1.2 General Site Description

The Grand Gulf Nuclear Station site is located in Claiborne County in southwestern Mississippi. The plant site is on the east side of the Mississippi River about 25 miles south of Vicksburg, Mississippi, 6 miles northwest of Port Gibson, Mississippi and 37 miles north-northeast of Natchez, Mississippi. The Grand Gulf Military Park borders a portion of the north side of the property, and the community of Grand Gulf is approximately 1-1/2 miles to the north. The Universal Transverse Mercator (UTM) Grid Coordinates for the approximate center of the location of the power block area of a new facility are N3,543,261 meters and E684,018 meters.

The property boundary shown on Figure 1.2-1 encompasses approximately 2100 acres of property that makes up the Grand Gulf Nuclear Station (GGNS) site. The site and its environs consist primarily of woodlands and farms. Within this area are two lakes, Gin Lake and Hamilton Lake. These lakes were once the channel of the Mississippi River and averaged about 8 to 10 feet in depth.

The western half of the plant site consists of materials deposited by the Mississippi River and extends eastward from the river about 0.8 mile. This area is generally 55 to 75 feet above mean sea level (msl).

The eastern half of the plant site is rough and irregular with steep slopes and deep-cut stream valleys and drainage courses. Elevations in this portion of the plant site range from about 80 feet above msl to more than 200 feet above msl at the inland of the site. Elevations of about 400 feet above mean sea level occur on the hilltops east and northeast of the site.

2.0 SITE CHARACTERISTICS[1]

The physical, environmental and demographic features of the GGNS site as they relate to an early site permit application are presented and discussed in this section. These site characteristics form the basis for future comparison (at the COL stage) with design characteristics of the selected plant type, to verify that the site is suitable for that plant type.

2.1 Geography and Demography

2.1.1 Site Location and Description

2.1.1.1 Site Location

Grand Gulf Nuclear Station is located in Claiborne County in southwestern Mississippi. The plant site is on the east side of the Mississippi River about 25 miles south of Vicksburg and 37 miles north-northeast of Natchez. The Grand Gulf Military Park borders a portion of the north side of the plant site property, and the community of Grand Gulf is about l-1/2 miles to the north. The town of Port Gibson is about 6 miles southeast of the plant site.

The Universal Transverse Mercator Grid Coordinates for the center of the area of the proposed location of the new reactor(s) on the site are approximately N3,543,261 meters and E684,018 meters.

The GGNS site property boundary shown on Figure 2.1-1 encompasses approximately 2100 acres of property. Figure 2.1-1 shows the location of significant plant facilities with respect to the site property boundary, and with respect to the proposed location of a new facility on the site.

2.1.1.2 Site Description

The site and its environs consist primarily of woodlands and farms and are about equally divided between two physiographic regions. The western half of the plant site property is in the alluvial plain of the Mississippi River; the eastern half is in the Loess or Bluff Hills. The elevation of the plant site property varies between 55 and 75 *feet above mean sea level in the alluvial plain region, whereas the Loess Hills portion varies from 80 to more than 200 feet above mean sea level (msl) at the inland of the site. Elevations of about 400 feet above mean sea level occur on the hilltops east and northeast of the site.*

Two lakes, Gin Lake and Hamilton Lake, are located in the western portion of the property. These lakes were once the channel of the Mississippi River and range from about 8 to 10 feet deep. A third lake, created from a borrow pit developed during construction of GGNS Unit 1 is located near the barge slip at the river.

2.1.1.2.1 General Arrangement of Structures and Equipment - GGNS Unit 1

The principal buildings and structures include the containment structure, the turbine building, the auxiliary building, the control building, the diesel generator building, the standby service water cooling towers and basins, the enclosure building, the radwaste building, the natural draft cooling tower and the auxiliary cooling tower. A structure which houses the administration

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[1] This ESP application makes use of material from the GGNS Updated Final Analysis Report (UFSAR) where considered appropriate. When such material (text) is used in this application (verbatim), it is shown in italics. Tables and figures taken from the UFSAR do not use italics but are referenced (by number) on the associated tables and figures of this document.

2.1.3 Population Distribution[2]

The permanent population data presented in this section were primarily based on the 2000 U.S. Census (Reference 1). The LandView 5[3], software was used to develop demographic data presented in this section of the report. The census data was augmented by information from other agencies and public organizations from the states of Mississippi and Louisiana (References 13 and14)[4]. The area, encompassed by a 50-mile radius from the center of the proposed power block location for a new facility on the site, includes all or a portion of the following 25 counties and parishes in Mississippi and Louisiana:

Mississippi Counties		Louisiana Parishes	
Adams	Lincoln	Caldwell	Madison
Amite	Madison	Catahoula	Richland
Claiborne	Rankin	Concordia	Tensas
Copiah	Sharkey	East Carroll	West Carroll
Franklin	Simpson	Franklin	
Hinds	Warren		
Issaquena	Wilkinson		
Jefferson	Yazoo		

[2] Sources for population data and projections, as well as information on seasonal variations (transient) population in the area around the GGNS, are identified and referenced in this section, as appropriate. The population data and general descriptions of human activity and seasonal variations are provided to comply with Regulatory Guide 1.70 (Section 2.1.3). In general, the GGNS UFSAR was the basis for the information included in this section. This information was updated with data obtained by research, as cited, conducted primarily in 2002. Except for population projections, which provide insight into future population growth, information provided in this section is a description of the current population based on research in 2002.

[3] **LandView®** reflects the collaborative efforts of the U.S. Environmental Protection Agency (EPA), the U.S. Census Bureau, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey (USGS) to provide the public readily accessible published federal spatial and demographic data. It is composed of two software programs: the LandView® database manager and the MARPLOT® map viewer. These two programs work in tandem to create a simple computer mapping system that displays individual map layers and the demographic and spatial information associated with them.

[4] This augmented information includes descriptions and data (current for 2002 to the degree practical) for facilities, schools, parks, recreational areas, etc. Population projections are provided in this section by distance and sector. However, no attempt is made to estimate projections for transient populations, school populations, specific community populations, etc. These would be assumed to grow at the same rates consistent with their associated segment's projections.

2.1.3.1 Permanent Population within 10 miles

Figure 2.1-3 shows a map of the area within 10 miles of the site. On this map, concentric circles have been drawn, with the site at the center point, at distances of 1, 2, 3, 4, 5, and 10 miles. The circles are then divided into 22.5-degree segments with each segment centered on one of the 16 cardinal compass points (e.g., north, north-northeast). Within each area thus formed by the concentric circles and radial lines, the projected permanent (resident) population for 2002, 2030 (the projected first year of facility operation) and each decade for five decades through the year 2070 have been estimated and are given in Table 2.1-1. The population data for the area within ten miles of the site was based on census block points from the LandView 5 software program provided by the U.S. Census Bureau.

The projected populations for each segment are based on averages of the population projections obtained from the Louisiana State University Parish population projections and the Mississippi Center of Policy Research and Planning projections for the Louisiana parishes and Mississippi counties, respectively (References 13, 14)[5].

There are no residents within the exclusion area boundary as defined for a new facility (see Section 2.1.2).

2.1.3.2 Permanent Population Between 10 and 50 miles

Figure 2.1-4 shows a map of the area within 10 to 50 miles of the site. On this map, concentric circles have been drawn, with the center of the proposed power block location on the site at the center point, at distances of 10, 20, 30, 40 and 50 miles. The circles are then divided into 22.5-degree segments with each segment centered on one of the 16 cardinal compass points (e.g., north, north-northeast). The projected permanent (resident) population for 2002, and each decade for five decades from the projected first year of plant operation, 2030, through the year 2070 for each area formed by the concentric circles and radial lines is given in Table 2.1-2. The basis of estimating the 2002 and the projected population distributions are the same as those described in Section 2.1.3.1.

2.1.3.3 Transient Population

2.1.3.3.1 Transient Population Within Approximately 10 Miles

Transient population, particularly within the low-population zone of the Grand Gulf site, shows both seasonal variations (due to the Grand Gulf Military Park, Warner-Tully YMCA Camp, Lake Claiborne, hunting camps, and fishing) and daily workday variations (due to employment, schools, and other sources of an occasional nature). Descriptions of the seasonal and daily variations in population in the area surrounding the Grand Gulf site are presented below.

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[5] Both Mississippi and Louisiana based the population projections on the same methodology, i.e., the Cohort-Component Method. The Louisiana projection also used the Shift-Share method of allocating growth among parishes. The Cohort-Component Method carries each sex/race group in the target population (either state or county/parish) individually forward in time, by five-year intervals and for five-year age categories. This method is widely used for long-range population projections, including the population projection of the United States for the years 1999 – 2100. (For additional detail on this example, see Reference 17).

The Grand Gulf Military Park is located approximately 1-1/2 miles north of the site and is contiguous to the site property. The park is open daily from 8:00 a.m. to 5:00 p.m. and had over 88,000 visitors who used the facilities and grounds in 2001. There were approximately 31,000 visitors to the park who paid for camping and tours in 2001. School groups, Boy Scouts, YMCA groups and others use Grand Gulf Military Park for field trips and nature studies. Most people visit the park on Sundays, with Saturday second in attendance. The park is most heavily populated during the months of June and July. (Reference 2)

The Warner-Tully YMCA Camp (Mississippi) consists of 108 acres of land located approximately 3-1/2 miles northeast of the site. Approximately 800 campers use the Warner-Tully camp facilities each year. The YMCA camp is open from late May to the end of August. (Reference 3)

Lake Claiborne (Mississippi) is a private development of residential and recreational facilities. It is located approximately 3-1/2 miles east of the site. Lake Claiborne, Inc. has a total of about 450 members; there are 51 families in full-time residence at the development. A maximum of 200 people use these facilities on a summer weekend (References 4 and 19).

Lake Bruin State Park consists of 53 acres located on the shore of Lake Bruin, Louisiana, approximately 9.5 miles southwest of the site. From July 2001 to June 2002, the park had approximately 36,000 visitors. (Reference 6)

There are approximately 150 hunting camps within Claiborne County. These camps are primarily used for deer hunting and other types of hunting, as well as sport fishing. The camps are too numerous to get an accurate number of hunters using the camps. Each camp, depending on the size of the camp, could have up to 20-30 hunters on a weekend day during hunting season. (References 5 and 15)

There are several hunting clubs located across the Mississippi River from the GGNS in Tensas Parish, Louisiana. Approximately 400 hunters are members of these clubs, primarily deer and duck hunters (Reference 17)

Mississippi's deer season traditionally opens early in October for archery and late November for guns. The season continues through early January. The greatest numbers of hunters are present on the first day of gun season, which is early November. Approximately 500-600 hunters are customarily in attendance at the camps for the first day of the first gun season. After the opening weekend, approximately 70% of the hunting population utilize the camps in the area until the end of the season in early January. (Reference 5)

Sport fishing in the area occurs in the months of April through September with Saturday the busiest day of the week. As many as 200-250 fishermen may be within the vicinity on weekends during the months noted above. The number of fishermen may drop to less than 150 during the week and depending on the weather conditions. (Reference 5)

The Kansas City Southern freight train passes north to northeast within 28 miles of the site twice daily. The train runs from Vicksburg to Meridian, MS, and then returns to Vicksburg. The train carries a crew of five. (Reference 7)

The Delta Queen Steamboat Company operates three paddle wheel tour boats on the Mississippi River, the Delta Queen, the Mississippi Queen and the American Queen. The Delta Queen is scheduled to pass the GGNS site a minimum of five times during the 2003 season. She has a full complement of 174 passengers and 75 crew. The Mississippi Queen is scheduled to pass the GGNS site a minimum of 8 times during the 2003 season with a full complement of

416 passengers and 156 crew. The American Queen is scheduled to pass the GGNS site a minimum of 13 times during 2003 with a full complement of 436 passengers and 161 crew. (Reference 8)

There is one primary forest product company, Anderson-Tully, that owns and leases land within the study area. Anderson-Tully has 12 people on logging crews that work in the vicinity. Anderson-Tully is located in Vicksburg, Mississippi. (Reference 9)

There is limited commercial fishing within the study area. Most of this occurs on the Mississippi River, the Big Black River and the Bayou Pierre River, with catfish being the most abundant catch. There are approximately 12 commercial fishermen who fish within the area. (Reference 5)

The GGNS Unit 1 facility has approximately 750 people who work at the plant site. Plant staffing is round the clock, with approximate numbers of personnel on site as indicated below for the normal day crews and night crews (Reference 18).

GGNS Approximate Staffing Levels

	Normal Week Day	Normal Weekend Day	Outage Week Day	Outage Weekend Day
Day	660	70	800*	210
Night	90	60	170*	140

* Outage week day estimated based on difference between outage weekend day and normal weekend plus normal week day staff.

The transient population within approximately 10 miles of the site is evaluated and discussed in detail as part of the assessment of the evacuation time estimate (ETE) of the 10-Mile Emergency Planning Zone (EPZ). The 10-Mile EPZ (or “plume exposure pathway” EPZ) is generally a circle about the site, roughly 10 miles in radius but expanded in several areas to encompass certain small or special communities (or facilities). The 10-Mile EPZ is illustrated in Figure 2-6 in Part 4 of this Application. The ETE study reviewed not only the permanent (resident) population but also provided a detailed and conservative assessment of transient populations. The transient population was analyzed in terms of: (1) transient work force, (2) recreational transients, and (3) special facilities such schools, nursing homes, and university populations within the 10-Mile EPZ. The method and results of the ETE study are summarized in Section 2.2 of Part 4 of this Application. Additional detailed discussion is provided in the study (i.e., Reference 24 in Section 2.3 of Part 4 in the application).

The 10-Mile EPZ transient population was estimated to be approximately 10,700. The approximate breakdown of this total is: work force transients, 1,100; recreational transients, 1,900; and special facilities, 7,700. This value is considered to be conservative since, when added to permanent population, it is recognized that some population segments (e.g., students and some portion of the work force) would also be counted in the permanent (U.S. Census) population values. In addition, this value represents a “weighting factor” of effectively 1.0. That is, no credit is taken in this emergency planning estimate for seasonal variation of the transient population within the 10-Mile EPZ.

2.1.3.3.2 Transient Population, 10 to 30 Miles

NRC guidance in Regulatory Guide 4.7, Position C.4, calls for particular consideration of population density out to 30 miles. This and later sections, therefore, provide discussions of transient popuations out to 30 miles from the site.

As discussed above, the detailed emergency planning study of populations within the 10-Mile EPZ provided estimates of transient (and permanent) populations within that area. For the area from 10 to 30 miles from the site, a different method was used for estimating transient populations. The general area from 10 to 30 miles was reviewed to identify which communities warranted additional research regarding recreational and other transients. Consultations were then made with appropriate organizations to estimate the weighted transient populations in these areas.

2.1.3.3.2.1 Recreational Transients

Figure 2.1-6 illustrates communities with a permanent population over 1000 within 50 to 60 miles of the site. From this figure, it is noted that the closest communities of Newelton, LA, St. Joseph, LA, and Port Gibson, MS are within 13 miles or closer. Since the total permanent and transient population of these communities are included within the 10-Mile EPZ population totals, no additional work was required to assess their transient populations. As shown in Figure 2.1-6, the next closest community over 1000 is Vicksburg, MS with a city center in the 25 mile range. Therefore, the assessment of recreational transients for the area of approximately 10 miles to 30 miles from the site focused on the Vicksburg area north and NE of the site.

Contacts were made with two key organizations involved in monitoring recreational (tourist) traffic; the Vicksburg Convention and Visitor’s Bureau and the Louisiana Office of Tourism. From these sources, information was obtained regarding the number of visitors and the average length of stay (References 20 and 21).

As expected the recreational visitor traffic to Vicksburg was relatively high. The weighted value was estimated to be approximately 9,800 people. These recreational transients were geographically distributed in direct proportion to the permanent population (US Census data). This estimate of weighted, recreational transients was combined with other transient and permanent (resident) population and is presented in Table 2.1-5.

2.1.3.3.2.2 Seasonal Population

While the tourist traffic load in the Vicksburg area was considered to be the major source of transient population, US Census data was used to estimate additional transients that might be considered seasonal. It is likely that this overlapped tourist information from the above noted sources, but was added in since it provided additional information regarding possible transients in areas within 30 miles other than the N to NE directions (i.e., the Vicksburg, MS area). This “seasonal population” was based on the 2000 Census which provided the number of temporary houses used for recreation or other seasonal work for Census block groups located within 10 to 30 miles from the GGNS site (Reference 22, U.S. Census, 2000, Summary File 3). This population was distributed based on cardinal direction and radial distance (10 to 30 miles) from the GGNS site. The 2000 Census data reported average household size in Mississippi to be 2.62 persons and the average household size in Louisiana was reported to be 2.63 (Reference 23, U.S. Census, 2000, Summary File 1). These household sizes were averaged and multiplied by the number of seasonal houses used for recreation or other seasonal work and distributed from 10 to 30 miles from GGNS. To be conservative, no weighting factor was applied to the seasonal housing data; although, individuals occupying these housing units are not expected to live in these homes full time. This estimate of seasonal transient population is combined with other transient and permanet (resident) population, presented in tabular form in Table 2.1-5.

