listed for Alternative 1 except for potential PMF flooding impacts to the new cooling tower. The tower would be located above the PMF elevation in a new footprint. Construction of this cooling tower is not anticipated to require relocation of material to one of the three potential spoil areas.

4.3.9 Terrestrial Ecology

4.3.9.1 Vegetation

Alternative 2 would cause some disturbance of existing plant communities in conjunction with the addition of any of the four configurations of new cooling towers and the relocation of soil that would accompany the construction of the towers for Alternatives 2A, 2B and 2C. Alternative 2D may or may not involve recontouring of the existing soil berm. However, no uncommon terrestrial communities or otherwise unusual vegetation occur on the lands to be disturbed under Action Alternative 2. With respect to vegetation, any direct, indirect, or cumulative impacts to the terrestrial ecology resources of the region are expected to be insignificant as a result of the proposed activities.

4.3.9.2 Wildlife

Under Alternative 2, the operating licenses for the three units at BFN would be renewed for up to 20 years, and Unit 1 would be restored to service. Associated with this would be the restoration of several existing cooling towers and/or the construction of new cooling towers, and the construction of three new facilities. These construction activities would result in the removal of some early successional habitats in the vicinity of the existing facilities. Because no rare or uncommon communities of animals exist on the site, this action alternative would not result in adverse impacts to any uncommon wildlife or their habitats.

4.3.9.3 Introduced Species

Because no intact native plant communities occur on lands to be disturbed by the proposed project, and because introduced plant species are already present in these areas, any direct, indirect, or cumulative impacts due to the establishment or spread of introduced plant species are anticipated to be insignificant as a result of the actions associated with Alternative 2.

Two introduced species, the European house sparrow and the European starling, are known to exist on the project site. These species are quite common in the project area. Alternative 2 would not result in increased population levels of introduced animal species.

4.3.9.4 Managed Areas and Ecologically Significant Sites

Because the proposed actions would occur within the lands presently utilized for the operation and maintenance of the BFN, no impacts to Managed Areas or Ecologically Sensitive Sites are anticipated.

4.3.9.5 Refurbishment Impacts

Similar to the experience with recovery of Units 2 and 3, no substantial ecological impacts are expected for the recovery of Unit 1. Site worker population could be temporarily increased to a peak of approximately 3,000 (possibly fewer if some of the workers remain at their parent companies and are not relocated to the BFN site). This influx of workers would require either permanent or temporary new office and shop buildings, and would increase the load on the waste treatment plant. The waste treatment system at BFN is sized to operate with a maximum plant population of approximately 4,500.

As was the case for recovery of Units 2 and 3, equipment being replaced would necessitate the disposal of the original items, which in some cases might involve decontamination and/or eventual shipment to a low-level waste repository. Refurbishment may also result in producing other materials requiring disposal, such as decontamination chemicals and worker C-zone items (booties, gloves, tape, rags, etc.).

Any of the sub-alternatives under Alternative 2 would involve major additions to existing cooling tower capacity. Some of this additional capacity may be accomplished by refurbishment of the existing cooling towers, and this could necessitate the disposal of fill materials (some of which contain non-friable asbestos) and possibly steel and concrete (see Section 4.3.3.2). Disposal of all such materials that cannot be recycled would be in permitted landfills, either on-site or off-site, thus impacts to terrestrial resources would be minimal and insignificant.

4.3.10 Aquatic Ecology

4.3.10.1 Fish

Refer to 4.2.10.1. With implementation of BMPs and other measures as needed, to prevent the entry of pollutants into surface waters potential impacts to aquatic life resulting from construction of new facilities would be insignificant.

Potential impacts from changes in thermal characteristics of CCW discharge from BFN and entrainment and impingement of fish are discussed in section 4.3.10.4.

4.3.10.2 Benthic Organisms

The refurbishment and restart of Unit 1 at EPU is proposed in addition to operating Units 2 and 3 at EPU for Alternative 2. To provide additional heat dissipation capacity for the restart of Unit 1, different cooling tower configurations have been identified. The new cooling towers would either be mechanical draft or new hybrid ("modified parabolic") towers in new or existing footprints. For any of the alternative configurations, discharge temperatures outside of the mixing zone would not exceed the current NPDES thermal limits. The proposed actions would not impact the benthic macroinvertebrate communities in the vicinity of BFN diffuser discharges. As discussed in section 4.2.10, Vital Signs monitoring will be continued to follow any unanticipated changes to the aquatic community in the vicinity of BFN.

4.3.10.3 Introduced Species

The Vital Signs Monitoring program is designed to track introduced species throughout the Tennessee Valley. Actual monitoring will document any increases in zebra mussel reproduction in the vicinity of BFN. Monitoring raw water for zebra mussel larvae inside BFN would allow formulation of treatment plans to prevent biofouling impacts to BFN operations resulting from zebra mussel infestation.

Grass carp abundance is not expected to be influenced by BFN operations. Introduced grass carp are normally sterile, so that their numbers can be maintained at desired levels by adjusting any future stocking rates.

4.3.10.4 Entrainment and Impingement of Fish and Shellfish, Heat Shock

If Unit 1 is not returned to operation, but Units 2 and 3 are relicensed under Alternative 1, the total maximum two-unit intake volume, even with past plant modifications that increased Condenser Circulating (i.e., cooling) Water (CCW) flow, would be within the bounds of previously-assessed intake volumes at which fish impingement and entrainment of fish eggs and larvae were determined to not adversely impact Wheeler Reservoir fish populations. With the return of Unit 1 to operation under Alternative 2, the total CCW flow would increase by about ten percent. This

increased CCW intake volume would potentially result in increased impingement of adult fish and entrainment of fish eggs and larvae. Increased discharge temperatures are not planned; thus, heat shock impacts are not anticipated.

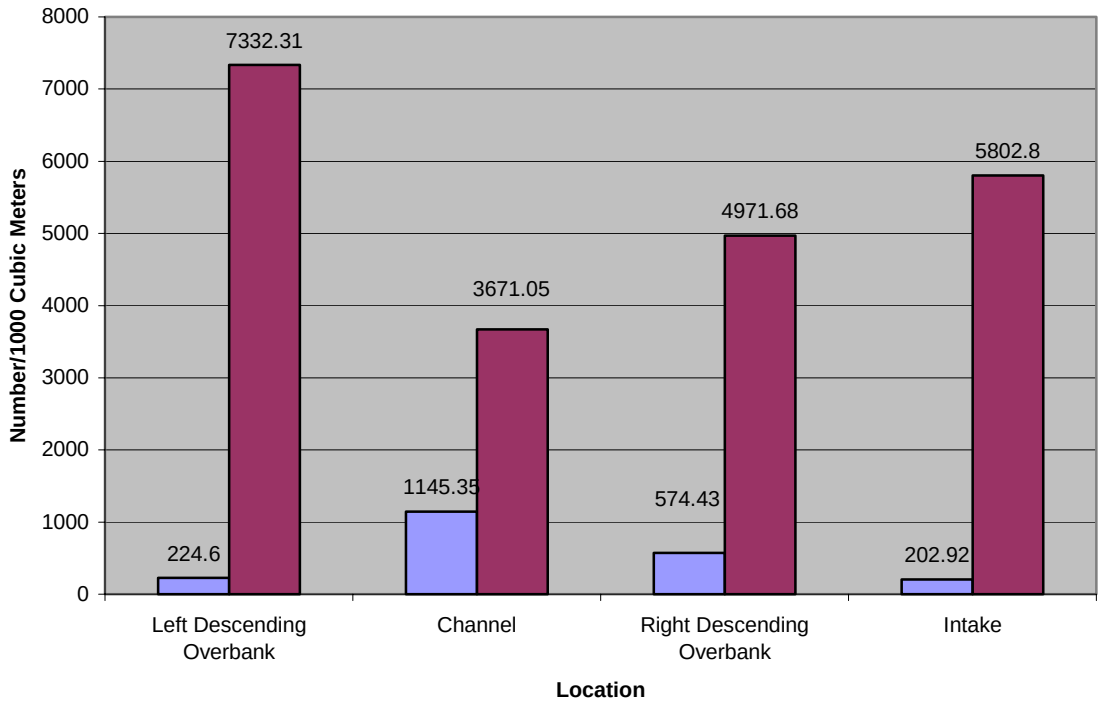
During operational monitoring (1974-1977), with all nine circulating pumps in operation, four species of fish (threadfin shad, gizzard shad, freshwater drum, and skipjack herring) represented 95% of the total fish impinged at BFN. No species other than these four comprised greater than one percent of total fish impinged. It was concluded in TVA (1980) that the operation of BFN has not caused an adverse environmental impact to the balanced indigenous fish community of Wheeler Reservoir. With the return of Unit 1 and associated ten percent increase in CCW flow, impingement rates are expected to slightly increase, but are not expected to result in significant impacts to fish populations of Wheeler Reservoir.

From 1971-1977, larval fish were sampled in the vicinity of BFN to assess any potential adverse impact to the indigenous fish community in Wheeler Reservoir (TVA, 1978b). The larval fish populations were consistently dominated (80-98%) by clupeids (shad). Total annual percent fish entrainment increased over the four-year study period from 1.0 to 11.7% of the total number estimated passing the plant. Other significant taxa comprising greater than one percent of the total number of larval fish collected were catastomids (suckers), cyprinids (minnows and carp), sciaenids (drum) and percichthyids (white and yellow basses). The three families of fish with the highest estimated entrainment during three-unit operation at BFN in 1977 were Clupeidae (12.1%), Catostomidae (4.5%), and Sciaenidae (6.1%). These estimates were reported to result in no significant impact to the reservoir population with concurrence from regulatory agencies. Subsequent monitoring of adult populations (TVA, 2000), including gillnetting and electrofishing, have reported no obvious decline in the populations of these families in Wheeler Reservoir. With the return of Unit 1 and associated ten percent increase in CCW flow, entrainment rates would be expected to similarly increase (i.e., to 13 % for Clupeidae, 5% for Catostomidae, and 6.7 % for Scianedae). This estimated change is not expected to result in any significant impact to fish populations in Wheeler Reservoir.

Flow studies conducted by TVA at BFN have indicated that the majority of water entrained originates from the right side of the main river channel. This pelagic area contains significantly lower densities of drifting fish larvae than found in the overbank areas (Figure 4.3.10-1). Higher densities of fish eggs (primarily freshwater drum eggs) are transported in the channel portion of the river, but entrainment of drum eggs (and larvae) has not resulted in noticeable decreased abundance of this species; nor is it expected to, under the increased CCW flow rates.

TVA will confirm the expected levels of impingement and entrainment by monitoring under current 2-unit operation and following return of Unit 1 to service. TVA's Vital Signs monitoring program will also continue to assess aquatic ecological communities in Wheeler Reservoir. Although not expected, if based on these monitoring studies it is determined that increased impingement and entrainment are resulting in unacceptable environmental impacts, TVA would assess the technologies, operational measures, and restoration measures that could be undertaken to remedy this and institute appropriate measures in consultation with appropriate federal and Alabama agencies .

Figure 4.3.10-1 Average Density of Fish Eggs and Larvae at Plant Transect (TRM 294.5) and Intake Basin at Browns Ferry Nuclear, 1978 - 1980



4.3.10.5 Microbiological Organisms

With the return of Unit 1 to operation, total CCW flow would increase by about ten percent over previous 3-unit operation. In 1978, TVA determined that almost all the phytoplankton in the CCW intake is coming from the north bank of the Tennessee River upstream of BFN. The plankton community is dynamic and can reproduce and recolonize rapidly. Therefore, to the extent Wheeler Reservoir plankton serves as a food source for other aquatic life, restart of Unit 1 is not anticipated to have an adverse effect on aquatic life dependent upon plankton as a food source. Operational monitoring during the first year of operation of Unit 1 would help to confirm the level of intake impacts to Wheeler Reservoir fish populations, and possibly to plankton densities. Thus, there would be no impacts to microbiological organisms resulting from any of the proposed action alternatives.

4.3.11 Threatened and Endangered Species

4.3.11.1 Animals

As described in Chapter 3, four listed species of animals are reported from Limestone County. Implementation of Alternative 2 would not result in adverse impacts to federally listed gray or Indiana bats. Gray bats likely forage along the shoreline of the Wheeler Reservoir, adjacent to the nuclear plant. However, renewal of the operating license resulting in the continued operation of the nuclear plant and modifications and construction of the cooling towers would not affect this species because they only forage over aquatic habitats and their foraging areas would not be altered by the proposed project. No suitable habitat for Indiana bats or the Tennessee cave salamander exists on the project site. Some habitat suitable for Appalachian Bewick's wren exists on the site; however, proposed modifications at the site would not eliminate this habitat. Therefore, Alternative 2 is expected to have no effect on listed terrestrial species or their critical habitat.

4.3.11.2 Aquatic

As described in Chapter 3, there are five federally protected aquatic species in Wheeler Reservoir in the vicinity of BFN, but these are found in habitats upstream of the plant. During the three phases of BFN's thermal variance monitoring (1985-1998) and current Vital Signs Monitoring programs, no threatened or endangered aquatic species were found within the area affected by construction or operational changes at BFN as proposed herein. The seven survey reports cited in section 3.11.1 support the conclusion that the proposed changes and additions to BFN would have no effect on the species listed in Section 3.11.2.

4.3.11.3 Plants

No occurrences of rare (i.e., federal- or state-listed) plant species are known on or immediately adjacent to the lands to be disturbed under Alternative 2. Therefore, no effects to rare plant species are anticipated under this Alternative.

4.3.12 Wetlands

Construction activities associated with Alternative 2 would require the excavation and removal of soil for the construction of new cooling tower capacity. None of the excavation or spoil areas would occur in wetlands, thus there would be no impacts to wetlands.

4.3.13 Socioeconomic Conditions

4.3.13.1 Demography

Under Alternative 2, Unit 1 recovery staffing requirements would have an impact on the population of Limestone and surrounding counties. Staffing would reach a peak of approximately 3,000 workers. This peak would only last about six months, while the construction project would last about six years in total. A staffing level of at least 1,500 would be maintained over approximately four years, with a staffing level of at least 2,000 being sustained over almost three years. Not all of these workers would be located at the plant site (e.g., design staff, which would exceed 500 workers for about three years). Furthermore, only a minority of on-site workers would relocate as a result of employment on this project, further mitigating the impact on the local area. Many workers would commute from their homes outside Limestone County. In 1971, at the peak of the original BFN construction, about 25% of the employees at the site changed their residence in order to work at the site. This suggests that no more than 750 workers (25% of 3,000 peak employment) would move into the area to work on this project, and very likely less than this. With families this would mean a maximum population increase of 2,000 to 2,500 persons. The duration of any such population increase would likely be three to four years, coinciding with the sustained staffing levels of 1,500 to 2,000.

This maximum population increase is equivalent to about twice Limestone's annual population growth through the 1990s (or four percent of the current county population). However, because many workers would commute from outside the county, a more meaningful comparison is made with the growth rate of the labor market area. The maximum population increase resulting from the project is equivalent to less than one-third the area's annual population growth (or 0.4% of the current area population). The most likely locations for those moving into the area outside Limestone County to work would include Huntsville, Florence, and Decatur in Alabama, along with possibly Pulaski and Fayetteville in Tennessee. The impact of population growth resulting from this project would be eased as a result of the gradual build-up in staffing. Peak staffing would be the result of almost four years of steady staffing increases.

4.3.13.2 Economic Conditions

Under Alternative 2, recovery of Unit 1 would generate additional income in the area from a large workforce over a time span of approximately six years (see Section 2.4.2.1).

A sustained employment level of 1,500 to 2,000, less at least 500 off-site workers, results in perhaps 1,000-1,500 new jobs over three to four years. This represents 3.5 to 5.2% of Limestone County's current employment level, or 0.3 to 0.4 % of labor market area employment. The income earned by 1,500 on-site workers would represent approximately four percent of annual earnings in Limestone County, but only 0.3% of the labor market area's annual earnings (and many of these workers would reside outside Limestone County). A permanent staff of 150 would be required to operate Unit 1, and their earnings would represent about 0.7% of Limestone County annual earnings and 0.1% of area earnings. Alternative 2 would have a beneficial, albeit relatively minor, effect on income in Limestone County and the broader labor market area.

4.3.13.3 Community Services and Housing

Under Alternative 2, during construction there most likely would be some short-term strain on community services, including police and emergency services. Schools likely would experience noticeable impact. Housing for movers could become a short-term concern. However, many of the movers would seek short-term rental facilities, including motels, or sites for trailers, easing somewhat the strains on the traditional housing market. Housing and the impacts on community services would be spread around geographically within the labor market area, including Huntsville, lessening the extent of the impacts on any one location or governmental jurisdiction. Also, many of the workers would commute on a weekly or other less than daily basis, and would not reside in the area all the time. Residential locations would depend on the availability of suitable facilities or sites, and could be anywhere in the labor market area. These strains on the local and area housing markets most likely would lead to increased prices for at least some types of housing. The impacts on housing prices would begin to diminish after the peak construction employment level is reached and then essentially disappear by the end of the construction period.

The increase in permanent employment associated with operation of Unit 1 in addition to Units 2 and 3 could have a temporary impact on the local housing market and housing prices in Limestone County and, to a lesser extent, the surrounding area. However, given the recent relatively fast growth in population in Limestone County, the impact likely would be minor and not very important. As of 2000, there were 2,209 vacant housing units in Limestone County, which are enough to absorb the peak number of new households that could be expected during the project, even if they all located in Limestone County.

4.3.13.4 Local Government Revenues

Under Alternative 2, in addition to the expenditures that would occur with Alternative 1, there would be significant capital expenditures on Unit 1, estimated to be about $1.24 billion. As a result, TVA in lieu of tax payments to the state would increase. In turn, there would be increases in the amounts redistributed by the state to north Alabama counties located in the TVA service area. The total annual payment to the state of Alabama is estimated to increase by about $4.3 million. Based on the current redistribution formula, about $660,000 would be redistributed to Limestone County. Madison and Morgan Counties would also receive similar increases, estimated to be about $710,000 and close to $560,000, respectively. Other counties in the area would receive smaller increases. In addition, there would be additional tax revenue associated with expenditures made in the area for materials associated with the proposed refurbishment as well as sales tax revenue associated with purchases by individuals employed during construction and subsequently during operation. The magnitude of these increases could vary greatly, depending on the amount of local purchases for construction and on the relocation and buying decisions of workers employed at the site.

4.3.13.5 Environmental Justice

As discussed in Section 3.13.4, the disadvantaged population percentage in the immediate area near the site is relatively small. Any negative impacts to persons living near the site would be small and would tend to be dispersed through the area. Potential impacts of concern would include air quality, transportation, visual, and noise. The use of BMPs and planned mitigation, as discussed in this chapter, would help maintain such impacts at a level of no significance. No disproportionate impacts to disadvantaged populations are expected.

4.3.14 Transportation

4.3.14.1 Highways and Roads

IMPACTS OF CONSTRUCTION

Additional traffic would be generated due to refurbishment of the Unit 1 at EPU and the associated construction of additional cooling tower capacity. No impacts to the state and county roads in the vicinity of the site are expected. The construction period spans almost six years with a construction workforce rising to peak levels of 3,055 employees on-site during the refurbishment period. Assuming an average ridership of 1.6 persons per vehicle, and a trip in and out each day, about 3,820 vehicles will be added to the road network due to daily commuters during this peak construction period. Assuming traffic is split equally in three directions on Shaw Road, Nuclear Plant Road, and Browns Ferry Road, the Average Daily Traffic (ADT) on these county roads would increase to approximately 2,900 vehicles per day, or a 180% increase in ADT. U.S. Highways 72 and 31 would not be significantly impacted.

For a more detailed analysis (Highway Capacity Analysis), the assessment of traffic effects for the project is based on the transportation planning and engineering concept of level of service (LOS). This concept addresses the quality of service, or operating conditions, provided by the roadway network, as perceived by motorists during the peak hour of traffic, typically the afternoon rush hour. Six LOS are designated as A through F, with A being the best. With this type of analysis, level of service D is viewed as the minimally acceptable LOS of the roadway because associated conditions can be tolerable for short periods of time, or peak hour conditions. In contrast, an LOS of E or F would be viewed as an unacceptable level. Peak work force levels were calculated using certain assumptions. First, it was assumed that 80% of the peak on-site personnel would work day shift and travel during peak hours. Also, at worst case, peak work force was determined using both peak construction forces and existing work forces common during an outage. As for the broad ADT analysis, an average ridership of 1.6 workers per vehicle was assumed. Current peak traffic was assumed at 12% ADT and the current truck composition is 10% of average daily traffic. Also, for this analysis, an even split was assumed on the three county roads toward U.S. Highway 72 or U.S. Highway 31.

The results of the level of service analysis show a decrease on the county roads from level of service C to D during the construction phase. The county roads would provide traffic flow conditions where tolerable average operating speeds are maintained but would be subject to

considerable and sudden variation. These conditions can be tolerable for short periods of time. In this instance, such conditions could occur twice during the day and last for up to one hour.

There will also be additional traffic added to the road network throughout the day in the form of construction material deliveries to the site and disposals from the site. This truck traffic will vary over the length of the refurbishment project. For example, the dry cask storage pad construction may generate up to 25 truck trips per day, but would only last approximately a month. The level of service analysis is based upon peak commuter traffic. This condition would only last approximately six months when the maximum work force would be on site; therefore, the analysis provides a conservative estimate. This conservatism offsets and compensates for unknown construction material truck deliveries and disposals, traffic growth, possibility of fewer sharing rides, and variation of traffic flows during peak hours on the local roads, without altering the final results regarding the significance of future road transportation impacts. The level of service analysis concentrates on peak hours; therefore, there would be no loss of level of service during off-peak hours when trucks will mostly travel.

There will be some additional delay at the various plant exits and the intersections with County Road 25 at shift changes. Those experiencing the delay would primarily be the construction commuters. Such a problem can be easily tolerated for the short duration of the peak construction period. If unacceptable delays routinely occur, which is not expected, delayed shift changes could be instituted to help alleviate the problem. In summary, TVA concludes that the roads in the area are capable of absorbing this additional traffic and stay within an acceptable level of service.

IMPACTS OF OPERATION

Additional commuter traffic generated during operation of the refurbished Unit 1 at EPU would result in an ADT increase on the county roads of less than five percent due to an additional workforce of approximately 150 employees. There would also be approximately 50% additional hydrogen and Calgon water chemistry truck deliveries; or less than ten trucks per week. This minor increase in operational traffic results in an insignificant impact to the transportation system.

Traffic growth would continue during the licensing period for 20 years following to year 2033. During this time, traffic volumes would increase, assuming 15% growth rate per decade, to approximately 22,000 vpd on U.S. Highway 72, and 26,600 vpd on U.S. Highway 31. The county roads would increase to approximately 2,700 vpd.

ANTICIPATED IMPACTS

The county roads are in good condition for access and would be adequate to support the traffic requirements during both construction and operation. Traffic increases during construction are much higher than that during operation; however, construction periods are temporary and peak forces only last for approximately six months. Nevertheless, even the traffic increases associated with the peak construction force levels do not result in any unacceptable service levels. There would be some delay turning onto County Road 25 from the plant due to traffic congestion at shift changes and leaving multiple exits simultaneously. Generally, as distance from the site increases and traffic becomes more disbursed, impacts to the transportation network decrease. The major multi-lane highways U.S. Highway 72 and U.S. Highway 31 would provide higher capacity levels and an increase in traffic would tend to be less noticeable in these areas.

Traffic and ADT predictions are projected over many years. These projections may vary greatly over such a length of time. However, over a long period of time, there is a natural progression to improve the quality of the local roadway network. Therefore, as traffic increases, roadway networks are expected to also improve.

4.3.14.2 Railroads

Alternatives 2A, 2B, 2C, or 2D would result in no impacts to the railway system.

4.3.14.3 River Transport

Alternatives 2A, 2B, 2C, or 2D would result in no impacts to river transportation. The potential for discharges from BFN under Alternative 2 to increase the production of steam fog was examined. Compared to three-unit operation of BFN at the original power levels, TVA estimates that for three-unit extended power uprate, the rate of evaporation during such events will increase approximately two percent on average, and on rare occasions might increase as much as much as seven percent. The original analyses for the impact of fog on local water transportation estimated that river traffic could be affected roughly 147 hours per year by diffuser-related operation at BFN (TVA, 1972). Assuming that fogging would increase in direct proportion to the rate of evaporation, this period would increase, at most, to about 158 hours per year. This increase is small and is not expected to significantly exacerbate any existing diffuser-related fog impairments to navigation in the vicinity of BFN.

4.3.14.4 Pipelines

Alternatives 2A, 2B, 2C or 2D would result in no impacts to pipelines.

4.3.14.5 Transmission Lines

If restarted, Unit 1 is projected to return to operation in 2007 with an output of 1,280 MW. An interim study of the impact on the transmission system of BFN Unit 1 restart as an upgraded unit being added in the year 2007 to the previously upgraded Units 2 and 3 has been completed. No new line right-of-ways or construction of new transmission lines would be required or are proposed for the restart of Unit 1. The results of this 2007 load flow study identify the cumulative effects of the three-unit generation changes as well as increased loads in the area and other generation changes in the area. The results of the analysis are:

1) An additional 500-kV circuit breaker would have to be installed in the existing BFN 500-kV switchyard. Other transient stability improvements may be required.
2) The Madison-Redstone 161-kV transmission line (13.2 miles) becomes overloaded due to a single contingency event and would require reconductoring.
3) The following 161-kV lines would become overloaded due to a single contingency event and would require the addition of a second 500-161kV transformer bank at the Madison 500kV substation.

- Limestone-Jetport 161-kV transmission line - 8.1 miles
- Limestone-North Huntsville 161-kV transmission line - 15.9 miles

4) Three 161kV circuit breakers at the Farley 161kV Substation would have to be replaced due to the increased fault currents associated with the addition of the second Madison transformer bank.
5) A Static Var Compensator would have to be installed at an existing TVA substation in order to supply area voltage support.

The right-of-ways that are occupied by the affected transmission lines have been kept clear of tall vegetation. Mowing and other maintenance equipment have been on these right-of-ways periodically over the operation life of the lines and extensive re-clearing the right-of-ways would not be required to reconductor the lines. Impacts associated with these activities are expected to be insignificant. The new Madison 500-161kV transformer bank and the Farley and Browns Ferry circuit breaker installation/replacement involves work within existing TVA property. There are already spaces available for the new transformer bank and circuit breaker installation/replacements therefore the work will require minimal site work. All work will be completed using TVA's Best Management Practices.

TVA continues to study the capability of its transmission system and analyses will be appropriately updated in the future.

4.3.15 Soils and Land Uses

4.3.15.1 BFN Environs

Potential impacts to site soils and land use associated with refurbishing Unit 1 and relicensing all three units are related to construction of cooling towers, buildings, and a dry cask storage facility. Two building are proposed, a Modifications Fabrication Building, and a new Administration Building. Alternative 2A proposes two new mechanical draft towers and Alternative 2B proposes two new hybrid towers. Alternative 2C proposes construction of five linear mechanical draft cooling towers and expansion of existing cooling tower 3. All of the Alternative 2C towers are to be built in the same location as existing towers. The single Alternative 2D cooling tower would be constructed in the location of the number 4 tower that previously burned and was not replaced. The existing Modifications Fabrication Building would be removed to enable construction of the dry cask storage facility. An Administration Building and a new Modifications Fabrication Building would be erected. Temporary land use would be required for activities when removing old components and constructing new components. In addition, the large number of temporary workers needed to accomplish the major refurbishment activities would require temporary facilities be installed for on-site parking, training, site security access, office space, change areas, fabrication shops, mockups, and related needs. This would require from 2.5 to 10 acres. Because any of these structures, either temporary or permanent, would be located on soil which has previously been disturbed, the impacts would be insignificant. The entire plant site is classified as built-up land; thus, any construction at the plant would have insignificant impact to on-site land use.

4.3.15.2 Future Land Uses/Modifications (Including Offsite)

Land use in the region surrounding a nuclear power plant may change as a result of plant-related population growth. The changes proposed by this action only support about 150 additional permanent employees. Any impacts would be temporary and insignificant.

4.3.15.3 Land Use Planning and Controls

Limestone County receives in lieu of taxes revenue from TVA and this revenue significantly aids the development of the county. This revenue would not be adversely affected by implementation of either of the Action Alternatives. No impacts to land development are expected from any of the proposed actions.

Impacts associated with continued use of transmission line right-of-ways (ROWs) after restart of Unit 1 are largely related to agricultural land use. Buildings cannot be built within the ROWs and the vegetation must be maintained to prevent interference with the lines. These effects would continue during the extended license period. No new ROWs for construction of transmission line are proposed as part of the alternatives addressed in this SEIS.

4.3.16 Visual Resources

In addition to the common proposed activities of constructing a dry cask storage facility and a new Modifications Fabrication Building, Alternative 2 proposes the construction of a permanent Administrative Building. These proposed facilities would have minor visual impacts on the industrial character of the plant site. However, adding the proposed facilities would increase the number of adversely-contrasting elements seen inside the development from the rural countryside. These incremental changes may not be individually significant, but together with other facilities, they would add to a continuous growth of structures seen in the landscape and a cumulative reduction of visual resources as seen from the countryside.

Approximately 514 personnel would occupy the new Administrative Building upon completion of construction. Most of these employees would likely be relocated from other existing plant office buildings, making those buildings available for incoming Unit 1 recovery personnel. Parking would be displaced during the construction of the Administrative Building; therefore, the existing gravel parking lots around and among the mechanical draft cooling towers would be used. Parking in these areas would be visually similar to the nearby parking that is being displaced. An additional parking facility, for approximately 200 automobiles, would be constructed immediately northeast of this area in the foreground of County Road 25. The parking facility would be viewable by motorists and workers on the northeast side of the plant site.

County Road 25 provides the main access route to both the plant entrances and to homes north of the site. Most views to the site will be from this area and from the homes across Wheelers Lake at Mallard Creek and Mallard Creek public use area. Increasing the number of vertical objects in the landscape would add to the visually discordant contrast between rural countryside and the industrial character of the plant site. The heights and related dimensions of the proposed structures are shown in Table 4.3.16-1.

Table 4.3.16-1 Summary of Height/Size Information	
Plant Feature (Proposed)	**Feature size same for each alternative**
Mechanical Draft Towers (1 or 2 proposed)	60 feet height
Parabolic Cooling Towers	60 feet height; 300 feet base diameter
Proposed Berms (Soil from existing berm)	10 feet to 40 feet height

Alternate 2A includes the same activities as Alternate 1 with the addition of two new mechanical draft cooling towers located on the west side of the existing cooling towers at the base of the existing berm. In order for the towers to be located in this area, the berm would be modified by removing a portion of the existing earth and placing it in one of three alternate sites. These sites are discussed in greater detail in section 3.1.16.

The new cooling towers proposed under this alternative would be architecturally similar to the existing towers. The proposed towers and the existing would be approximately the same height, as shown in Table 4.3.16-1. The new towers would be seen by motorists along Browns Ferry Road in the middleground as the plant site comes into view, and briefly in the foreground traveling north on County Road 25. Motorists traveling south on County Road 25 would see the upper portions of the towers briefly above the remaining berm on the east side. Residents across Wheelers Lake southwest and from Mallard Creek public use area would see additional vertical structures in the landscape that would obscure views to natural areas beyond. These additional towers would add to the continuous growth of visually discordant structures in middleground views for these residents.

Lowering and re-shaping the existing berm would have both positive and negative impacts. Motorists traveling south on County Road 25 would have much broader views of the cooling towers and of other main buildings within the plant site (i.e., the turbine/reactor building and the new Administrative Building). Residents north of the plant could have views of the skyline affected by the appearance of rooflines of industrial facilities. For these residents, the harmonious mosaic of cultural and natural features in the countryside becomes less intimate.

However, for motorists traveling north on County Road 25, and for workers and visitors within the plant site, re-shaping, lowering, and relocating the berms to one of three alternate locations could have a positive or beneficial affect. The topography surrounding BFN is gently rolling with little visual interest achieved through dramatic elevation changes. By creating elevation changes with berms, scenic classification could range from moderately desirable to desirable. Elevation changes, particularly with heights over ten feet, break up forms in the foreground and add visual interest to a viewshed.

Alternate 2B would be the same as Alternate 2A with the exception of two new hybrid “modified parabolic” cooling towers that would be used instead of the mechanical draft towers. These towers would provide a striking contrast when viewed adjacent to the existing mechanical draft towers. Materials, colors, and forms would be quite different. For residents across Wheeler Lake and visitors at Mallard Creek day use area, the towers would increase the number of adversely-contrasting elements as seen in the middleground across the river.

Alternate 2C, demolishing the four existing Ecodyne cooling towers, constructing five new linear mechanical draft cooling towers and increasing the size of the existing Balke-Durr cooling tower by 25%, would add to the number of linear elements seen across the plant site. The new mechanical draft towers would be larger than the existing Ecodyne cooling towers, providing a greater contrast to the broadly horizontal forms seen over the plant site now. Motorists along County Road 25 would have the greatest views of the new towers.

Alternative 2D is the construction of one 20-cell mechanical cell draft cooling tower to replace the one previously in position 4 that had previously burned down and was not replaced. For this alternative a slightly larger (longer) cooling tower (20-cell) vs 16 cell) would be constructed in lieu of the one earlier committed to for EPU of Units 2 and 3. The visual impact of this Alternative 2D would essentially be the same as that for Alternative 1 since a single mechanical cooling tower of a similar design (but slightly shorter length) would otherwise have been built in the same location for the EPU project.

In comparison, Alternatives 1 and 2D would have the least visual impact (of the Action Alternatives) for plant workers, visitors, and motorists along County Road 25. These alternatives would require the least amount of grading and earth moving activities, particularly since the berm adjacent to the cooling towers would not be disturbed. The new Administrative Building, modification and fabrication shop, and proposed dry cask storage facility would have little visibility from nearby homes and passing motorists. Development of these alternatives would result in fewer cumulative visual impacts within BFN industrial setting.

IMPACTS OF CONSTRUCTION

As the new Administrative Building reached completion, it would be seen in the foreground by passing motorists. Very little, if any, outdoor work for Alternatives 1 or 2 would take place at night. This is also true for work during the “No-Action Alternative” because it includes the dry cask spent fuel storage facility and the new modifications/fabrication building. Any outdoor night-time work would be minimal and would be the exception, not the general practice. There may be some indoor work scheduled at night, particularly for support tasks such as scaffolding and other job preparations. Scenic integrity in the area would be somewhat low during the construction process. The visual discord of construction would be temporary, and would last until site cleanup and reclamation of disturbed areas are complete.

Alternate 2A would have the same impacts of construction as Alternate 1 with additional grading and the introduction of two new vertical structures in the landscape. There would be a temporary increase in the amount of machinery seen on site from area residents and motorists. Construction activities would include tree removal from the berm area, material stockpiles, and related work seen in the foreground and middleground from the highway and nearby homes. There could potentially be an increase in truck traffic along County Road 25 as dirt is being hauled from the existing berm to one of the three alternate sites. Scaffolding, lift trucks, and other machinery would be seen by area residents during the construction of the two new mechanical draft cooling towers.

Alternate 2B would have similar visual impacts during construction as Alternate 2A. During the construction process, different types of machinery may be utilized to construct the modified parabolic cooling towers than the mechanical draft units, and frequencies for material deliveries may vary. However, visual discord would be temporary and would last until site cleanup is complete.

Alternate 2C would require various pieces of machinery, staging areas, and storage yards for the removal of the existing cooling towers and the construction of the new, larger towers. Some of this equipment, such as cranes, could be readily seen in the foreground by local residents and motorists along County Road 25. Scenic integrity could be low during this period. As with each of the proposed alternates, visual discord as a result of construction will last only until the site has been restored to pre-construction conditions

Alternate 2D would have construction impacts similar to Alternate 1 with additional grading and the introduction of one new vertical structure in the landscape. There would be a temporary increase in the amount of machinery seen on site from area residents and motorists. Construction activities would include material stockpiles, and related work seen in the foreground and middleground from the highway and nearby homes. Scaffolding, lift trucks, and other machinery would be seen by area residents during the construction of the one new mechanical draft cooling tower. Since the berm would not need to be lowered or re-shaped and removed, impacts associated with those activities would not occur

IMPACTS OF OPERATION

Under Alternatives 2A, 2B, 2C, and 2D, the impacts for operation would be identical and similar to those in Alternative 1. In each of these alternatives, additional plumes may be seen as a result of adding either one or two additional cooling towers. The shape, size, and duration of these plumes would vary with operations and atmospheric conditions.

4.3.17 Recreation

Impacts for Alternative 2 (A, B, C, and D) would be insignificant because no recreational facilities, resources, or uses would be affected. This includes activities associated with the construction of the proposed dry cask storage, the modification fabrication facilities, and the permanent Administration Building as well as the restoration and restart of Unit 1. Accordingly, cumulative impacts for Alternative 2 (A, B, C, and D) also would be insignificant.

4.3.18 Cultural Resources

4.3.18.1 Archaeological Resources

Under Alternative 2, TVA is considering refurbishing and restarting Unit 1 in addition to extending the licenses for all three units. The four variations of this alternative, 2A, 2B, 2C, and 2D, proposed the addition or replacement of cooling towers in the vicinity of the present mechanical draft towers. The proposed construction activities included in 2A, 2B, 2C, and 2D are in previously disturbed locations and would not directly affect historic properties, but would result in excess waste disposal in the three designated spoil disposal areas. The construction of the proposed dry cask storage facility, Modifications Fabrication Building, and Administration Building will not have any direct affects on historic properties, but would also result in disposal of material in the three designated spoil disposal areas.

The disposal of materials in these areas may affect historic properties that are listed or have the potential to be listed in the NRHP. One potentially eligible archaeological site was identified during the Phase I survey of Area 1 (see Figure 2.2-7). This site has a potential to have intact deposits that would provide valuable information about the prehistoric period in this region. The site is marked on BFN drawings and it is expected that it would be avoided by any future activities. If avoidance is not possible, a Phase II archaeological survey would be conducted. A Phase II survey would require additional excavation through close interval shovel testing, hand-dug test unit excavation and potentially backhoe trenching in order to delineate site boundaries and establish site significance. Any such investigations would require consultation with the SHPO. The Cox Cemetery, located in Area 2, would be avoided by all disposal activities.

4.3.18.2 Historical Structures

No historic structures were identified within the visual area of potential effect. Therefore, there will be No Affect on historic structures.

4.3.19 Environmental Noise

Additional or larger replacement cooling tower(s) are the only sources of potential noise effects from the action alternatives. The cooling towers for action Alternative 2A include the original cooling towers and two more similar ones located to the northeast of current towers 4, 5, and 6, see Figure 2.2-6. Cooling towers for Alternative 2B also include the original towers and two, circular towers. These round towers are about 300 feet in diameter, 60 feet high, and have 18, 300 horsepower fan-motors. See Figure 2.2-8 for the locations of the additional circular cooling towers. Alternative 2C expands tower 3 by 25%, replaces towers 1, 2, 5, and 6 with larger capacity ones, and erects a similar one on the site of tower 4. A single 20-cell mechanical draft cooling tower similar to, but slightly larger than those towers already at Browns Ferry, would be constructed under Alternative 2D.

4.3.19.1 Construction Noise

Potential construction noise effects for Alternatives 2A, 2B, 2C, and 2D come from sources typically found at medium size industrial construction projects. Construction projects have phases that usually include: clearing and/or demolition; site preparation and excavation; placing supports and foundations; erecting structures or buildings; and finishing and cleanup. Each of these phases has its own combination and number of noise emitting pieces of equipment and processes. For example, clearing and demolition routinely use grubbing hoes and bulldozers; while placing supports and foundations might need pile drivers and cement mixers. In general, equipment with larger engines makes more noise than equipment with smaller engines, and processes that rely on impact action produce higher peak noise than continuous operations. In addition, the condition of the equipment can greatly influence the noise emissions. Noise emissions at 50 feet from construction equipment range from about 75 dBA for a forklift or modern tractor to over 100 dBA for pile driving. Also, the duration of the construction phases impacts the potential noise effects.

Each of the Alternatives would have a slightly different set of equipment and phase durations for their respective construction. Where 2A and 2B would require more earthmoving than 2C, 2C requires demolition of existing cooling towers. Alternatives 2A and 2B might require more foundation work than 2C, but 2C probably requires more actual building of structures. Construction of the one tower for Alternative 2D, would require the least demolition and construction activities among the Alternative 2 options. The total time and equipment for these Alternatives should be about the same.

Predicting the level of intruding noise in the Paradise Shores area from any of the Alternatives would be highly speculative because of the variables discussed above. Based on other construction projects, it is likely that construction noise would be heard in the Paradise Shores area, and impact noise such as pile driving might be heard across the river at the Lakeview community. Although heard, the potential effect of this intruding noise should be insignificant for several reasons, including:

- Very little, if any, outdoor work for Alternatives 1 and 2 would take place at night. This is also true for work during the No-Action Alternative such as the dry cask spent fuel storage facility and the new modifications/fabrication building. Any outdoor night-time work would be minimal and would be the exception, not the general practice. There may be some indoor work scheduled at night, particularly for support tasks such as scaffolding and other job preparations, but this would be limited.
- The great majority of construction work to refurbish Unit 1 for restart will be done inside the generation building and reactor containment.
- Construction is usually a five-day-a-week operation. It follows the normal business week and leaves the weekends free from the intruding noise.
- The cooling towers' construction durations of the Action Alternatives are relatively short, about nine months, and the noisiest phases of the construction, usually site preparation and foundation work, are even shorter. It is expected that, following spoils removal, the site preparation and foundation work for the two additional cooling towers for Alternatives 2A and 2B will be about three months.
- None of the intruding noise from even the peak noise sources would be a hazard to hearing loss or interfere with communications.
- People understand and accept that construction projects use heavy equipment and that the equipment produces noise, and they understand that the construction has an ending point.

Although the construction would probably be heard, potential noise effects can be addressed or ameliorated in several ways if necessary. TVA would include contractual requirements for its construction vendors to only use equipment in good operating condition with factory equivalent muffler systems and to use portable noise barriers where practical. The residents of Paradise Shores would be notified about the cooling tower construction schedule and would be given a contact person and telephone number to respond to questions and concerns.

Overall, residents in the Paradise Shores area should hear construction noise, but this should be of a relatively short duration, and the long-term effect is expected to be insignificant for the reasons given above.

4.3.19.2 Intruding Noise

The intruding noise from the cooling towers for Alternative 2 was calculated using information from two potential vendors and the protocol in the EEI, Electric Power Plant Environmental Noise Guide (EEI, 1984). This guide gives a comprehensive method of estimating the sound power of the noise emitting equipment and calculating the propagated noise at a receiver location. It is assumed that the meteorological conditions are for summer, and no additional noise reducing factors such as ground or foliage attenuation were used.

Table 4.3.19-1 presents the total noise from each action alternative at both Paradise Shores and the Lakeview community.

Table 4.3.19-1 Total Noise at Paradise Shores and Lakeview Community for Alternative 2 (All data in dBA)

Location/Alternative	Total L_{eq} 24 hour	DNL 24 hour	Average annual DNL 17 days op.	Average annual DNL 27 days op.
Paradise Shores/ Current[1]	47	52	50	50
Alternative 2A	47	53	51	51
Alternative 2B	48	53	51	51
Alternative 2C, vendor 1[2]	54	61	53	53
Alternative 2C, vendor 2[3]	50	57	52	52
Alternative 2D	48	53	51	51
Lakeview Community/ Current[1]	44	48	46	46
Alternative 2A	44	48	46	46
Alternative 2B	44	48	46	46
Alternative 2C, vendor 1[2]	45	49	46	46
Alternative 2C, vendor 2[3]	43	47	46	46
Alternative 2D	44	48	46	46

[1]All original cooling towers operating at full capacity.

[2]Cooling tower vendor 1 is Balcke-Durr, which estimated noise values based on empirical handbook data.

[3]Cooling tower vendor 2 is Marley, which supplied noise data based on actual field measurements from similar towers.

4.3.19.3 Effects

4.3.19.3.1 Guidelines

The average annual day-night average sound level (DNL) for Alternatives 2A, 2B, 2C, and 2D are under the EPA guideline of 55 dBA based on 17 days of full capacity operation. At the high end of the operating range of 27 days, the average annual DNL for each alternative is still under EPA guideline. The primary noise source will be large cooling tower fan motors.

Table 4.3.19-1 shows the total noise levels at Paradise Shores and the Lakeview community for all original cooling towers operating at full capacity. Using these values as a baseline for comparison, the total noise level (24 hour DNL) for Alternative 2C (with either of two potential cooling tower vendors) would be above the three dBA incremental increase guideline (FICON, 1992) at Paradise Shores, but not at the Lakeview Community. This level, which calls for additional analysis, occurs only on the days that all of the Alternative 2C cooling towers (either potential vendor) operate and indicates a potential significant effect. Although the potential increase in the 24-hour DNL is above the FICON guidelines for both vendors in Alternative 2C, the potential increase in the average annual DNLs are 3 dBA or less for both vendors, which is not significant at the current DNL of 52 dBA. The additional analysis was completed and included all variations of Alternative 2 described in this document and potential mitigation presented at the end of this section.

As a comparison to the guideline used in the original EIS, none of the Alternatives 2A, 2B, 2C, or 2D causes total 24 hour DNLs above 65 dBA that HUD uses as normally acceptable for residential development (HUD, 1971, 1985).

4.3.19.3.2 Hearing Loss

No residents in any of the adjacent communities would be exposed to noise levels that are hazardous to their hearing from Alternatives 2A, 2B, 2C, or 2D.

4.3.19.3.3 Annoyance

There could be a small percentage of residents of Paradise Shores highly annoyed from the intruding noise associated with the action alternatives. The largest 24 hour DNL from Alternative 2C, vendor 1, could highly annoy as many as six to seven percent of the residents based on equation 3.19-1 or Table 3.19-1. Alternative 2C, vendor 2, has the next highest 24-hour DNL, which could highly annoy four to five percent. The percentage of highly annoyed from Alternatives 2A, 2B, and 2D are about two to three percent. The same techniques show that the current environment could also cause about two to three percent of the residents to be highly annoyed.

Less than two percent of the residents in the Lakeview community should be highly annoyed from the intruding noise associated with Alternatives 2A, 2B, 2C, or 2D.

4.3.19.3.4 Communication Interference

Sentence intelligibility would not be affected by the intruding noise associated with the action alternatives at Paradise Shores or the Lakeview community. The highest 24-hour L_{eq} is 54 dBA at Paradise Shores from Alternative 2C, vendor 1. At this level, EPA estimates sentence intelligibility to be 99% (EPA, 1974). None of the 24 hour DNLs would cause indoor communication interference based on the assumption that normal residential construction provides 20 dBA noise reduction (FICUN, 1980). This reduction would limit the intruding noise to 41 dBA or less inside the residences.

4.3.19.4 Summary

The potential 3 dBA or more increase in the total noise 24 hour DNL would not meet the guideline given by the Federal Interagency Committee on Noise (FICON) for Alternative 2C, vendors 1 and 2. These potential noise effects could be reduced by using a well planned operating procedure for the cooling towers and by using low-noise fan-motors in the design of the new towers. Operating the cooling towers farthest away from Paradise Shores when feasible would also significantly reduce the intruding noise to just a few days per year. This would reduce the percentage of residents who could be highly annoyed.

The EPA guideline of 55 dBA average annual DNL is met with all alternatives at both locations.

There are no noise consequences from Alternatives 2A, 2B, 2C, or 2D in the Lakeview community.

4.3.20 Safety and Health (Non-Radiological)

If Unit 1 recovery and license renewal/extended operation is added to the license renewal and continuing operation of Units 2 and 3, there is still no change to the Safety and Health Program described in Section 3.20. However, during the construction/modification work in recovering Unit 1 injury rates would be expected to be higher than during periods of operation. Based on a review of past performance, these injury rates would be expected to be approximately 20% higher than during periods of operation.

4.3.21 Radiological Impacts

4.3.21.1 Normal Operation

4.3.21.1.1 Occupational

Alternative 2 activities (as described in section 2.2.1) address Unit 1 recovery and operation at an EPU, and a 20-year operating license extension for all three units. This alternative has the most significant occupational radiation dose impact of the identified alternatives. Occupational radiation

dose refers to radiation dose received by individuals as a course of their employment. Parameters considered for the analysis included: baseline occupational dose, projected dose increments, and an estimated cancer risk increase for the projected dose increments.

Baseline Occupational Dose

This section contrasts the current industry and facility occupational radiation dose trends against the current limits established by federal regulation. Selected attributes for the comparison are the average annual dose received by a worker, average annual dose per reactor, the collective worker dose, and the percentage of workers that receive radiation dose above a given threshold. Radiation dose attributes are categorized by reactor type. Light water power reactors in use within the United States are either a pressurized water reactor (PWR), or boiling water reactor (BWR) design. BFN reactors are the BWR type. Title Ten of the Code of Federal Regulations Part 20 (10 CFR part 20) establishes occupational radiation dose limits. These limits are designed to minimize the potential health risk to the worker. The annual occupational radiation dose limit for a worker is 5.0 rem. Facility radiation exposure control policies ensure compliance with established federal regulations and incorporate ALARA (as low as reasonably achievable) philosophies. Table 4.3.21-1 summarizes the current occupational radiation dose trend for the BWR industry and BFN.

Table 4.3.21-1 Baseline Occupational Radiation Dose (rem)

	Average Annual Worker Dose	Annual Dose Per Reactor	Collective Worker Dose	Percent of Workers > 2 rem
BWR Industry -1999[1]	0.110	184	6473	0.029
BFN - 1999[2]	0.122	223	447	0
BFN - 2000[2]	0.122	167	333	0
BWR Ind. 1994-1999[1]	0.243	236	51902	0.467
BFN 1994-1999[2]	0.419	250	2999	0.061

[1] NUREG 0713 Vol. 21 (1999)
[2] BFN Radiological Data: 10CFR20.407 Submittals, or Facility Radiological Control Database.

Projected Dose Increments

Projected dose increments are a forecast of dose increase for the proposed activities. Activities that may contribute to a dose increase are EPU, additional facility maintenance or modification needed to support an extended license agenda, and Unit 1 recovery. Each of these topics is addressed in the following paragraphs.

EPU at Units 2 and 3 has been addressed by a specific environmental assessment (EA). A conservative basis assumption of that EA is that the annual collective dose would increase in direct proportion to the power level. Table 4.3.21-2 summarizes the current facility dose parameter and forecasts the EPU basis dose assumption.

Table 4.3.21-2 Extended Power Up-Rate Dose Impact		
	Average Annual Collective Dose (rem)	Average Annual Collective Dose Per Reactor (rem)
BFN 2-Unit (1994-2000)	438	219
Alternative 1	526	263
Alternative 2	789	263

Facility maintenance or modification needed to support a license extension (Alternative 2) for Units 2 and 3 should not be necessary. Unit 2 and 3 systems received repair and modification during the extended outages that concluded May 24, 1991, and November 19, 1995, respectively. Further, Units 2 and 3 will have received extended power up-rate modification prior to license extension. These units should be prepared to operate through the extended license period without additional significant maintenance, modification, or refurbishment.

Unit 1 has been in an extended outage since March 1985. The estimated resources (work within the power house, potential radiation exposure environment) to recover the unit is 7.385 million man-hours protracted over a five year period. An estimated dose rate (rem per hour) was derived from Unit 2 and 3 data. Data was corrected to account for radioactive material decay that has occurred during the Unit 1 extended outage (i.e., 15 years). The decay correction factor is 0.145. The average collective dose (1998 to May 2001) is 395 rem; the average annual man-hours in the power house for the same period is 541,712. The quotient of these values yields the desired dose rate: 0.00073 rem per hour. An estimated dose for the Unit 1 recovery is defined by the product of the man-hours, decay correction factor, and the dose rate; 782 rem (7.385×10^{6} hours X 0.145 X 7.3×10^{-4} rem/hour). An estimated collective dose for the Alternative 2 scenario (Unit 1 recovery, 3-unit EPU, and 20-year extended license) is 16,562 rem [782 rem + (263 rem/Reactor-year X 3 Reactors X 20 years)].

Cancer Risk

Health risk associated with radiation dose may be segregated into two general categories, non-stochastic and stochastic. A direct association of cause and effect is representative of the non-stochastic category. An example would be the death of an individual that received a radiation dose of 2,000 rem over a short period of time (a few hours). Stochastic effects are those that occur at random with no direct association to a causative agent. Cancer is an example of a stochastic effect. Cancer occurs spontaneously with no specific association with a causative agent. Hiroshima and Nagasaki bomb survivors who received radiation doses greater than 50 rem have experienced an increased cancer rate when compared with similar populations that only received background radiation dose. Background radiation dose is dose received by members of the public from naturally occurring radioactive materials in the earth's crust and cosmic radiation.

Stochastic Radiation Effects

Stochastic radiation effects are random events whose probability of occurring (rather than the severity of the effect) is a direct function of dose. These effects are normally regarded as having no threshold. Radiation carcinogenesis is generally regarded as stochastic. Cause-effect functions called *Dose Response Models* have been developed to estimate the stochastic effects for radiation exposure. A dose response model hypothetically relates a biological effect to the dose received by either a cell or an individual. It correlates the radiation dose received with the biological effect expected to be observed. There are currently four different hypothetical dose response models that

are commonly used to predict radiation induced biological effects. These models are illustrated in Figure 4.3.21-1 and explained as follows:

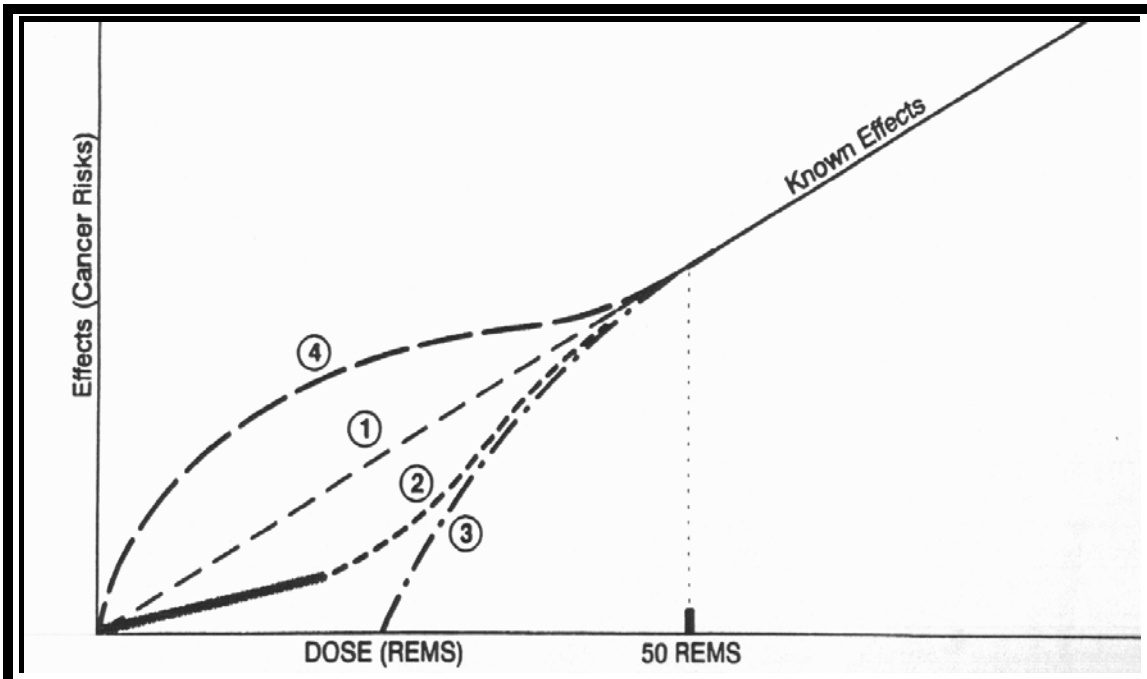
Curve 1: In the linear dose response model, the relationship between the dose received and the biological effect is considered directly proportional. The effect of any one unit of dose would be the same for either a high or a low dose. Thus if 10,000 rem resulted in one additional cancer, 1,000 rem would be predicted to result in 0.1 additional cancers, and 100 rem would be predicted result in 0.01 additional cancers. This is a simple linear proportionality.

Curve 2: The linear quadratic dose response model contains both a linear and a quadratic term. It hypothesizes that the effect is linear for a low dose (as in curve 1) and increases more aggressively as the dose is increased. Therefore, the dose response curve is linear in the low-dose range, becoming quadratic as the dose is increased. The majority of scientists today and the NRC endorse the use of the linear quadratic dose response model. (U.S. Nuclear Regulatory Commission. *Instructions Concerning Risks From Occupational Radiation Exposure.* Regulatory Guide 8.29. Washington, DC)

Curve 3: The third dose response model is known as the threshold model. It postulates that there is a level of dose below which there is no measurable or observable effect. Once that threshold dose is reached, the effect may increase with increasing dose by a linear, linear-quadratic, or quadratic model.

Curve 4: A few scientists believe that radiation effects level off with increasing exposure so that even a small dose implies a significant risk.

Figure 4.3.21-1 Dose Response Models That Predict How The Effects Of Radiation Vary With Dose At Low Levels



Estimated Cancer Risk

NUREG-0713 Vol. 1 Section 4.6.3.2 references the collective background radiation dose to the U.S. population to be on the order of 75 million rem/year. This background radiation dose is presumed to present no discernible health risks. Cancer risk is often assessed in terms of the relative increase with respect to the hypothetical causative agent. A fatal cancer risk coefficient of 4×10^{-4} rem^{-1} has been recommended by BEIR-V 1990. As an example; the possible annual cancer events from the U.S. background dose is 30,000 (75×10^{6} rem X 4×10^{-4} rem^{-1}). The increased total BWR industry collective dose for 1999 with respect to the 1999 U.S. background dose is 30,002.59 (75, 006,473 rem X 4×10^{-4} rem^{-1}). This represents a 0.0086% increase {100 X (30,002.59 - 30,000)/30,000}. Table 4.3.21-3 summarizes the relative annual cancer risk with respect to the U.S. background dose. Table 4.3.21-4 summarizes the relative cancer risk for the proposed actions relative to the BWR industry collective dose.