2.1.3.3.2.3 Transient Work Force

No net change in population was assumed for the 10 to 30 mile radius regarding work force population, based on reasonable judgment. Given the relatively large area and the dominance of the Jackson area as the largest population center, it's assumed that as many workers commute in as those commuting out of the 30 mile area.

2.1.3.3.2.4 Special Populations (Schools, Hospitals, Nursing Homes, etc.)

For special population (transients) from 10 to 30 miles, no net change in transient population was assumed based on reasonable judgment. The dominant portion of special population would be schools in the subject area, and these students and school staff would likely be captured in the Census information. While a certain amount of double counting of school related population was included in the 10-Mile EPZ total population, this was not considered appropriate for the 10 to 30 mile range.

2.1.3.3.3 Total Permanent and Transient Populations

Per the emergency planning study (discussed and referenced above), the total 2002 10-Mile EPZ population, permanent and weighted transient, was estimated to be approximately 20,500. The total population, permanent and transient, for the 10 to 20 mile and 20 to 30 mile areas are listed in Table 2.1-5. The total 2002 population, permanent and transient, for 0 to 30 miles was estimated to be approximately 128,300.

2.1.3.3.4 Projected Total Populations

Methods for determining projected permanent populations are discussed in Section 2.1.3.1. This same method used for permanent populations was applied to the projection of changes in transient populations based on the assumption that the growth rates for both population segments would be generally comparable, for the purposes of this analysis. Table 2.1-6 presents projected total populations, permanent and transient, for 0 to 10, 10 to 20, 20 to 30, and 0 to 30 miles, projected to 2030 (approximate start of facility operation) and 2070 (approximate end of life for the proposed new facility).

2.1.3.4 Low Population Zone

The definition of a low population zone (LPZ) as stated in 10 CFR 100 is: "the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident." The LPZ radius is 2.0 miles centered on the reactor for the existing GGNS Unit 1 plant (Reference GGNS UFSAR Section 2.1.3.4). The LPZ for a new facility, a 2 mile radial distance measured from the circumference of a 630 ft. circle encompassing the proposed power block location for a new facility will be essentially the same as for GGNS Unit 1. The center of the 630 ft. circle is approximately 1200 ft. west and 1000 ft. north of the GGNS Unit 1 reactor containment center. Figure 2.1-5 illustrates the approximate LPZ and indicates transportation routes within a 10-mile radius of the site. The number and density of residents in the area immediately surrounding the GGNS site (in both Mississippi and Louisiana) are low, enabling simple and effective evacuation procedures to be followed in the event of a serious accident. The permanent (resident) population within the LPZ is 51 people (LandView 5). The GGNS Unit 1 daily population of employees is about 750, with the approximate distribution between day and night as indicated above in Section 2.1.3.3. The permanent population density within the LPZ radius is about 4.1 persons per sq. mile. The roads within the area will be the primary transportation routes for evacuation. Table 2.1-3 lists facilities and institutions within 5 miles of the site.

Seasonal and peak daily transient population within the low population zone is mainly due to recreational use of the Grand Gulf Military Park, hunting and sport fishing and the work force at the GGNS site. Each of these contributors to the transient population in the LPZ are described in Section 2.1.3.3 above.

2.1.3.5 Population Center

A population center is defined in 10 CFR 100 as a densely populated area where there are about 25,000 inhabitants or more. The closest population center is Vicksburg, Mississippi, located approximately 25 miles north-northeast of the site, with a permanent 2000 population of 26,407. This is the only population center within 50 miles of the site. The nearest major city is Jackson, Mississippi, which lies 55 miles to the northeast of the site, and has a permanent population of 184,256 according to the 2000 US Census. The southwest portion of Jackson is located within the 50-mile radius. Figure 2.1-6 shows those communities in the area whose populations are over 1,000. Table 2.1-4 displays permanent populations and distances of all communities in the 50-mile radius area with a population of over 1,000. (Reference 1)

Research into transient populations between to 10 and 30 miles concluded, as expected, that the large majority of transients in the area consist of tourists visiting the Vicksburg, MS area, thus, acting to increase the effective, overall Vicksburg population (i.e., permanent combined with weighted transients). The majority of the Vicksburg, MS area is located within the 20 to 30 mile area. The land area between 20 and 30 miles from the site has an estimated 2002 total population (permanent and weighted transient) of approximately 59,400 (as shown in Table 2.1-5).

As discussed above, a conservative estimate of total permanent and transient population for the 10-Mile EPZ, was developed in support of the emergency planning information included in Part 4 of the application. As shown in Table 2.1-5, the current total population is estimated to be slightly over 20,000, based on a detailed study of protective action areas that comprise the 10-Mile EPZ. As shown in Table 2.1-6, this total population is expected to grow modestly and is projected to be approximately 21,800 in 2030 and approximately 23,700 by 2070 at end of life for the new facility. Based on the detailed evacuation time estimate study and as illustrated in Figure 2-6 in Part 4 of the application, the majority of this total population is distributed beyond 5 miles from the site, from the ESE to the WNW directions. Populations are concentrated around the city of Port Gibson, MS (ESE, approx. 5 miles); Alcorn State University (SSW, approx. 10 miles); St. Joseph, LA (WSW, >10 miles); and Newelton, LA (WNW, >10 miles).

While the total population of the 10-Mile EPZ is between 20,000 and 25,000, there are no significant communities between the site and the minimum population center distance (as defined in 10 CFR 100) of 2.7 miles. Thus, based on this analysis, Vicksburg remains the population center closest to the ESP site with a total permanent and weighted transient population of 25,000 or greater. Further, it is unlikely that population centers with 25,000 people or more (permanent and weighted transient) will exist within 2.7 miles of the proposed ESP site during the lifetime of any new plants that might be constructed at the site.

2.1.3.6 Population Density

The cumulative permanent (resident) population for 2000 was calculated using the data from LandView 5 software provided by the U.S. Census Bureau. The permanent population density for Claiborne County, in which the site is located, is 24.3 persons per sq. mile; for the state of Mississippi, it is 60.6 persons per sq. mile.

The projected total population (permanent and weighted transient) within a 30-mile radius for the year 2030, the projected initial year of plant operation, would be approximately 137,800 people and the projected average population density would be approximately 48 persons per sq. mile.

The projected total population (permanent and weighted transient) within the 30-mile radius for the year 2070 (i.e., the projected end of the initial 40 year plant licensed operating period) would be approximately 152,200 people. The projected average population density would be 52 persons per sq. mile. As shown in Table 2.1-6, the site's projected population density is well below the value specified in Regulatory Guide 4.7, Position C.4 (i.e., 500 persons/sq. mi. for the start of facility operation and 1000 persons/sq. mi. at the projected end of facility life).

2.1.3.7 Public Facilities and Institutions

A summary of the schools, hospitals and public parks in the area within about 10 miles from the site is given in Table 2.1-7.

During the 2000-2001 school year, the enrollment population for schools within the vicinity of the site can be found below. (Reference 10)

	Institution Population	
School Name	Students	Faculty
Port Gibson High School	565	33
Port Gibson Middle School	453	31
Arthur W. Watson Elementary	993	52
Chamberlain-Hunt Academy	111	16
Claiborne Educational Foundation	77	7
Alcorn State University	3,100	~194 (Reference 16)

Claiborne County Hospital has 32 beds. The staff consists of five doctors, ten registered nurses, six nurses' aides, and three X-ray technicians. (Reference 11)

The Claiborne County Courthouse houses the offices of the Circuit Clerk, Chancery Clerk, County Tax Assessor, County Superintendent of Education, and a courtroom. The county jail, located behind the courtroom, has one prison cell and can accommodate 25 inmates; yet, it generally has less than five inmates. (Reference 12)

Grand Gulf Military Park occupies about 150 acres, is located approximately 1-1/2 miles north of the site, and is contiguous to the site property. Lake Bruin State Park consists of 53 acres located on the shore of Lake Bruin. See Section 2.1.3.3 for additional discussion.

2.1.4 References

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2.3 Meteorology

2.3.1 Regional Climatology

The description of the general climate of the region at the time of licensing of Grand Gulf Nuclear Station Unit 1 was based primarily on climatological records for Vicksburg and Jackson, Mississippi. This description utilizes that data as appropriate and is augmented by more recent data from the Vicksburg station and the GGNS site meteorological tower.

Topographical considerations and examination of the records indicate that meteorological conditions at Vicksburg and Jackson are representative of the general climate of the region encompassing the site. Since Vicksburg is the closer of the two stations and borders the Mississippi River, the tables and figures included are based primarily on Vicksburg data when the period of record and observational procedures are considered adequate. Otherwise, Jackson data are presented.

Recent improvements in the National Oceanographic and Atmosphere Administration (NOAA) National Climatic Data Center (NCDC) data systems provide easy access to local meteorological data records since the middle of 1996. GGNS site data is also available for this period. Most of the tabular data in this section are from these recent data sources, but there was also an extensive amount of meteorological data gathered and evaluation that was performed for the licensing of Grand Gulf Unit 1 in the 1970s. In several cases, such as the reoccurrence rate of rare events based on many decades of observation, the original data is preferable. For example, the last few years have been unusually dry in the region, so it would be more accurate and more conservative, in terms of maximizing rainfall predictions, to use the Unit 1 licensing data rather than to draw long term rainfall conclusions on data from the last five years. General discussions of the regional climate dating from the Unit 1 licensing period are also still valid so the existing Unit 1 meteorological discussion and references in the GGNS Unit 1 UFSAR (Reference 4) are still applicable.

2.3.1.1 General Climate

The climate of southwestern Mississippi is humid and subtropical with a short cold season and a relatively long warm season. The predominant air mass over the region during most of the year is maritime tropical with origins over the Gulf of Mexico. In the winter, occasional southward movements of continental polar air from Canada bring colder and drier air into Mississippi. However, cold spells seldom last over 3 or 4 days.

In summer, the region is almost wholly dominated by the west- ward extension of the Bermuda High, a subtropical, semipermanent anticyclone. The prevailing southerly winds provide a generous supply of moisture and this, combined with thermal instability, produces frequent afternoon and evening showers and thundershowers over the region. The convective thundershowers of the summer season are more numerous than frontal type thunderstorms. However, the thunderstorms associated with the occasional polar front activity in late winter and early spring are more severe and sometimes produce tornadoes.

Mississippi is south of the average track of winter cyclones, but occasionally one moves over the state. In some winters a succession of such cyclones will develop in the Gulf of Mexico or in Texas and move over or near the state. Also the state is occasionally in the path of tropical storms or hurricanes (Reference 1).

It is common in wind direction data collection to divide the directions of the compass into sixteen 22.5 degree sectors centered on true north (N), north-northeast (N-NE), northeast (NE), east-northeast (E-NE), east (E), east-southeast (E-SE), southeast (SE), south-southeast (S-SE), south (S), south-southwest (S-SW), southwest (SW), west-southwest (W-SW), west (W), west-northwest (W-NW), northwest (NW) and north-northwest (N-NW). *The general airflow over the region is from the southerly sectors during much of the year, although the prevailing direction may be from one of the northerly sectors during some months.* The net air movement can be deduced from the annual resultant wind values for the GGNS site shown in Table 2.3-1. The average windspeed at the site has ranged from 3.7 mph to 4.4 mph between 1996 and 2003. The average windspeed at Vicksburg between 1997 and 2003 ranged from 7.0 mph to 7.6 mph as shown in Table 2.3-2.

The temperature regime of the site region can be described by the data that are shown in Table 2.3-3; four years of GGNS site data from 2000 to 2003, and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) design data (Reference 51) for Jackson, Mississippi. As can be seen from the table, the ASHRAE design values for the Jackson area are very close to those developed from the GGNS site data.

Climatic records of humidity in Vicksburg are shown in Table 2.3-4. These data show that relative humidity in the region is high throughout the year. Nighttime relative humidities are highest in summer and fall and lowest in winter. Daytime humidities are highest in winter. Seasonal variations are in the vicinity of 5 to 10 percent. Highest relative humidities occur in the early morning hours (00:00 – 06:00), averaging greater than 80 percent during all months. Lowest relative humidities occur during early and mid afternoon with averages ranging from about the mid-50s to the mid-60s for all months.

Mean annual precipitation in the region ranges from about 50 inches in northwestern Mississippi to 65 inches in the southeastern part of the State. During the freeze-free season, rainfall ranges from about 24 inches in the northwest to about 37 inches in the southeast, but during winter the precipitation maximum is centered in the northwest with the minimum on the coastal counties. The fall months are the driest of the year. Yearly average rainfall at the GGNS site for 2000 and 2001 is approximately 45 inches (Table 2.3-70), and at Vicksburg for the period of 1997 to 2001 was about 50 inches (Table 2.3-71).

While snowfall is not of much economic importance, it is not a rare event in Mississippi. During the 65 years from 1898 through 1957 and 1997 through 2001, measurable snow or sleet fell on some part of the state in all but 3 years. During these 65 years snow or sleet fell in January in 40 years, and in February in 32 years. Along the latitude of the site (about 32° N) snow has fallen in about 30 percent of the years. (References 1 and 3) Vicksburg snow events for the last five years are shown in Table 2.3-76.

Local (site) meteorological conditions are expected to result almost entirely from synoptic-scale atmospheric processes. That is, the local site does not have a unique micro-climate but rather the local meteorology is consistent with the wide area meteorology. There are two exceptions caused by local effects due to the Mississippi River. First, there is higher humidity directly adjacent to the Mississippi River, and so the Vicksburg humidity data is more appropriate for site estimates than the Jackson data. Second, *there is some evidence of channeling of extremely low level (less than 70 feet above grade) winds from the west into a trajectory along the river. This phenomenon has no effect on dispersion of effluents from the plant since the site is east of the area affected.*

2.3.1.2 Regional Meteorological Conditions for Design and Operating Bases

2.3.1.2.1 Severe Weather Phenomena

This section describes severe weather phenomena that may require consideration in design of safety related structures, systems and components. Most recent data is taken from the NCDC Storm Event database that covers the period of 1950 through 2002 (Reference 5), but even longer data periods are used for some phenomena to try to capture the occurrence of rare events.

2.3.1.2.1.1 Hurricanes

During the period 1899 to 2000 there were 117 tropical cyclones which affected the Middle Gulf Coast (Louisiana, Mississippi, Florida, Texas and Alabama). Of these, 39 (33.3 percent) were category 1, 30 (25.6 percent) were category 2, 36 (30.8 percent) were category 3, 10 (8.5 percent) were category 4 and 2 (1.8 percent) were category 5 hurricanes. Table 2.3-5 presents a monthly breakdown of the 117 cyclones and provides a definition of the storm categories.

Tropical cyclones, including hurricanes, lose strength as they move inland from the coast and the greatest concern for an inland site is possible flooding due to excessive rainfall. The extremes for rainfall presented below include possible hurricane effects.

The small diameter, extremely intense Camille hurricane (1969), whose center passed less than 10 miles to the east of Jackson Municipal Airport, generated gusts at Jackson of only 67 mph. The top winds in this hurricane at points on the coast were estimated at over 170 mph (Reference 7).

2.3.1.2.1.2 Tornadoes and Waterspouts

Tornadoes do occur in this area. A highly destructive tornado struck Vicksburg in December 1953. In addition, on April 17, 1978, a tornado struck GGNS. A detailed report of this event was submitted to the NRC via Reference 8. The tornadoes reported during the years 1950 - 2002 in the vicinity of Claiborne, Warren and Hinds Counties in Mississippi and Tensas Parish in Louisiana are shown on Table 2.3-6.

In the period from 1950 to April 2002, a total of 108 tornadoes touched down in these four districts, which have a combined area of 2,545 square miles (Reference 9). References 10 and 11 identify that local tornadoes have a mean path area of 0.43 square miles. The site recurrence frequency of tornadoes can be calculated using the point probability method as follows:

Total area of tornado sightings = 2,545 sq. mi.

Average annual frequency = 108 tornadoes ÷ 52.3 years = 2.07 tornadoes/year

Freq/yr of a tornado striking a particular point P = (0.43) (2.07) ÷ 2545 = 0.00035

Mean recurrence interval = 1/P = 2,860 years.

NUREG/CR-4461, (Reference 30) Tornado Climatology of the Contiguous United States, Rev. 1, published in April 2005 contains location-specific tornado information. This reference identifies that the Grand Gulf plant site at approximately 32ºN, 91ºW, has experienced 592 tornadoes from 1950 – 2003 in a 2 degree box (roughly 16,000 mi^2). This gives a point strike frequency by the above formula of 3.0×10^{-4} yr^{-1}, in good agreement with the local county data. The 95% upper limit for a point structure in the Central US is stated to be 3.9×10^{-4} yr^{-1}.