Table 4.3.21-3 Annual Occupational Radiation Dose Increased Cancer Risk Relative to U.S. Population Background Dose

	Average Annual Dose - 1999		
	U.S. Background	BWR Industry	BFN
Collective Dose (rem)	75×10^{6}	6473	447
Possible Cancer Increase	30,000	2.59	0.179
Percent Increase	0	0.009	0.0006

Table 4.3.21-4 Occupational Radiation Dose Increased Cancer Risk Relative to BWR Industry Collective Dose

	Collective Worker Dose		
	BWR Industry	Alternative 1	Alternative 2
Collective Dose (rem)	418,557	10,520	16,562
Possible Cancer Increase	167.4	4.2	6.6
Percent Increase	0	2.51	3.96

NUREG-1437 Vol. 1 Section 4.6.3.2 postulates the radiation dose attributable to license extension might result in a five percent increase in the calculated cancer incidence to workers, but there may be no increase. The estimated cancer risks for the proposed activities are bounded by the NUREG-1437 Vol. 1 Section 4.6.3.2 assumptions.

Conclusions

Occupational radiation dose attributed to the recovery of Unit 1, and normal three-unit operation to the conclusion of the current license and into an extended license period has been examined from multiple perspectives. Average annual dose to the worker and the average annual dose per operated reactors are consistent with current BWR industry trends. Worker radiation exposures are controlled to be significantly less than the limits established by federal regulation, 10 CFR part 20. The estimated cancer risk increase associated with the occupational dose forecast for Alternative 2 activities is demonstrated to be bounded by the assumptions stated by NUREG-1437 Section 4.6.3.2. In that the No Action Alternative (discontinue operation of Units 2 and 3 when their current licenses expire) and Alternative 1 have less occupational radiation dose significance than those analyzed for Alternative 2, these scenarios are similarly bounded.

4.3.21.1.2 Public

The radioactive effluent releases or exposures from BFN operations are expected to increase no more than 1.8 times (see following note) recently reported values after a restart of Unit 1. The recently calculated doses are a small fraction of the applicable radiological dose limits and are expected to remain a small fraction of dose limits. The impacts to the environment are expected to have negligible impact due to restart of Unit 1.

NOTE: Recent dose and release data reflect 2 reactors operating at 100% of initial rated power. The two operating reactors have been re-licensed to operate at EPU and it is assumed that Unit 1 would be re-licensed to operate at EPU before restart (i.e., three reactors at 120% vs. data for two reactors operated at 100%; 360% / 200%; hence 1.8).

4.3.21.2 Facility (Design Basis) Accidents

The design basis accidents addressed in Chapter 14 of the BFN UFSAR are independent of the age of the plant. Therefore, extension of the operating lifetime of the plant from 40 to 60 years will not impact these accidents. This applies to all three units.

4.3.21.3 Severe Accident Mitigation Alternatives

The BFN Severe Accident Mitigation Alternatives (SAMA) analysis is summarized in Section 4.2.21.3 and included as Appendix A of this SEIS. The SAMA analysis addresses restart of Unit 1 and operation of all three units at EPU, and therefore addresses both Alternatives 1 and 2.

4.3.22 Decommissioning Impacts

Under Alternative 2, Unit 1 would join Units 2 and 3 in extending operation for an additional 20 years past expiration of the current licenses. Similarly to Alternative 1, decommissioning would be delayed by this 20 year period under Alternative 2, providing an opportunity for decommissioning technology (including more advanced robotics) and the licensing framework to evolve and mature. In addition, it becomes more likely that a permanent spent fuel repository would be available prior to the completion of decommissioning. Consequently, in comparison with the No Action Alternative, the potential for adverse environmental effects from decommissioning could be reduced under either of the action alternatives.

4.4 Identification of Mitigation Measures

Mitigation includes avoiding, minimizing, rectifying, reducing, or compensating for the impacts. Some potential mitigation measures were identified in the discussions of environmental consequences earlier in Chapter 4. These measures are generally of two types:

- physical changes incorporated during project design and construction, and
- programs and environmental controls initiated to meet regulatory standards.

These potential mitigation measures are assumed to be implemented as part of the actions proposed in Chapter 2 and provide part of the basis for the identification of environmental impacts in Chapter 4. In other words, these measures would be integrated into the action and would be conducted as part of the project.

4.4.1 Air Resources

Mitigation measures to minimize potential air pollutant emissions during construction activities for the new Administration Building, the new Modifications Fabrication Building, the dry cask storage facility, and any new cooling towers would be the best management practices that TVA uses for construction of any new facilities. This would include such measures as wetting ground surfaces as appropriate to reduce fugitive dust, requiring equipment and trucks to be well-maintained and tuned for efficient fuel combustion, covering fuels and fueling connections to minimize evaporative losses, and requiring contractors to adhere to such policies.

No specific mitigation measures are expected to be required during operational use of the new facilities.

4.4.2 Geology

No mitigation is identified for Alternatives 1 or 2.

4.4.3 Solid Wastes Management and Past Practices

No mitigation is identified for Alternatives 1 or 2.

4.4.4 Hazardous Wastes Management and Past Practices

No mitigation is identified for Alternatives 1 or 2.

4.4.5 Spent Fuel Management

No adverse environmental impacts that require mitigation have been experienced or are expected from spent fuel management at BFN. This is because similar facilities (spent fuel pools at TVA nuclear plants and dry cask storage facilities at other utilities) have been in successful operation for years. Should an unexpected problem develop regarding the handling or storage of spent fuel, a number of options are available to the BFN staff. These range from minimizing worker dose (by decreased exposure time, increased distance to the source, and/or intervention of shielding) to modifying or selecting a different storage cask design. No mitigation measures are identified at this time for either alternative.

4.4.6 Surface Water Resources

No mitigation is identified for Alternatives 1 or 2.

4.4.7 Groundwater Resources

No mitigation is identified for Alternatives 1 or 2.

4.4.8 Floodplains and Flood Risk

No mitigation is identified for Alternatives 1 or 2.

4.4.9 Terrestrial Ecology

No mitigation is identified for Alternatives 1 or 2.

4.4.10 Aquatic Ecology

No mitigation has been identified as necessary for Alternatives 1 or 2. TVA will confirm the expected levels of impingement and entrainment of fish by monitoring under current 2-unit operation and following return of Unit 1 to service. TVA's Vital Signs monitoring program will also continue to assess aquatic ecological communities in Wheeler Reservoir. Although not expected, if based on these monitoring studies it is determined that the location, design, construction, and capacity of the cooling water structure were causing adverse environmental impact, TVA would undertake an assessment of reasonably available/achievable technologies, operational measures, and restoration measures to minimize that adverse impact at the BFN site, and institute that or those measures which in consultation with the permitting agencies are determined to be the appropriate.

4.4.11 Threatened and Endangered Species

No mitigation is identified for Alternatives 1 or 2. None of the alternatives are expected to affect any listed species.

4.4.12 Wetlands

No mitigation is identified for Alternatives 1 or 2, as there are no wetlands present in any of the areas proposed for spoil disposal or excavation.

4.4.13 Socioeconomic Conditions

No mitigation is identified for Alternatives 1 or 2.

4.4.14 Transportation

Specific site mitigation measures to improve the local roadways could include employee programs that provide flexible working hours. This would reduce road travel during peak hours. Delayed shift changes would also help alleviate the congestion at the plant entrances/exits. Restrictions for trucks traveling during the peak hour could also be made. None of these measures are being committed to at this time, but would be implemented if transportation delays become intolerable.

If very heavy loads are to be transported on the plant site, TVA would assess the impact of these loads over or adjacent to underground structures (e.g., a pipe or a concrete cable tunnel that could be damaged). Ground loadings in these critical areas would be minimized by constructing temporary “bridges” over the underground structures and/or using transport vehicles with increased axles and wheels to minimize load pressures. When heavy loads are hauled on public roadways, it is normal engineering practice for the transport company to define the route and obtain necessary permits for hauling heavy loads. In addition, trucks would meet all safety standards and hauling would comply with all federal, state, and local ordinances.

4.4.15 Soils and Land Uses

No mitigation is identified for Alternatives 1 or 2.

4.4.16 Visual Resources

No mitigation is identified for Alternatives 1 or 2.

4.4.17 Recreation

No mitigation is identified for Alternatives 1 or 2.

4.4.18 Cultural Resources

The archaeological site identified in Spoils Disposal Area 1, along with an adequate buffer zone, would be excluded from the disposal area or Phase II testing would be conducted to confirm the significance of the site. If the site is determined by Phase II testing not to be significant, no further consideration of the site would be required.

Cox Cemetery, along with an adequate buffer zone, would be excluded from Spoils Disposal Area 2.

4.4.19 Environmental Noise

The potential 3 dBA or greater increase in the 24 hour DNL for action Alternative 2C, vendors 1 and 2, at Paradise Shores would be reduced much of the time. Frequently, the intruding noise would have less than a 3-dBA increase when fewer than all of the cooling towers are running or when they run at reduced capacity. This would be especially noticeable if towers 3 and 4, which are closest to Paradise Shores, are the last to be operated and the first to be shut-down. The 24-hour L_{eq} drops by 6 dBA for both alternatives when towers 3 and 4 are not operating.

Using low-noise fans that operate at reduced speeds are effective when included as part of the cooling tower design. Low-noise fan-motors are 7 to 8 dBA less than standard ones. This reduction would lower the total noise at Paradise Shores to about background noise levels.

TVA would further analyze several options for mitigating the potential noise increase at Paradise Shores prior to accepting the final design for the cooling towers from the selected vendor. Some of the options include, but are not limited to: using low noise fans on all cooling towers for Alternative 2C; using low noise fans only on towers 3 and 4; instituting operating instructions to minimize the use of towers 3 and 4; and soliciting other noise reduction options from the cooling tower vendor.

4.4.20 Public and Occupational Safety & Health (Non-Radiological)

No work activities associated with license renewal and possible Unit 1 recovery are projected to require mitigation regarding health and safety. Any plant process or activity that results in harm to individuals, on site or off site, would be suspended (i.e., "stop work") until it could be re-evaluated and the problem corrected.

4.4.21 Radiological Impacts

BFN has been carefully designed, built, and is operated to minimize all releases of radiation emissions to the environment. To ensure public and worker safety, the plant is monitored to strict safety standards set by the regulator on a 24-hour a day, seven days a week basis. Nuclear plant emissions for TVA have always been at or below the safe levels permitted by federal standards. TVA has demonstrated and continues to demonstrate an excellent safety record in this area for its two operating units at BFN and at its other nuclear stations. TVA aggressively conducts a sustained effort to ensure that collective worker radiation doses, as well as annual and cumulative lifetime individual worker radiation doses, are maintained as low as reasonably achievable (ALARA).

Unexpected radiation dose problems are rare, but are mitigated in exactly the same manner as expected or anticipated problems, in keeping with the ALARA concept. This can involve a wide range of dose minimization strategies in the detailed work planning, including use of least exposure pathways, minimizing the time to complete the task, practicing the activity with mock-ups, etc. Additional shielding or the use of respirators may be adopted if it is determined that the total integrated dose is reduced (i.e., the dose increase from placement and removal of the shielding or due to the increased dwell time from being slowed down by the respirator is more than offset by the decrease in worker task dose). Although no activities associated with the Alternatives in this SEIS are projected to have associated radiological impacts requiring mitigation, any unexpected problems would be remedied accordingly.

4.5 Irreversible Adverse Impacts

Continued operation of the BFN units would result in unavoidable but very minor impacts to air and water quality, sound and visual resources. Air quality would continue to be affected by routine radioactive gaseous emissions typical of boiling water reactor operations. Water resources would continue to be affected in terms of surface use and quality because of routine radioactive effluent releases and the need for cooling water. Unit 1 operation (at EPU) would result in increased waste heat discharge to Wheeler Reservoir, but all regulatory temperature limits would be met. Unit 1 operation (at EPU) would also result in increased entrainment and impingement of aquatic biota, which is not anticipated to be environmentally significant. The routine discharge of chemicals would continue to have a minor affect on the aquatic biota near the plant discharge pipes. Also unavoidable would be the generation of additional low-level radioactive waste, which would be transported and managed off-site at a low-level radioactive waste disposal facility such as the one in Barnwell, South Carolina.

Alternative 1 essentially involves no change from the present day operation of BFN except that additional on-site storage capacity for spent fuel would be needed unless a national repository (such as the one being developed at Yucca Mountain, Nevada) is competed and becomes available before the current operating licenses for Units 2 and 3 expire (2014 and 2016, respectively). The irreversible adverse impacts are therefore limited to the continued generation of various types of wastes, including spent nuclear fuel, and a larger temporary facility to store that spent nuclear fuel.

Irreversible adverse impacts for Alternative 2 would be the same as those for Alternative 1; except for the addition of significant cooling tower capacity, some minor building changes and additions, and operating equipment refurbishments.

4.6 Relationship of Short-Term uses and Long-Term Productivity

The economic and societal returns to the TVA service region would be considerable for either Alternative 1 or 2, including continued stable and dependable electricity, and continued employment covering a wide spectrum of jobs and pay ranges. Demands for peaking and baseload energy are projected to increase, and license renewal of the BFN units is one way to help meet the continuing demand for baseload resources. Alternative 1 would maintain BFN as a preferred significant local employer with very minimal consumption of resources.

The construction of additional cooling tower capacity associated with Alternative 2 would result in small short-term impacts to the environment relative to the long-term maintenance and enhancement of productivity. The short-term impacts are primarily those that occur during the period of construction activities, including relocation of excavated spoils associated with increasing cooling tower capacity and equipment replacements during Unit 1 refurbishment. The major short-term uses of materials associated with Alternative 2 include the concrete, steel (reinforcement bars, sheet metal, structural beams, etc.), and fill composition used in constructing the additional cooling tower capacity. The use of short-term resources to restore Unit 1 for power production would affect the long-term productivity of the site by providing an additional reliable source for the production of bulk electric power. Alternative 2 would also provide an additional 150 permanent jobs and around 3,000 temporary jobs during Unit 1 recovery.

4.7 Irreversible and Irretrievable Commitment of Resources

The proposed action alternatives would result in irreversible and irretrievable commitments of resources including land, water, fuels, and other mineral resources over the 20-year extended lifetime of the facilities. Human resources (measured in man-years) are also included as a part of the comparison of the resource commitment by alternatives. This comparison is presented in Table 4.7-1. Listed values include EPU unless otherwise noted.

Depending on the alternative selected, cooling tower capacity addition could result in the removal of up to 106 acres of site land from most future uses. Continued operation of the plant would result in consumption of nuclear fuel and small amounts of fossil fuels, water, metals, and a number of other materials, some of which cannot readily be replaced or recycled. At this time, all constituents of the spent nuclear fuel are considered non-recoverable since no reprocessing of the spent fuel is allowed. Additional temporary spent fuel dry storage at the site would consume construction materials and result in minor increases in worker radiation exposure but would be built on already-disturbed site land.

The potential additional land resource commitment is irretrievable, but land is not considered to be in short supply in the region, given the large amount of non-industrialized property. Some river water would be evaporated during brief periods of cooling tower operation, typically less than one

month per year. Since this water is returned to the earth as vapor, however, it is not considered to be an irreversible and irretrievable commitment of resources.

Table 4.7-1 Irreversible and Irretrievable Commitments of Resources

Resource	Alternative 1	Alternative 2A	Alternative 2B	Alternative 2C	Alternative 2D
Land (acres)	no additional	up to 106	up to 106	no additional	no additional
Nuclear Fuel[1]					
Uranium oxide (lb.)	149,130	149,130	149,130	149,130	149,130
Zircaloy (lb.)	60,324	60,324	60,324	60,324	60,324
Stainless Steel (lb.)	6,641	6,641	6,641	6,641	6,641
Inconel (lb.)	777.5	777.5	777.5	777.5	777.5
Fuel Oil[2] (gal./yr)	385,000	385,000	385,000	385,000	385,000
Industrial Gases					
Hydrogen[3] (scf/yr)	16,850,000	25,880,000	25,880,000	25,880,000	25,880,000
Oxygen[4] (scf/yr)	7,995,000	12,300,000	12,300,000	12,300,000	12,300,000
Nitrogen[5] (scf/yr)	1,025,000	1,538,000	1,538,000	1,538,000	1,538,000
Ion Exchange Resins[6] (ft^3/yr)	3,914	5,871	5,871	5,871	5,871
Construction					
Steel[7] (tons)	1,058	1,764	1,854	1,845	1,651
Concrete[8] (cu. yds)	6,480	11,422	14,764	16,906	8,335
Labor (Man-years)	24,000[9]	35,750[10]	35,800[11]	35,700[12]	35,350[13]

(1) Per unit per reload (i.e., each reactor refueling batch; two years between refuelings).

(2) The same type of fuel oil is used for auxiliary heating boilers, emergency diesel generators, and various other diesel engines at BFN; annual consumption is essentially independent of Unit 1 restart.

(3) Used for reactor water chemistry control and generator internal atmosphere; in units of standard cubic feet per year.

(4) Predominantly used for reactor water chemistry control; in units of standard cubic feet per year.

(5) Predominantly used in containment atmosphere inerting; in units of standard cubic feet per year.

(6) Used for condensate demineralizers and radwaste processing; in units of cubic feet per year.

(7) Includes concrete reinforcing bars and anchors, framing members (girders, beams, columns), conduit, gratings, etc.

(8) Total concrete for buildings, cooling towers (includes equipment support pads, ducts, etc.), and dry cask storage facility.

(9) Total site staff of 1200 for 20 years.

(10) Total site staff of 1350 for 20 years + Unit 1 restart (avg. 1500 for 5 ½ years) + cooling tower work (~200 workers for 2 years) + spoils hill relocation (~100 workers for 1 year).

(11) Same as (10) except additional 50 man-years for construction of round cooling towers.

(12) Same as (10) except no spoils hill relocation and additional 50 man-years for construction of very large cooling towers.

(13) Same as (10) except cooling tower work is approximately 200 workers for ½ year and no spoils hill relocation.

4.8 References

10 CFR Part 51, Subpart A, Appendix B, "Environmental effect of renewing the operating license of a nuclear power plant."

Alabama Department of Environmental Management. (2001) Personal Correspondence.

Alabama Department of Transportation. Traffic Flow Maps showing 1998 Average Daily Traffic, reported by ADOT.

Barko, John W. and R. Michael Smart. 1981. Comparative Influences of Light and Temperature on the Growth and Metabolism of Selected Submersed Freshwater Macrophytes. Ecological Monographs 51:210-235.

Baxter, D. S. and J. P. Buchanan. 1998. Browns Ferry Nuclear Plant Thermal Variance Monitoring Program - Final Report. Tennessee Valley Authority, Water Management, Environmental Compliance.

Boston, W. Terry. 2000. "Electricity: Lifeline or Bottom Line?" Forum for Applied Research and Public Policy, Summer 2000, pp. 56-60.

Browns Ferry Nuclear Plant (BFN) - Units 1, 2, and 3 - Updated Final Safety Analysis Report (UFSAR), Amendment 18, dated November 16, 1999.

Brungs, W. A., Bernard R. Jones. 1977. Temperature Criteria for Freshwater Fish: Protocol and Procedures. U. S. Environmental Protection Agency, Office of Research and Development. EPA-600/3-77-061.

Burns, Earl R., A. Leon Bates, and David H. Webb. 1989. Aquatic Plant Management Program – Current Status and Season Workplan. Tennessee Valley Authority, Muscle Shoals, Alabama.

Dycus, D. L. and T. F. Baker. 2000. Aquatic Ecological Health Determinations for TVA Reservoirs - 1999. Tennessee Valley Authority, Water Management, Chattanooga.

Dycus, D. L. and T. F. Baker. 2001. Aquatic Ecological Health Determinations for TVA Reservoirs - 2000. Tennessee Valley Authority, Water Management, Chattanooga.

EPRI/NEI 2001. Proceedings: 2001 Electric Power Research Institute/Nuclear Energy Institute Decommissioning Technology Workshop, April 30 to May 1, 2001, New Orleans, LA.

Gough, D. I. 1978. "Induced Seismicity", Monograph Chapter from the Intergovernmental Conference on the Assessment and Mitigation of Earthquake Risks, 1978 version of a paper submitted to February, 1976 conference, pp. 91-117.

Harper, W. L. 2001. Browns Ferry Nuclear Plant Tower Usage and Load Reductions Under Proposed Increase in Reactor Power Levels and Unit 1 Restart. TVA Internal Memorandum.

Harper, W. L. 2002. Addendum to Browns Ferry Nuclear Plant Tower Usage and Load Reductions Under Proposed Increase in Reactor Power Levels and Unit 1 Restart. TVA Internal Memorandum, May 1, 2001.

Higgins, J. M. and Kim, B. R. 1981. "Phosphorus Retention Models for Tennessee Valley Authority Reservoirs." Water Resources Research, Vol. 17, No. 3, pp. 571-576.

Maceina, M. J., P. W. Bettoli, S. D. Finely, and V. J. DiCenzo. 1998. Analyses of the sauger fishery with simulated effects of a minimum size limit in the Tennessee River of Alabama. North American Journal of Fisheries Management 18: 104-113.

Mundahl, N. D. 1990. Heat Death of Fish in Shrinking Stream Pools. Amer. Midl. Nat. 123:40-46.

Report–Operating License Renewal Stage, Edwin I. Hatch Nuclear Plant. Appendix D, Applicant's Environmental Report–Operating License Renewal Stage Edwin I. Hatch Nuclear Plant.

Shiao, M. C. 2001. Browns Ferry Nuclear Plant—Model Analysis of Wheeler Reservoir for 1988. TVA Internal Memorandum.

Smith, C. S. and J. W. Barko. 1990. Ecology of Eurasian Watermilfoil. Journal of Aquatic Plant Management 28:55-64.

Stanley, R. A. and A. W. Naylor. 1972. Photosynthesis in Eurasian Watermilfoil (*Myriophyllum spicatum* L.). Plant Physiology 50:149-151.

TVA calculation ND-Q0999-980016, R3, R14-000207-104

Tennessee Valley Authority. 1978b. Biological Effects of Intake – Browns Ferry Nuclear Plant. Voluem 4: Effects of the Browns Ferry Nuclear Plant Cooling Water Intake on the Fish Populations of Wheeler Reservoir. Division of Forestry, Fisheries, and Wildlife Development, Norris, Tennessee.

Tennessee Valley Authority. 1983. "A Supplemental 316(a) Demonstration for Alternative Thermal Discharge Limits for Browns Ferry Nuclear Plant, Wheeler Reservoir, Alabama."

Tennessee Valley Authority 1990. "Tennessee River and Reservoir System Operation and Planning Review." Final Environmental Impact Statement. TVA/RDG/EOS-91/1.

TVA. 1990. "Water Resources Issues Analysis: Wheeler Reservoir Watershed Region." TVA/WR/WQ-90/6.

Tennessee Valley Authority. (1993) "Two-Dimensional Water Quality Modeling of Wheeler Reservoir." Report No. WR28-1-3-105.

TVA. 1999. "Response to Request for Additional Information on Individual Plant Examination for External Events." Revision 1.

Tennessee Valley Authority. 1999. Browns Ferry Nuclear Plant - National Pollutant Discharge Elimination System Permit Number AL 0022080 - Renewal Application.

Tennessee Valley Authority. (2000) "Aquatic Ecological Health Determinations for TVA Reservoirs—1999."

Transportation Research Board. *Highway Capacity Manual, Special Report 209*. 3rd ed. Washington: Transportation Research Board. 1994.

U.S. Department of Commerce, Bureau of the Census. www.census.gov/hhes/www/saipe/.

U.S. Nuclear Regulatory Commission. 1990. Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station. NUREG/CR-0672 and Addenda 3 and 4, Washington, D.C.

U.S. Nuclear Regulatory Commission. 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plant. NUREG-1437, Washington, D.C.

U.S. Nuclear Regulatory Commission. 1999. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report, Section 6.3 - Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants. NUREG-1437, Vol. 1, Addendum 1, Washington, D.C.

U.S. Nuclear Regulatory Commission. 2000a. Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans, dated April 2000. NUREG 1700, Washington, D.C.

U.S. Nuclear Regulatory Commission. 2000b. Integrated Rulemaking Plan for Nuclear Power Plant Decommissioning, dated June 28, 2000. SECY-00-145, Washington, D.C.

Van, T. K., W. T. Haller, and L. A. Garrard. 1978. The Effect of Day Length and Temperature on Hydrilla Growth and Tuber Production. Journal of Aquatic Plant Management 16:57-59.

Yeats, R. S., K. Sieh and C. R. Allen. 1996. The Geology of Earthquakes, Oxford University Press, 576p.

APPENDIX A

BFN SEVERE ACCIDENT MITIGATION ALTERNATIVES ANALYSIS

Abbreviations and Acronyms

AC ..... Alternating Current

ADS..... Automatic Depressurization System

AFW ..... Auxiliary Feed Water

ATWS..... Anticipated Transient Without Scram

BFN ..... Browns Ferry Nuclear Plant

BWR..... Boiling Water Reactor

CDF..... Core Damage Frequency

CFR..... Code of Federal Regulations

CRD ..... Control Rod Drive

CS ..... Core Spray

CV ..... Check Valve

DC ..... Direct Current

DW ..... Dry Well

ECCS ..... Emergency Core Cooling System

EECW ..... Emergency Equipment Cooling Water

ENMKCTT..... ATWS Core Damage End State

EOP..... Emergency Operating Procedure

EPU..... Extended Power Uprate

HFO..... High Winds, Floods, Transportation and Other External Events

HP ..... High Pressure

HPCI..... High Pressure Coolant Injection

HPGTET..... High Pressure General Transient (Event Tree)

HVAC ..... Heating, Ventilation and Air Conditioning

IPE ..... Individual Plant Examination

IPEEE..... Individual Plant Examination of External Events

ISLOCA ..... Interfacing System Loss Of Coolant Accident

LERF ..... Large Early Release Frequency

LLOCA ..... Large Loss Of Coolant Accident (Event Tree)

LOCA ..... Loss Of Coolant Accident

LPGTET ..... Low Pressure General Transient Event Tree

MAAP ..... Modular Accident Analysis Program

MLOCA ..... Medium Loss Of Coolant Accident (Event Tree)

MOV ..... Motor Operated Valve

MSIV ..... Main Steam Isolation Valve

NLERF ..... “No” Large Early Release Frequency

NPSH ..... Net Positive Suction Head

PORV ..... Power Operated Relief Valve

PSA ..... Probabilistic Safety Analysis

PSW ..... Plant Service Water

PWR ..... Pressurized Water Reactor

RBCCW..... Reactor Building Closed Cooling Water

RCP..... Reactor Coolant Pump

RCIC ..... Reactor Core Isolation Cooling

RHR ..... Residual Heat Removal

RHRSW..... Residual Heat Removal Service Water

ROM ..... Rough Order of Magnitude

RPV ..... Reactor Pressure Vessel

RWCU ..... Reactor Water Clean Up

RWST..... Reactor Water Storage Tank

SAMA ..... Severe Accident Mitigation Alternative

SBO..... Station Blackout

SG ..... Steam Generator

SGTR ..... Steam Generator Tube Rupture

SLC ..... Standby Liquid Control

SQUG..... Seismic Qualification Utility Group

SRV..... Safety/Relief Valve

TRANCDBIN ..... Event Tree for Binning Transient Core Damage Sequences

TVA ..... Tennessee Valley Authority

UFSAR ..... Updated Final Safety Analysis Report

USNRC ..... United States Nuclear Regulatory Commission

UV ..... Under Voltage

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I. Methodology

The methodology selected for this analysis involves identifying those Severe Accident Mitigation Alternatives (SAMA) candidates that have the most potential for reducing core damage frequency and person-rem risk. The phased approach consists of:

- Extending the Browns Ferry Nuclear Plant (BFN) Probabilistic Safety Analysis (PSA) results to a Level 3 analysis by determining offsite dose and economic baseline risk values.
- Determining the maximum averted risk that is possible based on the BFN baseline risk.
- Identifying potential SAMA candidates based on BFN PSA results, the USNRC, and industry documents.
- Screening out potential SAMA candidates that are not applicable to the BFN design or are of low benefit in boiling water reactors.
- Screening out SAMA candidates whose estimated cost exceeds the maximum possible averted risk.
- Performing a more detailed cost estimate and Level 3 dose and economic risk evaluation of remaining candidates to see if any have a benefit in risk aversion that exceeds the expected cost.

II. Level 3 PSA Analysis

The MACCS2 code was used to perform the Level 3 consequence analysis for the BFN. Plant-specific release data includes the time-nuclide distribution of releases, release frequencies, and release locations. The behavior of the population during a release (evacuation/sheltering parameters) was based on the generic MACCS2 model. This data was used in combination with site-specific meteorology and population data to simulate the impact risks (exposure and economic) to the surrounding (within 50 miles) population from the release accident sequences at the BFN.

A. Population

Population estimates for the year 2036 within 50 miles of the BFN plant were provided by TVAN (Reference 11) and are shown in Tables II-1 and II-2.