*Waterspouts are similar to tornadoes but they do not form under the same meteorological conditions; they form over water bodies and do, on occasion, cross the coastline and penetrate several kilometers inland, (*Reference 12*). The water bodies in the vicinity of the Grand Gulf site area not likely to spawn waterspouts.*

2.3.1.2.1.3 Thunderstorms

Table 2.3-7 presents the thunderstorm data for the region from 1955 through 2002. About 62 percent of the thunderstorms in this area occur during the warm months (March-July), indicating that the majority are warm air-mass thunderstorms. From 1955 - 2002, 421 thunderstorms are listed for this area, with Hinds County receiving approximately 40 percent, Claiborne County receiving 12 percent, Warren County receiving 32 percent, and Tensas Parish receiving 16 percent of the thunderstorms. The total of 298 storms shown in the table is less than the sum of the individual totals (421) for each of the three counties and Tensas Parish because some of the individual storms extended into more than one county.

2.3.1.2.1.4 Lightning

Data on lightning stroke density is extremely sparse. Analysis has shown that the density per square mile is approximately one-half of the number of storm days from the isokeraunic map. This was partially confirmed by a two-year count in a region with 27 storm days per year where the average stroke density was approximately 15 strokes per square mile per year (Reference 13).

The annual mean number of thunderstorm days in the site area is estimated to be 66 based on interpolation from the isokeraunic map (Reference 14); *therefore it is estimated that the annual lightning stroke density in the Grand Gulf site area is 33 strokes per square mile.*

2.3.1.2.1.5 Hail

From 1955 - 2002, 279 hailstorms occurred in the region per year, with Hinds County receiving approximately 57 percent, Claiborne County receiving 6 percent, Warren County receiving 19 percent, and Tensas Parish receiving 18 percent of the hailstorms, as shown in Table 2.3-8. For this table, each occurrence of hail was counted as an individual event, even if two counties recorded hail simultaneously. The most probable months of occurrence of hail are March and April. Property damage occurs infrequently, with 6 recorded events in Warren County, 14 in Hinds County, 4 in Claiborne County, and 2 in Tensas Parish in this 47-year period.

2.3.1.2.1.6 High Air Pollution Potential

The atmospheric ventilation rate is numerically equal to the product of the mixing height and the wind speed within the mixing layer. Higher ventilation rates are better for dispersing pollution than lower ventilation rates.

A tabulation of daily mixing heights and mixing layer wind speeds for both morning and afternoon was obtained from the National Climatic Data Center for 1992 through 2000 at the Jackson International Airport in Jackson, Mississippi (Reference 15). This data was used to generate the morning and afternoon ventilation rates in Table 2.3-9.

Morning ventilation is less than 4600 m^2/s throughout the year, and is less than 3100 m^2/s from May through October. Afternoon ventilation is higher than 5600 m^2/s from March through September, but lower than 4900 m^2/s from October through February. Based on this and the tendency of pollutants to collect during the course of a day, the highest daily air pollution potentials exist during the lower afternoon ventilation rates from October through February.

Lowest air pollution potentials occur in the spring due to the relatively high mean ventilation rates.

Other data sources provide independent checks of this conclusion, including the Grand Gulf Unit 1 UFSAR which cites data collected in 1959 through 1962 (Reference 4). *According to Korshover* (Reference 16), *in a 35-year period from 1936 through 1970, there were 36 cases of 4 days or more of atmospheric stagnation over southwest Mississippi, … with maximum probability in October and the minimum in March.*

2.3.1.2.2 Probable Maximum Annual Frequency and Duration of Freezing Rain

An ice storm (also called glaze ice) is the accretion of ice, generally clear and smooth, formed on exposed objects by the freezing of a film of supercooled water deposited by rain, drizzle, or possibly condensed from supercooled water vapor. The weight of this ice is often sufficient to greatly damage telephone and electric power lines and poles. The ice coating on roads frequently slows down, or even completely paralyzes, transportation and makes movement of personnel and equipment extremely difficult.

Most glaze is the result of freezing rain or drizzle falling on surfaces with temperatures between 25 and 32 º F. The glaze belt of the United States includes all of the area east of the Rocky Mountains. However, in the southeast and Gulf Coast sections of the country, below freezing temperatures seldom last more than a few hours after glaze storms (Reference 17).

The occurrences and durations of recorded ice storms and heavy snow storms in the three counties and one parish around the GGNS site for the 8 year period 1993 through 2001 is shown in Table 2.3-10 (the storm database of Reference 5 contains this type of data for this location starting in 1993). From these data, conservatively including the heavy snowstorm of 1997, the frequency of ice storms in the Grand Gulf area is estimated to be 4 in eight years or 0.5 per yr.

The ice storm reported December 22, 1998 at 8:00 PM through December 25 at 5:00 AM, was the longest lasting storm with a total duration of 57 hours. Property damage was estimated at $16.6 million. It is noted that while the ice storm duration was 57 hours, that period was over an area of 27 counties. The time would have been less at a single location. Vicksburg reported the following history: 2 hours of trace rain (about 0.01 inches), followed by one dry hour, and then 8 hours of rain for a total of 0.4 inches at the start of the storm, then a period of 15 hours with only a trace of precipitation, and then 11 hours of rain totaling 0.85 inches, followed by only a trace of precipitation for the remainder of the storm. A conservative approach would be to neglect the dry/trace precipitation periods and assume this represents a 19 hour ice storm duration. Reference 4 also discussed combining periods of ice storms in this manner and developed a 12-hour maximum based on the ten years 1954 through 1963. Based on the Reference 4 maximum duration of 12 hours in 10 years of data, and this maximum value of 19 hours in 18 years of data, the maximum probable duration in 100 years would be 27 hours assuming a logarithmic extrapolation, i.e., 27 = 12 +(19-12)*log(100-10)/log(18-10).

The total number of glaze storms reported in the broad general area surrounding the plant site, during the period 1917 through 1953 inclusive, ranged from 1 to 7. It is estimated that about 30 percent of these caused ice coatings in excess of 0.5 inches in some portions of the area (Reference 17). As noted above, Vicksburg received about 1.27 inches of precipitation during the 1998 ice storm. A 100-yr return period 48-hour probable maximum winter precipitation depth is developed in Section 2.3.1.2.5.

2.3.1.2.3 Probable Maximum Annual Frequency and Duration of Dust Storms

The occurrence of dust, blowing dust, or blowing sand is a comparatively rare phenomenon in the Jackson/Grand Gulf area. Although there are categories for dust and sand in the meteorological data collection system used at Vicksburg, no hours are identified under this category in the period 1997 to 2001. The hourly weather records for the years 1955 through 1964 cited in the Grand Gulf Unit 1 UFSAR do include 33 hours of dust blowing at the Jackson Airport (out of this 87,600 hour period). It is conservative to continue to use these data. These statistics are shown in Tables 2.3-11 through 2.3-14.

The total hours of occurrence are shown for each month of each of the ten years in Table 2.3-11*. April had the largest total. From the yearly totals shown in this table, the probable maximum annual frequency (probability=0.01) of dust storms in the Grand Gulf area is estimated to be 14/8,760 or 0.16 percent.*

Table 2.3-12 *shows the number and duration of discrete occurrences of dust storms by month. A discrete occurrence is defined as one hour, or more than one consecutive hour, during which dust, blowing dust, or blowing sand was reported by the National Weather Service. There were no occurrences of more than one hour during the ten year period.*

Table 2.3-13 *summarizes the monthly statistics on the dust storm occurrences and* Table 2.3-14 *presents a summary of frequency and duration for each of the 10 years. From these data the probable maximum duration (probability = 0.01) of the dust storm in the Grand Gulf area is estimated to be about two hours.*

2.3.1.2.4 Estimated Weight of the 100-Year Return Snowpack

Mississippi is not a heavy snow load region. SEI/ASCE 7-02, "Minimum Design Loads for Buildings and Other Structures," identifies that the Grand Gulf ESP site is located in a snow load zone of 5 lbf/ft^2 based on a 50-yr recurrence. This is converted to a 100-yr recurrence weight of 6.1 lbf/ft^2 (psf) using a factor of 1.22 (1 / 0.82) taken from SEI/ASCE 7-02 Table C7-3.

Local snow measurements support this SEI/ASCE 7-02 (Reference 53) value. The current NCDC storm event database for surrounding counties (Reference 5) identifies that the greatest snowfall in its period of data, 1993 to September 2002, occurred on December 14, 1997. That storm deposited 8 inches of snow in Claiborne, Hinds and Warren counties. Reference 29 records that a site in the Vicksburg area saw a total of 10.1 inches of snow fall in January 1919. Reference 25 identifies the maximum 24-hour snowfall at Jackson was 10.6 inches in January 1940.

Snowpack, as used in this section, is defined as a layer of snow and/or ice on the ground surface, and is usually reported daily, in inches, by the National Weather Service at all first order weather stations. The density of the snowpack varies with age and the conditions to which it has been subjected. Thus, the depth of the snow-pack is not a true indication of the pressure which the snow-pack exerts on the surface which it covers. A more useful statistic for estimating the snowpack pressure is the water equivalent (in inches) of the snowpack.

In the Jackson/Grand Gulf area, snow melts and/or evaporates quickly, usually within 48 hours, and before additional snow is added; thus, the water equivalent of the snowpack can be considered equal to the water equivalent of the falling snow as reported hourly during snowfall. The data during the period studied indicate that the water equivalent of the maximum snowpacks in the Jackson area was between 0.08 and 0.12 inches of water per inch of snow. Reference 19 states that freshly fallen snow has a snow density (the ratio of the volume of melted water to the original volume of snow) of 0.07 to 0.15. Using this Reference 19 data for conservatism, the greatest snowpack weight seen in the 83 year data period is 6.06 psf (10.6 in * (0.07+0.15)/2 in water/in snow * 144 in^2/ft^2 * 0.0361lbf/in^3 of water). This value is consistent with the SEI/ASCE 7-02-derived 100-yr return weight of 6.1 psf.

2.3.1.2.5 Estimated Weight of the 48 Hour Probable Maximum Winter Precipitation

The 48-hour winter PMP, as defined in Hydrometeorological Report (HMR) No.53 dated April 1980 (Reference 55), is generated from the maximum 24-hr winter month PMP (Figure 27, March) of 30 inches, and the maximum 72-hr winter month PMP (Figure 37, March) of 39 inches. HMR 53 notes in Section 7.3 that winter point rainfall "would reasonably be not much different from the 10-mi^2 values" so no correction is applied for smaller areas. HMR 53 also recommends interpolation with a smooth depth-duration curve from (0,0) for intermediate time periods between 24 and 72 hours. Doing this gives a 48-hour winter PMP of 35 inches of rainwater.

Maximum frozen precipitation is not described in HMR 53. The NCDC storm database (Reference 5) was researched and, as documented in Section 2.3.1.2.2, there have been 4 ice storms in local counties and parishes in the 11 year period from 1993 to 2003. In these 11 years of data, the maximum precipitation during an ice storm has been 1.27" in a 1998 storm in Vicksburg. The precipitation records of Vicksburg were reviewed for the 12/14/1997 and 1/27/2000 events; the precipitation amounts reported were 0.26" and 0.86". The 1996 storm is described in the storm database as leaving 0.5" to 1" of ice. Using the Gumbel distribution and the method of moments as suggested by Wilks (Reference 56), the 100-yr return frozen precipitation is 1.9", based on the 11 years of ice thickness data of 1.27", 1", 0.86", 0.26" and seven years of 0" of Reference 5. It is considered reasonable and conservative to use this value, 1.9" of frozen precipitation, for the 48-hour probable maximum winter precipitation (PMWP) for the ESP site.

2.3.1.2.6 Weight of Snow and Ice on Safety-Related Structures

NRC Regulatory Guide 1.70 suggests that the combination of extreme live loads to be considered in the design of a nuclear power plant structures should include the weight of the 100-year snowpack at ground level plus the weight of the 48-hour Probable Maximum Winter Precipitation (PMWP) at ground level for the month corresponding to the selected snowpack. The winter PMP calculated using the methodology of HMR 53 is 35 inches (Section 2.3.1.2.5); however, the winter PMP for the Grand Gulf area refers only to rainfall. Rain will not remain on top of the snowfall, so it is not reasonable to add the weight of 35 inches of rain water to the maximum snowpack weight of 6.1 psf from Section 2.3.1.2.4.

To define the snow load for extreme live loads to be considered for roof structural design purposes, the 100-yr return value for frozen precipitation as calculated in Section 2.3.1.2.5, used as the limiting 48-hour frozen PMWP, is combined with the weight of the 100-year return snowpack of Section 2.3.1.2.4. Frozen precipitation at a depth of 1.9" of ice creates a load of 9.9 psf (1.9 in *144 in^2/ft^2 * 0.0361 lbf/in^3 of water = 9.9 psf). The combination of the 100-yr recurrence snow load (Section 2.3.1.2.4), plus this bounding 48-hour frozen PMWP weight, produces a snow load of 16.0 lbf/ft^2 (6.1 lbf/ft^2 + 9.9 lbf/ft^2).

As an alternative, and as suggested in the ASCE publication "Snow Loads: A Guide to the Use and Understanding of the Snow Load Provisions of ASCE 7-02" (Reference 54), the given snow load can be increased to account for additional factors, including rain on snow. The load is calculated as:

$p_f = (I)\ C_{100}\ p_g + C_{rs}$

where,

p_f = net roof load (psf)

p_g = 50-yr snow load (psf)

I = importance (= maximum value of 1.2 in Table 7-4)

C_{100} = multiplication factor for converting 50-yr to 100-yr loads (= 1.22 from SEI/ASCE 7-02 Table C7-3)

C_{rs} = additional rain-on-snow surcharge load (= 5 lbf/ft^2 for <20 lbf/ft^2 zones per SEI/ASCE 7-02 Section 7.10)

This gives a total equivalent snow load of:

$p_f = 1.2 * 1.22 * 5\ \text{lbf/ft}^2 + 5\ \text{lbf/ft}^2$

$= 12.3\ \text{lbf/ft}^2$

The larger of these two methods produces a snow load of 16.0 psf, which will be used with extreme live loads to be considered for safety related roof structural design for the ESP facility.

2.3.1.3 Meteorological Data to be Used in Evaluating the Ultimate Heat Sink

Meteorological data is used in accident analyses and other analyses to determine the effectiveness of safety related heat removal systems; i.e., the ultimate heat sink. This section discusses GGNS site and local area meteorological data which may impact design of safety related heat removal systems.

2.3.1.3.1 Meteorological Parameters

The controlling meteorological parameters required for the analysis of cooling tower performance are the wet bulb temperature and the coincident dry bulb temperature. Table 2.3-3 presents data on these parameters from two data sources: ASHRAE data for Jackson, Mississippi (Reference 51), and data from the GGNS site meteorological tower, 2000 –2003 (Reference 2). The GGNS data relevant to this assessment covers a limited period (see discussion of site instrumentation in Section 2.3.3). However, Table 2.3-3 shows that the GGNS data are consistent with the ASHRAE published data for Jackson, MS. Therefore, the GGNS site temperatures are acceptable for UHS design purposes.

2.3.1.3.2 Worst 1-Day, 5-Day, and 30-Day High Temperature Periods

a. Worst 1-Day Period

The hourly data for the worst 1-day, August 1, 1998, are shown in Table 2.3-16.

b. Worst 5-Day Period

The first 5 daily average values of the wet bulb temperature were summed and divided by five to calculate the first 5-day average. Then the sixth day's data was added to the sum and the first day value was subtracted from the sum. This new sum was divided by five to get the 2nd five day average. This process was repeated until all the observations were exhausted. Each five day period of data was averaged and the maximum average was selected as the worst 5 consecutive days. The daily average wet bulb and coincident dry bulb temperatures for the worst 5-day period are shown in Table 2.3-17.

c. Worst 30-day period

The same method of running averages as was used for the worst 5-day period was used to find the worst 30 consecutive days. The daily average wet bulb and coincident dry bulb temperatures for the worst 30 day period are shown in Table 2.3-18.

2.3.1.3.3 Limiting Cold Weather for UHS

Although freezing is not a common problem for ponds near the Grand Gulf site, occasionally cold streaks do occur that could potentially freeze UHS water sources. An analysis was made of the daily minimum and maximum temperatures recorded at Port Gibson from 1930 through 2001 (Reference 57). Cold spells were quantified in terms of accumulated freezing degree days (AFDD), which is defined as the maximum of the integral of (32-temperature) from the start of a cold spell as described in US Army Corp of Engineer report ERDC/CRREL Technical Note (TN) 04-3 (Reference 58). For all but five winters in this 72-year period, the cold spells were determined to be less than 50 AFDDs. The limiting cold spell occurred in January/February 1940, when temperature hit the recorded low value of -5°F in a two-week cold period that accumulated 98 AFDDs. This value of 98 AFDDs is defined as the site characteristic for use in evaluating the potential for water freezing in the UHS water storage facility.

2.3.1.4 Design Basis Tornado Parameters

The Design Basis Tornado characteristics are specific to the site and region of the country in which the site is located. However, rather than conducting site research on tornado characteristics, most sites in the past licensing proceedings have relied on NRC endorsed studies that set conservative values for key design basis tornado characteristics. These characteristics were then used in the design of the subject facility.