B. Meteorological Data Sampling Method

The atmospheric dispersion of radioactive material from a postulated accident depends on the meteorological conditions that exist from the start of the accident through a period of tens to hundreds of hours following the accident. Since the weather that could occur coincident with the accident is diverse, representative meteorological data sequences are selected as input to the dispersion model to reflect the dependence of the transport and dispersion process on the site weather. The selection process is done by means of sampling techniques from a full year of hourly weather data taken from the BFN on-site meteorological tower. For this analysis, the technique referred to as weather bin sampling in the MACCS2 V1.12 code was used for the 1980 year of data. This year was selected because it was deemed to be a representative year of meteorological data from the site area. The data recovery rate for all pertinent parameters was nearly 100%. Wind roses and joint frequency distributions that were run on this year of data all showed that it was typical for Browns Ferry. In general, annual meteorology does not vary markedly from year to year. Each year will have some anomalies, but as long as the site instrumentation was working properly one year should be as representative as the next.

This sampling method ensures a complete coverage of diurnal, seasonal, and 4-day cycles without the statistical noise of methods that utilize random sampling and includes the important “rain tails” (deposition due to delayed rain).

The meteorological data assessment is done by sorting the weather sequence into categories that provide a realistic representation of the year's weather without overlooking weather conditions that are instrumental in producing major consequences. A set of 40 weather categories has been selected for the MACCS2 V1.12 model to reflect these requirements. Up to eight meteorological scenarios are selected for each category, limited by the number of meteorological scenarios available for that category.

Table II-1. Estimated Population Distribution Within a 10-Mile Radius of BFN, Year 2036

Sector	0-1 mile	1-2 miles	2-3 miles	3-4 miles	4-5 miles	5-10 miles	10 miles total
N	2	18	203	379	501	2,501	3,604
NNE	0	5	33	379	521	1,931	2,869
NE	2	10	65	114	278	8,350	8,819
ENE	6	82	365	289	432	2,273	3,447
E	11	54	25	13	53	5,170	5,326
ESE	5	9	208	0	0	86	308
SE	2	0	0	0	2	7,626	7,630
SSE	0	0	1	0	1	16,037	16,039
S	0	3	29	59	25	1,768	1,884
SSW	0	2	12	235	343	3,708	4,300
SW	0	0	3	90	381	1,523	1,997
WSW	0	0	70	122	79	168	439
W	0	55	200	15	3	69	342
WNW	0	0	1	4	2	85	92
NW	0	2	8	4	33	640	687
NNW	52	467	272	84	104	3,104	4,083
TOTAL	80	707	1,495	1,787	2,758	55,039	61,866

Reference 11.

Table II-2. Estimated Population Distribution Within a 50-Mile Radius of BFN, Year 2036

Sector	0-10 mile	10-20 miles	20-30 miles	30-40 miles	40-50 miles	50 miles total
N	3,604	2,710	6,269	19,130	8,662	40,375
NNE	2,869	10,929	3,393	3,965	5,432	26,588
NE	8,819	21,034	23,783	16,920	17,488	88,044
ENE	3,447	35,534	69,528	63,014	10,840	182,363
E	5,326	5,731	136,377	105,268	12,263	264,965
ESE	308	1,096	4,229	20,885	17,799	44,317
SE	7,630	40,473	12,373	11,248	36,295	108,019
SSE	16,039	28,541	26,702	36,087	42,023	149,392
S	1,884	7,038	4,083	8,813	15,505	37,323
SSW	4,300	12,873	1,467	2,417	6,519	27,576
SW	1,997	6,376	3,318	4,075	19,955	35,721
WSW	439	3,957	3,895	29,617	4,376	42,284
W	342	3,855	17,460	37,892	4,842	64,391
WNW	92	3,124	28,974	51,789	11,954	95,933
NW	687	11,805	9,717	6,912	4,615	33,736
NNW	4,083	3,232	3,110	24,997	16,467	51,889
TOTAL	61,866	198,308	354,678	443,029	235,035	1,292,916

Given a postulated large accident, large numbers of early fatalities and injuries are normally associated with relatively low probability weather events such as rainfall or wind speed slowdowns within 50 miles of the plant site or with stable weather and moderate wind speeds at the start of the release. In MACCS2 V1.12, these weather data types have been selected to be among the 40 categories utilized in the assessment process.

With this information, weather sequences can be sampled to reflect the weather data for the full year. This ensures representation of each type of weather sequence, those important to realistic representation of the weather data set, and those important to the occurrence of the most serious accident consequences due to rainout in high population areas.

C. Atmospheric Transport and Dispersion

The dispersion model implemented in MACCS2 V1.12 is described in detail in NUREG/CR-4691, Volume 2. It is a Gaussian, time-dependent, plume segment model that has been in use for consequence assessments since the Reactor Safety Study (RSS) in 1975. The plume is assumed to be transported in a straight line downwind in accordance with the measured wind direction.

For each start hour selected by the meteorological sampling technique, the MAACS2 V1.12 dispersion model uses the subsequent meteorological conditions to predict the dispersion and transport of the released plume of radioactive material. The sequence of hourly recordings is used to account for changing meteorological conditions.

In MACCS2 V1.12, the effects of release duration, mixing layer depth, building wake, plume rise due to sensible heat buoyancy, and dry and wet removal processes are included. The ground concentration is calculated from the air concentration and the deposition rate.

D. Nuclide Release

The current design basis core inventory is provided in Table II-3 (Reference 9). Data from three district fuel types each representing Extended Power Uprate (EPU) conditions are found in the table. Each of the major hypothetical accidents identified in the IPE study (Reference 12) was assigned to one of several release categories based on the primary system and containment responses to the accident conditions calculated by the Modular Accident Analysis Program (MAAP). Each release category has associated release fractions of the initial core radionuclide inventory, which are used as input data to the consequence analysis model. In addition to the release magnitude, the parameters that characterize the various releases due to hypothetical accident sequences are time of release, duration of release, warning time for evacuation, height of release, and energy content of the released radioactive plume.

The time of start of release was taken from MAAP runs and refers to the time interval between the start of the hypothetical accident and the release of radioactive material from the containment building to the atmosphere. This parameter is used to calculate the decay of radioactivity as well as timing used in computing dose accumulated by evacuees in relation to plume location and deposited material. The duration of release is the total time during which radioactive material is emitted into the atmosphere; it is used to account for continuous releases by adjusting for horizontal dispersion due to changes in wind direction.

Table II-3. BFN Core Inventory

Isotope Number	Isotope Name	Release Group	Activity, Bq		
			GE Uprated 35 GWD/MTU	Framatome Commercial 37 GWD/MTU	Framatome Blended LEU 37 GWD/MTU
1	Cr-51	6	1.733959E+17	1.888302E+17	1.690426E+17
2	Mn-54	6	9.240809E+15	1.419054E+16	1.413400E+16
3	Mn-56	6	3.508059E+17	4.014056E+17	3.618304E+17
4	Fe-55	6	5.283289E+16	6.162424E+16	5.597064E+16
5	Co-58	6	2.133386E+16	2.100312E+16	2.128580E+16
6	Co-60	6	2.124906E+16	1.014821E+16	9.469780E+15
7	As-78	4	2.493803E+16	2.730689E+16	2.725035E+16
8	Ge-78	4	2.430765E+16	2.696767E+16	2.691114E+16
9	Se-81	4	2.229497E+17	2.040950E+17	2.066391E+17
10	Se-81m	4	6.230267E+15	1.452975E+16	1.458629E+16
11	Se-83	4	1.985262E+17	2.326456E+17	2.374512E+17
12	Br-82	2	2.410412E+16	1.215524E+16	1.175949E+16
13	Br-83	2	5.110854E+17	4.946900E+17	5.059972E+17
14	Br-84	2	8.935515E+17	9.215368E+17	9.498048E+17
15	Kr-83m	1	5.119335E+17	4.975168E+17	5.116508E+17
16	Kr-85	1	5.356786E+16	5.286116E+16	5.370920E+16
17	Kr-85m	1	1.093124E+18	1.034609E+18	1.071357E+18
18	Kr-87	1	2.108227E+18	2.080525E+18	2.156848E+18
19	Kr-88	1	2.970967E+18	2.883336E+18	2.996408E+18
20	Rb-86	3	9.503702E+15	6.925660E+15	6.840856E+15
21	Rb-88	3	3.016196E+18	2.968140E+18	3.081212E+18
22	Rb-89	3	3.875543E+18	3.872716E+18	4.042324E+18
23	Sr-89	5	3.997417E+18	4.014169E+18	4.155507E+18
24	Sr-90	5	4.271295E+17	4.635952E+17	4.720756E+17
25	Sr-91	5	4.980885E+18	5.031732E+18	5.201340E+18
26	Sr-92	5	5.359613E+18	5.314384E+18	5.483992E+18
27	Y-90	7	4.533537E+17	4.840330E+17	4.896018E+17
28	Y-91	7	5.122977E+18	5.173762E+18	5.343362E+18
29	Y-91m	7	2.891816E+18	2.911604E+18	3.024676E+18
30	Y-92	7	5.384116E+18	5.371140E+18	5.512477E+18
31	Y-93	7	6.185039E+18	4.070594E+18	4.155398E+18
32	Y-94	7	6.207698E+18	6.416896E+18	6.529967E+18
33	Y-95	7	6.642980E+18	6.671248E+18	6.756052E+18

Table II-3. BFN Core Inventory (Continued)

Isotope Number	Isotope Name	Release Group	Activity, Bq		
			GE Uprated 35 GWD/MTU	Framatome Commercial 37 GWD/MTU	Framatome Blended LEU 37 GWD/MTU
34	Zr-95	7	7.233216E+18	7.205513E+18	7.279010E+18
35	Nb-95	7	7.262049E+18	7.228128E+18	7.304451E+18
36	Nb-95m	7	5.266046E+16	8.002671E+16	8.076168E+16
37	Zr-97	7	7.387842E+18	7.052866E+18	7.041559E+18
38	Nb-97	7	7.444378E+18	7.081134E+18	7.098095E+18
39	Nb-97m	7	7.004245E+18	6.688209E+18	6.705170E+18
40	Mo-99	6	7.588759E+18	7.519596E+18	7.491320E+18
41	Mo-101	6	6.788063E+18	6.756120E+18	6.699582E+18
42	Tc-99m	6	6.628846E+18	6.642980E+18	6.642980E+18
43	Tc-101	6	6.790889E+18	6.756120E+18	6.699582E+18
44	Tc-104	6	4.921459E+18	4.918632E+18	4.692488E+18
45	Ru-103	6	6.049352E+18	6.105888E+18	5.908012E+18
46	Rh-103m	6	5.450070E+18	6.105888E+18	5.908012E+18
47	Ru-105	6	4.008402E+18	4.042324E+18	3.816180E+18
48	Rh-105	6	3.779432E+18	3.816180E+18	3.618304E+18
49	Ru-106	6	2.176919E+18	2.219038E+18	2.060737E+18
50	Rh-106	6	2.336916E+18	2.385819E+18	2.202077E+18
51	Rh-106m	6	7.194206E+16	7.434484E+16	6.247228E+16
52	Rh-107	6	2.245045E+18	2.303842E+18	2.114446E+18
53	Pd-109	6	1.192344E+18	1.325769E+18	1.207044E+18
54	Ag-109m	6	1.191779E+18	1.325769E+18	1.207044E+18
55	Ag-110m	6	1.578485E+16	1.263580E+16	1.057223E+16
56	Ag-111	6	2.589349E+17	2.202077E+17	2.015508E+17
57	Ag-112	6	1.373825E+17	1.011994E+17	9.384976E+16
58	Cd-115	6	7.198474E+16	3.109480E+16	2.939872E+16
59	Cd-117	6	4.053691E+16	3.081212E+16	2.939872E+16
60	In-113m	6	5.515087E+15	1.158988E+16	1.125066E+16
61	In-115m	6	7.211167E+16	3.109480E+16	2.939872E+16
62	In-116m	6	3.129323E+16	1.984414E+16	1.851554E+16
63	In-117m	6	4.737773E+16	2.823973E+16	2.688287E+16
64	In-117	6	3.742913E+16	2.304144E+16	2.188243E+16
65	Sn-113	4	5.515087E+15	1.156161E+16	1.125066E+16
66	Sn-121	4	8.791065E+16	5.303077E+16	5.113681E+16
67	Sn-123m	4	6.024632E+16	3.280366E+16	3.138964E+16

Table II-3. BFN Core Inventory (Continued)

Isotope Number	Isotope Name	Release Group	Activity, Bq		
			GE Uprated 35 GWD/MTU	Framatome Commercial 37 GWD/MTU	Framatome Blended LEU 37 GWD/MTU
68	Sn-127	4	2.649842E+17	1.325769E+17	1.263580E+17
69	Sn-128	4	6.456411E+17	5.512260E+17	5.399188E+17
70	Sb-125	4	7.809883E+16	4.576589E+16	4.418288E+16
71	Sb-131	4	3.341278E+18	3.137748E+18	3.137748E+18
72	Sn-125	4	6.875060E+16	1.970280E+16	1.901023E+16
73	Sb-127	4	4.169530E+17	3.307356E+17	3.166016E+17
74	Sb-129	4	1.261318E+18	1.257926E+18	1.232485E+18
75	Sb-130	4	4.079072E+17	4.183664E+17	4.098860E+17
76	Te-125m	4	1.681805E+16	9.995565E+15	9.647868E+15
77	Te-127	4	4.135640E+17	3.279102E+17	3.137761E+17
78	Te-127m	4	5.549027E+16	5.540528E+16	5.314384E+16
79	Te-129	4	1.241813E+18	1.192910E+18	1.167468E+18
80	Te-129m	4	1.856077E+17	2.408434E+17	2.351898E+17
81	Te-131m	4	5.704482E+17	7.688896E+17	7.462752E+17
82	Te-131	4	3.533500E+18	3.363892E+18	3.335624E+18
83	Te-132	4	5.673388E+18	5.710136E+18	5.653600E+18
84	Te-133	4	4.799906E+18	4.466344E+18	4.494612E+18
85	Te-133m	4	3.033156E+18	3.703108E+18	3.703108E+18
86	Te-134	4	6.883258E+18	7.321412E+18	7.406216E+18
87	I-128	2	5.017583E+16	3.505232E+16	3.250820E+16
88	I-130	2	1.324921E+17	8.084648E+16	7.208340E+16
89	I-131	2	3.980134E+18	3.957520E+18	3.900984E+18
90	I-132	2	5.758192E+18	5.794940E+18	5.766672E+18
91	I-133	2	8.189240E+18	8.254256E+18	8.225988E+18
92	I-134	2	9.011838E+18	9.158832E+18	9.158832E+18
93	I-135	2	7.660628E+18	7.830236E+18	7.801968E+18
94	Xe-131m	1	4.449383E+16	5.286116E+16	5.201312E+16
95	Xe-133	1	8.209027E+18	7.915040E+18	7.886772E+18
96	Xe-133m	1	2.545533E+17	2.586522E+17	2.566734E+17
97	Xe-135	1	2.863548E+18	2.660019E+18	2.939872E+18
98	Xe-135m	1	1.589510E+18	1.693253E+18	1.670639E+18
99	Xe-138	1	6.812588E+18	7.067000E+18	7.095268E+18
100	Cs-134	3	8.505841E+17	7.123536E+17	6.586444E+17
101	Cs-134m	3	2.184834E+17	1.537779E+17	1.413400E+17

Table II-3. BFN Core Inventory (Continued)

Isotope Number	Isotope Name	Release Group	Activity, Bq		
			GE Uprated 35 GWD/MTU	Framatome Commercial 37 GWD/MTU	Framatome Blended LEU 37 GWD/MTU
102	Cs-135m	3	1.007472E+17	1.305982E+17	1.116586E+17
103	Cs-136	3	2.894643E+17	2.374512E+17	2.374512E+17
104	Cs-137	3	5.622505E+17	6.021084E+17	5.992816E+17
105	Cs-138	3	7.536249E+18	7.632360E+18	7.660628E+18
106	Ba-137m	9	5.325691E+17	5.710136E+17	5.681868E+17
107	Ba-139	9	7.352507E+18	7.293144E+18	7.321412E+18
108	Ba-140	9	7.115056E+18	7.321412E+18	7.321412E+18
109	Ba-141	9	6.676902E+18	6.614712E+18	6.642980E+18
110	Ba-142	9	6.348993E+18	6.303764E+18	6.360300E+18
111	La-140	7	7.372294E+18	7.801968E+18	7.801968E+18
112	La-141	7	6.707996E+18	6.671248E+18	6.699516E+18
113	La-142	7	6.495986E+18	6.529908E+18	6.558176E+18
114	La-143	7	6.227440E+18	6.218960E+18	6.303764E+18
115	Ce-141	8	6.764532E+18	6.699516E+18	6.727784E+18
116	Ce-143	8	6.267016E+18	6.275496E+18	6.332032E+18
117	Ce-144	8	5.565969E+18	5.653600E+18	5.681868E+18
118	Pr-142	8	3.106653E+17	2.301015E+17	2.103139E+17
119	Pr-143	7	6.117195E+18	6.077620E+18	6.134156E+18
120	Pr-144	7	5.597064E+18	5.681868E+18	5.710136E+18
121	Pr-144m	7	6.688209E+16	7.915040E+16	7.999844E+16
122	Pr-145	7	4.257161E+18	4.268468E+18	4.296736E+18
123	Pr-147	7	2.673022E+18	2.674153E+18	2.676980E+18
124	Nd-147	7	2.693940E+18	2.693940E+18	2.693940E+18
125	Nd-149	7	1.535518E+18	1.517992E+18	1.498204E+18
126	Nd-151	7	7.765220E+17	7.660628E+17	7.434484E+17
127	Pm-147	7	6.914353E+17	9.469780E+17	9.922068E+17
128	Pm-148	7	1.175666E+18	7.151804E+17	6.784320E+17
129	Pm-148m	7	1.758552E+17	1.438841E+17	1.450148E+17
130	Pm-149	7	2.348505E+18	2.295362E+18	2.219038E+18
131	Pm-150	7	1.885193E+16	1.778057E+16	1.520818E+16
132	Pm-151	7	7.782180E+17	7.745432E+17	7.519288E+17
133	Sm-153	7	1.823569E+18	1.713043E+18	1.597144E+18
134	Sm-155	7	1.447322E+17	1.382310E+17	1.294679E+17
135	Sm-156	7	8.915727E+16	8.593472E+16	7.971576E+16

Table II-3. BFN Core Inventory (Continued)

Isotope Number	Isotope Name	Release Group	Activity, Bq		
			GE Uprated 35 GWD/MTU	Framatome Commercial 37 GWD/MTU	Framatome Blended LEU 37 GWD/MTU
136	Eu-154	7	4.692347E+16	3.218594E+16	3.162907E+16
137	Eu-155	7	3.293420E+16	1.344002E+16	1.275678E+16
138	Eu-156	7	5.975629E+17	7.840978E+17	6.897957E+17
139	Eu-157	7	7.997017E+16	8.028112E+16	7.123536E+16
140	Eu-158	7	3.386506E+16	3.109480E+16	2.855068E+16
141	Gd-159	7	9.078890E+17	6.689622E+17	6.417401E+17
142	W-187	6	1.594598E+16	1.583008E+16	1.540606E+16
143	Pu-238	8	1.485766E+16	1.274887E+16	4.183664E+16
144	Np-239	8	7.756739E+19	7.293144E+19	6.812588E+19
145	Pu-239	8	1.765619E+15	1.763923E+15	1.840247E+15
146	Pu-240	8	2.288295E+15	2.580868E+15	2.448009E+15
147	Pu-241	8	6.637326E+17	6.303764E+17	6.162424E+17
148	Am-241	7	8.127050E+14	8.112916E+14	8.112916E+14
149	Cm-242	7	1.819328E+17	1.840247E+17	1.648024E+17
150	Cm-244	7	8.497361E+15	7.717164E+15	6.049352E+15

** From Reference 9.*

The warning time for evacuation was estimated based on review of the accident sequences. This time is the interval between awareness of impending core melt and the release of radioactive material from the containment building. Finally, the height of release and the energy content of the released plume affect the manner in which the plume would be dispersed in the atmosphere.

E. Evacuation and Other Protective Measures

Evacuation and other protective measures (i.e., sheltering and relocation) are taken to avoid or reduce immediate exposure to the passing radioactive plume and ground contamination. Evacuation is potentially the most effective method of avoiding radiation exposure and can provide essentially total protection if completed prior to arrival of the plume.

The evacuation model does not account for actual road networks, road capacity limitations, or lateral travel possibilities (evacuation is assumed to be in a straight-line radially away from the plant).

F. Results

The results of the Level 3 consequence analysis provide projected offsite radiation doses and offsite economic costs (in 2016 dollars) as a function of accident conditions (Reference 9). This information forms part of the input data to the economic model described in Section III of this analysis. In the exposure and economic cost evaluation of each base case and each SAMA, for each plant damage state, the maximum (as determined by the mean value) dose and offsite cost from the three fuel types was selected.

III. Determination of Present Value

This section explains how the Tennessee Valley Authority (TVA) calculated the monetized value of the status quo (i.e., accident consequences without SAMA implementation). TVA also used this analysis to establish the maximum benefit that a SAMA could achieve if it eliminated all BFN risk. The following costs are included in the analysis:

1. Offsite exposure cost
2. Offsite economic cost
3. Onsite exposure cost
4. Onsite cleanup cost
5. Replacement power cost

The cost will be determined independently for both Unit 2 and Unit 3. Two real discount rates will be used in the calculations. A 7% discount rate will be used to reflect a "base case" discount rate and 3% will be used to provide analysis sensitivity to the discount rate, in accordance with Reference 10.

The sum of these costs will be used to screen out SAMAs that are not economically feasible; if the estimated cost of implementing a SAMA exceeds the maximum benefit, then it will be discarded from further analysis. Exceeding this threshold would mean that a SAMA would not have a positive net value even if it could eliminate all severe accident costs.

For the purposes of this analysis, the "present" is considered to be the year 2016. All constant dollar values from Reference 10 have been recalculated to the Year 2016 using a 3% inflation rate. Specifics are noted in the text to this section.

A. Offsite Exposure Cost

The baseline annual offsite exposure risk was converted to dollars using the United States Nuclear Regulatory Commission (USNRC) conversion factor of $2,000 per person-rem (Reference 10, Section 5.7.1.2), and discounting to present value using the USNRC standard formula (Reference 10, Section 5.7.1.3):

$$W_{pha} = C \times Z_{pha}$$

Where:

W_{pha} = monetary value of public health risk after discounting

C = $[1-\exp(-rt_f)]/r$

t_f = years remaining until end of facility life = 20 years

r = real discount rate (as fraction) = either 0.03 or 0.07/year

Z_{pha} = monetary value of public health (accident) risk per year before discounting ($/year)

The calculated value for C using 20 years with a 3% discount rate is 15.04 and with a 7% discount rate is 10.76. Therefore, calculating the discounted monetary equivalent of accident risk involves multiplying the dose (person-rem per year) by monetary value of unit dose (1 person/rem) and by the C value (Reference 10 Section 5.7.12). Since the "present" for this analysis is the Year 2016, the future value of $2,000 at a 3% inflation rate was calculated to be $3,097, which was used in this calculation. The calculated offsite exposure cost is for each of the units is presented in Table III-1.

Table III-1. Calculated Offsite Exposure Cost for Units 2 and 3.

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
C	15.04	10.76	15.04	10.76
Z_{pha}	$9,373	$9,373	$19,449	$19,449
W_{pha}	$140,970	$100,853	$292,513	$209,271

B. Offsite Economic Cost

The Level 3 analysis showed an annual offsite economic risk for the two units and discount rates is presented in Table III-2. Calculated values for offsite economic costs caused by severe accidents must be discounted to present value as well. This is performed in the same manner as for public health risks and uses the same C value. The resulting values are also presented in Table III-2.

Table III-2. Calculated Offsite Economic Cost for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
C	15.04	10.76	15.04	10.76
Sum of Annual Economic Risk	$6,500	$6,500	$13,700	$13,700
Offsite Economic Costs	$97,760	$69,940	$206,048	147,412

C. Onsite Exposure Cost

TVA evaluated occupational health using the USNRC methodology in Reference 10, Section 5.7.3, which involves separately evaluating "immediate" and long-term doses.

Immediate Dose - For the case where the plant is in operation, the equation that the USNRC recommends using (Reference 10, Sections 5.7.3 and 5.7.3.3) is:

$$W_{IO} = R\{(FD_{IO})_S - (FD_{IO})_A\} \{[1 - \exp(-rt_f)]/r\}$$

Where:

W_{IO} = monetary value of accident risk avoided due to immediate doses, after discounting

R = monetary equivalent of unit dose ($/person-rem)

F = accident frequency (events/yr)

D_{IO} = immediate occupational dose (person-rem/event)

S = subscript denoting status quo (current conditions)

A = subscript denoting after implementation of proposed action

r = real discount rate

t_f = years remaining until end of facility life.

The values used in the BFN analysis are:

R = \$3,097/person-rem (\$2,000 inflation at 3% to 2016 values)

r = 0.03 and 0.07

D_{IO} = 3,300 person-rem/accident (best estimate)

t_f = 20 years (license extension period)

F = 1.05E-6 for Unit 2 and 1.90E-6 for Unit 3 (total core damage frequency)

For the basis discount rate, assuming $(FD_{IO})_A$ is zero, the best estimate of the immediate dose cost is:

$$W_{IO} = R\,(FD_{IO})_S\,\{[1 - \exp(-rt_f)]/r\}$$

The results of the immediate dose cost calculations are presented in Table III-3.

Table III-3. Immediate Dose Cost for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Core Damage Frequency (per year)	1.05E-6	1.05E-6	1.90E-6	1.90E-6
Immediate Dose Cost	\$161	\$115	\$292	\$209

Long-Term Dose - For the case where the plant is in operation, the USNRC equation (Reference 10, Sections 5.7.3 and 5.7.3.3) is:

$$W_{LTO} = R\{(FD_{LTO})_S - (FD_{LTO})_A\}\,\{[1 - \exp(-rt_f)]/r\}\{[1 - \exp(-rm)]/rm\}$$

Where:

W_{LTO} = monetary value of accident risk avoided long-term doses, after discounting, \$

m = years over which long-term doses accrue

The values used in the BFN analysis are:

R = \$3,097/person-rem (\$2,000 inflated at 3% to 2016 values)

r = 0.03 AND 0.07

D_{LTO} = 20,000 person-rem/accident (best estimate)

m = "as long as 10 years"

t_f = 20 years (license extension period)

F = 1.05E-6 for Unit 2 and 1.90E-6 for Unit 3 (total core damage frequency)

For the basis discount rate, assuming $(FD_{LTO})_A$ is zero, the best estimate of the long-term dose is:

$$W_{LTO} = R\ (FD_{LTO})_S\ \{[1 - \exp(-rt_f)]/r\}\ \{[1 - \exp(-rm)]/rm\}$$

The results of the long-term dose cost calculations are presented in Table III-4.

Table III-4. Long-Term Dose Cost for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Core Damage Frequency (per year)	1.05E-6	1.05E-6	1.90E-6	1.90E-6
Long-term Dose Cost	\$845	\$503	\$1,527	\$910

Total Occupational Exposure - Combining Equations 1 and 2 above and using the above numerical values, the total accident related on-site (occupational) exposure avoided (W_O) is presented in Table III-5.

$$W_O = W_{IO} + W_{LTO}$$

Table III-5. Total Occupational Exposure Cost for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Immediate Dose Cost	$161	$115	$292	$209
Long-term Dose Cost	$845	$503	$1,527	$910
Total Occupational Exposure Cost	$1,006	$618	$1,819	$1,119

It should be noted that if the maximum exposures were used in the above calculations, there would be a negligible impact on the overall conclusions.

D. Onsite Cleanup and Decontamination Cost

The net present value (year 2001 dollars) that the USNRC provides for cleanup and decontamination for a single event is $1.1 billion, discounted over a 10-year cleanup period (Reference 10, Section 5.7.6.1). The USNRC uses the following equation in integrating the net present value over the average number of remaining service years:

$$U_{CD} = [PV_{CD}/r][1-\exp(-rt_f)]$$

Where:

PV_{CD} = Net present value of a single event

r = real discount rate

t_f = years remaining until end of facility life.

The values used in the BFN analysis are:

PV_{CD} = $1.714E+9 ($1.1E+9 inflated at 3% to 2016 values)

r = 0.03 and 0.07

t_f = 20

The resulting net present value of cleanup integrated over the license renewal term is multiplied by the total core damage frequency to determine the expected value of cleanup and decontamination costs. The resulting monetary equivalent is presented in Table III-6.

Table III-6. Expected Value of Cleanup and Decontamination Costs for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Net Present Value of Cleanup and Decontamination Costs	2.58+10	1.84E+10	2.58E+10	1.84E+10
Core Damage Frequency (per year)	1.05E-6	1.05E-6	1.90E-6	1.90E-6
Expected Value of Cleanup and Decontamination Costs	$27,090	$19,320	$49,020	$34,960

E. Replacement Power Cost

Long-term replacement power costs was determined following the USNRC methodology in Reference 10 Section 5.7.6.2. The net present value of replacement power for a single event, $P_{V_{RP}}$, was determined using the following equation:

$$PV_{RP} = [\$1.2E + 08/r] * [1 - \exp(-rt_f)]^2 \quad \text{(2001 dollars)}$$

$$PV_{RP} = [\$1.9E + 08/r] * [1 - \exp(-rt_f)]^2 \quad \text{(2016 dollars)}$$

Where:

PV_{RP} = net present value of replacement power for a single event, ($). This yields a PV_{RP} for 2016 of $2.18E+9 at 3% and $1.52+9 at 7%.

r = 0.03 and 0.07

t_f = 20 years (license renewal period)

To attain a summation of the single-event costs over the entire license renewal period, the following equation is used:

$$U_{RP} = [PV_{RP} /_r] * [1 - \exp(-rt_f)]^2 \quad (r > 5\%)$$

$$U_{RP}^2 = 1.9E+10 \quad (r = 1\%, \text{2001 dollars})$$

Where:

U_{RP} = net present value of replacement power over life of facility ($-year). Reference 10, Section 5.6.7.2 provides a recommended discount rate value of between 1.9E+10 at 1% and 1.2E+10 at 5%. A linear extrapolation of 1.55E+10 was made to determine the current present value (2001) of replacement power at a 3% discount rate. This value was inflated to 2016 values. This yields a U_{RP} for 2016 of $2.41E+10 for 3% and $1.23+10 for 7%.