Regulatory Guide 1.76 (Reference 41), based on WASH-1300, has been used since the 1970s by the industry to establish the appropriate design basis tornado characteristics, depending on the proposed site location in the country. Since the issuance of this guide, additional tornado data has become available by way of the National Severe Storms Forecast Center. Using this later data and Regulatory Guide 1.76 methodology, the NRC developed an interim position, establishing an update to the design basis tornado characteristics. The NRC's updated criteria were described in its safety evaluation, dated March 25, 1988 (Reference 42). NUREG/CR-4461 (Reference 30) provides location-specific tornado maximum wind speed information. The ESP site, which is approximately 32ºN, 91ºW, is located in Region 3 as indicated in Figure 8-3, and Table 8-1 indicates that for a 10^{-7} yr^{-1} design probability the recommended maximum wind speed is 300 mph. The maximum wind speed in a tornado is the sum of the translational speed and the rotational speed. For this evaluation, the translational speed has been assumed to be

$u_t = 0.20 * u_o$

where,

u_o is the recommended design wind speed, and

the fraction 0.20 is consistent with NRC guidance (AEC 1974).

The design basis tornado characteristics defined for this project, as listed below, are based on the NRC's interim position (Reference 42), with the exception of maximum wind speeds which are defined in NUREG/CR-4461 (Reference 30).

Maximum wind speed, mph	300
Rotational speed, mph	240
Maximum Translational speed, mph	60
Radius of maximum rotational, speed, ft	150
Pressure drop, psi	2.0
Rate of pressure drop, psi/sec	1.2

2.3.1.5 100-Year Return Period Fastest Mile of Wind

*The records of the National Weather Service for Jackson, Mississippi (*Reference 22*) report the fastest mile of wind to be 68 mph. This occurred in 1952. Other records (*Reference 25*) show that the height of the wind sensor in 1952 was approximately 46 feet above ground level. Reducing 69 mph from 46 feet to the standard 30 foot level gives a value of 64 mph.*

The fastest hourly averaged wind speed recorded by the Grand Gulf meteorological tower at 33 feet in the period from 1996 through 2003 was 31 mph in 1999. The fastest hourly average wind speed recorded at Vicksburg in the period from 1997 through 2001 was 33 mph, also in 1999. This more recent data covers a shorter period than that utilized in the Grand Gulf Unit 1 UFSAR, so the Grand Gulf UFSAR analysis continues to be appropriate for long term return periods for maximum wind speeds.

Reference 23 *indicates a value of approximately 83 mph for the 100-year return period fastest mile of wind in the Grand Gulf area.*

*A Gumbel-Lieblein extreme value analysis (*Reference 18*) of Jackson wind data, corrected for differences in measurement levels for the years 1960 through 1975, gave a value of 61 mph for the 30 foot level 100-year return period fastest mile of wind.*

In Reference 23, Thorn *cites the often used power law as a representative estimate of the vertical wind profile. This vertical distribution of the wind velocity is expressed as,*

$$u_z = u_{30} (z/30)^{(1/n)}$$

Where z is the height above ground, u_z *is the wind speed at height z,* u_{30} *is the wind speed at 30 feet, and n is a constant depending on surface roughness. For the Grand Gulf site the value of n is approximately 7 since the terrain characteristics can be described as being level or slightly rolling land with some obstructions.*

It is also necessary to account for wind gusts in structural design. SEI/ASCE 7-02 (Reference 53) (which is a replacement of ANSI A58.1-1982) redefines the basic wind speed for structural design purposes to be the peak (3-second) gust at 33 ft elevation. According to SEI/ASCE 7-02 Table C6-3, the ratio of the 100-year to 50-year mean recurrence interval values is typically 1.07, which means that the 50-year return period 3-second gust wind speed identified in SEI/ASCE 7-02 of 90 mph for the Grand Gulf site, corresponds to a 100-year return period 3-second gust wind speed value of 96 mph.

2.3.1.6 Other Regional Meteorological and Air Quality Conditions Considered

Any other regional meteorological or air quality conditions not discussed above, which need to be considered for design of safety related structures, systems and components of a new facility will be determined and evaluated as required by 10 CFR 52.

2.3.2 Local Meteorology

2.3.2.1 Normal and Extreme Values of Meteorological Parameters

The following sections contain information on wind, air temperature, atmospheric water vapor, precipitation, fog and smog, atmospheric stability, and mixing heights at the GGNS and surrounding area.

2.3.2.1.1 Winds

2.3.2.1.1.1 Wind Distributions (All Meteorological Conditions)

Wind data is available from both the Vicksburg meteorological station and the Grand Gulf meteorological tower. Both sets of data are discussed here to provide a fuller description of winds in the area.

2.3.2.1.1.1.1 Vicksburg Wind Data

Tables 2.3-19 to 2.3-30 present monthly percent joint frequency distributions for wind directions and speeds, based on a 5-year period of record from 1997 through 2001, for Vicksburg. Table 2.3-31 provides an annual summary of the data. On an annual basis, Vicksburg wind data collected in the five years 1997 through 2001 show central N is the most frequent (13.8 percent) wind direction. The wind is from SE through central S 30.8 percent of the time. Westerly (W-SW - W-NW) and easterly (E-NE - E-SE) winds are least frequent, with frequencies of 9.1 and 16.1 percent, respectively (Table 2.3-31). Southerly components prevail in spring, summer, and winter, while northerly components prevail in the fall (Tables 2.3.19 to 2.3.30).

Winds average greater than 8.1 mph from January through April, and 7.7 mph or less from May through December. Mean annual wind speed is 7.4 mph (Table 2.3-31).

The Vicksburg meteorological station winds are presented graphically in Figures 2.3-8 to 2.3-13. These wind roses cover the period from 1997 through 2001 and represent the frequency of winds coming from a particular direction by the length of the line in that direction. Vicksburg records a usual pattern of winds coming from the north or south. At Vicksburg, winds from the west occur as infrequently as winds from the east. However, the year 2001 is seen to be one where most winds come from the eastern half of the rose (Figure 2.3-13).

2.3.2.1.1.1.2 Grand Gulf Wind Data

The same wind data assessment was applied to GGNS site data collected at the Grand Gulf Meteorological Tower for the period from 2001 through 2003 (Reference 2). Monthly relative frequencies of wind direction and speed for the Grand Gulf site are shown in Tables 2.3-32 through 2.3-43, and data for all years is shown in Table 2.3-44. Winds average greater than 4.5 mph from November through April, and 4.0 mph or less from May through September. Mean annual wind speed is 4.3 mph.

Wind roses are presented for the Grand Gulf site in Figures 2.3-1 to 2.3-4 from the 3-year period 2001 through 2003. The normal wind pattern shows winds primarily from the right half of the rose (N to E to S), with the highest frequency originating in the NE or SE. In all years, few winds blew from the west. In general, the wind roses from Vicksburg and Grand Gulf show the same trend towards prevailing winds from the NE and SE.

2.3.2.1.1.1.3 Wind Direction Persistence

Hourly weather observation records from the National Weather Service at Vicksburg, Mississippi for the years 1997 through 2001 were examined for wind direction persistence. The longest persistence periods from a single sector (22.5 degrees), three adjoining sectors (67.5 degrees), and five adjoining sectors (112.5 degrees) were determined for each sector (and calm) during each year. The results are shown in Tables 2.3-45 through 2.3-47. During the period, the single sector persistence was greatest (28 hours) for the central north direction. The average maximum persistence (17.6 hours) was also greatest for the central north direction. For the persistence in three adjoining sectors, the central south sector had the longest period of persistence (109 hours) and the largest average maximum persistence (63.8 hours) as shown in Table 2.3-46. The longest persistence period (105 hours) from five adjoining sectors occurred in the S-SE sector (Table 2.3-47). The central north sector showed the greatest average maximum persistence (57.2 hours).

Wind persistence data similar to the above are shown in Tables 2.3-48 through 2.3-50 for the Grand Gulf site. The statistics shown in these tables cover a three-year period from 2001 through 2003. Table 2.3-48 shows that the longest single sector persistence period was 32 hours from the northeast sector. The NE sector also had the greatest average maximum persistence in a single sector. For the longest persistence in three adjoining sectors, the N-NE sector had the longest period with 102 hours, and the greatest average maximum persistence, as shown in Table 2.3-49. The persistence data for five adjoining sectors (Table 2.3-50) shows the central N-NE sector with the longest persistence period (122 hours) and the greatest average maximum persistence.

Table 2.3-51 presents a comparison of the maximum persistence period for the GGNS site in hours with historic data from Jackson and Table 2.3-52 presents a comparison of the maximum persistence periods for Vicksburg and GGNS. While there are differences in the preferred sectors, the data demonstrate that it is not likely that any single wind direction would persist for a substantial period of time. Table 2.3-53 is the maximum wind direction persistence period for each sector at Jackson from Reference 4 to provide historic comparison.

2.3.2.1.2 Air Temperature

Table 2.3-54 shows that recent temperature extremes for the Vicksburg weather station have ranged from 107 ºF (August and September 2000) to 16 ºF (January 2001) (Reference 3). Table 2.3-55 shows that recent temperature extremes for the GGNS meteorological station have ranged from 104.2 ºF (August 2000) to 17.3 º F (January 2001) (Reference 2). The data shows good agreement between the two locations.

Figures 2.3-14 and 2.3-15 present the site hourly temperatures for the years 2000 and 2001 (Reference 2). A comparison of the two years is made in Figure 2.3-16, where the maximum and minimum temperatures measured in 96 hour intervals are plotted against the start date of the interval. Other observed temperature extremes include 110ºF in the 1967-2004 record for the Vicksburg Military Park, 107ºF in the 1896-2003 record at Jackson, MS, -5ºF in the Jackson data and -8ºF in St. Joseph, LA in a 1930-2001 database (Reference 57).

To develop site 100-yr return temperature extremes, long term data was obtained from the US Historical Climatological Network (Reference 57) for the years 1930 through 2001 at the nearby Port Gibson station. Maximum recorded temperature was 105ºF in August 2000, and minimum recorded temperature was -5ºF in January 1940. Using the method of Wilks (Reference 56), parameters were developed for Gumbel distributions, and the resulting 100-yr return values for local maximum and minimum temperatures are 108°F and -6ºF, respectively.

2.3.2.1.3 Atmospheric Water Vapor

All of Mississippi experiences high humidity during much of the year. At Vicksburg humidities of 90 percent or higher have occurred at any hour of the day. They are most frequent in the early morning hours. In the summer, at times there develops a combination of high temperatures together with high humidities; this usually builds up progressively for several days and becomes oppressive for one or more days. Humidities of less than 50 percent occur on some days each month, usually in the early afternoon hours. Humidities drop under 30 percent on about one-quarter of the October and November days; the number of days with such low humidities diminishes in the other months. In July and August there may be none. (Reference 25).

The saturation deficit tables (Tables 2.3-57 through 2.3-68) were prepared from 5 years (1997-2001) of Vicksburg hourly weather observations (Reference 3). These tables show the total monthly occurrences as a function of windspeed and wind direction segment for the 5 year period. Table 2.3-69 shows the total annual occurrences as a function of windspeed and wind direction segment.

Mean relative humidities for four time periods per day at Vicksburg are shown in Table 2.3-4 (Reference 3). Given the similarity of the two locations alongside the Mississippi River, these data are considered representative for the ESP site.

2.3.2.1.4 Precipitation

2.3.2.1.4.1 Rain

The GGNS site rainfall data covers the time period from 2000-2001 and the Vicksburg data covers the time period from 1997-2001 (References 2 and 3). Monthly and annual mean and extreme precipitation amounts for the GGNS site and Vicksburg, Mississippi are presented in Tables 2.3-70 and 2.3-71, respectively. Average monthly precipitation at the GGNS site follows a seasonal trend, reaching a maximum mean in March (10.02 inches) and a minimum mean in November (0.02 inches). Maximum annual mean precipitation has been 46.85 inches. For Vicksburg, the maximum mean precipitation is in December (9.94 inches) and a minimum mean in May (0.38 inches). The maximum annual precipitation in Vicksburg is 59.76 inches.

Table 2.3-72 and Table 2.3-73 provide monthly frequency distribution of rainfall rates at the Grand Gulf site and Vicksburg, respectively.

In general, the Vicksburg data appears to be representative of the Grand Gulf area. The variations between the two locations from month to month, particularly during the summer months, are likely reflective of the occurrence of heavy shower and thunderstorm activity common in the area.

The maximum short period precipitation was determined for the Grand Gulf Unit 1 UFSAR (Reference 4). As discussed previously, that data is still valid and conservative as compared to recent experience. Maximum point precipitation values are given in Table 2.3-74 for the 2-hour to 10-day durations shown. *These were interpolated from the maps of USWB Technical Papers 40 and 49* (References 26 and 27). Technical Memorandum NWS HYDRO-35 (Reference 52) was consulted for updated (from Technical Paper 40) 30-minute and 1-hour duration precipitation values shown in Table 2.3-74. For comparison purposes, the recent 5-year maximum short period precipitations are listed for Vicksburg, Mississippi in the table.

or systematic up and down or cross valley flow, it would be inappropriate to apply recirculation factors as indicated in Regulatory Guide 1.111 (Reference 47).

Receptor locations for the Grand Gulf site were evaluated as specified in NUREG 1555 which states: "*X*/Q and/or D/Q at points of potential maximum concentration outside the site boundary, at points of maximum individual exposure, and at points within a radial grid of sixteen 22½ degree sectors (centered on true north, north-northeast, northeast, etc.) and extending to a distance of 80 km (50 mi) from the station. A set of data points should be located within each sector at increments of 0.4 km (0.25 mi) to a distance of 1.6 km (1 mi) from the plant, at increments of 0.8 km (0.5 mi) from a distance of 1.6 km (1 mi) to 8 km (5 mi), at increments of 4 km (2.5 mi) from a distance of 8 km (5 mi) to 16 km(10 mi), and at increments of 8 km (5 mi) thereafter to a distance of 80 km (50 mi). Estimates of *X*/Q (undecayed and undepleted; depleted for radioiodines) and D/Q radioiodines and particulates should be provided at each of these grid points."

2.3.5.3 Results

Results of the analysis, based upon 2 years of data collected onsite, are presented in Tables 2.3-143 through 2.3-146.

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2.4 Hydrologic Engineering

2.4.1 Hydrologic Description

2.4.1.1 Site and Facilities

The site for the Grand Gulf Nuclear Station is on the east bank of the Mississippi River in the vicinity of river mile 406, approximately 25 miles south of Vicksburg, Mississippi, and 6 miles northwest of Port Gibson, Mississippi. It is bounded on the west by the Mississippi River and on the east by loessial bluffs forming part of the hilly region that extends from Vicksburg to Baton Rouge, Louisiana. The Mississippi River floodplain adjacent to the site is relatively low and flat with elevations ranging from 55 to 75 ft. (All elevations in this report [GGNS UFSAR] *are in feet above mean sea level, datum of 1929.)*

The plant site is in the loessial uplands with a plant yard grade elevation of 132.5 ft. This elevation is well above the water levels in the Mississippi River as summarized below:

Item	*Elevation (ft. msl)*
U. S. Army Corps of Engineers design project flood elevation	102.1 (References 7 and 33) [96.2 ft as reported in Reference 8]
Existing grade of west bank levee (GG Project design flood elevation)	*103*
100-yr flood elevation	*91.4*
Mean annual flood elevation	*76.5*
Low Water Reference Plane for RM 406	37.5 (Reference 1) [34 ft as reported in Reference 8]
Low water elevation (lowest recorded at Vicksburg projected to Grand Gulf)	*28*

The main exterior access route to the site is via the Grand Gulf road. An access road leading from the Grand Gulf road to the site has been constructed. A construction heavy-haul road, about 6800 feet long, connects a barge landing on the Mississippi River to the access road. The barge slip used during construction of GGNS Unit 1 is located at river mile 406.4 (Figure 2.4-1).

The Universal Transverse Mercator (UTM) Grid Coordinates for the center of the location of the power block area for a new facility is approximately N3,543,261 meters and E684,018 meters. The proposed location for the power block area for the new facility is west of the main plant access road (Figure 2.4-1). The grade elevation for a new facility will be established in consideration of requirements to provide flood protection for associated safety-related structures, systems and components.

The plant makeup and service water is supplied by a series of radial collector wells located in the floodplain parallel to the Mississippi River. … During normal operation, plant service water is discharged to the circulating water system to supply the required circulating water system makeup water. The circulating water system blowdown is discharged to the discharge basin and from there is discharged by a single pipeline to the Mississippi River. (Figure 2.4-1)

A number of investigations have been conducted in regards to the radial collector wells (Mississippi River and alluvial aquifer) which supply cooling and makeup water (Plant Service Water (PSW)) for the existing GGNS Unit 1 plant. The studies have dealt primarily with the hydrogeologic setting, aquifer hydraulics, well yields and well conditions. The studies determined that, based upon the total projected PSW demands for the existing GGNS Unit 1 plant, the aquifer which supplies the existing PSW wells is capable of meeting system demands through the design life of the existing plant. However, addition of new facility(ies) to the site, with a (maximum) requirement of approximately 85,000 gpm makeup water (made up of 78,000 gpm maximum blowdown from Table 1.3-1, and about 7,000 gpm for facility miscellaneous makeup requirements) could not be supported by collector wells drawing water from the alluvial aquifer.

Therefore, makeup (cooling tower makeup and other raw water needs) and normal service water for a new facility would be supplied from the Mississippi River via an intake located on the east bank of the river and on the north side of the existing barge slip (Figure 2.1-1).

Effluent from a new facility would be combined with that from the existing GGNS Unit 1 facility, and the combined effluent would be discharged into the river downstream of the intake such that recirculation to the embayment area and intake pipes would be precluded.

Emergency cooling water (ultimate heat sink) for a new facility would be provided by closed-cooling system(s) that utilize enclosed basins with mechanical draft cooling towers or similar heat removal mechanisms. This emergency cooling system would not be reliant on the river intake, with the possible exception of normal (non-emergency operation) makeup water supply.

There are two streams that girdle the plant site as shown in Figure 2.4-1*. Both streams drain into Hamilton Lake. The stream to the south, draining Basin B, was rerouted around the plant site and a 15-foot culvert was placed at its outlet to safely carry local floods and site drainage. This rerouted stream does not cause any significant modification to the natural drainage and is designed to carry the probable maximum flood. The stream to the north, draining Basin A, which receives most of its water from the watershed outside the plant area was not rerouted. However, a 12-foot culvert was placed under the access road to connect it to the flood plain. The plant yard is graded to direct runoff from rainfall on the roofs and the yard away from the buildings to the two streams.*

The proposed location of the power block and cooling towers of the new facility are to the west the access road and downstream of these Streams A and B culverts under the access road (Figure 2.4-1). The plant yard for a new facility would likewise be graded such that runoff is directed away from buildings. The two streams, A and B, would be used for directing runoff away from new facility areas and buildings, to the maximum extent possible, and eventually to the Mississippi River.

2.4.1.2 Hydrosphere

The dominant hydrologic feature in the vicinity of the site is the Mississippi River (Figures 2.4-2, 2.4-3, and 2.4-3a). The site is located in the Lower Mississippi River Region, and the major tributaries, major cities, and other pertinent features of the Mississippi River in the area are shown on Figures 2.4-3 and 2.4-3a. *The streamflow system within the region is composed chiefly of the Mississippi River and its tributary streams between Cairo, Illinois, the Gulf of Mexico and the coastal area streams of southern Louisiana. The total drainage area of the streams within the region is about 102,400 sq mi, 40,740 sq mi of which contribute flow to the Mississippi River.… The subbasins and major rivers of the Mississippi River Basin are shown in* Figure 2.4-4 *and drainage features of these basins are summarized in* Table 2.4-1.

At the plant site, the natural floodplain is about 60 miles wide. However, the flow is confined to a width of about two to four miles by high bluffs on the east bank and man-made levees with top elevations ranging from 101 to 103 ft on the west bank. The river has a width of about [one-half to] *one mile during dry seasons. The width increases to about four miles during floods.*

Several lakes are in the floodplain in the vicinity of the site. However, their hydrologic characteristics have no influence on the plant site. Of immediate relevance to the plant site are two small and steep streams [Stream A and Stream B]*. The one to the north of the site is perennial, draining Basin A with an area of 2.8 sq miles, and the other to the south and adjacent to the plant facilities is intermittent, draining Basin B with an area of 0.6 sq miles. Both drain into Hamilton Lake in the floodplain of the Mississippi River.*

Rivers of the Mississippi basin have numerous river-control structures ranging from levees and navigational locks to major dams. Details of these structures are described in subsection 2.4.4. In the site region, the U. S. Army Corps of Engineers has built levees on the west bank with top elevations ranging from 101 to 103 ft. The Corps of Engineers has completed revetments along the east and west river banks in the site area, including the east bank that borders the GGNS site, to maintain the river channel (Reference 1, and Figure 2.4-5). There are 1,610 miles of authorized levees on the main stem of the Mississippi River (Reference 2).

2.4.2 Floods

2.4.2.1 Flood History

Floods on the Mississippi River occur primarily as a result of precipitation and snow melt runoff from its major tributaries, the Ohio, Missouri, Arkansas, and Red Rivers (Figure 2.4-4). *The Ohio River contributes 66 to 76 percent of the mean flow of the Mississippi River during the period January to March, while the Missouri contributes 47 to 52 percent during the period June to September* (Table 2.4-1). *Major floods on the Ohio generally occur between mid-January and mid-April, those on the Missouri and the Upper Mississippi generally occur between mid-April and the end of July. The Arkansas and White Rivers experience floods between the beginning of April and the end of June. Thus, the flood season on the Lower Mississippi generally extends from mid-December to July. The number of peaks, duration of near-peak flow, and the flood volumes during a year all vary greatly.*

Flood discharges at Vicksburg during six of the highest recent floods are summarized in Table 2.4-4. A water surface profile for the Mississippi River between river miles 360 and 480 for the 1937 flood, and the low water reference plane profile for the year 1993, are shown in Figure 2.4-6. Based on these flood discharges and the profile for the 1937 flood, the highest recorded water level was about 40 ft below the GGNS Unit 1 plant grade of 132.5 ft. Updated information on floods at Vicksburg (Reference 7) indicates that no flood since the construction of GGNS has exceeded the discharge of the 1973 flood.

Hydrographs for the Mississippi River showing maximum, minimum, and average stages at Vicksburg, Mississippi, (based on data collected from 1932 to 2000) and at Natchez, Mississippi, (based on data collected from 1940 to 2000) are shown in Figures 2.4-7 and 2.4-8. Figure 2.4-9 illustrates the annual maximum instantaneous peak streamflow at Vicksburg from 1858 to 1999.

No historical data exist on the flooding of the two intermittent local streams [Figure 2.4-1]*. An indication of the extremes of rainfall and runoff observed over small areas in Mississippi and Louisiana is given in* Tables 2.4-5 (Reference 34) and 2.4-6 (References 35 and 36). *From* *these tables it is noted that the maximum observed 24-hr rainfall in the region varies from 7.9 to 21.40 in. and maximum observed stream flow varies from 147 to 1581 cfs/sq mi.*

2.4.2.2 Flood Design Considerations

Safety-related structures, systems, and components for a new facility would be designed to withstand the worst flooding caused by an appropriate combination of several hypothetical events, as required by GDC-2. The events to be considered would include: probable maximum flood (PMF) of the Mississippi River coincident with wind-generated waves (Section 2.4.3.6); seismic failure of upstream dams coincident with the U. S. Army Corps of Engineers design-project flood (DPF) (Section 2.4.4); ice flooding (Section 2.4.7); and PMF of the two small streams adjacent to the plant (Section 2.4.3.3). The elevation of the structures of a new facility would be well above the Mississippi River DPF, eliminating Mississippi River flooding concerns from the design of safety-related structures, systems and components. Therefore, the event which will control the facility flood design is the probable maximum precipitation (PMP) on the watersheds for the site (Section 2.4.2.3).

To establish design flood considerations for the GGNS site in its existing configuration, acceptable methods of estimating the PMF were used. The PMF for the Mississippi River is estimated based upon the flood defined by the U. S. Army Corps of Engineers design-project flood. The PMF for the two local streams was estimated based upon methods recommended in Regulatory Guide 1.59 [Design Basis Floods for Nuclear Power Plants].

The design flood considerations for the site areas are based on the local drainage areas which can be seen on Figure 2.4-10. Material from the GGNS UFSAR, which details the design basis flood design considerations for GGNS Unit 1, is included herein for information only. A similar evaluation, by the COL applicant, would be required for a new facility in addition to establishment of the final site grade, plant location and design and design of ESP facility and site drainage systems.

All safety-related systems, structures and components (SSCs) for the new facility would be located above maximum flood elevation, or flood protection would be provided such that the requirements of GDC-2 and 10 CFR 100 would be met.

2.4.2.3 Effects of Local Intense Precipitation

The effects of local intense precipitation on the GGNS Unit 1 site have been evaluated in the GGNS UFSAR (Reference 8). This information has been reviewed and is considered to be not directly applicable for the determination of maximum floodwater elevation for a new facility on the ESP site. Newer probable maximum precipitation (PMP) standards published since GGNS Unit 1 was licensed indicate higher levels of local intense precipitation for the site, and as noted in Section 2.4.1.1, the proposed location of the power block for the new facility is to the west the site access road and downstream of Streams A and B main discharge culverts under the access road. Therefore, final local PMP flood height determination for the ESP site will need to be determined after the plant design is finalized, exact location determined, and site grading and drainage has been designed. Sections of the GGNS UFSAR which discuss the GGNS Unit 1 PMP analysis are included below (material quoted from the GGNS UFSAR is presented in *italics* font). Updated PMP information as would be needed for evaluation of flooding concerns for a new facility on the ESP site is also presented.

Consistent with the GGNS UFSAR, the position regarding Regulatory Guide 1.59 (as described in UFSAR Appendix 3A) remains unchanged for the ESP facility; the PMF for the two local streams close to the plant site will be estimated based on the unit hydrograph method in accordance with Regulatory Guide 1.59 (Reference 8).

The effect of a local probable maximum precipitation (PMP) event on the adjacent drainage areas and site drainage systems for GGNS Unit 1 is based on the evaluations discussed below through Section 2.4.3.5.

The estimated local probable maximum precipitation (PMP) and the resulting maximum floodwater elevation for the existing GGNS Unit 1 site configuration was calculated for the drainage areas, Basin A and Basin B (Figure 2.4-10). The footprint of the existing GGNS Unit 1 plant and the proposed construction areas for a new facility are shown on Figure 2.4-10. The new facility construction area for the power block would be primarily located in Basin A and Basin B drainage areas, except for a small area located on the southwest corner of the proposed construction site. This area drains away from Basin B and thus would not contribute to flooding from Basin B.

The runoff model in the original GGNS analysis used a very conservative assumption, in that the runoff coefficient (i.e., the percentage of rain that appears as direct runoff) was set at 1.0 (see Section 2.4.2.3.3.2.3, Peak Discharges). This assumption essentially models the drainage basins as if they were covered, such that all rainwater is allowed to run off without benefit of soil infiltration.

Local intense precipitation PMP for the ESP site has been computed using the guidelines of Hydrometeorological Report (HMR) No. 52 (Reference 69). The location-specific numbers that are generated for the ESP site are as follows:

Duration, area	**Multiplier to 1-hr, 1-mi^2 PMP**	**HMR 52 Source**	**PMP Depth (in.)**	**Comments**
5-min, 1-mi^2	0.325	Fig. 36	6.2”	multiplier*1-hr PMP
15-min, 1-mi^2	0.505	Fig. 37	9.7”	multiplier*1-hr PMP
30-min, 1-mi^2	0.735	Fig. 38	14.1”	multiplier*1-hr PMP
1-hr, 1-mi^2	1		19.2”	Fig. 24
1-hr, 10-mi^2	0.825	Fig. 28	15.8”	Fig. 29
6-hr, 10-mi^2	1/0.615	Fig. 23	31.2”	multiplier*1-hr PMP

NOTE: HMR 52 does not provide guidance for any precipitation duration beyond 1 hour for a 1-mi^2 area.

As discussed above, the final local PMP flood height determination for the ESP site will be made at COL. However, given the physical site topography and the proposed location of the ESP facility power block, being to the west of the site access road and downstream of existing Culverts 1 and 9, it is reasonable to expect that the PMP driven floodwater elevation of Streams A and B, at the locations adjacent to the ESP power block site, would be substantially less than that of the proposed ESP site grade of approximately 132.5 ft msl. General site drainage characteristics are illustrated in SSAR Figures 2.4-13, Sh. 1, and 2.4-18. To the north of the ESP site, the topography drops off to Sedimentation Basin A (downstream of the discharge of

Stream A from Culvert 9). To the south of the ESP Site, the topograhpy drops off toward Sedimentation Basin B (downstream of the discharge of Stream B from Culvert 1). In general, the final graded ESP site with this configuration, taking full advantage of the current topography, would be provided more than adequate runoff capability to the north and south with flow directed to Streams A and B. The ultimate discharge point for storm water from the ESP site is the Mississippi River which is generally unaffected by local intense rainfall events. With a Mississippi River PMF, described in SSAR 2.4.3.5.1 of slightly above 103 ft. msl, the 29 foot elevation difference to the proposed plant grade ensures that slopes and drainage systems can be designed to discharge PMP-event flows to Streams A and B.

Since the receiving water bodies (Streams A and B downstream from Culverts 1 and 9) are expected to be capable of accommodating PMP-event flows from the ESP site without flooding the site, the potential and extent of flooding from a local PMP event for the ESP site will be dependent upon facility design, final grade and drainage system design. Final ESP site drainage systems may employ a number of techniques including grading slopes to efficiently move runoff water, additional drainage channels, etc. However, given the basic topography, this assessment concludes that the ESP site power block area is favorably located for adequate site drainage. It is, therefore, reasonable to expect that a fully-effective drainage system can be designed at COL.

2.4.2.3.1 Precipitation Distribution

*Distribution of local intense precipitation at GGNS is based upon PMP data obtained from U. S. Weather Bureau Hydrometeorological Report (HMR) No. 33 (*Reference 9*). Per HMR 33, the all season PMP values for a 10 square mile area and various storm durations are:*

Duration (hr)	*6*	*12*	*24*	*48*
PMP (in.)	*30.5*	*36.0*	*40.0*	*43.0*

The drainage basins for streams A and B are shown in Figure 2.4-10*, and have approximate areas of 2.8 and 0.6 square miles, respectively. Because these basins are small, the PMP rainfall values from HMR 33 are of too long a duration for the determination of a PMF (or PMP induced flood). Temporal distribution per the procedures outlined in EM-1110-2-1411* (Reference 10) *yields the PMP distribution given in* Table 2.4-7.

Based on the guidance of HMR 51 (Reference 70) and HMR 53 (Reference 11), the distribution of local intense precipitation at the ESP site for a 10 square-mile area is:

Duration (hr)	6	12	24	48	72
PMP (in.)	31.25	37.5	45	50	53

Local intense PMP distribution values to be used for the ESP site flooding analysis by the COL applicant were determined using the guidance of HMR 52, and are indicated above in Section 2.4.2.3.

2.4.2.3.2 Runoff Model

The model adopted for determination of the peak discharge for basins A and B is based on the unit hydrograph concept. The approach consists of estimating basin lag, developing a representative dimensionless hydrograph (Reference 12*), and synthesizing a unit hydrograph for any selected rainfall duration.*

The lag in hours is based on the curves given by Chow (Reference 13*). From these curves, it is possible to estimate basin lag based on length and slope of the channel.*

The dimensionless hydrograph adopted is based on observed data and upon curves developed by Hudlow (Reference 12) *and Feddes* (Reference 14) *for small drainage basins varying in size from 0.5 square miles to 75 square miles. Mean dimensionless hydrographs developed by Hudlow* (Reference 12) *for a stream in east central Texas with a drainage area of 0.48 to 9.2 square miles, and by Feddes* (Reference 14) *for a two square mile basin near Bryan, Texas. The watershed characteristics of basin J* (Reference 12) *and Hudson Creek near Bryan, Texas,* (Reference 14*) are similar to those of basins A and B as discussed below.*

The pertinent data for different parameters for basins A and B, at the plant site, along with the characteristics of basin J and Hudson Creek, are as follows:

Basin	*Drainage Area (sq mi)*	*L (mi)*	*Lca (mi)*	*S (ft/mi)*	*Lag (hr)*
A	*2.8*	*3.4*	*1.9*	*48.53*	*1.60*
B	*0.6*	*1.52*	*0.53*	*64.14*	*0.65*
J	*0.48*	*0.96*	*0.33*	*62.80*	
Hudson Creek	*1.98*	*2.18*	*1.15*	*34.32*	

Where:

L = *Length of the longest watercourse from point of interest to the watershed divide*

Lca = *Length of water course from point of interest to the intersection of a line perpendicular to the stream alignment passing through the centroid of basin*

S = *Overall slope of longest watercourse from point of interest to divide*

An average graph as shown in Figure 2.4-11 *has been used as being representative for the site region. On the dimensionless hydrograph, the ordinate is the discharge multiplied by the lag plus one-half the rainfall duration divided by the volume of runoff. The abscissa is time expressed as a percent of lag plus half the duration.*

The lag times obtained above were applied to the dimensionless hydrograph (Figure 2.4-11*) to produce the unit hydrograph given in* Table 2.4-8 *and* Figure 2.4-12*. The unit durations of the unit hydrographs used are 0.5 hr and 0.25 hr for basins A and B, respectively. The precipitation increments used for both basins are given in* Table 2.4-9*. The flood hydrographs obtained for* *the two basins along with the unit hydrograph and precipitation distribution are shown in* Figure 2.4-12*.*

The Plant area is divided into several drainage subareas shown on Figure 2.4-13 *based upon site features such as roads, abandoned railroad beds, or other features, which would tend to divide flow. The peak discharge for each subarea is calculated using the rational equation:*

$Q = CIA$

in which

- Q = *peak discharge from the area in cubic feet per second (cfs) due to the assumed storm condition.*
- C = *coefficient of runoff.*
- I = *intensity of precipitation in in/hr corresponding to the time of concentration (Tc).*
- A = *drainage area in acres.*

The Basin A and B drainage areas would remain the same, the length of the longest watercourse would not be altered, and the overall slope would be unchanged in an ESP site analysis. Thus, the runoff model is considered representative of that required for a new facility in the proposed location on the ESP Site. However, the unit hydrograph shown in Figure 2.4-12 for the GGNS Unit 1 analysis would change due to the increase in the PMP values indicated in Section 2.4.2.3 above. Additionally, the proposed location for the power block for the ESP facility is to the west of the site access road and downstream of the main culverts discharging the runoff flow from the GGNS Unit 1 site area, and final plant design, site grading and drainage design are not know. Therefore, a new PMP analysis for the ESP site will be required by the COL applicant to determine the PMF flood levels from local intense precipitation.