After applying a correction factor to account for BFN's size relative to the "generic" reactor described in NUREG/BR-0184 (i.e., 1190 MWe/910 MWe), the replacement power costs are presented in Table III-7.

Table III-7. Expected Replacement Power Costs for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Net Present Value of Replacement Power over the Life of the Facility	2.41E+10	1.23E+10	2.41E+10	1.23E+10
Correction Factor for size	1.31	1.31	1.31	1.31
Replacement Power Cost	3.16E+10	1.61E+10	3.16E+10	1.61E+10
Core Damage Frequency (F)	1.05E-6	1.05E-6	1.90E-6	1.90E-6
Replacement power costs per accident damage frequency	$33,180	$16,905	$60,9040	$30,590

F. Baseline Screening

The sum of the baseline costs is presented in Table III-8.

Table III-8. Total Costs for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Monetary Value of Public Health Risk After Discounting	$140,970	$100,853	$292,513	$209,271
Offsite Economic Costs	$97,760	$69,940	$206,048	$147,412
Total Accident on-site exposure avoided	$1,006	$619	$1,819	$1,118
Expected Value of Cleanup and Decontamination Costs	$27,090	$19,320	$49,020	$34,960
Replacement Power Costs	$33,180	$16,905	$60,040	$30,590
Total	$300,006	$207,637	$609,440*	$423,351

** The most conservative value in Table III-8 is $609,440. Including the effects of restart of Unit 1 (described in Section V.HH), the maximum value for the three-unit plant is $3.6 million. This value was conservatively rounded to $10 million for initial screening of SAMAs that are not economically feasible; if the estimated cost of implementing a SAMA exceeded $10 million, it was discarded from further analysis. Exceeding this threshold means that a SAMA would not have a positive net value even if it could eliminate all severe accident costs associated with all three units.*

IV. SAMA Candidates and Screening Process

An initial list of SAMA candidates was developed from lists of Severe Accident Mitigation Alternatives for Hatch Nuclear Plant (Reference 8) and, most importantly, from the plant specific risk profile as provided by the BFN PSA (References 2 and 3) and the BFN Individual Plant Examination of External Event (IPEEE) (References 4 through 7). This initial list was then screened to remove those that met the following criteria:

- does not apply to the BFN or to BWRs in general,
- already in place at BFN, or
- Rough order of magnitude (ROM) costs exceed the screening cost savings.

This screening process will leave unique SAMA candidates that are applicable to BFN and are of potential value in averting the risk of severe accidents. A preliminary cost estimate will be prepared for each of these candidates based on previous design/procedural modifications of similar scope to focus on those that had the possibility of having a positive benefit and to eliminate those whose costs were clearly beyond the possibility of any corresponding benefit.

A more detailed estimate will be prepared for those items that appear to be cost effective.

The initial list of candidates is provided in Tables IV-1 and IV-2.

Table IV-1. Initial Screening of Generic SAMAs

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
1	Cap downstream piping of normally closed component cooling water drain and vent valves.	SAMA to reduce the frequency of a loss of component cooling event, a large portion of which was derived from catastrophic failure of one of the many single isolation valves.	N/A	N/A
2	Enhance loss of component cooling procedure to facilitate stopping reactor coolant pumps.	SAMA to reduce the potential for RCP seal damage due to pump bearing failure.	B	N/A
3	Enhance loss of component cooling procedure to present desirability of cooling down RCS prior to seal LOCA.	SAMA would reduce the potential for RCP seal failure.	B	N/A
4	Additional training on the loss of component cooling.	SAMA would potentially improve the success rate of operator actions after a loss of component cooling (to prevent RCP seal damage).	B	N/A
5	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	SAMA would reduce effect of loss of component cooling by providing a means to maintain the centrifugal charging pump seal injection after a loss of component cooling.	B	N/A
5A	Procedure changes to allow cross connection of motor cooling for RHRSW pumps.	SAMA would allow continued operation of both RHRSW pumps on a failure of one train of PSW.	N/A	N/A
6	On loss of essential raw cooling water, proceduralize shedding component cooling water loads to extend component cooling heatup.	SAMA would increase time before the loss of component cooling (and reactor coolant pump seal failure) in the loss of essential raw cooling water sequences.	B	N/A
7	Increase CRD pump lube oil capacity.	SAMA would lengthen the time before control rod drive (CRD) pump failure due to lube oil	None	Phase II SAMA 01
8	Eliminate the RCP thermal barrier dependence on component cooling such that loss of component cooling does not result directly in core damage.	SAMA would prevent the loss of recirculation pump seal integrity after a loss of component cooling. Watts Bar Nuclear Plant IPE said that they could do this with essential raw cooling water connection to charging pump seals.	B	N/A
9	Add redundant DC Control Power for SW Pumps.	SAMA would increase reliability of SW and decrease core damage frequency due to a loss of SW. Relevant, potential concern at BFN is loss of DC-D	D	SAMA 57

Table IV-1. Initial Screening of Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
10	Create an independent RCP seal injection system, with a dedicated diesel.	SAMA would add redundancy to RCP seal cooling alternatives, reducing CDF from loss of component cooling or service water or from a station blackout event.	B	N/A
11	Use existing hydro test pump for RCP seal injection.	SAMA would provide an independent seal injection source, without the cost of a new system.	B	N/A
12	Replace ECCS pump motor with passively cooled motors.	SAMA would eliminate ECCS dependency on EECW.	None	Phase II SAMA 02
13	Install improved RCS pumps seals.	RCP seal O-ring constructed of improved materials would reduce probability of RCP seal LOCA	B	N/A
14	Install additional component cooling water pump.	SAMA would reduce probability of loss of component cooling leading to RCP seal LOCA.	B	N/A
15	Prevent centrifugal charging pump flow diversion from the relief valves.	If relieve valve opening causes a flow diversion large enough to prevent RCP seal injection, then the modification would reduce the frequency of the loss of RCP seal cooling.	B	N/A
16	Change procedures to isolate RCP seal letdown flow on loss of component cooling, and guidance on loss of injection during seal LOCA.	SAMA would reduce CDF from loss of seal cooling.	B	N/A
17	Implement procedures to stagger CRD pump use after a loss of service water.	SAMA would allow injection with CRD to be extended after a loss of service water.	None	Phase II SAMA 03
18	Use fire protection system pumps as a backup seal injection and high pressure make-up.	SAMA would reduce the frequency of the RCP seal LOCA and the SBO CDF.	B	N/A
19	Procedural guidance for use of cross-tied component cooling or service water pumps.	SAMA would reduce the frequency of the loss of component cooling water and service water.	None	Phase II SAMA 04
20	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	SAMA would potentially improve the success rate of operator actions subsequent to support system failures.	None	Phase II SAMA 05

Table IV-1. Initial Screening of Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
21	Improved ability to cool the residual heat removal heat exchangers	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the fire protection system or by installing a component cooling water crosstie.	None	Phase II SAMA 06
22	Provide reliable power to Control Building fans	SAMA would increase availability of control room ventilation on a loss of power.	N/A	Control Bay HVAC was not a critical function represented in the BFN models
23	Provide a redundant train of ventilation.	SAMA would increase the availability of components dependent on room cooling.	None	Phase II SAMA 07
24	Procedures for actions on loss of HVAC.	SAMA would provide for improved electrical equipment reliability upon a loss of Control Building HVAC)	C	N/A
25	Add a diesel building switchgear room high temperature alarm.	SAMA would improve diagnosis of a loss of switchgear room HVAC. Option 1: Install high temp alarm Option 2: Redundant louver and thermostat	None	Phase II SAMA 08
26	Create ability to switch fan power supply to direct current (DC) in an SBO event.	SAMA would allow continued operation in an SBO event. This SAMA was created for reactor core isolation cooling system room at Fitzpatrick Nuclear Power Plant.	N/A	N/A
27	Delay containment spray actuation after large LOCA.	SAMA would lengthen time of RWST availability.	N/A	N/A
28	Install containment spray pump header automatic throttle valves.	SAMA would extend the time over which water remains in the RWST, when full CS flow is not needed	N/A	N/A
29	Install an independent method of suppression pool cooling.	SAMA would decrease the probability of loss of containment heat removal.	D	SAMA 124
30	Develop an enhanced drywell spray system.	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.	D	SAMA 46
31	Provide dedicated existing drywell spray system.	SAMA would provide a source of water to the containment to control containment pressure, when used in conjunction with containment heat removal. This would use an existing spray loop instead of developing a new spray system.	C	N/A
32	Install an unfiltered hardened containment vent.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products not being scrubbed.	C	N/A

Table IV-1. Initial Screening Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
33	Install a filtered containment vent to remove decay heat.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products being scrubbed. Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber	E	Cost in excess of $5M per unit
34	Install a containment vent large enough to remove ATWS decay heat.	Assuming that injection is available, this SAMA would provide alternate decay heat removal in an ATWS event.	None	Phase II SAMA 09
35	Create/enhance hydrogen recombiners with independent power supply.	SAMA would reduce hydrogen detonation at lower cost, Use either a new, independent power supply, a nonsafety-grade portable generator, existing station batteries, or existing AC/DC independent power supplies.	N/A	N/A
35A	Install hydrogen recombiners.	SAMA would provide a means to reduce the chance of hydrogen detonation.	N/A	N/A
36	Create a passive design hydrogen ignition system.	SAMA would reduce hydrogen denotation system without requiring electric power.	N/A	N/A
37	Create a large concrete crucible with heat removal potential under the basemat to contain molten core debris.	SAMA would ensure that molten core debris escaping form the vessel would be contained within the crucible. The water cooling mechanism would cool the molten core, preventing a melt-through of the basemat.	E	Cost well in excess of $10M per unit
38	Create a water-cooled rubble bed on the pedestal.	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.	E	Cost well in excess of $10M per unit
39	Provide modification for flooding the drywell head.	SAMA would help mitigate accidents that result in the leakage through the drywell head seal.	N/A	Containment failure dominated by wet well failure or dry well shell failure other than head region (BFN IPE NUREG-1150)*
40	Enhance fire protection system and/or standby gas treatment system hardware and procedures.	SAMA would improve fission product scrubbing in severe accidents.	C	N/A
41	Create a reactor cavity flooding system.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.	C	N/A

* *Reference 16*

Table IV-1. Initial Screening of Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
42	Create other options for reactor cavity flooding.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.	D	SAMA 41
43	Enhance air return fans (ice condenser plants).	SAMA would provide an independent power supply for the air return fans, reducing containment failure in SBO sequences.	N/A	N/A
44	Create a core melt source reduction system.	SAMA would provide cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal from the vitrified compound would be facilitated, and concrete attack would not occur.	E	Cost well in excess of $10M per unit
45	Provide a containment inerting capability.	SAMA would prevent combustion of hydrogen and carbon monoxide gases.	C	N/A
46	Use the fire protection system as a back-up source for the containment spray system.	SAMA would provide redundant containment spray function without the cost of installing a new system.	None	Phase II SAMA 10
47	Install a secondary containment filter vent.	SAMA would filter fission products released from primary containment.	C	N/A
48	Install a passive containment spray system.	SAMA would provide redundant containment spray method without high cost.	None	Phase II SAMA 11
49	Strengthen primary/secondary containment.	SAMA would reduce the probability of containment overpressurization to failure.	E	Cost well in excess of $10M per unit
50	Increase the depth of the concrete basemat or use an alternative concrete material to ensure melt-through does not occur.	SAMA would prevent basemat melt-through.	N/A	N/A
51	Provide a reactor vessel exterior cooling system.	SAMA would provide the potential to cool a molten core before it causes vessel failure, if the lower head could be submerged in water.	E	Cost well in excess of $10M per unit
52	Construct a building to be connected to primary/secondary containment that is maintained at a vacuum.	SAMA would provide a method to depressurize containment and reduce fission product release.	E	Cost well in excess of $10M per site
53	Not Used	None	N/A	N/A

Table IV-1. Initial Screening of Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
54	Proceduralize alignment of spare diesel to shutdown board after Loss of Offsite Power and failure of the diesel normally supplying it.	SAMA would reduce the SBO frequency.	N/A	N/A
55	Not Used	None	N/A	N/A
56	Provide an additional diesel generator.	SAMA would increase the reliability and availability of onsite emergency AC power sources.	F	N/A
57	Provide additional DC battery capacity	SAMA would ensure longer batter capability during an SBO, reducing the frequency of long-term SBO sequences.	None	Phase II SAMA 12
58	Use fuel cells instead of lead-acid batteries.	SAMA would extend DC power availability in an SBO.	None	Phase II SAMA 12
59	Procedure to crosstie high pressure core spray diesel.	SAMA would improve core injection availability by providing a more reliable power supply for the high pressure core spray pumps.	N/A	N/A
60	Improve 4.16 kV bus crosstie ability.	SAMA would improve AC power reliability.	D	SAMA 132
61	Incorporate an alternate battery charging capability.	SAMA would improve DC power reliability by either cross-tying the AC buses, or installing a portable diesel-driven batter charger.	None	Phase II SAMA 13
62	Increase/improve DC bus load shedding.	SAMA would extend battery life in an SBO event.	None	Phase II SAMA 12
63	Replace existing batteries with more reliable ones.	SAMA would improve DC power reliability and thus increase available SBO recovery time.	None	Phase II SAMA 13
63A	Mod for DC Bus A reliability Loss of DC Bus A causes a loss of main condenser, prevents transfer from the main transformer to offsite power, and defeats one half of the low vessel pressure permissive for LPCI/CS injection valves.	SAMA would increase the reliability of AC power and injection capability.	N/A	Loss of DC bus does not cause plant trip at BFNP
64	Create AC power crosstie capability with other unit.	SAMA would improve AC power reliability.	C	N/A
65	Create a crosstie for diesel fuel oil.	SAMA would increase diesel fuel oil supply and thus diesel generator, reliability.	C	N/A

Table IV-1. Initial Screening of Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
66	Develop procedures to repair or replace failed 4 kV breakers.	SAMA would offer a recovery path from a failure of the breakers that perform transfer of 4.16kV non-emergency busses from unit station service transformers, leading to loss of emergency AC power.	None	Phase II SAMA 14
67	Emphasize steps in recovery of offsite power after an SBO.	SAMA would reduce human error probability during offsite power recovery.	C	N/A
68	Develop a severe weather conditions procedure.	For plants that do not already have one, this SAMA would reduce the CDF for external weather-related events.	C	N/A
69	Develop procedures for replenishing diesel fuel oil.	SAMA would allow for long-term diesel operation.	C	BFN UFSAR 8.5.3.4
70	Install gas turbine generator.	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.	E	Cost greater than $10M for site
71	Not Used	None	N/A	N/A
72	Create a back-up source for diesel cooling. (Not from existing system)	This SAMA would provide a redundant and diverse source of cooling for the diesel generators which would contribute to enhanced diesel reliability.	E	Cost greater than $10M for site
73	Use Fire Protection System as a back-up source for diesel cooling.	This SAMA would provide a redundant and diverse source of cooling for the diesel generators which would contribute to enhanced diesel reliability.	None	Phase II SAMA 15
74	Provide a connection to an alternate source of offsite power.	SAMA would reduce the probability of a loss of offsite power event.	F	N/A
75	Bury offsite power lines.	SAMA could improve offsite power reliability, particularly during severe weather.	E	Cost greater than $10M for site
76	Replace anchor bolts on diesel generator oil cooler. Millstone Nuclear Power Station found a high seismic SBO risk due to failure of the diesel oil cooler anchor bolts.	For plants with a similar problem, this would reduce seismic risk. Note that these were Fairbanks Morse DGs.	D	SAMA 138

Table IV-1. Initial Screening of Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
77	Change Undervoltage (UV), Auxiliary Feedwater Actuation Signal (AFAS) Block and High Pressurizer Pressure Actuation Signals to 3-out-of-4, instead of 2-out-of-4 logic.	SAMA would reduce risk of 2/4 inverter failure.	N/A	N/A
78	Provide DC power to the 120/240 V vital AC system from the Class 1E station service battery system instead of its own battery.	SAMA would increase the reliability of the 120 VAC Bus.	N/A	N/A
79	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture (SGTR).	SAMA would enhance depressurization during a SGTR.	N/A	N/A
80	Improve SGTR coping abilities.	SAMA would improve instrumentation to detect SGTR, or additional system to scrub fission product releases.	N/A	N/A
81	Add other SGTR coping abilities.	SAMA would decrease the consequences of an SGTR.	N/A	N/A
82	Increase secondary side pressure capacity such that an SGTR would not cause the relief valves to lift.	SAMA would eliminate direct release pathway for SGTR sequences.	N/A	N/A
83	Replace steam generators (SG) with a new design.	SAMA would lower the frequency of an SGTR.	N/A	N/A
84	Revise emergency operating procedures to direct that a faulted SG be isolated.	SAMA would reduce the consequences of an SGTR.	N/A	N/A
85	Direct SG flooding after a SGTR, prior to core damage.	SAMA would provide for improved scrubbing of SGTR releases.	N/A	N/A
86	Implement a maintenance practice that inspects 100% of the tubes in an SG.	SAMA would reduce the potential for an SGTR.	N/A	N/A
87	Locate RHR inside of containment.	SAMA would prevent ISLOCA out the RHR pathway.	E	Cost greater than $10M per unit
88	Not Used.	None	N/A	N/A

Table IV-1. Initial Screening of Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
89	Install additional instrumentation for ISLOCAs.	Pressure of leak monitoring instruments installed between the first two pressure isolation valves on low-pressure inject lines, RHR suction lines, and HPSI lines would decrease ISLOCA frequency.	A	N/A
90	Increase frequency for valve leak testing.	SAMA could reduce ISLOCA frequency.	A	N/A
91	Improve operator training on ISLOCA coping.	SAMA would decrease ISLOCA effects.	A	N/A
92	Install relief valves in the CC System.	SAMA would relieve pressure buildup from an RCP thermal barrier tube rupture, preventing an ISLOCA.	N/A	N/A
93	Provide leak testing of valves in ISLOCA paths. At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested.	This SAMA would help reduce ISLOCA frequency.	A	N/A
94	Revise EOPs to improve ISLOCA identification. Salem Nuclear Power Plant had a scenario where an RHR ISLOCA could direct initial leakage back to the pressurizer relief tank, giving indication that the LOCA was inside containment.	Procedure enhancements would ensure LOCA outside containment could be identified as such.	N/A	N/A
95	Ensure all ISLOCA releases are scrubbed.	This SAMA would scrub all ISLOCA releases. One example is to plug drains in the break area so that the break point would cover with water.	A	N/A
96	Add redundant and diverse limit switches to each containment isolation valve.	Enhanced isolation valve position indication could reduce the frequency of containment isolation failure and ISLOCAs.	A	N/A
97	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	SAMA would prevent flood propagation, for a plant where internal flooding from turbine building to safeguards areas is a concern.	N/A	Doors open into turbine building. No flooding scenarios propagating from turbine building to safeguards area (BFN IPE)
98	Improve inspection of rubber expansion joints on main condenser.	SAMA would reduce the frequency of internal flooding, for a plant where internal flooding due to a failure of circulating water system expansion joints is a concern.	None	Phase II SAMA 17

Table IV-1. Initial Screening of Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
99	Implement internal flood prevention and mitigation enhancements.	This SAMA would reduce the consequences of internal flooding.	D	SAMA 128
100	Implement internal flooding improvements such as those implemented at Fort Calhoun.	This SAMA would reduce flooding risk by preventing or mitigating: a rupture in the RCP seal cooler of the component cooling system an ISLOCA in a shutdown cooling line, an AFW flood involving the need to remove a watertight door.	N/A	N/A
101	Install a digital feedwater upgrade.	This SAMA would reduce the chance of a loss of main feedwater following a plant trip.	C	N/A
102	Perform surveillances on manual valves used for back-up AFW pump suction.	This SAMA would improve success probability for providing alternative water supply to the AFW pumps.	N/A	N/A
103	Install manual isolation valves around AFW turbine-driven steam admission valves.	This SAMA would reduce the dual turbine-driven AFW pump maintenance unavailability.	N/A	N/A
104	Install accumulators for turbine-driven AFW pump flow control valves (CVs).	This SAMA would provide control air accumulators for the turbine-driven AFW flow CVs, the motor-driven AFW pressure CVs and SG PORVs. This would eliminate the need for LOCA manual action to align nitrogen bottles for control air during a LOOP.	N/A	N/A
105	Proceduralize intermittent operation of HPCI.	SAMA would allow for extended duration of HPCI availability.	C	If RCIC is available, HPCI used in test mode to control pressure and avoid cycling.
106	Increase the reliability of safety relief valves. (Adding signals to add electrical signal to open automatically).	SAMA reduces the probability of a certain type of medium break LOCA. Hatch evaluates medium LOCA initiated by an MSIV closure transient with a failure of SRVs to open. Reducing the likelihood of the failure for SRVs to open subsequently reduces the occurrence of this medium LOCA.	C	N/A
107	Install motor-driven feedwater pump.	This would increase the availability of injection subsequent to MSIV closure.	E	Cost greater than $10M per unit
108	Procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	SAMA increases availability of required RHR/CS pumps. Reduction in room heat load allows continued operation of required RHR/CS pumps, when room cooling is lost.	None	Phase II SAMA 18

Table IV-1. Initial Screening of Generic SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
109	Increase available NPSH for injection pumps.	SAMA increases the probability that these pumps will be available to inject coolant into the vessel by increasing the available NPSH for the injection pumps.	C	NPSH concerns are not a concern in the dominant BFN sequences. RHR has been demonstrated to operate satisfactorily at less than "minimum" NPSH. Torus water temperature leading to loss of lube oil cooling rather than NPSH, is a limiting concern for HPCI and RCIC
110	Increase the SRV reseat reliability.	SAMA addresses the risk associated with dilution of boron caused by the failure of the SRVs to reseat after SLC injection.	None	Phase II SAMA 19
111	Reduce DC dependency between high pressure injection system and ADS.	SAMA would ensure vessel depressurization and high pressure injection upon a DC failure.	None	Phase II SAMA 20
112	Modify RWCU for use as a decay heat removal system and proceduralize use.	SAMA would provide an additional source of decay heat removal.	C	N/A
113	Use of CRD for alternate boron injection.	SAMA provides an additional system to address ATWS with SLC failure or unavailability.	None	Phase II SAMA 21
114	Increase seismic ruggedness of plant components.	SAMA would increase the availability of necessary plant equipment during and after seismic events.	D	SAMA 138
115	Allow cross connection of uninterruptable compressed air supply to opposite unit.	SAMA would increase the ability to depressurize containment using the hardened vent.	N/A	N/A

**Note:*

N/A indicates that the proposed SAMA is not applicable to BFN or the BWR-4/Mark I design.

A indicates that the proposed SAMA is related to mitigation of an Intersystem LOCA (ISLOCA). ISLOCA contributes little risk for boiling water reactors, because of the lower primary pressures. Because of the low risk contribution due to ISLOCA, this SAMA has not been developed further.

B indicates that the proposed SAMA is related to RCP seal leakage. A review of NUREG-1560 (Reference 13) indicates that although RCP seal leakage is important for PWRs, recirculation pump leakage does not significantly contribute to CDF in BWRs.

C indicates that the proposed SAMA has already been installed at BFN.

D indicates that similar item is addressed under other proposed SAMAs.

E indicates that SAMA did not pass initial cost screening and was therefore not examined in detail.

F Primary cause of loss of existing, redundant hardware is due to a common cause event, which another string of hardware would not alleviate.

Table IV-2. Initial Screening of Plant Specific SAMAs

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
116	borate torus water	borate torus water to mitigate ATWS upon water injection from the torus.	None	Phase II SAMA 22
117	automate torus cooling	automate torus cooling on high torus temperature to avoid lack of torus cooling due to operator error	None	Phase II SAMA 23
117a	provide torus positive pressure relief valves	provide torus positive pressure relief valves to prevent containment overpressure failure	None	Phase II SAMA 24
117b	reduce DW head bolt pretension	reduce DW head bolt pretension to allow DW to “burp” thereby preventing catastrophic containment overpressure failure	None	Phase II SAMA 24
118	Eliminate operator action to inhibit ADS for ATWS	Mitigate failure to inhibit ADS due to operator error during ATWS conditions.	D	SAMA 116
119	Eliminate fine water level control for ATWS	Mitigate failure to control water level at TAF due to operator error for ATWS conditions.	D	SAMA 116
120	Provide redundancy for SLC	ATWS, Provide redundancy to mitigate failure of SLC due to hardware failure during ATWS conditions.	D	SAMA 116
121	automate SLC initiation	automate SLC initiation to mitigate failure of SLC due to operator error during ATWS conditions	None	Phase II SAMA 25
122	RPV replacement	replace the RPV to reduce probability of Excessive LOCA	E	Cost greater than $10M per unit
122a	RPV inspection	increase the RPV inspection frequency to reduce probability of Excessive LOCA	None	Phase II SAMA 26
123	remove DW high pressure signal from ADS logic	remove DW high pressure signal from ADS logic to mitigate loss of all HP injection coupled with failure to depressurize due to operator error	C	N/A
124	provide independent torus cooling system	mitigate failure of torus cooling due to hardware failure	None	Phase II SAMA 27
125	Eliminate operator action to initiate torus cooling	Mitigate loss of all HP injection due to hardware failure coupled with failure of torus cooling due to operator error	D	SAMA 117
126	Eliminate operator action to depressurize reactor in event of HP injection failure.	Mitigate loss of all HP injection due to operator error coupled with failure to depressurize due to operator error	D	SAMA 123
127	Provide core cooling system outside interfacing system LOCA zone of influence	Mitigate effects of interfacing system LOCA	D	SAMA 133
128	Provide core cooling system outside flood zone of influence	Mitigate effects of internal Flooding	D	SAMA 133
129	Not used	None	N/A	N/A
130	Not used	None	N/A	N/A

Table IV-2. Initial Screening of Plant Specific SAMAs (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
131	Not used	None	N/A	N/A
132	Improve 4kV crosstie capability	Provide 4kV shutdown bus crosstie capability from Unit 1/2 to Unit 3.	None	Phase II SAMA 28
133	Provide HP diesel-driven pump.	Provide capability to inject river water at HP via diesel-driven pump to mitigate Station Blackout	None	Phase II SAMA 29
134	Provide additional LP core cooling system	Mitigate SORV coupled with failure of LP injection due to hardware failure	D	SAMA 133
135	Not used	None	N/A	N/A
136	Not used	None	N/A	N/A
137	Reduce fire risk	Mitigate Fire effects	K	N/A
138	Reduce earthquake risk	Mitigate Earthquake effects	G, H, I	N/A
139	Reduce HFO risk	Mitigate effects of High winds, Floods, Transportation, and Other (HFO) External Events.	J	N/A

**Note:*

N/A indicates that the proposed SAMA is not applicable to BFN or the BWR-4/Mark I design.

A indicates that the proposed SAMA is related to mitigation of an Intersystem LOCA (ISLOCA). Because of the low risk contribution due to ISLOCA, this SAMA has not been developed further.

B indicates that the proposed SAMA is related to RCP seal leakage. A review of NUREG-1560 (Reference 13) indicates that although RCP seal leakage is important for PWRs, recirculation pump leakage does not significantly contribute to CDF in BWRs.

C indicates that the proposed SAMA has already been installed at BFN.

D indicates that similar item is addressed under other proposed SAMAs.

E indicates that SAMA did not pass initial cost screening and was therefore not examined in detail.

F Primary cause of loss of existing, redundant hardware is due to a common cause event, which another string of hardware would not alleviate.

G "The outliers identified [in accordance with the Seismic Qualification Utility Group Generic Implementation Procedure criteria] for BFN Unit 3 were resolved during the Cycle 7 refueling outage that completed on March 13, 1997." "TVA considers the commitments regarding USI A-46 and the seismic portion of IPEEE to be complete for BFN Unit 3." Letter from TVA to the USNRC. R08 970411 803 (Reference 14).

H "...TVA has completed the resolution of outliers for BFN Unit 2 identified in accordance with the Seismic Qualification Utility Group (SQUG) Generic Implementation Procedure (GIP) criteria." "The outliers identified for BFN Unit 2 were resolved ... during the Cycle 9 refueling outage that completed on October 19. 1997." "TVA considers the commitments regarding USI A-46 and the seismic portion of IPEEE to be complete for BFN Unit 2." Letter from TVA to the USNRC. R08 971118 922 (Reference 15).