2.4.2.3.3 Site Drainage System

2.4.2.3.3.1 Basic Design

Finished grade for a new facility would be sloped away from buildings. A storm drainage system for a new facility would be designed to carry the 100-year runoff. Storm runoff for the new facility would be carried away from the plant area by a storm drainage system consisting of appropriate combinations of swales, open channels, subsurface system(s) of catch basins and pipes, and culverts. Runoff from a new facility would then be routed to streams A and B, and would subsequently drain to either Lake Hamilton or Lake Gin, as appropriate, and to the Mississippi River.

2.4.2.3.3.2 Drainage of Local Intense Precipitation

The following sections describe the assumptions and analyses made to determine peak runoff discharge from the existing GGNS Unit 1 site areas.

2.4.2.3.3.2.1 Time of Concentration

The time of concentration (Tc) is defined as the time required for the precipitation falling at the most remote point of the basin to reach the discharge point. The time of concentration includes overland flow time and channel flow time.

*The overland flow time of concentration, (Tco), is computed based upon the method proposed by E. E. Seelye (*Reference 15*) and by Chow (*Reference 16*). The formula proposed by Chow to calculate overland flow time is:*

$$Tco = (2/3)\ [(L*n)/SQR(S)]^{0.467}$$

in which:

Tco	=	*Time of flow for overland flow in minutes*
L	=	*Longest overflow length in feet*
S	=	*Average slope of surface*
n	=	*Retarding coefficient representing the surface roughness. The recommended value of n varies from 0.02 for smooth pavements to 0.80 for dense grass cover (*Reference 16*).*

The average surface slope is determined from the difference in high and low surface elevations divided by the average length of the area.

The channel flow time (Tcd) is calculated based on the average velocity of flow in the channel and length of channel up to the discharge point; then

$$Tc = Tco + Tcd$$

The calculated time of concentration for different subareas ranges from about 24 to 48 minutes. However, during the PMP, the detention of the water due to ponding in each subarea will result in a longer time of concentration. Therefore, an average concentration time of 30 minutes was used for analyzing the site drainage system capacity during the PMP.

2.4.2.3.3.2.2 Rainfall Intensity

The PMP rainfall intensity corresponding to a time of concentration of 30 minutes, as used in the analysis, is 16.4 inches/hour. This value is based on the probable maximum half-hour precipitation of 8.2 inches as determined from HMR-33 (Reference 9) *and EM-1110-2-1411* (Reference 10).

The PMP rate for GGNS Unit 1, and likewise for the ESP site, was calculated in accordance with the criteria of Regulatory Guide 1.59. As stated above, a more recent report, HMR No. 52 (Reference 69), shows an increase in the probable maximum rainfall rate for the ESP site. Therefore, a new analysis will be required by the COL applicant for a new facility located on the ESP Site.

PMP rainfall intensity corresponding to a time of concentration of 30 minutes, to be used in the ESP site analysis, is 28.2 inches per hour. This value is based on the probable maximum half-hour precipitation rate of 14.1 inches per hour from HMR 52, as noted above.

2.4.2.3.3.2.3 Peak Discharges

Peak discharges from the various subareas were calculated using the rational formula with a rainfall intensity of 16.4 inches/hour and a runoff coefficient of 1.0. Therefore, peak discharge for each subarea is estimated as 16.4 times its area in acres. Peak discharges for Basins A and B were calculated using flood hydrographs developed from the unit hydrographs. For Culvert No. 2, the peak discharge was calculated as the difference between the peak discharges at Culvert

No. 1 and the plant subareas. The boundaries and areas in acres for the plant drainage subareas during a PMP are shown in Figure 2.4-13.

The proposed construction areas for the power block of a new facility are downstream of these culverts (Figure 2.4-18). and to the west of the site access road. And, as stated above, a more recent report, HMR No. 52 (Reference 69), shows an increase in probable maximum rainfall rate for the ESP site. Therefore, a new analysis will be required by the COL applicant for a new facility located on the ESP Site.

2.4.2.3.3.2.4 Ice and Snow

Snowfall in the GGNS site area occurs about once a year with an average depth of 2 inches (Reference 17, Appendix C). *The site is not subject to heavy snow accumulations.*

The maximum depth of precipitation during the winter PMP is smaller than that of the all-season PMP considered in subsection 2.4.2.3.1. Thus, the flood elevation at the site during this condition will be lower than those occurring during the all-season PMP (subsection 2.4.2.3.3).

Similarly, with regards to maximum flooding considerations, the localized intense precipitation due to winter PMP at the plant site would not affect the design of any new safety-related facilities at the GGNS ESP Site.

2.4.3 Probable Maximum Flood (PMF) on Streams and Rivers

The PMF for the Mississippi River has been calculated based on the design-project flood (DPF) for the Lower Mississippi Basin, calculated by the U. S. Army Corps of Engineers (Reference 17). The application of the Corps of Engineers DPF methods for establishing the Mississippi River PMF meets the guidance of Regulatory Guide 1.59. This is consistent with the GGNS UFSAR Project Position on Regulatory Guide 1.59, as described in UFSAR Appendix 3A (Reference 9).

It is important to note that, based on the analysis in Section 2.4.3.5.1, the total Mississippi River and floodplain discharge capacity for water level elevation slightly above 103 feet msl (i.e., above the west bank levee of the Mississippi River) is about 11 million cfs, which is far greater than the estimated PMF discharge of 6.6 million cfs, which was calculated by doubling the DPF discharge rates (see last paragraph in Section 2.4.3.4.1). Thus, the maximum water surface elevation due to a PMF flood in the Mississippi River is about 29 feet below the GGNS Unit 1 plant grade elevation of 132.5 feet msl. Since the proposed site for a new facility is in a location adjacent to the existing GGNS facility, and is located on the bluffs on the east side of the property (Figure 2.4-1), the maximum PMF water surface elevation from a Mississippi River flood would not affect any safety-related structures, systems, or components of the new facility.

2.4.3.1 Probable Maximum Precipitation (PMP)

2.4.3.1.1 Mississippi River Basin

A hypothetical combination of precipitation storms, grouped into sequences, was used to estimate the DPF for the Lower Mississippi River Basin. A number of hypothetical combinations and practical storm transpositions, with regard to time and locations, were developed to establish flood magnitudes that have a reasonable chance of occurring. Details of the hydrometeorological conditions related to the storm combinations are given in Reference 18.

2.4.3.1.2 Local Streams

Distribution of local PMP is discussed in Section 2.4.2.3, and the adopted PMP distribution is provided there. The maximum PMP rainfall intensity is discussed in Subsection 2.4.2.3.3.2.2.

2.4.3.2 Precipitation Losses

2.4.3.2.1 Mississippi River Basin

For the purposes of flood estimation, the Mississippi Basin was divided into drainage areas and subareas. Infiltration indices were determined for each of the subareas by making infiltration studies of storms and floods of record for which adequate hydrologic data were available (Reference 18).

2.4.3.2.2 Local Streams

Information provided by the U. S. Soil Conservation service (Reference 19) *indicates that the predominant soils in this region are of types A and B, which have infiltration rates* (Reference 16) *of 0.30 to 0.45 in/hr and 0.15 and 0.30 in/hr, respectively. In the determination of the PMF for local streams, it was conservatively assumed that no infiltration or retention losses occurred.*

2.4.3.3 Runoff and Stream Course Models

2.4.3.3.1 Mississippi River

Analyses of observed flood discharges at key tributary gaging stations were made for the purpose of determining infiltration indices, recession curves, base flows, and unit hydrographs. Unit hydrographs were developed for 37 separate drainage areas varying in size from 1060 to 80,000 sq mi. These were used to compute flood hydrographs of surface runoff from transposed storms and storms of record for locations where discharge records were not available. Unit hydrographs for 30 areas were determined from floods of record, and synthetic unit hydrographs were computed for seven areas where the recorded hydrologic data were insufficient. Details of the various unit hydrographs are given in an U. S. Army Corps of Engineers report (Reference 18*).*

2.4.3.3.2 Local Streams

Runoff models for streams A and B, and for the GGNS Unit 1 plant drainage subareas are discussed in subsection 2.4.2.3.2. A description of the stream course model is contained in subsection 2.4.2.3.3.2.

In assessing the effect of local PMP on the plant area, the following conservative assumptions have been made:

a. The storm drains are assumed to be blocked and do not carry any runoff.

b. No runoff occurs through the abandoned gravel railroad beds, thereby causing all of the runoff to flow over the bed and the abandoned rails if present.

c. The runoff coefficient for peak discharges from subareas around the plant is C = 1.0, and no loss due to infiltration or retention occurs.

d. The time for peak discharge in the peripheral ditch coincides with the peak discharges coming from the subareas. Actually, peak discharges will not occur at the same time.

2.4.3.4 Probable Maximum Flood Flow

2.4.3.4.1 Mississippi River

There are innumerable combinations of storms of record that could produce major floods. However, on the basis of meteorological conditions accompanying flood-producing storms, about 35 different storm combinations were studied. Of these, the 13 most logical combinations in which tributary flows occurred without reservoir effects were computed and studied for each storm period and for the total period of each storm combination. The tributary storms and floods forming the various hypothetical floods were analyzed in meteorologically feasible sequences that would cause their peak flow to coincide, as nearly as practicable, at key discharge stations on the Mississippi River. The unregulated flows as a result of 13 hypothetical floods, computed for the tributaries, were routed down the Mississippi River. The preliminary results of the routing of these 13 hypothetical floods were used for comparative purposes in selecting some of the major flood combinations for detailed study. In the detailed study, the storm combinations and arrangements for four hypothetical floods were modified to maximize the flood flows at key locations. Detailed descriptions of the modified storm combinations are given in Reference 18.

The unregulated flows determined for the key gaging stations of the tributary areas were used as a basis for determining the modified hydrographs for the four hypothetical floods due to the operation of reservoirs.

Modified hydrographs were determined for three groups of reservoirs: group E (existing), group EN (existing and due for completion in near future), and group END (existing, near future, and those proposed in the distant future).

The unregulated and modified flows were routed down the Mississippi River to determine the daily flows at St. Louis, Missouri; Cairo, Illinois; Memphis, Tennessee; Helena and Arkansas City, Arkansas; and Vicksburg and Natchez, Mississippi.

The design-project flood discharge obtained (Reference 17) *at certain key locations along the Mississippi River is shown in* Figure 2.4-14*. The Grand Gulf site is located at approximately river mile 406. The DPF hydrograph for the Mississippi River at the site was developed from the Corps of Engineers-derived DPF hydrograph for Arkansas City, which is located at river* mile *547 (*Reference 18*). For this purpose, the discharge for the DPF at Arkansas City was lagged by an appropriate interval of time and augmented to account for the inflow from the Yazoo and Big Black River Basins and other tributaries. Assuming an average flood velocity of 100 mi/day (about 6 fps), a lag of 36 hrs was used. Since the maximum estimated inflow from the Yazoo and Black River Basin is approximately 100,000 cfs* (Figure 2.4-14*) i.e., only three percent of the peak DPF discharge, its addition does not cause a significant change in the DPF hydrograph. The regulated and unregulated hydrographs are shown in* Figure 2.4-15.

In order to assign an approximate frequency to the DPF to estimate its severity, a frequency analysis of the Mississippi River floods at Vicksburg was performed. Table 2.4-10 *lists the historical flood peaks for the period 1932 – 1979 at Vicksburg Gaging Station (Station No. 072890).* Data from 1932 through 1988 (Reference 20) has been added to Table 2.4-10 for information and comparison. *In* Figure 2.4-16*, the flood frequency curve for the Mississippi River at Vicksburg obtained from USGS Statistical Computer output based on the Log-Pearson Type III method is plotted. The flood discharges and stages at the site for different frequencies (10, 25, 50 and 100 years) are given in* Table 2.4-11.

Probable maximum flood (PMF) in the Mississippi River at the site is determined from the design project flood (DPF). The DPF is equivalent approximately to the standard project flood

(SPF) but is probably somewhat higher. Studies completed to date indicate that the SPF is generally 40 to 60 percent of the PMF (Reference 16)*. Hence, it would be conservative to assume that the DPF is approximately 50 percent of the PMF. At Grand Gulf, the DPF, unregulated by reservoirs, is estimated to be about 3.3 million cfs (*Figure 2.4-15*). Thus, the PMF (unregulated) may be about 6.6 million cfs. The PMF hydrographs at the site are shown in* Figure 2.4-17.

2.4.3.4.2 Local Streams

*The maximum discharges during probable maximum flood for basins A and B are 13,900 and 4,630 cfs respectively (*Figure 2.4-12*), at discharge points A and B (*Figure 2.4-10*) in the floodplain. For drainage basin A, peak flow of 13,900 cfs is equal to a PMF discharge of 4,965 cfs/sq mi and for basin B a PMF discharge of 4,630 cfs corresponds to a discharge of 7,720cfs/sq mi. Examination of the data in* Table 2.4-6 *for observed Mississippi Basin floods indicates that PMF flood discharges of 4,965 and 7,720) cfs/sq mi for basins A and B, respectively, are several times higher than those observed in basins of these sizes on the east bank of the Mississippi River.*

*The natural drainage area up to culvert 1 (basin B) is about 0.5 sq mi. Due to site grading, about 0.35 sq mi of the drainage area of basin B drains up to culvert 1 (*Figure 2.4-18*) and a balance of the drainage from 0.15 sq mi area flows towards basin A. The corresponding prorated PMF discharge in the rerouted outlet channel for basin B at the 15 ft diameter (*Figure 2.4-18*) corrugated-metal culvert 1 (drainage area of 0.35 sq mi) is 2,700 cfs. This value corresponds to the discharge that will be flowing through the channel during the PMF, including the runoff from the plant yard.*

2.4.3.5 Water Level Determinations

2.4.3.5.1 Mississippi River

Figure 2.4-19 *shows the rating curve for the Mississippi River at the site. This rating curve is based on the rating curve at Vicksburg. It is obtained by correlating the stages at Vicksburg and at the site during the period 1972 - 1974 and using the data from water surface profiles (*Figure 2.4-6*), assuming that the discharges at the two locations are equal, since there are no major tributary streams between these locations, except the Big Black River which has a runoff of less than 1 percent of the Mississippi River flow at Vicksburg.*

A flood which produces a peak discharge of about 6.6 million cfs will overtop the levee with maximum elevation of 103 ft. (which can contain about 3 million cfs) and inundate the wide alluvial floodplain west of the levee. The discharge capacity of the floodplain west of the levee at water level elevation of slightly above 103 feet is conservatively estimated using Manning's roughness coefficient of 0.1, slope of floodplain of 0.2-ft./mile and floodplain width of 60 miles. Based on this analysis, the total river and floodplain discharge capacity for water level elevation slightly above 103 feet is about 11 million cfs, which is far greater than the estimated PMF discharge of 6.6 million cfs. Thus, the maximum water surface elevation due to a PMF flood, in the Mississippi River, is about 29 feet below the plant yard elevation of 132.5 ft.

Since the proposed site for a new facility is in a location adjacent to the existing GGNS plant, and is located on the bluffs area on the east side of the property (Figure 2.4-1), the maximum PMF water surface elevation from a Mississippi River flood would not affect any safety-related structures, systems or components of a new facility at this location.