I "The staff's review of the licensee's action regarding outliers indicates that identified outliers have been resolved by analysis or corrective actions." "The staff has also concluded that its findings regarding the USI A-46 program do not warrant any further regulatory action under the provisions of 10 CFR 50.54(f)." Letter from the USNRC to TVA dated 3/21/2000 and attached USI A-46 SER (Reference 7).

J "These events were screened out in a manner consistent with the guidance given in NUREG-1407...." Letter from the USNRC to TVA dated 6/22/2000, and attached IPEEE SER (Reference 6).

K "No plant modifications were found to be necessary as a result of the fire IPEEE for BFN Units 2 and 3." Letter from the USNRC to TVA dated 6/22/2000, and attached IPEEE SER (Reference 6).

V. SAMA Analysis Results for BFN

A. Summary of Phase II SAMA Analysis

A summary of Phase II SAMAs is shown in Table V-1.

SAMA hardware implementation costs were first estimated in 2001 dollars and are based on costs of previous modifications judged to be similar in scope to the proposed SAMA (Reference 17). New or revised procedures were estimated to cost $50K per unit. These values were then inflated (at 3%/year) to arrive at Year 2016 estimated costs. This step is necessary to make the costs directly comparable to estimated costs averted.

Figure V-1 presents a sample table of results that summarizes the comparison of the baseline PRA results and the PRA results of each SAMA.

Baseline PRA Results

SAMA PRA Results

MAAP Case	Baseline Case	SAMA 02 Case
PIHDEP	3.65E-07	2.09E-07
PIHDEPV	2.52E-07	2.07E-07
PIHDLV	7.75E-10	4.14E-10
ENMKCTT	7.39E-08	7.08E-08
OIA	6.90E-08	8.61E-08
OIALF	2.93E-08	2.15E-08
MIALF	1.36E-07	1.37E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.80E-09
PID	2.88E-08	2.84E-08
NIH	295E-08	2.96E-08
Person-rem	3.03	2.36
Unit 2 Total Cost (3%)	$299,986	$235,953
Unit 2 Total Cost (7%)	$207,731	$163,200
SAMA 02 Saving (3%)	$64,033	
SAMA 02 Saving (7%)	$44,531	

Total cost for Baseline Case

Savings = Baseline case - SAMA case, e.g., $299,986 - $235,953 = $64,033

Total cost with SAMA Implemented

Figure V-1. Sample Table of Results

Table V-1. Summary of Phase II SAMA Analysis

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
1	7	Increase CRD pump lube oil capacity.	SAMA would lengthen the time before control rod drive (CRD) pump failure due to lube oil	N/A	N/A	No significant risk decrease. See Section V.B
2	12	Replace ECCS pump motor with air-cooled motors.	SAMA would eliminate ECCS dependency on ERCW.	$6M per unit	$9.3M per unit	See Section V.C
3	17	Implement procedures to stagger CRD pump use after a loss of service water.	SAMA would allow injection with CRD to be extended after a loss of service water.	$50k/unit	$78k/unit	No significant risk decrease. See Section V.D
4	19	Procedural guidance for use of cross-tied component cooling or service water pumps.	SAMA would reduce the frequency of the loss of component cooling water and service water.	$50k/unit	$78k/unit	See Section V.E
5	20	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	SAMA would potentially improve the success rate of operator actions subsequent to support system failures.	$50k/unit	$78k/unit	See Section V.F
6	21	Improved ability to cool the residual heat removal heat exchangers	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the fire protection system or by installing a component cooling water crosstie.	$1M/unit	$1.5M/unit	See Section V.G
7	23	Provide a redundant train of ventilation.	SAMA would increase the availability of components dependent on room cooling.	$6M/unit.	$9.3M per unit	See Section V.H
8	25	Add a diesel building switchgear room high temperature alarm.	SAMA would improve diagnosis of a loss of switchgear room HVAC. Option 1: Install high temp alarm Option 2: Redundant louver and thermostat	option 1: $400k per building option 2: $6M per building	Option 1: $623K per building. Option 2: $9.3M per building.	See Section V.I

Table V-1. Summary of Phase II SAMA Analysis (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
9	34	Install a containment vent large enough to remove ATWS decay heat.	Assuming that injection is available, this SAMA would provide alternate decay heat removal in an ATWS event.	$2M/unit	$3.1M/unit	See Section V.J
10	46	Use the fire protection system as a back-up source for the containment spray system.	SAMA would provide redundant containment spray function without the cost of installing a new system.	$500k/unit	$779k/unit	See Section V.K
11	48	Install a passive containment spray system.	SAMA would provide redundant containment spray method.	$6M/unit	$9.3M/unit	See Section V.L
12	57	Provide additional DC battery capacity.	SAMA would ensure longer batter capability during an SBO, reducing the frequency of long-term SBO sequences.	$1M/plant	$1.5M/plant	See Section V.M.
	58	Use fuel cells instead of lead-acid batteries.	SAMA would extend DC power availability in an SBO.	$6M/plant	$9.3M/plant	
	62	Increase/improve DC bus load shedding.	SAMA would extend battery life in an SBO event.	$50k/plant	$78k/plant	
	9	Add redundant DC Control Power for SW pumps	SAMA would increase reliability of SW and decrease core damage frequency due to a loss of SW. Relevant potential concern at BFN is loss of DC-D	$1M/plant	$1.5M/plant	
13	61	Incorporate an alternate battery charging capability.	SAMA would improve DC power reliability by either cross-tying the AC buses, or installing a portable diesel-driven battery charger.	$1M/unit	1.5M/unit	See Section V.N
	63	Replace existing batteries with more reliable ones.	SAMA would improve DC power reliability and thus increase available SBO recovery time.	$6M/plant	$9.3M/plant	

Table V-1. Summary of Phase II SAMA Analysis (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
14	66	Develop procedures to repair or replace failed 4 kV breakers.	SAMA would offer a recovery path from a failure of the breakers that perform transfer of 4.16kV non-emergency busses from unit station service transformers, leading to loss of emergency AC power.	$50k/unit	$78k/unit	See Section V.O
15	73	Use Fire Protection System as a back-up source for diesel cooling.	This SAMA would provide a redundant and diverse source of cooling for the diesel generators which would contribute to enhanced diesel reliability.	$1M/plant	$1.5M/plant	See Section V.P
16		This reference is reserved.				
17	98	Improve inspection of rubber expansion joints on main condenser.	SAMA would reduce the frequency of internal flooding, for a plant where internal flooding due to a failure of circulating water system expansion joints is a concern.	$100k/unit	$155k/unit	See Section V.R
18	108	Procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	SAMA increases availability of required RHR/CS pumps. Reduction in room heat load allows continued operation of required RHR/CS pumps, when room cooling is lost.	$50k/unit	$78k/unit	See Section V.S
19	110	Increase the SRV reseat reliability.	SAMA addresses the risk associated with dilution of boron caused by the failure of the SRVs to reseat after SLC injection.	$700k/unit	$1.09M/unit	See Section V.T
20	111	Reduce DC dependency between high pressure injection system and ADS.	SAMA would ensure vessel depressurization and high pressure injection upon a DC failure.	$500k/unit	$779k/unit	See Section V.U

Table V-1. Summary of Phase II SAMA Analysis (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
21	113	Use of CRD for alternate boron injection.	SAMA provides an additional system to address ATWS with SLC failure or unavailability.	$2M/unit	$3.1M/unit	See Section V.V
22	116	Borate torus water	Borate torus water to mitigate ATWS upon water injection from the torus.	$6M/unit	$9.3M/unit	See Section V.W
23	117	Automate torus cooling	Automate torus cooling on high torus temperature to avoid lack of torus cooling due to operator error	$400k/unit	$623k/unit	See Section V.X
24	117a	Provide torus positive pressure relief valves	Provide torus positive pressure relief valves to prevent containment overpressure failure	$700k/unit	$1.09M/unit	See Section V.Y
	177b	Reduce DW head bolt pretension	Reduce DW head bolt pretension to allow DW to “burp” thereby preventing catastrophic containment overpressure failure	$50k/unit	$78k/unit	
25	121	Automate SLC initiation	Automate SLC initiation to mitigate failure of SLC due to operator error during ATWS conditions	$400k/unit	$623k/unit	See Section V.Z
26	122a	RPV inspection	Increase the RPV inspection frequency to reduce probability of Excessive LOCA	$100k/unit	$155k/unit	See Section V.AA
27	124	Provide independent torus cooling system	Mitigate failure of torus cooling due to hardware failure	$6M/unit	$9.3M/unit	See Section V.BB
28	132	Improve 4kV crosstie capability	Provide 4kV shutdown bus crosstie capability from Unit 1/2 to Unit 3.	$5M/plant	$7.8M/plant	See Section V.CC
29	133	Provide HP diesel-driven pump.	Provide capability to inject river water at HP via diesel-driven pump to mitigate Station Blackout	$6M/unit	$9.3M/unit	See Section V.DD

B. Phase II SAMA Number 01: Increase CRD Lube Oil Capacity

This SAMA has the potential to increase the time before CRD pump failure due to failure of lube oil. The original SAMA addressed a PWR concern relating to charging pumps. The closest equivalent in BWRs are the CRD pumps.

The risk significance of the CRD pumps in the BFN models is modest. The risk reduction worth impact of the CRD system is approximately 6% and 3% for Unit 2 and Unit 3, respectively. In addition the contribution of lube oil failure to CRD system unavailability (BFN IPE) is approximately 0.2% of the total system unavailability.

It is therefore concluded that there is no significant risk reduction potential associated with this SAMA.

C. Phase II SAMA Number 02: Eliminate ECCS Dependency on EECW

This SAMA would replace ECCS pump motors with passively cooled motors. This would reduce the functional dependency of the RHR and Core Spray pumps on EECW.

To bound the potential impact of this SAMA, the dependency on all RHR and Core Spray pumps on EECW has been eliminated. In addition, the RHR and Core Spray top event models were reviewed. It was determined that failure of the pump coolers contributed approximately 20% to the split fractions representing the RHR pumps and the Core Spray system. All split fractions associated with the RHR pumps and Core Spray system were reduced by 20%. This has the effect of increasing the calculated availability of these pumps.

These changes necessitated changes to be made in the split fraction assignment rules in the low pressure general transient event tree (LPGTET), as well as the large and medium LOCA event trees (LLOCA and MLOCA, respectively). In addition, the split fraction adjustments were made directly to the master frequency file (which is the reference table for the split fractions used in the scenario quantification).

These changes reflect the following bounding assumption: Replacing the pump motors with passively cooled motors completely removes any dependency on EECW.

PSA Model Results

The results from this case indicates about a 18.6% reduction in Unit 2 CDF (CDF_{new}=8.5438E-7). The new end state frequencies are presented in Table V-2. For Unit 3 there is a 11.5% reduction in CDF (CDF_{new}=1.6788E-6) and the new end state frequencies are presented in Table V-3.

Table V-2. Unit 2 SAMA Number 02 Results

MAAP Case	Baseline Case	SAMA 02 Case
PIHDEP	3.65E-07	2.09E-07
PIHDEPV	2.52E-07	2.07E-07
PIHDLV	7.75E-10	4.14E-10
ENMKCTT	7.39E-08	7.08E-08
OIA	6.90E-08	8.61E-08
OIALF	2.93E-08	2.15E-08
MIALF	1.36E-07	1.37E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.80E-09
PID	2.88E-08	2.84E-08
NIH	2.95E-08	2.96E-08
Person-rem	3.03	2.36
Unit 2 Total Cost (3%)	$299,986	$235,953
Unit 2 Total Cost (7%)	$207,731	$163,200
SAMA 02 Saving (3%)	$64,033	
SAMA 02 Saving (7%)	$44.531	

Table V-3. Unit 3 SAMA Number 02 Results

MAAP Case	Baseline Case	SAMA 02 Case
PIHDEP	8.59E-07	6.38E-07
PIHDEPV	4.20E-07	3.71E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.42E-07
OIA	1.60E-07	2.27E-07
OIALF	1.11E-08	8.43E-09
MIALF	1.32E-07	1.33E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.94E-08
PID	9.67E-09	9.37E-09
NIH	3.75E-09	3.76E-09
Person-rem	6.28	5.48
Unit 3 Total Cost (3%)	$609,146	$533,518
Unit 3 Total Cost (7%)	$423,366	$370,691
SAMA 02 Saving (3%)	$75,628	
SAMA 02 Saving (7%)	$52,675	

D. Phase II SAMA Number 03: Implement Procedures to Stagger CRD Pump Use After Loss of Service Water

This SAMA originally was originally associated with the PWR concern of loss of high pressure injection following loss of service water. The CRD system at BFN can act as a source of high pressure injection and is dependent on RCW. RCW provides oil bearing cooling and thrust bearing cooling. Staggering CRD pump operation would have little benefit on loss of service water.

E. Phase II SAMA Number 04: Enhance Ability to Crosstie Service Water

Several systems at BFN provide the generic 'service water' systems support function. These systems include RCW, EECW, RHRSW, and RBCCW.

The base case models reflect the capability to realign swing RHRSW pumps to support EECW.

To bound the potential benefit of further enhancing the ability to cross tie service water systems (via hardware and procedural changes), the following assumptions were made:

1. If insufficient EECW flow occurs and the RHRSW swing pumps are available, the actions necessary to align the swing pumps for EECW service are assumed to occur with a probability of 1.

2. RBCCW is assumed to be successful if RCW is available. In other words, it is assumed that RCW is cross-tied to RBCCW.

3. The frequency of the initiator Loss of RBCCW is assumed to be zero.

To reflect these changes, top OEE, alignment of the swing RHRSW to support EECW, is assumed to be successful if the swing pumps are available. Also top RBC representing the availability of the RBCCW system is assumed to be available if RCW is available.

PSA Model Results

The results from this case indicates about a 0.9% reduction in Unit 2 CDF (CDF_{new}=1.0400E-6). The new end state frequencies are presented in Table V-4. Unit 3 there is a 1.6% reduction in CDF (CDF_{new}=1.8675E-6) and the new end state frequencies are presented in Table V-5.

Table V-4. Unit 2 SAMA Number 04 Results

MAAP Case	Baseline Case	SAMA 04 Case
PIHDEP	3.65E-07	3.63E-07
PIHDEPV	2.52E-07	2.49E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.33E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.33E-07
PJHNSP	6.14E-08	6.13E-08
PLF	4.07E-09	3.87E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.79E-08
Person-rem	3.03	3.01
Unit 2 Total Cost (3%)	$299,986	$297,934
Unit 2 Total Cost (7%)	$207,731	$206,328
SAMA 04 Saving (3%)	$2,052	
SAMA 04 Saving (7%)	$1,403	

Table V-5. Unit 3 SAMA Number 04 Results

MAAP Case	Baseline Case	SAMA 04 Case
PIHDEP	8.59E-07	8.43E-07
PIHDEPV	4.20E-07	4.17E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.50E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.26E-07
PJHNSP	1.28E-07	1.27E-07
PLF	2.11E-08	2.00E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.50E-09
Person-rem	6.28	6.19
Unit 3 Total Cost (3%)	$609,146	$600,706
Unit 3 Total Cost (7%)	$423,366	$417,524
SAMA 04 Saving (3%)	$8,440	
SAMA 04 Saving (7%)	$5,842	

F. Phase II SAMA Number 05: Enhanced Recovery of Failed Support Systems

The base case models explicitly consider the recovery of key support systems. Specific recovery actions considered in one or both base case models are:

1. Alignment of RHRSW swing pumps to support EECW operation (top OEE).
2. Restoration of power at a diesel auxiliary board (top ODSB).
3. Restoration of power to support diesel room cooling (top ODSBU3).
4. Restoration of power at a 480V Reactor MOV board (top RMOV).
5. Alignment of spare battery charger (top CPREC).
6. Recovery of power at a 4-kV shutdown board (top SDREC).
7. Alignment of power to a unit board from 161-kV results in a loss of the 500-kV supply (top OUB).
8. Recovery of power at specific unit boards (UBREC).
9. Other electric power recovery actions (top OX).

To estimate a bound for the potential impact of improved procedures, each of the split fractions associated with the above top events were assumed to improve (i.e., be more reliable) by a factor of 3.

The models were then quantified with all of the above operator recovery actions simultaneously improved.

PSA Model Results

The results from this case indicates about a 0.2% reduction in Unit 2 CDF (CDF_{new}=1.0473E-6). The new end state frequencies are presented in Table V-6. For Unit 3 there is a 0.1% reduction in CDF (CDF_{new}=1.8954E-6) and the new end state frequencies are presented in Table V-7.

Table V-6. Unit 2 SAMA Number 05 Results

MAAP Case	Baseline Case	SAMA 05 Case
PIHDEP	3.65E-07	3.63E-07
PIHDEPV	2.52E-07	2.51E-07
PIHDLV	7.75E-10	7.77E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.88E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.08E-09
PID	2.88E-08	2.85E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	3.02
Unit 2 Total Cost (3%)	$299,986	$299,202
Unit 2 Total Cost (7%)	$207,731	$207,187
SAMA 05 Saving (3%)	$784	
SAMA 05 Saving (7%)	$544	

Table V-7. Unit 3 SAMA Number 05 Results

MAAP Case	Baseline Case	SAMA 05 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	8.69E-09
NIH	3.75E-09	3.36E-09
Person-rem	6.28	6.28
Unit 3 Total Cost (3%)	$609,146	$608,907
Unit 3 Total Cost (7%)	$423,366	$423,208
SAMA 05 Saving (3%)	$239	
SAMA 05 Saving (7%)	$158	

G. Phase II SAMA Number 06: Fire Water as Backup for RHR Heat Exchanger Cooling

To estimate the potential impact of providing a connection from the fire water system to the RHR heat exchangers, the following assumptions were made:

1. The fire water system was assumed to be capable of providing adequate cooling water flow to all Unit 2 and 3 RHR heat exchangers

2. The fire water system was assumed to have a 100% availability.

3. Any required operator actions associated with aligning the fire water system to provide flow to the RHR heat exchanger was assumed to be successfully completed in a timely manner.

To implement this bounding model, split fractions representing guaranteed success associated with the four RHRSW pumps were used. (In other words, the failure fraction for top events SW2A, SW2C, SW2B, and SW2D were set to zero.)

PSA Model Results

The results from this case indicates about a 2.6% reduction in Unit 2 CDF (CDF_{new}=1.0230E-6). The new end state frequencies are presented in Table V-8. For Unit 3 there is a 9.3% reduction in CDF (CDF_{new}=1.7201E-6) and the new end state frequencies are presented in Table V-9.

Table V-8. Unit 2 SAMA Number 06 Results

MAAP Case	Baseline Case	SAMA 6 Case
PIHDEP	3.65E-07	3.39E-07
PIHDEPV	2.52E-07	2.39E-07
PIHDLV	7.75E-10	8.01E-10
ENMKCTT	7.39E-08	7.53E-08
OIA	6.90E-08	7.81E-08
OIALF	2.93E-08	2.97E-08
MIALF	1.36E-07	1.38E-07
PJHNSP	6.14E-08	6.10E-08
PLF	4.07E-09	3.24E-09
PID	2.88E-08	2.93E-08
NIH	2.95E-08	2.99E-08
Person-rem	3.03	2.93
Unit 2 Total Cost (3%)	$299,986	$290,684
Unit 2 Total Cost (7%)	$207,731	$201,252
SAMA 06 Saving (3%)	$9,302	
SAMA 06 Saving (7%)	$6,479	

Table V-9. Unit 3 SAMA Number 06 Results

MAAP Case	Baseline Case	SAMA 6 Case
PIHDEP	8.59E-07	7.52E-07
PIHDEPV	4.20E-07	3.46E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.53E-07
OIA	1.60E-07	1.63E-07
OIALF	1.11E-08	1.13E-08
MIALF	1.32E-07	1.34E-07
PJHNSP	1.28E-07	1.26E-07
PLF	2.11E-08	2.03E-08
PID	9.67E-09	9.99E-09
NIH	3.75E-09	3.84E-09
Person-rem	6.28	5.68
Unit 3 Total Cost (3%)	$609,146	$551,355
Unit 3 Total Cost (7%)	$423,366	$383,183
SAMA 06 Saving (3%)	$57,791	
SAMA 06 Saving (7%)	$40,183	

H. Phase II SAMA Number 07: Provide a Redundant Train of Ventilation

A limited number of systems are dependent on room or area cooling at BFN. The RHR and Core Spray pumps, as modeled, require fan coolers. In addition, room cooling is required for operation of the diesel generators.

A review of the systems analyses for the RHR and Core Spray systems (BFN IPE) reveals that the contribution (including common cause) to RHR or Core Spray pump unavailability due to fan cooler failure is less than 20%.

To bound the potential impact of a redundant ventilation for the RHR and Core Spray pumps, the split fractions representing these pumps (i.e., RPA, RPB, RPC, RPD and CS) were reduced by 20%.

In addition, the top event representing recovery of diesel generator room cooling was set to guaranteed success.

This bounding modeling approach assumes that the redundant ventilation has an availability of 1.0 (i.e., an unavailability of 0.0) and is independent of any support system such as electric power.

PSA Model Results

The results from this case indicates about a 18.6% reduction in Unit 2 CDF (CDF_{new}=8.5408E-7). The new end state frequencies are presented in Table V-10. For Unit 3 there is a 11.5% reduction in CDF (CDF_{new}=1.6788E-6) and the new end state frequencies are presented in Table V-11.

Table V-10. Unit 2 SAMA Number 07 Results

MAAP Case	Baseline Case	SAMA 07 Case
PIHDEP	3.65E-07	2.08E-07
PIHDEPV	2.52E-07	2.07E-07
PIHDLV	7.75E-10	4.14E-10
ENMKCTT	7.39E-08	7.08E-08
OIA	6.90E-08	8.61E-08
OIALF	2.93E-08	2.15E-08
MIALF	1.36E-07	1.37E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.80E-09
PID	2.88E-08	2.84E-08
NIH	2.95E-08	2.96E-08
Person-rem	3.03	2.36
Unit 2 Total Cost (3%)	$299,986	$235,850
Unit 2 Total Cost (7%)	$207,731	$163,129
SAMA 07 Saving (3%)	$64,136	
SAMA 07 Saving (7%)	$44,602	

Table V-11. Unit 3 SAMA Number 07 Results

MAAP Case	Baseline Case	SAMA 07 Case
PIHDEP	8.59E-07	6.37E-07
PIHDEPV	4.20E-07	3.71E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.42E-07
OIA	1.60E-07	2.27E-07
OIALF	1.11E-08	8.43E-09
MIALF	1.32E-07	1.33E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.94E-08
PID	9.67E-09	9.38E-09
NIH	3.75E-09	3.76E-09
Person-rem	6.28	5.48
Unit 3 Total Cost (3%)	$609,146	$533,509
Unit 3 Total Cost (7%)	$423,366	$370,685
SAMA 07 Saving (3%)	$75,637	
SAMA 07 Saving (7%)	$52,681	

I. Phase II SAMA Number 08: Improve Diagnostics for Diesel Generator Room HVAC

The base case models include the consideration of recovery of a diesel aux board (top ODSB, Unit 2 and Unit 3 models) and recovery of power associated with diesel C room cooling (top ODSBU3, Unit 3).

To bound the potential impact of improved diagnostics for loss of cooling to diesel generator rooms, top events relating to diesel support recovery (ODSB and ODSBU3) were set to guaranteed success.

PSA Model Results

The results from this case indicates about a 0.03% reduction in Unit 2 CDF (CDF_{new}=1.0495E-6). The new end state frequencies are presented in Table V-12. For Unit 3 there is about a 0.04 reduction in CDF (CDF_{new}=1.8966E-6) and the new end state frequencies are presented in Table V-13.

Table V-12. Unit 2 SAMA Number 08 Results

MAAP Case	Baseline Case	SAMA 08 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	3.03
Unit 2 Total Cost (3%)	$299,986	$299,880
Unit 2 Total Cost (7%)	$207,731	$207,658
SAMA 08 Saving (3%)	$106	
SAMA 08 Saving (7%)	$73	

Table V-13. Unit 3 SAMA Number 08 Results

MAAP Case	Baseline Case	SAMA 08 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	6.28	6.28
Unit 3 Total Cost (3%)	$609,146	$608,956
Unit 3 Total Cost (7%)	$423,366	$423,236
SAMA 08 Saving (3%)	$190	
SAMA 08 Saving (7%)	$130	

J. Phase II SAMA Number 09: Install a Containment Vent Large Enough to Remove ATWS Decay Heat

This SAMA would provide redundancy in the ability to remove decay heat and be of sufficient size to successfully handle ATWS decay heat levels.

To estimate the potential effects of this SAMA, the event tree structure (event tree TRANCDBIN) was reviewed along with the logic rules that determine whether a sequence is assigned to core damage or “success.” The relevant logic macro (AHEAT) was modified to reflect the vent (top event VNT) as a potential success path.

PSA Model Results

The results from this case indicates about a 0.9% reduction in Unit 2 CDF (CDF_{new}=1.0400E-6). The new end state frequencies are presented in Table V-14. For Unit 3 there is a 4.2% reduction in CDF (CDF_{new}=1.818E-6) and the new end state frequencies are presented in Table V-15.

Table V-14. Unit 2 SAMA Number 09 Results

MAAP Case	Baseline Case	SAMA 09 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	6.41E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	2.97
Unit 2 Total Cost (3%)	$299,986	$295,207
Unit 2 Total Cost (7%)	$207,731	$204,376
SAMA 09 Saving (3%)	$4,779	
SAMA 09Saving (7%)	$3,355	

Table V-15. Unit 3 SAMA Number 09 Results

MAAP Case	Baseline Case	SAMA 09 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	7.30E-08
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	6.28	5.84
Unit 3 Total Cost (3%)	$609,146	$570,657
Unit 3 Total Cost (7%)	$423,366	$396,348
SAMA 09 Saving (3%)	$38,489	
SAMA 09 Saving (7%)	$27,018	

K. Phase II SAMA Number 10: Fire Protection System as Backup Source for Containment Spray

This SAMA considers the use of the Fire Protection water as a backup source for Containment Spray.

To bound the potential impact of this SAMA, the analysis performed for Phase II SAMA 11 (the installation of a passive containment spray system) was used.

L. Phase II SAMA Number 11: Installation of a Passive Containment Spray System

This SAMA would result in the installation of a system capable of providing containment spray and be independent of operator actions.

To bound the potential impact of this SAMA, the top event representing the containment spray function (top event DWS) was set to "success."

PSA Model Results

The results from this case indicates about a 0.9% increase in Unit 2 CDF (CDF_{new}=1.0588E-6). The new end state frequencies are presented in Table V-16. For Unit 3 there is a 1.1% increase in CDF (CDF_{new}=1.9177E-6) and the new end state frequencies are presented in Table V-17.

Table V-16. Unit 2 SAMA Number 11 Results

MAAP Case	Baseline Case	SAMA 11 Case
PIHDEP	3.65E-07	3.67E-07
PIHDEPV	2.52E-07	2.53E-07
PIHDLV	7.75E-10	7.52E-10
ENMKCTT	7.39E-08	7.51E-08
OIA	6.90E-08	1.00E-07
OIALF	2.93E-08	3.05E-08
MIALF	1.36E-07	1.65E-07
PJHNSP	6.14E-08	6.16E-08
PLF	4.07E-09	4.14E-09
PID	2.88E-08	0.00E+00
NIH	2.95E-08	1.20E-09
Person-rem	3.03	Not meaningful
Unit 2 Total Cost (3%)	$299,986	Not meaningful
Unit 2 Total Cost (7%)	$207,731	Not meaningful
SAMA 11 Saving (3%)	Not meaningful	
SAMA 11 Saving (7%)	Not meaningful	

Table V-17. Unit 3 SAMA Number 11 Results

MAAP Case	Baseline Case	SAMA 11 Case
PIHDEP	8.59E-07	8.66E-07
PIHDEPV	4.20E-07	4.24E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.55E-07
OIA	1.60E-07	1.73E-07
OIALF	1.11E-08	1.15E-08
MIALF	1.32E-07	1.37E-07
PJHNSP	1.28E-07	1.29E-07
PLF	2.11E-08	2.16E-08
PID	9.67E-09	0.00E+00
NIH	3.75E-09	2.20E-10
Person-rem	6.28	Not meaningful
Unit 3 Total Cost (3%)	$609,146	Not meaningful
Unit 3 Total Cost (7%)	$423,366	Not meaningful
SAMA 11 Saving (3%)	Not meaningful	
SAMA 11 Saving (7%)	Not meaningful	

The core damage frequency for this SAMA should be equal to the base case evaluation. The cost of the different cases does not significantly differ from the baseline costs. The fact that the calculated core damage frequencies are slightly greater than the baseline case is attributed to model resolution limitations.

The primary impact of this SAMA is to shift release categories to more benign releases. From the data presented in Table III-8, the maximum costs averted are bounded by $300k and $610k for Units 2 and 3, respectively.

M. Phase II SAMA Number 12: Provide Additional DC Battery Capacity

This SAMA would provide additional functional battery life and be especially beneficial during a Station Blackout event.

To bound the potential impact of this SAMA, the logic associated with determining whether a sequence involves core damage or is “success” was modified. This was done by adding additional statements in the split fraction logic in the TRANCDBIN event tree (specifically for the split fraction assignment logic associated with top event NCD). Any sequence involving successful scram, no stuck open relief valves and successful operation and control of either HPCI or RCIC was considered to be successfully mitigated.