2.4.3.5.2 Local Streams

STREAM A

*A 12 foot-diameter corrugated metal culvert (Culvert 9) is provided where the stream draining the area designated Basin A crosses the access road (*Figures 2.4-1 and 2.4-18*). The drainage area at Culvert 9 is about 2.7 square miles and has a peak discharge of 13,490 cfs prorated from the Basin A flood hydrograph (*Figure 2.4-12*). The top of the access road has a minimum elevation of 125 feet. The locally depressed road at this location acts as a broad crested weir during high flows (see profile and section of* Figure 2.4-20*). Water level resulting from the discharge over the access road is calculated using a weir discharge coefficient of 2.9* (Reference 21*) and an average weir length of 580 feet (*Figure 2.4-20*). It is conservatively assumed that Culvert 9 is completely blocked causing the entire PMF flow to overtop the access road. The resulting water surface elevation at the road is 128.9 feet.*

A backwater analysis of stream A using the HEC-2 program for water surface profiles (Reference 22) *was performed to determine the water level at the outlet of the drainage ditch northeast of the power block. Coefficients of expansion and contraction used in the analysis were 0.3 and 0.1, respectively* (Reference 22)*. The cross sections used in the analysis are shown in* Figure 2.4-21*. The PMF peak discharge was taken as 13,490 cfs, and a conservative Manning's coefficient of 0.1 was used. Based on this analysis the maximum water level at the ditch outlet into Stream A is 128.93 feet.*

Given the PMP values determined for the ESP site, using HMR 52, and in consideration of (the lack of) definition the final site grade, plant design and design of ESP facility and site drainage systems, a similar evaluation for Stream A would be required, by the COL applicant, for a new facility on the ESP site.

STREAM B

The stream draining the area designated Basin B is rerouted around the Unit 1 cooling tower. The rerouted channel is concrete lined to a depth of 5 feet, with a 6.67-foot bottom width and side slopes of 3:1. Riprap is provided above the concrete to the plant yard grade. The riprap gradation curve is shown in Figure 2.4-22*. Based on this curve, the median riprap size is about 9 inches. The channel slope of 0.4 percent in the downstream reaches and 1 percent upstream of Culvert 15 makes a hydraulically steep channel* (Reference 23)*. A 15-foot-diameter culvert (Culvert 1) is placed at the downstream end of the channel and under the access road to pass the flow to the floodplain. The channel and culvert are designed to safely pass the PMF from Basin B without endangering safety-related facilities.*

The headwater level for Culvert 1 is calculated using the basic data in Table 2.4-12*. The entrance coefficient of 0.3 is based on the smooth tapered inlet as shown in* Figure 2.4-23 (Reference 24).

*The water surface profile due to the PMP for the Basin B stream channel (*Figure 2.4-24*) is calculated using a standard step backwater method* (Reference 23)*. The analysis uses a peak discharge at Culvert 1 of 2,775 cfs for a drainage area of about 0.35 square mile, prorated from the Basin B hydrograph (*Figure 2.4-12*). It conservatively assumes concurrent peak discharges at all the culverts draining into the channel, obtained from the rational formula as discussed in subsection 2.4.2.3.3.2.1.3* [Section 2.4.2.3.3.2.3]*. The channel backwater analysis assumes a composite Manning's n value as given in* Table 2.4-13 *and expansion and contraction coefficients of 0.3 and 0.1, respectively. Peak discharges for each culvert are subtracted to yield corresponding discharges along the channel.*

Because of the headwater level required at the culvert, the water depth in the channel is greater than the normal depth. Thus, a hydraulic jump, as shown in Figure 2.4-24*, occurs about 1,200 feet upstream of the entrance to Culvert 1. Upstream of this hydraulic jump there is uniform flow in the channel. Based on the criteria of Chow* (Reference 23)*, the ratio of upstream to downstream depths for this jump yields a Froude number of 1.1. This Froude number classifies the jump as undular or low energy* (Reference 23). *The corresponding energy dissipation of this type of jump is very low, less than 1 percent.*

The possibility of a substantial amount of blockage of Culvert 1 is highly unlikely because the channel is lined up to the l00-year flood level and riprap is placed above the concrete. The watershed drained by the channel (upstream of Culvert 2 and the plant yard) contains no source for debris that may cause blockage. However, in the unlikely event that some debris could cause blockage of about 45 percent of the culvert entrance area, part of the PMF discharge can be passed through the culvert and the remaining volume can be impounded in the channel and the yard area around the Unit 1 cooling tower below elevation 132.8 feet.

Given the PMP values determined for the ESP site, using HMR 52, and in consideration of (the lack of) definition the final site grade, plant design and design of ESP facility and site drainage systems, a similar evaluation for Stream B would be required, by the COL applicant, for a new facility on the ESP site.

2.4.3.6 Coincident Wind Wave Activity

The maximum water surface elevation in the Mississippi River at the plant site, due to wind-wave activity coincident with the PMF, was computed for the following conditions:

a. Static PMF flood elevation of 103 ft (levee top elevation)

b. An overland wind velocity of 40 mph; the wind velocity over water was assumed to be 1.3 times higher than over land

c. Near the plant site, the east bank bluff consists of natural loessial slope approximately 2 (horiz.) to 1 (vert.) and covered with vegetation

A rise in water level in the Mississippi River to an elevation of 103 feet will create a lake between the bluffs and the levees; the boundaries of the lake near the site are shown in Figure 2.4-25*. The actual fetch (shown by line A in* Figure 2.4-25*) is approximately 4.3 mi which is assumed to be the effective fetch.*

A ground surface profile along the fetch is shown in Figure 2.4-26*. This profile is typical of the floodplain near the site. The average depth of water in the lake (except for the channel of the Mississippi River) is approximately 35 ft.*

On the basis of the preceding data and with 40 mph over land wind speed, the wind setup, significant wave height $H_{s,}$ *the maximum wave height, and the wave runup were determined by using the procedures described by Shore Protection Manual* (Reference 25).

The significant wave height for this case is 4.4 ft and the wave period is 4.1 seconds. The results of these computations are summarized in Table 2.4-14*. The maximum water surface elevation, including runup will be 108.8 ft. Therefore, the plant, at an elevation of 132.5 ft, will not be affected.*

The integrity of the east bank bluffs in the vicinity of the plant due to water and wind-wave action during a prolonged severe Mississippi River flood was evaluated for GGNS Unit 1 (Reference 8, Section 2.4.3.6). The proposed location for a new facility power block (approximate center of the proposed location for the power block of a new facility, the ground water levels are expected to be generally lower in the area of the new facility in comparison to those measured in the area of GGNS Unit 1 power block and cooling tower.

2.4.13 Accidental Releases of Liquid Effluents in Ground and Surface Waters

In the event of an accidental release of liquid radioactive material at the site, the contaminants would encounter the regional water table beneath the site and would move laterally toward the Mississippi River to the west. There are no ground water users between the plant and the river; therefore, potential contamination of existing ground water users is nil. During normal plant operation, the contaminants would be captured by the radial collector well field pumpage and would not enter the Mississippi River. However, it is assumed that the wells would be inoperable by the time the contaminants reached the well field; therefore, the contaminants could ultimately enter the Mississippi River.

Should a spill occur, the contaminants would initially encounter the ground water within the Catahoula Formation which forms a local ridge beneath the site (Figure 2.4-37). *The Catahoula consists of low-permeable silt and clay material; however, it is conservatively assumed that the contaminants would move along fracture paths within these deposits at the same flow rate as in the adjacent terrace deposits. Based on aquifer test data from test well TW-1* (Figure 2.4-33), *the hydraulic conductivity of the sand and gravel lenses in the lower terrace deposits is about* 3.0×10^5 *ft/yr. The alluvium adjacent to the terrace deposits consists principally of silt and clay deposits underlain by basal sand deposits*. *The hydraulic conductivity of the alluvium between the terrace deposits and Hamilton Lake* (Figure 2.4-37*) is conservatively assumed to be about* 5.0×10^3 *ft/yr. The hydraulic conductivity of the alluvial aquifer between Hamilton Lake and the Mississippi River, as determined from aquifer tests, is about* 1.3×10^5 *ft/yr. The Catahoula Formation underlies the terrace deposits and alluvium, and is assumed to comprise a confining layer to downward ground water movement. The travel time analysis is based on the ground water flow rates through each of the three zones of hydraulic conductivity: terrace deposits, clay-silt alluvium, and alluvial aquifer. The effective porosity in each zone is conservatively assumed to be 25 percent.*

The hydraulic head difference across two of the three zones was determined from well hydrographs. The maximum difference between water levels in wells OW-29A and OW-43, and OW-43 and the Mississippi River is conservatively assumed to be the hydraulic head difference used to compute the hydraulic gradient across the terrace deposits, clay-silt alluvium, and alluvial aquifer, respectively. Hydraulic gradients and flow lengths for each of the three flow zones are contained in Table 2-4-37.

The hydraulic head difference across the terrace deposits was determined by using the difference in average water level between DW-8 (Reference 60) *located near the radwaste building and OW-29A* (Reference 61, and Figure 2.4-33).

The stage of the Mississippi River generally controls the regional ground water table at the site. Figures 2.4-33 and 2.4-42 *show the ground water contours during normal and flood conditions, respectively. During flood conditions, the ground water flow direction is temporarily reversed at the site. An accidental release during flood conditions would result in a temporary movement of contaminants away from the Mississippi River. However, the ground water flow direction would return to normal after flood conditions wane, and the contaminants would move toward the river. Existing ground water users east of the site … would not be affected by an accidental release of contaminants during flood conditions. Contaminants released during flood conditions would require a longer travel time to reach the river than during low conditions. The travel time* *analysis conservatively assumes a maximum hydraulic gradient under low river-stage conditions.*

The travel times of the ground water movement through the terrace deposits, clay-silt alluvium, and alluvial aquifer were computed ….

…. *The computed travel time for contaminants from an accidental spill to move in the ground water from the site to the Mississippi River is about 12.5 yrs. This travel time represents a highly conservative value. The actual travel time would be longer due to the low-permeable silts and clays within the Catahoula ridge beneath the site and alluvium adjacent to the terrace deposits.*

The concentration of contaminants would be reduced during migration by the processes of ion exchange, dispersion, and radioactive decay. The total effect of these processes on the contaminant concentrations at the point where the contaminants would enter the Mississippi River was determined ….

The radionuclides considered in this analysis are strontium (Sr-90) and cesium (Cs-137), as they comprise the greatest potential health hazard in the event of an accidental spill. The maximum concentrations of Sr-90 and Cs-137 are 3.36E+01 and 3.56E+01 μcuries/cc, respectively. These maximum concentrations are contained in two RWCU phase separator tanks. It is assumed that … [an accidental] *spill … would be released instantaneously into the ground water beneath the site.*

A conservative estimate of the longitudinal dispersion D_L, was determined for the terrace deposits, clay-silt alluvium, and alluvial aquifer as the product of the mean grain size (d_{50}) of each material and the average interstitial ground water velocity in each material. Mean grain-size values were determined from data contained in Appendix 2.5B [Appendix 2.5B of Reference 8 not included herewith]. *Calculated dispersion coefficients are contained in* Table 2.4-37.

…Conservative limits of the data were used to compute the average interstitial velocities of the radionuclides. Parameter values and velocities are contained in Table 2.4-37.

… [T]*he concentrations of Sr-90 and Cs-137 are reduced below Maximum Permissible Concentration (Sr-90 - 3.0 x 10^{-7} μC/cc; Cs-137 - 2.0 x 10^{-5} μC/cc) at a distance of about 57 ft from the* [existing GGNS Unit 1] *plant, at a time corresponding to the ground water travel time through the terrace deposits. The concentration of the contaminants at the Mississippi River after the estimated ground water travel time of 12.5 years to the river would be essentially zero ($<10^{-20}$ μC/cc).*

Site hydrogeological characteristics relevant to this analysis have not changed in any significant way since the performance of the GGNS Unit 1 UFSAR analysis described and referenced above. Key assumptions have been reviewed and found to be valid for a new facility at the proposed location. The evaluation for GGNS Unit 1 indicated that the strontium and cesium isotopic concentrations would be below the maximum permissible concentration at a distance of 57 feet from the plant. Since the proposed location of a new facility, about 1200 ft west and 1000 ft north of the GGNS Unit 1 plant, is still approximately 5,400 feet from the Mississippi River, the isotopic concentrations from a similar spill into the ground water from a new facility would be expected to be well below the maximum permissible concentration before they reach the Mississippi River.

To identify any additional nuclides that should be considered in future (COL) analyses of an accidental release from a new facility at the proposed ESP site, a screening analysis was performed. This screening analysis proposed a hypothetical accidental release from the new facility's radwaste handling system. The ESP facility radwaste building's location was assumed to be positioned at the western-most portion of the proposed ESP facility power block area footprint. Appropriate values were established, applicable to the ESP site, for evaluating transport to the Mississippi River with no credit taken for retardation or retention through sub-surface media. Thus, using this conservative transport time analysis, and considering nuclide decay times, those nuclides which could be expected to challenge Part 20 concentration limits for the ESP site were identified as "nuclides of interest." Based on this screening analysis, the "nuclides of interest" (i.e., those that should be considered in a postulated accidental release of radioactive material) are: Cs-134, Cs-137, Sr-90, Co-60, Fe-55, and Ni-63. Distribution coefficients for these nuclides are listed in Table 2.4-37. The values in the table, for the listed nuclides, are considered to be the site characteristic for distribution coefficients.

The nearest downstream user of Mississippi River water is Southeast Wood Fiber located at the Claiborne County Port facility, approximately 0.8 mile downstream of the Grand Gulf site property and about 2 miles from the barge slip location. The maximum intake requirement for this facility is estimated to be less than 0.9 million gallons/day (mgd) for industrial purposes; however, none of this intake is used as potable water (Reference 3). There are only three public water supply systems in the state of Mississippi that use surface water as a source, and none of these are located within 50 miles of the GGNS site (Reference 4). There are no downstream or upstream intakes within 100 miles of the GGNS site that use the Mississippi River as a potable water supply (References 3 and 5). Tables 2.4-2a and 2.4-2b identify the nearby surface water users of the Mississippi River and the maximum rate of withdrawal from the Mississippi River. Since users on the Louisiana side of the river are outside the region of interest for the GGNS ESP Site evaluation (i.e., greater than 50 miles), withdrawal rates for these users are not provided in Table 2.4-2b.

Based on information on water use for 1995 (Reference 6), total surface water withdrawals in Claiborne County were 0.47 million gallons per day (mgd), broken down as follows:

Quantity (mgd)	Usage
0.35	IRRIGATION
0.12	Livestock

Detailed data pertaining to surface water use in Claiborne County and in adjacent Mississippi counties are presented in Table 2.4-3 (Reference 6). A discussion of ground water users is provided in Section 2.4.12.2.

2.4.14 References

1. U. S. Army Corps of Engineers, Mississippi Valley Division, 1998 Flood Control and Navigation Maps – Mississippi River, 61st Edition, 1998

2. Mississippi River Commission, "State of the Lower Mississippi Valley," Report of Mississippi River Commission Public Meetings, April, 2001.

3. Mississippi Department of Environmental Quality, Office of Land and Water Resources, Surface Water Withdrawal Permit Information provided by Cliff Hornbeak, July, 2002.

61. Bechtel Corp, Status Report. Program to Resolve High Ground Water Level Issues, Engineering Report GGNS-90-0004, Rev. 0.

62. Skibitzke, H. E., "Determination of the Coefficient of Transmissibility from Measurements of Residual Drawdown in a Bailed Well, in Methods of Determining Permeability, Transmissibility and Drawdown," U. S. Geological Survey Water-Supply Paper 1536-1, 1963.

63. Dept. of the Navy, "Soil Mechanics, Foundations, and Earth Structures." NAVFAC DM-7, 1961.

64. Grand Gulf Nuclear Station Potable Water Wells Physical and Chemical Water Analysis, MS Department of Health Environmental Laboratory, data analysis done in 1999 (Work Order No. 021699-006), 2000 (Work Order No. 031500-118), and 2002 (Work Order No. 022502-020).

65. USGS – http://waterdata.usgs.gov/nwis/qw

66. USGS - http://waterdata.usgs.gov/ms/nwis/gwlevels

67. Entergy Operations, Inc., “GGNS Rainfall and Ground Water Level Data,” Annual Reports for 1996 – 2001

68. Handbook of Steel Drainage and Highway Construction Products, 2nd Ed., American Iron and Steel Institute, R. R. Donnelly and Sons Co., 1971.

69. National Oceanic and Atmospheric Administration (NOAA), Application of Probable Maximum Precipitation Estimates—United States East of the 105th Meridian, Hydrometeorological Report No. 52, August 1982

70. National Oceanic and Atmospheric Administration (NOAA), Probable Maximum Precipitation Estimates, US East of the 105th Meridian, Hydrometeorological Report No. 51, June 1978

During the COL phase additional borings, laboratory testing, and geophysical surveys will be performed to confirm the current base-case material properties as well as their variabilities throughout the site. If the COL phase investigations indicate differences in material properties that may have a significant impact on design motions, we will evaluate the need to perform additional site response analyses with the updated properties to develop revised design motions.

2.5.2.4 Site Response Analysis

The site response analyses followed Approach 2A recommended in McGuire et al., 2001 (Reference 194) in which the 1 to 2 Hz and 5 to 10 Hz controlling earthquake spectra (R.G. 1.165) scaled to the UHS are used as control motions (Figure 2.5-63). Transfer functions, soil surface-to-hard rock outcropping, are developed for each controlling earthquake, enveloped, and the envelop applied to the rock UHS. This process is intended to conservatively maintain the hazard level of the rock outcrop UHS while incorporating variability in site-specific dynamic material properties (Reference 194).

Variability in the base case shear-wave velocity profile is accommodated through development of 60 randomized profiles for each control motion. The profile randomization scheme is based on an analysis of variance of over 500 measured profiles (Reference 194; Reference 197), and randomly varies both shear-wave velocity as well as layer thickness. The profile analysis of variance (Reference 194; Reference 197) used measured shear-wave velocity profiles from alluvial sites located in both the WUS and CEUS, resulting in a generic COV of about 0.3 for shear-wave velocity. Based upon experience with measured profiles in the Embayment region as well as an examination of the three suspension log profiles taken at the site (Figure 2.5-80), the generic model was considered unlikely to underestimate site-specific variability across the foundation footprint. Site-specific footprint (soil) variabilities typically reflect a COV closer to 0.2, but require a minimum of 20-40 profiles to reasonably constrain the model parameters. To provide for uncertainty in depth to hard rock, depth is randomized using a uniform distribution from 850m to 1,150m.

To accommodate variability in modulus reduction and hysteretic damping curves, the curves are independently randomized about the base case values. A log normal distribution is assumed with a σ_{ln} of 0.30 at a cyclic shear strain of 3 x 10^{-2} %. These values are based on an analysis of variance on a suite of laboratory test results. An upper and lower bound truncation of 2σ is used to prevent modulus reduction or damping models that are not physically possible. The random curves are generated by sampling the transformed normal distribution with a σ_{ln} of 0.30, computing the change in normalized modulus reduction or percent damping at 3 x 10^{-2} % shear strain, and applying this factor at all strains. The random perturbation factor is reduced or tapered near the ends of the strain range to preserve the general shape of the median curves (Reference 198).

The ensemble average, or mean transfer function, for each of two control motions (1 to 2 Hz and 5 to 10 Hz), then reflects the best estimate effect of the soil/soft rock column, accommodating site specific variability in dynamic material properties as well as depth to basement material. For the top of loess, the two mean transfer functions (5% damped response spectra), corresponding to the 1 to 2 Hz and 5 to 10 Hz control motions (Figure 2.5-63), are shown in Figure 2.5-64 along with their envelop. To accommodate the possibility of removing the surficial loess to a depth of about 50 ft for structure embedment, transfer functions were also estimated considering the top of 1,000 ft/sec material as surficial outcrop (Figure 2.5-60). The corresponding estimate of the mean transfer function is shown in Figure 2.5-65 and shows little

MATERIAL	ESP Vs (fps)	UFSAR Vs (fps)
Loess	590 to 1,450	670
Upland Complex Alluvium	740 to 1,750	1,100 to 1,600
Upland Complex Old Alluvium	530 to 3,360	1,640 to 1,720
Catahoula Formation	1,500 to 2,830	1,640 to 1,720

3.1.4.4 Hydrology

The hydrologic conditions of the ESP Site and vicinity are described in detail in Section 2.4. The descriptions include hydrologic features and characteristics that should be accounted for in the design of the ESP Facility. These hydrologic engineering characteristics include floods, ice effects, cooling water supply, low-water considerations, accidental releases in surface water, and ground water.

Section 2.4.2 presents information on the flooding history, flood design considerations, and the effects of local intense precipitation. The probable maximum precipitation event was determined to control facility flood design. Therefore, at COL, safety-related structures of the ESP Facility will need to be verified above the calculated flood elevation or be designed to withstand the effects of flooding due to local intense precipitation. Probable maximum precipitation is discussed in Section 2.4.2.3 and 2.4.3.1.

Section 2.4.3 describes the probable maximum flood characteristics for local streams and for the Mississippi River, and Section 2.4.10 discusses the flooding protection requirements. As described in Section 2.4.3, the maximum flood elevation of the river is about 103 ft msl, based on the height of the flood control levees on the west side of the river. Floods in the river would not affect the ESP Facility, the location of which is proposed at a similar grade elevation as that of the existing GGNS Unit 1 facility, on the bluffs east of the river.

Section 2.4.7 describes the effects of ice formation in the river at the location of the ESP Site, and the probable maximum winter flood on the river level. In Section 2.4.8 of the NRC Safety Evaluation Report (NUREG-0831) for GGNS Unit 1, the NRC concluded that the occurrence of a major ice jam on the Mississippi River is very unlikely, and concurred that ice flooding was not a design basis consideration for the GGNS site. Therefore, ice flooding is similarly not a design basis consideration for the ESP site.

Section 2.4.11 describes low river water considerations for the site, including the evaluation of plant requirements and ultimate heat sink (UHS) dependability requirements. The ultimate heat sink for the ESP Facility would be provided from closed-loop cooling systems utilizing basin type reservoirs, and would not rely on the river intake for cooling capability. Therefore, the UHS would be unaffected by a low river stage.

Section 2.4.13 describes the potential effects on ground water from accidental radiological releases. The evaluation for GGNS Unit 1 in their UFSAR indicated that strontium and cesium isotopic concentrations for a design basis accidental spill would be below the maximum permissible concentration at a distance of 57 feet from the location of the spill. A conservatively estimated ground water travel time from GGNS Unit 1 to the Mississippi River was determined as about 12.5 years. Since the proposed location of the ESP Facility is approximately 5,400 feet from the Mississippi River, the isotopic concentrations from a similar spill, including strontium and cesium, into the ground water should be well below the maximum permissible concentration before they reach the Mississippi River. Additional “nuclides of interest” which would require consideration in analyses at COL are discussed in Section 2.4.13, and include Cs-134, Co-60, Fe-55 and Ni-63. Due to the large separation distance from the MS River and the long transit time, the potential for effluents that may reach a surface water body and surface water users exceeding the Part 20 limits is minimal.

Section 2.4.12 describes the regional and local aquifers, their formation, sources and sinks. Section 2.4.12.1 describes plant requirements from the ground water system and describes ground water quality. Section 2.4.12.2 describes the site hydrogeologic systems including the aquifers present and their characteristics (depth, permeability, potentiometric levels and velocity), and present and projected future ground water users. The design basis for subsurface hydrostatic loading is presented in Section 2.4.12.4.

The information contained in Section 2.4 on surface water and ground water conditions was evaluated and was determined to be adequate in support of the ESP Facility. These data would be used as appropriate in the design of the ESP Facility to ensure that no hydrology related site parameters would pose an undue risk to the operation of the ESP Facility.

3.1.5 Potential Off-site Hazards

The potential offsite hazards for the ESP Facility are described in Section 2.2. The description includes nearby industrial, transportation and military facilities.

Sections 2.2.1 and 2.2.2.5 addresses area airports and associated air transportation routes, as they may affect the ESP Facility. No commercial airport facilities are located within 10 miles of the GGNS site. The nearest commercial airport is located in Jackson, MS, approximately 65 miles northeast of the site. There are 5 general/public aviation airports located within the vicinity of the site. These general/public aviation airports are used only for small planes.

As noted in Section 2.2.3, highway accidents are not a concern for the ESP Site. The ESP Site area is accessible by U. S. Highway 61 and State Highway 18 which connect Port Gibson (5 miles southeast of the site) with Natchez, Jackson, and Vicksburg. U. S. Highway 61 passes approximately 4.5 miles east-southeast of the GGNS site at its closest point. The distance beyond which an exploding truck will not have an adverse effect on plant operations, nor prevent safe shutdown, is calculated to be 1,658 feet (0.31 miles). Since the closest point of U. S. Highway 61 to the ESP Site is about 4.5 miles, there is no hazard to the plant due to an accident on U.S. Highway 61.

There are currently no active rail lines in the vicinity of the ESP Site. Therefore, potential accidents involving railway traffic are not evaluated.

The nearest bank of the river is approximately 1.1 miles from the proposed location for the ESP Facility on the GGNS ESP Site. In addition, a new facility would be located on the bluffs to the east of the river, which are approximately 65 feet above the normal river level. As noted above for the GGNS Unit 1 plant, this bluff would provide an earthen shield against possible explosions originating from river barge traffic. Based on the combination of distance from the river bank and the intervening bluff, this would preclude any damage to the structures of the ESP Facility at the proposed location, resulting from an explosion originating from a ship or barge on the river.

Section 2.2.3.1 discusses explosions due to pipelines and nearby industrial facilities. Evaluation of the existing pipelines, their proximity to the site and the materials passing through them resulted in the determination that they do not represent a design concern for facilities at the ESP

Site. There are no existing industrial facilities potentially representing an explosive source which would constitute a design consideration for the ESP Site.

Section 2.2.3.1 discusses explosions due to onsite hydrogen storage, and due to liquid-hydrogen delivery truck accidents/explosions. Liquefied hydrogen is delivered to the GGNS site by United States Department of Transportation (USDOT) approved truck, with a maximum capacity of 17,000 gallons. There are no regulations specifying a minimum distance between a liquid-hydrogen delivery truck and a safety-related structure. The current truck route on the GGNS (ESP) Site results in about 400 ft separation from the outer boundary of the proposed location for the power block of the ESP Facility, which is less than the minimum separation distance of 1285 ft calculated per Regulatory Guide 1.91 (Reference 1). However, the probability of an accident resulting in a hydrogen explosion calculated per the Regulatory Guide 1.91 methodology is 4.1×10^{-7} per year. Therefore, according to the guidelines presented in Regulatory Guide 1.91 (criteria is less than 10^{-6} per year), a liquid-hydrogen truck explosion event need not be considered a design basis accident for the ESP Facility on the site.

The presence of the 20,000 gallon liquid-hydrogen storage tank located in the north end of the abandoned GGNS Unit 2 cooling tower basin (Figure 2.2-4) presents a potential hazard of an explosion. An analysis was performed to determine the safe separation distance between the liquid-hydrogen storage tank and any GGNS Unit 1 safety-related structure. These calculations are valid for the ESP Facility at the GGNS ESP Site, so long as the minimum separation distances stated in the report are maintained, or structures are appropriately designed for the expected blast pressure. The proposed area for construction of the ESP Facility is beyond the minimum separation distance requirements given in the calculation for both blast considerations and gaseous cloud considerations.

Toxic chemicals are discussed in Section 2.2.3.1.2. The closest point of U.S. Highway 61 to the GGNS site is 4.5 miles. Therefore, an accidental release of toxic chemicals transported on U. S. Highway 61 would not endanger the safe operation of the ESP Facility at its proposed location on the ESP Site. In the year 2000, the majority of the hazardous materials transported near the GGNS site were fuel products moving on the Mississippi River. The 6-year onsite wind frequency distribution data (1996-2001) reported in Section 2.3 shows that the winds that originated from compass sectors W-SW, W, W-NW and NW, that would carry the hot plume from a fire caused by explosion to the proposed location for a new facility, had speeds generally under 20 mph. An analyses presented in the GGNS Unit 1 UFSAR concluded that a wind speed greater than 70 mph would be required to direct a plume toward GGNS Unit 1. The proposed location for the ESP Facility is on the bluffs above the river and about 1.1 miles inland. Since the proposed location for the ESP Facility is very near to that of the existing GGNS Unit 1, no toxic hazard to the ESP Facility would be expected.

There are no military installations, chemical or munitions plants, stone quarries, or major gasoline-storage areas located within 5 miles of the ESP site. Therefore, they do not need to be considered as a hazard for the ESP Facility on the ESP Site.

Section 2.2.3.1.3 discusses the possible offsite fire hazards to an ESP Facility on the GGNS ESP Site. It was concluded that offsite fires do not pose a design basis threat to a new facility on the site.

A collision (by river traffic) with the proposed cooling system intake is not considered likely and not a design basis event for the ESP Facility as discussed in Section 2.2.3.1.4.

Liquid spills on the Mississippi River do not pose a threat to safe shutdown of the ESP Facility, as the river intake is utilized only for non-safety related water supply. Any potential intrusion of hazardous chemicals or liquids into the proposed embayment and makeup water system could be mitigated by orderly shutdown of the facility, if required.

3.1.6 Site Characteristics - Security Plans

The ESP Facility power block proposed location (approximate center of the power block area) is approximately 1200 ft west and 1000 ft north of the existing GGNS Unit 1 Facility. A site plot plan is provided in Figure 2.1-1.

3.1.6.1 Land Sufficient To Implement The Criteria Of 10 CFR 73.55

Based upon the general location at the GGNS site on which the nuclear unit or units would be located; e.g., in the general vicinity of the GGNS Unit 1, there is sufficient land and distance to the site boundary and appropriate topography to implement the criteria of 10 CFR 73.55 relating to the development of a security plan. This conclusion is based in part on the fact that GGNS Unit 1 has implemented a security plan meeting the requirements of 10 CFR 73.55 and the interim compensatory measures required by the NRC's Order of February 25, 2002. While GGNS Unit 1 is still in the process of implementing the requirements of the revised design basis threat (DBT) Order of April 25, 2003, preliminary evaluations would indicate that neither the amount of land, the particular location of the GGNS site in relation to the topography and site boundaries or the distances to the site boundary or other natural features, would preclude compliance with the revised DBT.

It should be noted that existing commercial nuclear power plants, such as GGNS Unit 1, were designed to meet evolving 10 CFR 73.55 requirements, including effective changes in the DBT and revised DBT, on an "add-on" basis after completion of the initial physical design. Even given these circumstances, plants such as GGNS Unit 1 are capable of meeting the evolving NRC security requirements. For a plant which would be built in the future, security considerations (e.g., barriers, access, fences) would be incorporated as initial design requirements and inputs and integrated into the overall design as an important element, making it reasonable to conclude that such a facility will be able to meet NRC security requirements.

Given the opportunity to design security into a new facility, the distance specified in Regulatory Guide 4.7 would be sufficient to satisfy the criteria of 10 CFR 73.55 although a larger distance could be used at the GGNS ESP site, and even a smaller distance could be accommodated.

3.1.6.2 Site Characteristics That May Require Mitigation

No site characteristics that require significant mitigation in order to control close approaches to the proposed location of a new facility have been identified. As indicated Figure 2.1-1, the nearest public road is about 3000 feet from the general area of the proposed power block building site. The Mississippi river is approximately 1 mile from the proposed power block building site. Safety-related structures necessary for the ultimate heat sink would not be located on an accessible, navigable waterway.

3.1.6.3 Identification of Potential Hazards in the Site Vicinity

Initially, given the successful implementation of a security plan by Entergy Operations for GGNS Unit 1, there are no potential hazards in the site vicinity which would preclude the development of a security plan for the new unit or units. The new reactor or reactors will be sited at some distance from the existing GGNS Unit 1, and provisions will be made such that construction activities at a new facility will not adversely affect the ability of GGNS Unit 1 or any new operating unit to meet NRC security requirements. Similarly, the design of the security plan and defensive strategy will be such that during operation or other activities on site, the security plans of the units on site positively reinforce each other, or will be independent with regard to their individual ability to meet NRC security requirements and the design basis threat, as revised.

3.1.6.4 Law Enforcement Agencies

Given the location of a new facility in relationship to GGNS Unit 1 which has, as part of its security plan, made provisions with relevant local law enforcement agencies, there is high assurance that similar provisions can be made with regard to any new facility, in that the jurisdictions and local law enforcement agencies are the same as for GGNS Unit 1.

In summary, given the proposed location of a new facility near GGNS Unit 1, and the ability to assure compliance with NRC provisions through design, there is a high assurance that NRC security requirements can be met for a new facility.

3.1.7 Site Characteristics - Emergency Plans

Information regarding emergency planning capability is provided in the ESP Application, Emergency Planning Information, Part 4. The GGNS Unit 1 evacuation time estimate (ETE) performed in 1986 was re-evaluated in support of this application. This re-evaluation included an assessment of updated population levels and distributions and transportation networks. As part of the effort, each major roadway was driven and traffic count data was obtained, as appropriate. Improvement in several key roadways was noted, and updated roadway capacities were estimated to support this evaluation. Local Mississippi and Louisiana emergency management agency officials, as well as state department of transportation representatives, were consulted and provided their concurrence regarding the findings. Based on this re-evacuation of the ETE, it was determined that there are no physical characteristics unique to the GGNS site that could pose a significant impediment to the development of the required emergency plans for the ESP Facility.

3.1.8 Population Density

As described in Section 2.1.1 and Section 2.1.3.6, the ESP Site is located in a mostly rural, low population density, area. Table 2.1-6 presents estimated total population (permanent and weighted transient) for various distances from the site. As shown this table, average total population densities, projected to 2030 and 2070 are below 100 persons per square mile and, thus, well below the NUREG-0800 guidance of 500 persons per square mile at the projected start of facility operation, and less than 1000 persons per square mile at the projected end of facility life..

3.1.9 References

1. U.S. Nuclear Regulatory Commission (NRC), February 1978, Evaluations of Explosions Postulated To Occur on Transportation Routes Near Nuclear Power Plants, Regulatory Guide 1.91, Revision 1, Washington, DC.