This approach involved making the bounding assumption concerning the reliability of operation of HPCI and RCIC for 24 hours. For the purposes of providing a bounding assessment of this SAMA, representing the operation of HPCI/RCIC for 24 hours with the top event representing 6 hours of operation is conservative.

PSA Model Results

The results from this case indicates about a 45.1% reduction in Unit 2 CDF (CDF_{new}=5.7609E-7). The new end state frequencies are presented in Table V-18. For Unit 3 there is a 51.1% reduction in CDF (CDF_{new}=9.2730E-7) and the new end state frequencies are presented in Table V-19.

Table V-18. Unit 2 SAMA Number 12 Results

MAAP Case	Baseline Case	SAMA 12 Case
PIHDEP	3.65E-07	2.24E-08
PIHDEPV	2.52E-07	1.68E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	3.67E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	5.92E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.02E-08
NIH	2.95E-08	2.52E-08
Person-rem	3.03	1.44
Unit 2 Total Cost (3%)	$299,986	$145,161
Unit 2 Total Cost (7%)	$207,731	$100,069
SAMA 12 Saving (3%)	$154,825	
SAMA 12 Saving (7%)	$107,662	

Table V-19. Unit 3 SAMA Number 12 Results

MAAP Case	Baseline Case	SAMA 12 Case
PIHDEP	8.59E-07	2.57E-07
PIHDEPV	4.20E-07	1.89E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	4.81E-08
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.07E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	6.54E-09
NIH	3.75E-09	3.57E-09
Person-rem	6.28	3.01
Unit 3 Total Cost (3%)	$609,146	$289,719
Unit 3 Total Cost (7%)	$423,366	$201,195
SAMA 12 Saving (3%)	$319,427	
SAMA 12 Saving (7%)	$222,171	

N. Phase II SAMA Number 13: Improve DC Power Reliability

Two specific Phase I SAMAs focused on improving DC power reliability. Phase I SAMA 61 would incorporate additional/alternate battery charging capacity. Phase I SAMA 63 would replace station batteries with more reliable ones.

It should be noted that the PSA models already take credit for aligning the spare battery charger.

Reanalyzing the PSA models with “improved” failure probabilities assumed for the station batteries bound the potential impact of improving DC reliability. For the purposes of this analysis, it was assumed that it was possible to improve the unavailability of each of the three station batteries by a factor of 10. This is believed to be a conservative assumption.

PSA Model Results

The results from this case indicates about a 12.3% reduction in Unit 2 CDF (CDF_{new}=9.2059E-7). The new end state frequencies are presented in Table V-20. For Unit 3 there is a 3.2% reduction in CDF (CDF_{new}=1.8372E-6) and the new end state frequencies are presented in Table V-21.

Table V-20. Unit 2 SAMA Number 13 Results

MAAP Case	Baseline Case	SAMA 13 Case
PIHDEP	3.65E-07	3.67E-07
PIHDEPV	2.52E-07	1.76E-07
PIHDLV	7.75E-10	4.83E-10
ENMKCTT	7.39E-08	7.43E-08
OIA	6.90E-08	6.62E-08
OIALF	2.93E-08	2.77E-08
MIALF	1.36E-07	1.35E-07
PJHNSP	6.14E-08	6.15E-08
PLF	4.07E-09	2.97E-09
PID	2.88E-08	5.32E-09
NIH	2.95E-08	4.14E-09
Person-rem	3.03	2.78
Unit 2 Total Cost (3%)	$299,986	$273,464
Unit 2 Total Cost (7%)	$207,731	$189,607
SAMA 13 Saving (3%)	$26,522	
SAMA 13 Saving (7%)	$18,124	

Table V-21. Unit 3 SAMA Number 13 Results

MAAP Case	Baseline Case	SAMA 13 Case
PIHDEP	8.59E-07	8.61E-07
PIHDEPV	4.20E-07	3.74E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.48E-07
OIA	1.60E-07	1.58E-07
OIALF	1.11E-08	8.83E-09
MIALF	1.32E-07	1.30E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	5.70E-09
NIH	3.75E-09	2.47E-09
Person-rem	6.28	6.12
Unit 3 Total Cost (3%)	$609,146	$593,311
Unit 3 Total Cost (7%)	$423,366	$412,432
SAMA 13 Saving (3%)	$15,835	
SAMA 13 Saving (7%)	$10,934	

O. Phase II SAMA Number 14: Develop Procedures to Repair or Replace failed 4-kV Breakers

The specific concern addressed by this SAMA centers on the potential for failure to transfer 4-kV non-emergency busses from the unit station service transformers could lead to the loss of emergency AC power.

To bound the potential impact of this SAMA, the models were reanalyzed with the transfer of power at the unit board level assumed to occur without fault.

PSA Model Results

The results from this case indicates about a 0.02 % increase in Unit 2 calculated CDF (CDF_{new}=1.0500E-6). The new end state frequencies are presented in Table V-22. For Unit 3 there is a 0.01% increase in the calculated CDF (CDF_{new}=1.8971E-6) and the new end state frequencies are presented in Table V-23. These changes are due to model resolution limitations. Any costs averted would be very small.

Table V-22. Unit 2 SAMA Number 14 Results

MAAP Case	Baseline Case	SAMA 14 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.76E-10
ENMKCTT	7.39E-08	7.40E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.08E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	Not meaningful
Unit 2 Total Cost (3%)	$299,986	Not meaningful
Unit 2 Total Cost (7%)	$207,731	Not meaningful
SAMA 14 Saving (3%)	Not meaningful	
SAMA 14 Saving (7%)	Not meaningful	

Table V-23. Unit 3 SAMA Number 14 Results

MAAP Case	Baseline Case	SAMA 14 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	6.28	Not meaningful
Unit 3 Total Cost (3%)	$609,146	Not meaningful
Unit 3 Total Cost (7%)	$423,366	Not meaningful
SAMA 14 Saving (3%)	Not meaningful	
SAMA 14 Saving (7%)	Not meaningful	

P. Phase II SAMA Number 15: Redundant and Diverse Source of Cooling to the Diesel Generators

This SAMA would provide a redundant and diverse source, such as the fire protection system, of cooling water for the diesel generators.

To bound the potential impact of this SAMA, the “logical loop” linking the operation of the diesel generators and their normal cooling water source (EECW) was broken. Three assumptions were made:

1? It was assumed that the fire protection system has sufficient capacity to service all eight diesel generators.

2? It was further assumed that the fire protection system is aligned for diesel cooling in a timely manner.

3? The fire protection system is assumed to be perfectly available (i.e., its unavailability is zero) and the operators align the system (or a passive alignment scheme has been implemented) without failure.

To accomplish this model change, top OEE in the high pressure general transient event tree (HPGTET) was set to “success”. This has the effect of making the generator status macros (e.g., “NOGA” for diesel A) dependent only on the hardware status of the diesel and its associated equipment. In the large LOCA and medium LOCA event trees (LLOCA and MLOCA, respectively), the definition of the generator status macros were modified directly.

PSA Model Results

The results from this case indicates about an 18.9% reduction in Unit 2 CDF (CDF_{new}=8.5117E-7). The new end state frequencies are presented in Table V-24. For Unit 3 there is a14.3% reduction in CDF (CDF_{new}=1.6266E-6) and the new end state frequencies are presented in Table V-25.

Table V-24. Unit 2 SAMA Number 15 Results

MAAP Case	Baseline Case	SAMA 15 Case
PIHDEP	3.65E-07	2.06E-07
PIHDEPV	2.52E-07	2.15E-07
PIHDLV	7.75E-10	4.22E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.59E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	2.34
Unit 2 Total Cost (3%)	$299,986	$233,386
Unit 2 Total Cost (7%)	$207,731	$161,384
SAMA 15 Saving (3%)	$66,600	
SAMA 15 Saving (7%)	$46,347	

Table V-25. Unit 3 SAMA Number 15 Results

MAAP Case	Baseline Case	SAMA 15 Case
PIHDEP	8.59E-07	6.52E-07
PIHDEPV	4.20E-07	3.76E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.41E-07
OIALF	1.11E-08	1.12E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.72E-09
NIH	3.75E-09	3.72E-09
Person-rem	6.28	5.35
Unit 3 Total Cost (3%)	$609,146	$518,608
Unit 3 Total Cost (7%)	$423,366	$360,367
SAMA 15 Saving (3%)	$90,538	
SAMA 15 Saving (7%)	$62,999	

Q. This Section Not Used

This section is reserved.

Table V-26. This Table Reserved

MAAP Case	Baseline Case	SAMA # Case

Table V-27. This Table Reserved

MAAP Case	Baseline Case	SAMA # Case

R. Phase II SAMA Number 17: Improve Inspection of Rubber Expansion Joints on Main Condenser

This SAMA has the potential to decrease the frequency of internal flooding events impacting the turbine building.

To estimate the potential impact of improved inspection of condenser expansion joints, the basis for the turbine building flood frequencies was reviewed. Plant-specific screening of the generic flood database in support of the BFN IPE determined that 11 events were applicable to BFN. These 11 events formed the basis for the estimate of the turbine building flooding frequency in the IPE. Two of the eleven events involved failure of expansion joints (of all types). This observation supports the assumption that eliminating expansion joint failure would result in an approximate 20% reduction in the turbine building flooding frequency.

To represent the potential impact of the implementation of this SAMA, the models were reanalyzed with the initiating event flooding frequencies reduced from the base case by 20%. The new flooding frequencies for small and large turbine building floods become 1.152×10^{-2} and 1.760×10^{-3} per year, respectively.

PSA Model Results

The results from this case indicates about a 0.7% reduction in Unit 2 CDF (CDF_{new}=1.0423E-6). The new end state frequencies are presented in Table V-28. For Unit 3 there is a 0.6% reduction in CDF (CDF_{new}=1.8858E-6) and the new end state frequencies are presented in Table V-29.

Table V-28. Unit 2 SAMA Number 17 Results

MAAP Case	Baseline Case	SAMA 17 Case
PIHDEP	3.65E-07	3.64E-07
PIHDEPV	2.52E-07	2.50E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.37E-08
OIA	6.90E-08	6.82E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.34E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.99E-09
PID	2.88E-08	2.80E-08
NIH	2.95E-08	2.94E-08
Person-rem	3.03	3.01
Unit 2 Total Cost (3%)	$299,986	$298,379
Unit 2 Total Cost (7%)	$207,731	$206,631
SAMA 17 Saving (3%)	$1,607	
SAMA 17 Saving (7%)	$1,100	

Table V-29. Unit 3 SAMA Number 17 Results

MAAP Case	Baseline Case	SAMA 17 Case
PIHDEP	8.59E-07	8.55E-07
PIHDEPV	4.20E-07	4.18E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.51E-07
OIA	1.60E-07	1.59E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.30E-07
PJHNSP	1.28E-07	1.27E-07
PLF	2.11E-08	2.08E-08
PID	9.67E-09	9.42E-09
NIH	3.75E-09	3.73E-09
Person-rem	6.28	6.25
Unit 3 Total Cost (3%)	$609,146	$605,979
Unit 3 Total Cost (7%)	$423,366	$421,176
SAMA 17 Saving (3%)	$3,167	
SAMA 17 Saving (7%)	$2,190	

S. Phase II SAMA Number 18: Procedure to Trip Unneeded RHR/CS Pumps on Loss of Room Ventilation

This SAMA would increase the availability of RHR and/or Core Spray pumps by lessening the heat load on the room when area cooling is lost.

This SAMA has common elements to Phase II SAMAs 2 and 7. To bound the potential benefit of implementing Phase II SAMA 18, all requirements for area cooling were removed for the top events representing the RHR and CS pumps by reducing each corresponding split fraction by 20%. It has been determined earlier (see Phase II SAMAs 2 and 7) that ventilation failure contributed less than 20% to RHR and Core Spray failure.

PSA Model Results

The results from this case indicate about a 3.4% reduction in Unit 2 CDF (CDF_{new} = 1.0144E-6). The new end state frequencies are presented in Table V-30. For Unit 3 there is a 3.6% reduction in CDF (CDF_{new} = 1.8284E-6) and the new end state frequencies are presented in Table V-31.

Table V-30. Unit 2 SAMA Number 18 Results

MAAP Case	Baseline Case	SAMA 18 Case
PIHDEP	3.65E-07	3.58E-07
PIHDEPV	2.52E-07	2.39E-07
PIHDLV	7.75E-10	7.77E-10
ENMKCTT	7.39E-08	7.08E-08
OIA	6.90E-08	6.37E-08
OIALF	2.93E-08	2.15E-08
MIALF	1.36E-07	1.37E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.82E-09
PID	2.88E-08	2.84E-08
NIH	2.95E-08	2.96E-08
Person-rem	3.03	2.93
Unit 2 Total Cost (3%)	$299,986	$290,382
Unit 2 Total Cost (7%)	$207,731	$201,092
SAMA 19 Saving (3%)	$9,604	
SAMA 19 Saving (7%)	$6,639	

Table V-31. Unit 3 SAMA Number 18 Results

MAAP Case	Baseline Case	SAMA 18 Case
PIHDEP	8.59E-07	8.35E-07
PIHDEPV	4.20E-07	4.11E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.42E-07
OIA	1.60E-07	1.38E-07
OIALF	1.11E-08	8.43E-08
MIALF	1.32E-07	1.33E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.94E-08
PID	9.67E-09	9.37E-09
NIH	3.75E-09	3.78E-09
Person-rem	6.28	6.05
Unit 3 Total Cost (3%)	$609,146	$586,415
Unit 3 Total Cost (7%)	$423,366	$407,556
SAMA 19 Saving (3%)	$22,731	
SAMA 19 Saving (7%)	$15,810	

T. Phase II SAMA Number 19: Increase the SRV Reseat Reliability

This SAMA would reduce the likelihood that an SRV would fail to reseat following a successful lift.

To bound the potential impact of this SAMA, the PSA models were reanalyzed with the assumption that any valves that lift would successfully reseat. The baseline PSA models associated with initiating events involving the inadvertent lifting of relief valves were not altered in the assessment of this SAMA.

PSA Model Results

The results from this case indicates about a 5.8% reduction in Unit 2 CDF (CDF_{new}=9.8871E-7). The new end state frequencies are presented in Table V-30. For Unit 3 there is a 3.8% reduction in CDF (CDF_{new}=1.8259E-6) and the new end state frequencies are presented in Table V-31.

Table V-32. Unit 2 SAMA Number 19 Results

MAAP Case	Baseline Case	SAMA 19 Case
PIHDEP	3.65E-07	3.69E-07
PIHDEPV	2.52E-07	2.08E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	6.98E-08
OIA	6.90E-08	5.16E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.38E-07
PJHNSP	6.14E-08	6.12E-08
PLF	4.07E-09	4.12E-09
PID	2.88E-08	2.74E-08
NIH	2.95E-08	2.98E-08
Person-rem	3.03	2.84
Unit 2 Total Cost (3%)	$299,986	$281,125
Unit 2 Total Cost (7%)	$207,731	$194,638
SAMA 19 Saving (3%)	$18,861	
SAMA 19 Saving (7%)	$13,093	

Table V-33. Unit 3 SAMA Number 19 Results

MAAP Case	Baseline Case	SAMA 19 Case
PIHDEP	8.59E-07	8.68E-07
PIHDEPV	4.20E-07	3.59E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.46E-07
OIA	1.60E-07	1.45E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.34E-07
PJHNSP	1.28E-07	1.27E-07
PLF	2.11E-08	2.14E-08
PID	9.67E-09	9.54E-09
NIH	3.75E-09	3.79E-09
Person-rem	6.28	6.06
Unit 3 Total Cost (3%)	$609,146	$587,115
Unit 3 Total Cost (7%)	$423,366	$408,073
SAMA 19 Saving (3%)	$22,031	
SAMA 19 Saving (7%)	$15,293	

U. Phase II SAMA Number 20: Reduce the Dependency between the High Pressure Injection System and ADS

This SAMA would reduce the likelihood that failure of the DC power system would significantly impact redundant means of mitigating transients and small LOCAs.

To bound the potential impact of this SAMA, the PSA models were reanalyzed with the DC dependency for HPCI completely removed.

PSA Model Results

The results from this case indicates about a 1% reduction in Unit 2 CDF (CDF_{new}=1.0396E-6). The new end state frequencies are presented in Table V-32. For Unit 3 there is a 2.1% reduction in CDF (CDF_{new}=1.8579E-6) and the new end state frequencies are presented in Table V-33.

Table V-34. Unit 2 SAMA Number 20 Results

MAAP Case	Baseline Case	SAMA 20 Case
PIHDEP	3.65E-07	3.70E-07
PIHDEPV	2.52E-07	2.48E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	1.42E-09
PID	2.88E-08	2.13E-08
NIH	2.95E-08	2.88E-08
Person-rem	3.03	3.03
Unit 2 Total Cost (3%)	$299,986	$299,709
Unit 2 Total Cost (7%)	$207,731	$207,601
SAMA 20 Saving (3%)	$277	
SAMA 20 Saving (7%)	$130	

Table V-35. Unit 3 SAMA Number 20 Results

MAAP Case	Baseline Case	SAMA 20 Case
PIHDEP	8.59E-07	8.66E-07
PIHDEPV	4.20E-07	3.84E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.93E-08
PID	9.67E-09	2.46E-09
NIH	3.75E-09	2.96E-09
Person-rem	6.28	6.20
Unit 3 Total Cost (3%)	$609,146	$600,209
Unit 3 Total Cost (7%)	$423,366	$417,232
SAMA 20 Saving (3%)	$8,937	
SAMA 20 Saving (7%)	$6,134	

V. Phase II SAMA Number 21: Use of CRD for Alternate Boron Injection

The intent of this SAMA is to provide a second means of injecting a boron solution into the vessel in the event of an ATWS and failure of the SLC System.

The potential benefit of this SAMA was bounded by crediting operation of the CRD hydraulic system as a redundant backup to the SLC system. This was accomplished by modifying the split fraction logic rules that select the value used for top event NCD in the event tree TRANCDBIN. The top event NCD determines whether a sequence involves core damage or is successfully mitigated.

Three assumptions were made:

1. It was assumed that success of top event OSLC (the operator actions associated with initiating the SLC system) was necessary for success of the CRD system in delivering the boron solution to the reactor. Actions by the operator are assumed to be necessary to initiate boron injection via the CRD system. This assumption completely couples those actions with the actions associated with initiating the SLC system. The implication of this assumption is that the CRD system would provide redundancy for hardware failures of the SLC system.

2. It was assumed that any additional operator actions associated with initiating the CRD are represented by top event OSLC.

3. It was also assumed that any additional failure modes of the CRD system over those analyzed in the base case PSA were not significant contributors to CRD system unavailability in its postulated function of delivering boron solution to the reactor.

PSA Model Results

The results from this case indicates about a 1.5% reduction in Unit 2 CDF (CDF_{new}=1.0336E-6). The new end state frequencies are presented in Table V-34. For Unit 3 there is a 0.9% reduction in CDF (CDF_{new}=1.8811E-6) and the new end state frequencies are presented in Table V-35.

Table V-36. Unit 2 SAMA Number 21 Results

MAAP Case	Baseline Case	SAMA 21 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	5.77E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	2.94
Unit 2 Total Cost (3%)	$299,986	$292,089
Unit 2 Total Cost (7%)	$207,731	$202,187
SAMA 21 Saving (3%)	$7,897	
SAMA 21 Saving (7%)	$5,544	

Table V-37. Unit 3 SAMA Number 21 Results

MAAP Case	Baseline Case	SAMA 21 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.36E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	6.28	6.19
Unit 3 Total Cost (3%)	$609,146	$601,425
Unit 3 Total Cost (7%)	$423,366	$417,948
SAMA 21 Saving (3%)	$7,721	
SAMA 21 Saving (7%)	$5,428	

W. Phase II SAMA Number 22: Borate Torus Water

The intent of this SAMA is to provide additional reactivity control by replacing the water in the torus with borated water.

No specialized model was created to provide a bounding assessment of the potential impact of this SAMA. The base case PSA models map all ATWS core damage sequences to a single endstate: ENMKCTT. To bound the potential impact of this SAMA, the frequency of this endstate was set to zero. This has the same effect as assuming that all ATWS scenarios are successfully mitigated.

This analysis does not consider any detrimental effects on plant availability and associated costs that would result with the introduction of borated water into the vessel not in response to an ATWS.

PSA Model Results

The results from this case indicates about a 7.0% reduction in Unit 2 CDF (CDF_{new}=9.7584E-7). The new end state frequencies are presented in Table V-36. For Unit 3 there is a 8.0% reduction in CDF (CDF_{new}=1.7457E-6) and the new end state frequencies are presented in Table V-37.

Table V-38. Unit 2 SAMA Number 22 Results

MAAP Case	Baseline Case	SAMA 22 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	0.00E-00	0.00E+00
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	2.62
Unit 2 Total Cost (3%)	$299,986	$263,961
Unit 2 Total Cost (7%)	$207,731	$182,440
SAMA 22 Saving (3%)	$36,025	
SAMA 22 Saving (7%)	$25,291	

Table V-39. Unit 3 SAMA Number 22 Results

MAAP Case	Baseline Case	SAMA 22 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	0.00+00	7.75E-10
ENMKCTT	0.00E+00	0.00E+00
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	6.28	5.44
Unit 3 Total Cost (3%)	$609,146	$535,250
Unit 3 Total Cost (7%)	$423,366	$371,488
SAMA 22 Saving (3%)	$73,896	
SAMA 22 Saving (7%)	$51,878	

X. Phase II SAMA Number 23: Automate Torus Cooling

The purpose of this SAMA is to eliminate the possibility of failing to initiate torus cooling because of operator error.

To represent the potential impact of this SAMA, the operator action associated with the initiation of torus cooling was set to "guaranteed success."

This change was implemented in the low pressure transient event tree (LPGTET), the large LOCA event tree (LLOCA) and the medium LOCA event tree (MLOCA) by setting the value (failure probability) of top event OSP (operator initiates torus cooling) to 0.

The model adopted assumes that the contribution to failure of any necessary sensors, monitors or other actuation devices does not significantly contribute to the likelihood of actuation failure.

PSA Model Results

The results from this case indicates about a 6.4% reduction in Unit 2 CDF (CDF_{new}=9.8217E-7). The new end state frequencies are presented in Table V-38. For Unit 3 there is a 9.0% reduction in CDF (CDF_{new}=1.7264E-6) and the new end state frequencies are presented in Table V-39.

Table V-40. Unit 2 SAMA Number 23 Results

MAAP Case	Baseline Case	SAMA 23 Case
PIHDEP	3.65E-07	3.51E-07
PIHDEPV	2.52E-07	1.99E-07
PIHDLV	7.75E-10	7.70E-10
ENMKCTT	7.39E-08	7.42E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	2.76E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.94E-08
Person-rem	3.03	2.82
Unit 2 Total Cost (3%)	$299,986	$279,786
Unit 2 Total Cost (7%)	$207,731	$193,723
SAMA 23 Saving (3%)	$20,200	
SAMA 23 Saving (7%)	$14,008	

Table V-41. Unit 3 SAMA Number 23 Results

MAAP Case	Baseline Case	SAMA 23 Case
PIHDEP	8.59E-07	7.86E-07
PIHDEPV	4.20E-07	3.33E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.48E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.54E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.68E-09
Person-rem	6.28	5.73
Unit 3 Total Cost (3%)	$609,146	$555,650
Unit 3 Total Cost (7%)	$423,366	$386,214
SAMA 23 Saving (3%)	$53,496	
SAMA 23 Saving (7%)	$37,152	

Y. Phase II SAMA Number 24: Containment Overpressure Protection

This Phase II SAMA represents the potential impact of two specific Phase I SAMAs: 117a (Provide Torus Positive Pressure Relief Valves); and, 117b (Reduce Drywell Head Bolt Pretension).

Without the consideration of additional recovery actions, this SAMA would not alter the calculated core damage frequency, but instead changes the core damage endstate for selected sequences. The current models only consider a limited number of plant damage endstates. The only “containment failed late” endstate is “PLF.” All sequences mapped to PLF were instead mapped to success; thus, bounding the potential benefit of the SAMA.

PSA Model Results

As analyzed, results from this case indicates negligible (less than 0.4%) change in the calculated Unit 2 CDF (CDF_{new} = 1.0460-06). The new end state frequencies are presented in Table V-40. For Unit 3 there is also a negligible (less than 1.1%) change in the calculated CDF (CDF_{new} = 1.8766-06) and the new end state frequencies are presented in Table V-41.

Table V-42. Unit 2 SAMA Number 24 Results

MAAP Case	Baseline Case	SAMA 24 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	0
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	3.03
Unit 2 Total Cost (3%)	$299,986	$299,775
Unit 2 Total Cost (7%)	$207,731	$207,605
SAMA 24 Saving (3%)	$211	
SAMA 24 Saving (7%)	$126	

Table V-43. Unit 3 SAMA Number 24 Results

MAAP Case	Baseline Case	SAMA 24 Case
PIHDEP	8.59E-07	8.59E-7
PIHDEPV	4.20E-07	4.20E-7
PIHDLV	0.00+00	0.00+00
ENMKCTT	1.52E-07	1.52E-7
OIA	1.60E-07	1.60E-7
OIALF	1.11E-08	1.11E-8
MIALF	1.32E-07	1.32E-7
PJHNSP	1.28E-07	1.28E-7
PLF	2.11E-08	0.00E-0
PID	9.67E-09	9.67E-9
NIH	3.75E-09	3.75E-9
Person-rem	6.28	6.27
Unit 3 Total Cost (3%)	$609,146	$607,672
Unit 3 Total Cost (7%)	$423,366	$422,449
SAMA 24 Saving (3%)	$1,474	
SAMA 24 Saving (7%)	$917	

Z. Phase II SAMA Number 25: Automate SLC Initiation

This SAMA would eliminate the failure of the SLC system to inject boron solution to the vessel due to operator error.

To represent the potential impact of this SAMA, the operator action associated with the initiation of the SLC system was set to "guaranteed success."

This change was implemented in the high pressure transient event tree (HPGTET) by setting the value (failure probability) of top event OSLC (operator initiates SLC injection) to 0.

The model adopted assumes that the contribution to failure of any necessary sensors, monitors or other actuation devices does not significantly contribute to the likelihood of actuation failure.

PSA Model Results

The results from this case indicates about a 2.3% reduction in Unit 2 CDF (CDF_{new}=1.0258E-6). The new end state frequencies are presented in Table V-42. For Unit 3 there is a 1.2% reduction in CDF (CDF_{new}=1.8746E-6) and the new end state frequencies are presented in Table V-43.

Table V-44. Unit 2 SAMA Number 25 Results

MAAP Case	Baseline Case	SAMA 25 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	5.00E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	2.89
Unit 2 Total Cost (3%)	$299,986	$288,300
Unit 2 Total Cost (7%)	$207,731	$199,527
SAMA 25 Saving (3%)	$11,686	
SAMA 25 Saving (7%)	$8,204	

Table V-45. Unit 3 SAMA Number 25 Results

MAAP Case	Baseline Case	SAMA 25 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.30E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	6.28	6.16
Unit 3 Total Cost (3%)	$609,146	$598,263
Unit 3 Total Cost (7%)	$423,366	$415,729
SAMA 25 Saving (3%)	$10,883	
SAMA 25 Saving (7%)	$7,637	

AA. Phase II SAMA Number 26: Decrease Frequency of Excessive LOCA

This Phase II SAMA addressed Phase I SAMA 122a (Increase the Inspection Frequency of the Reactor Vessel).

To bound the potential impact of this SAMA, the models were reanalyzed with the initiating event frequency of “Excessive LOCA” set to 0.

PSA Model Results

The results from this case indicates about a 0.9% reduction in Unit 2 CDF (CDF_{new}=1.0404E-6). The new end state frequencies are presented in Table V-44. For Unit 3 there is about a 0.5% reduction in CDF (CDF_{new}=1.8872E-6) and the new end state frequencies are presented in Table V-45.

Table V-46. Unit 2 SAMA Number 26 Results

MAAP Case	Baseline Case	SAMA 26 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	5.96E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	3.00
Unit 2 Total Cost (3%)	$299,986	$297,089
Unit 2 Total Cost (7%)	$207,731	$205,720
SAMA 26 Saving (3%)	$2,897	
SAMA 26 Saving (7%)	$2,011	

Table V-47. Unit 3 SAMA Number 26 Results

MAAP Case	Baseline Case	SAMA 26 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.51E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	6.28	6.25
Unit 3 Total Cost (3%)	$609,146	$606,075
Unit 3 Total Cost (7%)	$423,366	$421,236
SAMA 26 Saving (3%)	$3,071	
SAMA 26 Saving (7%)	$2,130	

BB. Phase II SAMA Number 27: Provide an Independent Torus Cooling System

This SAMA would mitigate the failure of torus cooling due to hardware failures.

The base case models already include consideration of the possibility of recovery of torus cooling, if failure was due to hardware unavailability. To bound the potential impact of this SAMA, the top event in the low pressure transient event tree (LPGTET), the large LOCA event tree (LLOCA) and the medium LOCA event tree (MLOCA) which represents recovery of suppression pool cooling (top SPR) was set to 'guaranteed success".

The results of the reanalysis with SPR set to guaranteed success are shown below in Tables V-46 and V-47.

PSA Model Results

The results from this case indicates a 2.9% reduction in Unit 2 CDF (CDF_{new} = 1.0196-06). The new end state frequencies are presented in Table V-46. For Unit 3 there is about a 16.0% reduction in CDF (CDF_{new} = 1.5929-06) and the new end state frequencies are presented in Table V-47.

Table V-48. Unit 2 SAMA Number 27 Results

MAAP Case	Baseline Case	SAMA 27 Case
PIHDEP	3.65E-07	3.49E-07
PIHDEPV	2.52E-07	2.49E-07
PIHDLV	7.75E-10	7.36E-10
ENMKCTT	7.39E-08	7.40E-08
OIA	6.90E-08	5.92E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.37E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	1.44E-09
PID	2.88E-08	2.87E-08
NIH	2.95E-08	2.96E-08
Person-rem	3.03	2.93
Unit 2 Total Cost (3%)	$299,986	$290,682
Unit 2 Total Cost (7%)	$207,731	$201,272
SAMA 27 Saving (3%)	$9,304	
SAMA 27 Saving (7%)	$6,459	

Table V-49. Unit 3 SAMA Number 27 Results

MAAP Case	Baseline Case	SAMA 27 Case
PIHDEP	8.59E-07	6.22E-07
PIHDEPV	4.20E-07	3.77E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.59E-07
OIA	1.60E-07	1.49E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.23E-09
PID	9.67E-09	9.66E-09
NIH	3.75E-09	3.75E-09
Person-rem	6.28	5.30
Unit 3 Total Cost (3%)	$609,146	$513,069
Unit 3 Total Cost (7%)	$423,366	$356,625
SAMA 27 Saving (3%)	$96,077	
SAMA 27 Saving (7%)	$66,741	

CC. Phase II SAMA Number 28: Improve 4-kV Crosstie Capability

This SAMA seeks to improve the ability to crosstie emergency boards from Units 1 and 2 to Unit 3. This would be accomplished using the shutdown busses. Likewise, the ability to crosstie Unit 3 boards to support Unit 2 was considered. It is noted that the base case model already includes limited support of Unit 2 emergency busses from Unit 3.

To bound the potential impact of this SAMA, individual split fraction rules and macro-logic associated with AC power support of RHR, Core Spray, and long term operation of HPCI and RCIC were modified. It was assumed that any Unit 3 diesel could feed any Unit 1 or 2 4-kV shutdown board, and that any Units 1 or 2 diesel could feed any Unit 3 4-kV shutdown board. It was further assumed that any necessary operator actions to accomplish required breaker manipulations would be done without fail and that breaker and bus failures would not significantly contribute to failure.

PSA Model Results

The results from this case indicates about a 4.2% reduction in Unit 2 CDF (CDF_{new}=1.0053E-6). The new end state frequencies are presented in Table V-48. For Unit 3 there is a 29.3% reduction in CDF (CDF_{new}=1.3417E-6) and the new end state frequencies are presented in Table V-49.

Table V-50. Unit 2 SAMA Number 28 Results

MAAP Case	Baseline Case	SAMA 28 Case
PIHDEP	3.65E-07	3.09E-07
PIHDEPV	2.52E-07	2.33E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	9.95E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.82E-09
PID	2.88E-08	2.83E-08
NIH	2.95E-08	2.95E-08
Person-rem	3.03	2.86
Unit 2 Total Cost (3%)	$299,986	$284,458
Unit 2 Total Cost (7%)	$207,731	$196,914
SAMA 28 Saving (3%)	$15,528	
SAMA 28 Saving (7%)	$10,817	

Table V-51. Unit 3 SAMA Number 28 Results

MAAP Case	Baseline Case	SAMA 28 Case
PIHDEP	8.59E-07	5.35E-07
PIHDEPV	4.20E-07	2.55E-07
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.51E-07
OIA	1.60E-07	9.80E-08
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.92E-08
PID	9.67E-09	8.43E-09
NIH	3.75E-09	3.67E-09
Person-rem	6.28	4.44
Unit 3 Total Cost (3%)	$609,146	$428,814
Unit 3 Total Cost (7%)	$423,366	$297,993
SAMA 28 Saving (3%)	$180,332	
SAMA 28 Saving (7%)	$125,373	

DD. Phase II SAMA Number 29: Provide High Pressure Diesel-Driven Pump

This SAMA would provide an additional means of mitigating a station blackout event by allowing river water to be injected into the vessel via a high pressure, diesel-driven pump.

To bound the potential impact of this SAMA, a variant of the model developed to consider Phase II SAMA 12 was used. To estimate the effect of an independent diesel driven high pressure injection source, two changes were made to the base case models. First a new logic rule was added to the TRANCDBIN event tree for top event NCD. Top event NCD determines whether a sequence is assigned to a core damage state or represents successful mitigation of the event. This new "success" rule states that if RPS is successful and if HPCI and operator control are successful, then core damage is averted. Next, the split fractions, including the one representing "guaranteed failure" of short term HPCI operation were modified. It was estimated that the unavailability of a diesel driven injection system, including start, 24-hour operation and maintenance would be on the order of 0.1. Therefore the HPCI split fractions were reduced by one order of magnitude.

PSA Model Results

The results from this case indicates about a 74.1% reduction in Unit 2 CDF (CDF_{new}=2.7173E-7). The new end state frequencies are presented in Table V-50. For Unit 3 there is a 82% reduction in CDF (CDF_{new}=3.4154E-7) and the new end state frequencies are presented in Table V-51.

Table V-52. Unit 2 SAMA Number 29 Results

MAAP Case	Baseline Case	SAMA 29 Case
PIHDEP	3.65E-07	0.00E+00
PIHDEPV	2.52E-07	5.69E-08
PIHDLV	7.75E-10	7.71E-10
ENMKCTT	7.39E-08	7.41E-08
OIA	6.90E-08	1.24E-08
OIALF	2.93E-08	2.82E-08
MIALF	1.36E-07	1.41E-08
PJHNSP	6.14E-08	6.09E-08
PLF	4.07E-09	1.75E-10
PID	2.88E-08	2.67E-09
NIH	2.95E-08	2.15E-08
Person-rem	3.03	0.92
Unit 2 Total Cost (3%)	$299,986	$86,794
Unit 2 Total Cost (7%)	$207,731	$60,314
SAMA 29 Saving (3%)	$213,192	
SAMA 29 Saving (7%)	$147,417	

Table V-53. Unit 3 SAMA Number 29 Results

MAAP Case	Baseline Case	SAMA 29 Case
PIHDEP	8.59E-07	0.00E+00
PIHDEPV	4.20E-07	5.13E-08
PIHDLV	0.00+00	0.00E+00
ENMKCTT	1.52E-07	1.56E-07
OIA	1.60E-07	1.83E-08
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.38E-08
PJHNSP	1.28E-07	8.74E-08
PLF	2.11E-08	1.35E-09
PID	9.67E-09	7.40E-10
NIH	3.75E-09	1.79E-09
Person-rem	6.28	1.48
Unit 3 Total Cost (3%)	$609,146	$134,133
Unit 3 Total Cost (7%)	$423,366	$93,730
SAMA 29 Saving (3%)	$475,013	
SAMA 29 Saving (7%)	$329,636	

EE. Verification of the Model

Two RISKMAN® models were received from BFN for use in the SAMA analysis. Model U2011701 represents the base case for the operation of Unit 2 while model U3011701 represents the base case for the operation of Unit 3.

Because multiple computers were used to perform the required analyses, it was first necessary to verify that these computers would reproduce the results of the base cases. For each computer used in the SAMA analysis, models U2011701 and U3011701 were reanalyzed and the results compared to the original base case results. In all cases, the base case results were reproduced exactly.

FF. Reassignment of Core Damage Scenario End States

Models U2011701 and U3011701 characterized core damage scenarios as either 'LERF' or 'NLERF'. These characterizations are referred to as "end states". LERF scenarios are those core damage sequences that result in a "large early release" of radioactive material. The sum of the frequencies of these scenarios is the "large early release frequency." In a similar manner, core damage scenarios that do not involve a "large early release" were assigned to the 'NLERF' (no 'LERF') end state.

The LERF and NLERF end states do not sufficiently differentiate the core damage sequences to enable linkage to the conditional offsite consequence analyses. The offsite consequence analyses, and supporting MAAP analyses, utilized the end state definitions developed for the BFN Unit 2 IPE. It was therefore necessary to reassign the core damage scenarios used in the base case models to the set of end states consistent with the Level 2 (MAAP) and Level 3 (MACCS2) analyses.

The base case models with the IPE endstate binning were named U2PDSB and U3PDSB corresponding to Unit 2 and Unit 3, respectively.

Since only the assignments of end states were changed, the total calculated core damage frequency for either unit did not change.

GG. Investigation of the Impact of "Truncation Frequency" Chosen

Since the models are so large and take a significant amount of time to run, an analysis was performed to verify that the "truncation frequency" used in the U2011701 and U3011701 models would yield reasonable results. To accomplish this, several computer runs were completed. These runs included a baseline run for each unit with additional computer runs for both units with the resolved sequence frequencies truncated at 1E-13, 1E-14, and 1E-15. For Unit 2 an additional run was completed with the frequency truncated at 1E-16. The results of these runs are presented in Figures V-2 and V-3.

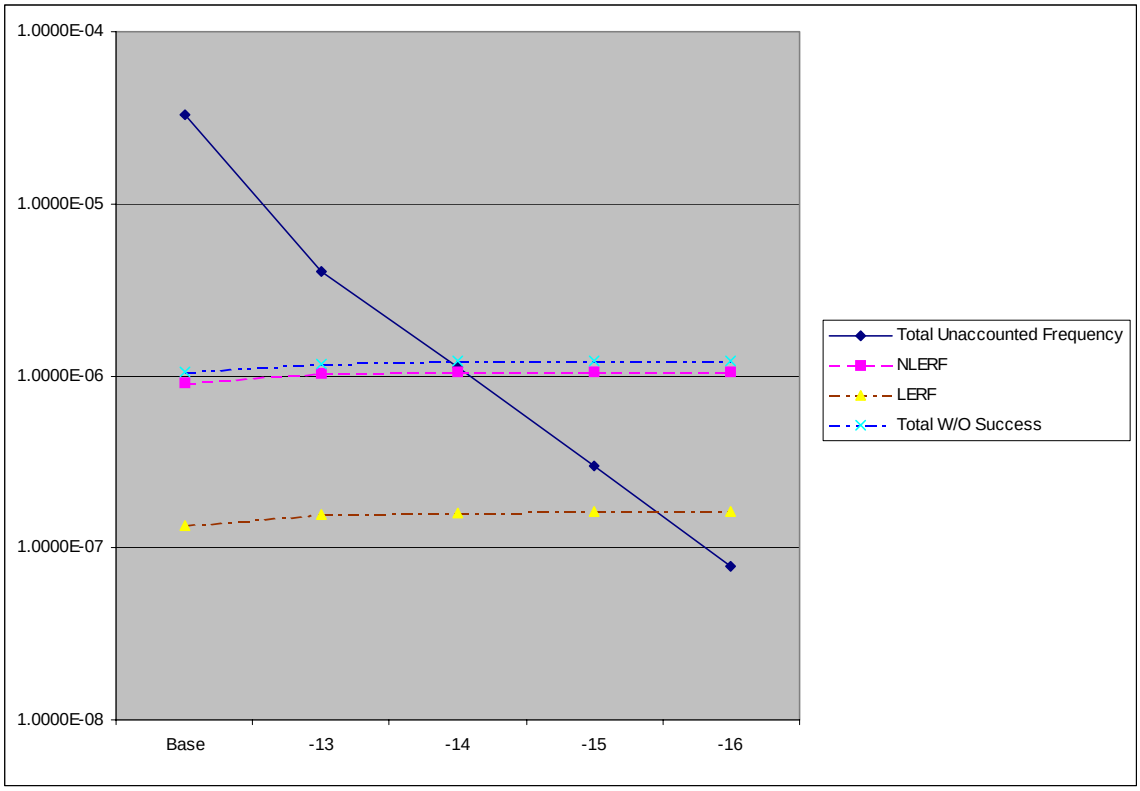

Figure V-2. Results of the Truncation Frequency Verification for Unit 2

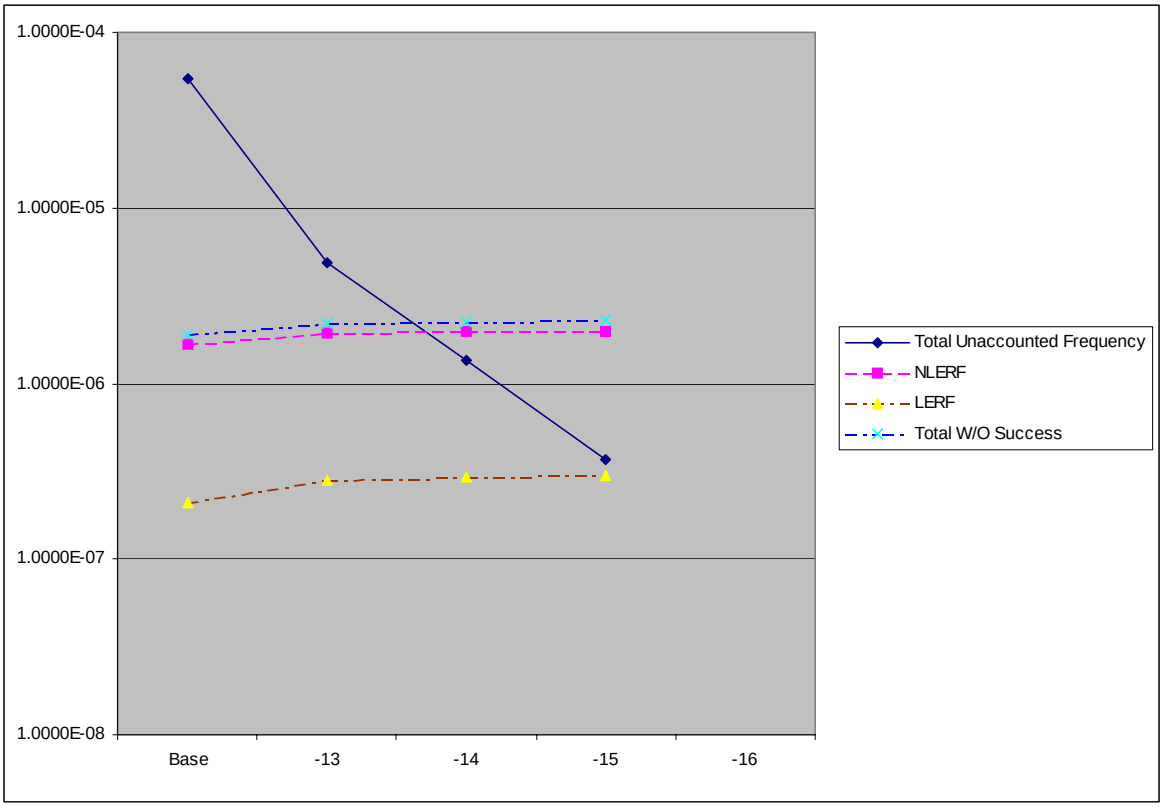

Figure V-3. Results of the Truncation Frequency Verification for Unit 3

As can be seen in Figures V-2 and V-3, there is very little change of the values for LERF and NLERF at truncation frequencies below 1E-13. Based on these results the SAMA computer runs were truncated at 1E-13.

HH. Extrapolation to Operation of All Three Units Operating at EPV Power Level

Browns Ferry Nuclear plant is comprised of three individual units that share certain systems and buildings. In the consideration of the cost/benefit measures of potential SAMAs, therefore, it is important to consider how multiple unit events may impact the evaluation.

As discussed in the BFN Multi Unit PRA, selected initiators, have the potential to result in core damage in both Unit 2 and Unit 3. SBO is an example of a class of scenarios

with this potential. The cost of such scenarios, in the unlikely event that they were to occur, would likely be equal to or less than the cost associated with two independent core damage events. It is therefore concluded that considering post accident costs as the sum of Unit 2 and Unit 3 costs unit basis is appropriate and conservative for such initiators.

Implementation costs are considered on a per plant basis for specific SAMAs. One example would be replacement of the station batteries. The cost/benefits comparison for these specific SAMAs are then made on a plant basis.

Up to this point the detailed evaluations of the individual SAMAs have utilized the PSAs that are current and available. These PSAs address the operation of Units 2 and 3 operating at 105% of their original licensed power level. Both PSAs assume that Unit 1 is in extended layup and not operating.

The analysis now addresses how the conclusions of the SAMA cost/benefit analysis are potentially impacted if operation of all three units under EPUP conditions is considered.

The operation of unit 1 would increase the calculated core damage frequency of Units 2 and 3. The units share certain equipment (e.g., diesel generators, RHR Service Water and Emergency Equipment Cooling Water) resulting, in selected scenarios, in decreased availability of equipment to a particular unit. Success criteria for selected systems are also impacted.

The Multiple Unit PSA (reference 18) performed in 1995 provides some insight into the potential affect of multiple unit operation. That study provides a basis for the comparison of the core damage frequency of Unit 2 with both other units operating with the IPE results. The IPE assumed that only Unit 2 was operational. The observation is made in the Multiple Unit PSA that the mean core damage frequency of Unit 2 is a factor of 4 greater with all three units operating compared to only Unit 2 operating. For the purpose of the SAMA screening analysis, it is assumed that the baseline core damage frequencies for Unit 1 and Unit 2 are equal with a mean value 4 times the currently calculated Unit 2 core damage frequency mean. This is felt to be a conservative assumption.

Because Unit 1 is more closely associated with Unit 2 than it is with Unit 3, it is expected that the return to service will have a larger impact on Unit 2 that it will on Unit 3. Units 1 and 2 share the electrical system in a more intimate manner than do Units 1 and 3. In addition, RHR System interunit cross connections are possible between Units 1 and 2, as well as Units 2 and 3, but not directly between Units 1 and 3. It is assumed that the maximum impact on the calculated core damage frequency of Unit 3 will be a factor of 2 over the currently calculated value.

If we further assume that the potential economic savings of the individual SAMAs scale by the same factor as the baseline PSA core damage frequency results, then the preceding analyses can be revisited to identify individual SAMAs that warrant further attention. This assumption is felt to be conservative since ATWS scenarios (which have relatively severe offsite impacts) would be “increased” in frequency in the scaled model but, in fact, not appreciably increased in frequency due to the restart of Unit 1.

II. Uncertainty

An important consideration in any PSA involves the evaluation of uncertainty and its potential impact on the information provided to support management decisions. The uncertainty in the total core damage frequency was calculated for both base case models. The results are shown in Table V-52.

Table V-54. Core Damage Uncertainty

	Unit 2	Unit 3
Mean value	1.0498E-6	1.9866E-6
5th percentile	2.4458E-7	3.1794E-7
50th percentile	7.2170E-7	1.1919E-6
95th percentile	2.8152E-6	5.6597E-6

Note that the ratio of the 95th percentile to the mean is 2.7 and 2.8 for Units 2 and 3, respectively. The values in Table V-52 reflect the uncertainty in the data distributions used in the analysis. Each of the Phase II SAMA evaluations were reviewed to determine if a factor of 3 would alter the decision to screen any of them

VI. SAMA Analysis Results

A. SAMA Analysis Results for BFNP

A summary comparison of estimate costs and costs averted is shown in Table VI-1 for the Phase II SAMAs.

It should be noted that additional engineering analyses is warranted to further consider those SAMAs identified as cost effective via this analysis. The analysis documented here is bounding in nature. In addition, as noted in the text, potential negative impacts associated with the SAMAs were not considered.

B. SAMA Analysis Results from Previous Submittals

A review of previously approved and submitted SAMA analyses was performed to determine the potential scope of changes that would reasonably be expected to be applicable to this analysis. The following paragraphs are quoted from the conclusion of each referenced SAMA analysis.

Calvert Cliffs (approved) – "BGE identified and committed to pursue one enhancement in accordance with the CCNPP modification process. This involves the installation of a watertight door between the service water pump room and the adjacent fan room to reduce the likelihood of core damage from internal flooding events. BGE also committed to further evaluate the adequacy of CCNPP procedures regarding response to internal floods following resolution of the hardware flooding enhancement. BGE concluded that no additional mitigation alternatives are cost-beneficial and warrant implementation at CCNPP."

Oconee (approved) – "Because the environmental impacts of potential severe accidents are of small significance and because additional measures to reduce such impacts would not be justified from a public risk perspective, Duke concludes that no additional severe accident mitigation alternative measures beyond those already implemented during the current term license would be warranted for Oconee."

Hatch (in review by the USNRC) – "None of the SAMAs analyzed would be being[sic] justified on a cost-benefit basis."

Arkansas Nuclear One Unit 1 (approved by the USNRC) – "As a result of this reassessment, the "marginally" cost-beneficial SAMA 129 became more cost-beneficial. All other SAMA candidates retained negative net values. SAMA 129 involves improvements in training and awareness associated with operator actions required to swapover from the injection phase to low-pressure recirculation during a large LOCA. This SAMA does not relate to adequately managing the effects of aging during the period of extended operation and based on further information provided by Entergy, appears to be adequately addressed within the current operations training cycle. Therefore, no further action is necessary as part of license renewal pursuant to 10 CFR Part 54."

Table VI-1. Evaluation of Phase II SAMAs

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Estimated Cost (2016)	Maximum Cost Avoidance (Base Case)	Screening Cost Avoidance for Impact of Uncertainty	Screening Cost Avoidance for Impact of Three-Unit Operation	Screening Cost Avoidance for Impact of both Uncertainty and Three-Unit Operation	Cost Effective?
1	7	Increase CRD pump lube oil capacity.	N/A	N/A	N/A	N/A	N/A	N
2	12	Replace ECCS pump motor with air-cooled motors.	$9.3M/unit	$76k/unit	$228k/unit	$256k/plant	$768k/unit	N
3	17	Implement procedures to stagger CRD pump use after a loss of service water.	$78k/unit	N/A	N/A	N/A	N/A	N
4	19	Procedural guidance for use of cross-tied component cooling or service water pumps.	$78k/unit	$8k/unit	$24k/unit	$17k/unit	$51k/unit	N
5	20	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	$78k/unit	$1k/unit	$3k/unit	$3k/unit	$9k/unit	N
6	21	Improved ability to cool the residual heat removal heat exchangers	$1.5M/unit	$58k/unit	$174k/unit	$115k/unit	$347k/unit	N
7	23	Provide a redundant train of ventilation.	$9.3M/unit	$75k/unit	$225k/unit	$256k/unit	$770k/unit	N
8	25	Add a diesel building switchgear room high temperature alarm.	Option 1: $623k per building Option 2: $9.3M per building	$0.2k/unit	$0.6/unit	$0.4/unit	$1k/unit	N
9	34	Install a containment vent large enough to remove ATWS decay heat.	$3.1M/unit	$38k/unit	$114k/unit	$77k/unit	$231k/unit	N

Table VI-2. Evaluation of Phase II SAMAs

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Estimated Cost (2016)	Maximum Cost Avoidance (Base Case)	Screening Cost Avoidance for Impact of Uncertainty	Screening Cost Avoidance for Impact of Three-Unit Operation	Screening Cost Avoidance for Impact of both Uncertainty and Three-Unit Operation	Cost Effective?
10	46	Use the fire protection system as a back-up source for the containment spray system.	$779k/unit	N/A	N/A	N/A	N/A	N
11	48	Install a passive containment spray system.	$9.3M/unit	N/A	N/A	N/A	N/A	N
12	57	Provide additional DC battery capacity.	$1.5M/plant	$474k/plant	$1.4M/plant	$1.9M/plant	$5.6M/plant	*Y(1)
	58	Use fuel cells instead of lead-acid batteries.	$9.3M/plant					N
	62	Increase/improve DC bus load shedding.	$78k/plant					Y
13	61	Incorporate an alternate battery charging capability.	1.5M/unit	$27k/unit	$81k/unit	$106k/unit	$318k/unit	N
	63	Replace existing batteries with more reliable ones.	$9.3M/plant	aa				N
14	66	Develop procedures to repair or replace failed 4 kV breakers.	$78k/unit	N/A	N/A	N/A	N/A	N
15	73	Use Fire Protection System as a back-up source for diesel cooling.	$1.5M/plant	$157k/plant	$471k/plant	$713k/plant	$2.1M/plant	*Y(2)

** Note: Y(1) Potentially cost-beneficial for three-unit operation.*
Y(2) Potentially cost-beneficial for three-unit operation when uncertainty is considered.

Table VI-3. Evaluation of Phase II SAMAs

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Estimated Cost (2016)	Maximum Cost Avoidance (Base Case)	Screening Cost Avoidance for Impact of Uncertainty	Screening Cost Avoidance for Impact of Three-Unit Operation	Screening Cost Avoidance for Impact of both Uncertainty and Three-Unit Operation	Cost Effective?
17	98	Improve inspection of rubber expansion joints on main condenser.	$155k/unit	$3k/unit	$9k/unit	6.4k/unit	$19k/unit	N
18	108	Procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	$78k/unit	$23k/unit	$69k/unit	$45k/unit	$136k/unit	*Y(2)
19	110	Increase the SRV reseat reliability.	$1.09M/unit	$22k/unit	$66k/unit	$75k/unit	$226k/unit	N
20	111	Reduce DC dependency between high pressure injection system and ADS.	$779k/unit	$9k/unit	$27k/unit	$18k/unit	$54k/unit	N
21	113	Use of CRD for alternate boron injection.	$3.1M/unit	$8k/unit	$24k/unit	$32k/unit	$95k/unit	N
22	116	borate torus water	$9.3M/unit	$74k/unit	$222k/unit	$148k/unit	$443k/unit	N
23	117	automate torus cooling	$623k/unit	$53k/unit	$159k/unit	$107k/unit	$321k/unit	N
24	117a	provide torus positive pressure relief valves	$1.09M/unit	$1k/unit	$3k/unit	$3k/unit	$9k/unit	N
	117b	reduce DW head bolt pretension	$78k/unit					N
25	121	automate SLC initiation	$623k/unit	$12k/unit	$36k/unit	$46k/unit	$140k/unit	N
26	122a	RPV inspection	$155k/unit	$3k/unit	$9k/unit	$12k/unit	$35k/unit	N
27	124	provide independent torus cooling system	$9.3M/unit	$96k/unit	$288k/unit	$192k/unit	$576k/unit	N
28	132	Improve 4kV crosstie capability	$7.8M/plant	$196k/plant	$588k/plant	$484k/plant	$1.4M/plant	N
29	133	provide HP diesel-driven pump.	$9.3M/unit	$475k/unit	$1.4M/unit	$950k/unit	$2.9M/unit	N

** Note: Y(1) Potentially cost-beneficial for three-unit operation.*
Y(2) Potentially cost-beneficial for three-unit operation when unit uncertainty is considered.

VII. References

1. Reserved.

2. Browns Ferry Nuclear Plant Probabilistic Safety Assessment, Unit 2 Summary Report, R0.

3. Browns Ferry Nuclear Plant Probabilistic Safety Assessment, Unit 3 Summary Report, R0.

4. Letter from TVA to the USNRC, Browns Ferry Nuclear Plant (BFN) – Generic letter (GL) 88-20, Supplement 4, Individual Plant Examination of External Events (IPEEE) for Sever Accident Vulnerabilities – Partial Submittal of Report. RIMS R08 950724 976.

5. Letter from TVA to the USNRC, Browns Ferry Nuclear Plant (BFN) – Units 1, 2, and 3 – Final Response to Request for Additional Information Regarding Browns Ferry Nuclear Plant Individual Plant Examination for External Events (IPEEE) (TAC Nos. M83595, M83596, M83597). RIMS R08 990129 770.

6. Letter from the USNRC to TVA, Browns Ferry Units 1, 2, and 3, Individual Plant Examination of External Events (IPEEE) and Related Generic Safety Issues. Issuance of Staff Evaluation (TAC Nos. M83595, M83596, M83597). 6/22/2000.

7. Letter from the USNRC to TVA, Browns Ferry, Units 1, 2, and 3 RE: Completion of Licensing Action for Generic Letter 87-02 (TAC Nos. M83595, M83596, M83597). 3/21/2000.

8. Edwin I. Hatch Nuclear Plant, Application for License Renewal, Environmental Report, Appendix D, Attachment F. February 2000.

9. TVA calculation CN-BFN-MEB-MDN0-999-2001-0011, R0.

10. Regulatory Analysis Technical Evaluation Handbook, NUREG/BR-0184.

11. TVA calculation CN-BFN-MEB-MDN0-999-2001-0016, Revision 0

12. Browns Ferry Nuclear Plant, Unit 2 Probabilistic Risk Assessment Individual Plant Examination, September 1992.

13. NUREG-1560, “Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance,” Volume 2, NRC, December 1987.

14. Letter from TVA to USNRC, RO8 970411 803.

15. Letter from TVA to USNRC, RO8 971118 922.

16. NUREG-1150, “Severe Accident Rises: An assessment for Five U.S. Nuclear

Power Plants," U.S. Nuclear Regulatory Commission, Washington, D.C., June 1989.

17. Tennessee Valley Authority, "BFN Completed Capital Projects," RIMS B44 010824 001.

18. PLG, "Browns Ferry Multi-Unit Probabilistic Risk Assessment," prepared for Tennessee Valley Authority, PLG-1045, January 1995.