Early Site Review

NUREG-0131

U. S. Nuclear Regulatory Commission

for

Blue Hills Site

Gulf States Utilities Company

Office of Nuclear Reactor Regulation

Docket Nos. 50-510 and 50-511

January 1977

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BY THE

U. S. NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF

GULF STATES UTILITIES COMPANY

BLUE HILLS SITE

DOCKET NO. 50-510 AND 50-511

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1.0 INTRODUCTION AND GENERAL DISCUSSION

1.1 Introduction

The Gulf States Utilities Company (the applicant) filed with the Nuclear Regulatory Commission (NRC) an application, docketed on July 30, 1974, for licenses to construct and operate the proposed Blue Hills Station Units 1 and 2. The proposed site is located in Newton County, Texas approximately nine miles west of the Texas-Louisiana border on the Toledo Bend Reservoir.

Since the time the application was docketed, on July 30, 1974, the applicant has announced three delays which resulted in an eight year delay of the inservice dates for both units. This was the result of a reevaluation by the applicant of its system load growth. While it was not possible for the NRC staff to proceed with the licensing effort toward the issuance of a construction permit, the applicant stated that they wished to continue working with the NRC staff on the suitability of the Blue Hills site for a nuclear power plant and resolve all site related safety issues in the Preliminary Safety Analysis Report. On this basis, we have continued our review of the Preliminary Safety Analysis Report site related issues; i.e., predominantly Chapter 2, and issue a Safety Evaluation Report (this report) on the site related safety issues.

We have completed our review, to the extent possible at this time, in the areas of seismology, geology, meteorology, hydrology, and in the area of hazards to a nuclear power plant which could result from man's activities.

The information provided for our review consisted of the Preliminary Safety Analysis Report including Amendments 1 through 5 to the application. Copies of this report and its amendments are available for public inspection at the U. S. Nuclear Regulatory Commission's Public Document Room, 1717 H Street, N.W., Washington, D. C. and at the Newton County Public Library, Newton, Texas 75966.

This report summarizes the results of our technical evaluation of the proposed Blue Hills site suitability for a nuclear power plant performed by the NRC staff and delineates the scope of the technical matters considered in evaluating the suitability of the site for a nuclear power plant. Additional details as to the scope and bases used by the NRC staff to evaluate the radiological safety aspects of proposed nuclear power plant sites are provided in the Nuclear Regulatory Commission's Standard Review Plan For The Review Of Safety Analysis Reports For Nuclear Power Plants, NUREG-75/087 (hereinafter also referred to as the Standard Review Plan). The Standard Review Plan is the result of many years of experience by the NRC staff in establishing and promulgating guidance to enhance the safety of nuclear facilities and in assessing Safety Analysis Reports.

The applicant has filed an Environmental Report for the Blue Hills site to evaluate those matters relating to environmental impact assessment which can reasonably be reviewed at this time. We will report on the results of our evaluation of the Environmental Report for the Blue Hills site in an Environmental Statement to be issued about July 1977.

This report and the findings contained herein can be referenced at some future date should the applicant decide to request the NRC staff to resume the review of their application to build a nuclear power plant at the Blue Hills site. At that time we will require that the applicant identify any information describing the Blue Hills site contained in the Preliminary Safety Analysis Report, including Amendments 1 through 5 which has changed since the publication of this report.

A chronology of the principal actions related to our review of the Blue Hills Station Units 1 and 2 Preliminary Safety Analysis Report for site related matters is included as Appendix A to this report. The bibliography for this report is enclosed as Appendix B.

1.2 General Description of Site

The Blue Hills site is located in the northeast corner of Newton County, Texas, two miles southwest of Toledo Bend Reservoir and 17 miles east of Sam Rayburn Reservoir. The site is about 25 miles east-northeast of Jasper and 10 miles north of Wiergate and Burkeville. The Texas-Louisiana border is nine miles east of the site. State Highway 87 is a north-south route about two miles west of the site. Farm-to-Market Road 255 runs east-west about two miles south of the site. This road ends at Farm-to-Market Road 692, which runs north-south, and is approximately 6.5 miles east of the plant site. Figure 1.2-1 of this report shows the general location of the site.

The Universal Transverse Mercator coordinates of the site location are N3, 445, 607 meters and E 434,012 meters.

The elevation of the site is 270 feet above mean sea level. The locations of major rivers and lakes are shown in Figure 1.2-1 of this report. Figure 2.1-2 of the Preliminary Safety Analysis Report shows other rivers and creeks within five miles of the site.

Figure 1.2-1
General Location of Blue Hills Site

The site is composed of an area of abou. 3,016 acres. The site is totally owned by the applicant with the exception of the mineral rights within two parcels of land inside the exclusion area. The exclusion area (radius of 0.85 mile or 1,369 meters as measured from the outside diameter of the contain t building) is entirely within the site boundary.

1.3 Identification of Agents and Contractors

Gulf States Utilities Company of Beaumont, Texas was the sole applicant for a facility license for Blue Hills Station Units 1 and 2 and subsequently has been the sole participant in the review of the Blue Hills site suitability for a nuclear power plant. Project management services for the Preliminary Safety Analysis Report was provided by Bechtel, through its Los Angeles Power Division, Houston Area Office.

Bechtel has had prime responsibility for developing information and analyses for the following areas that this review has been concerned with: hydrology, geology, seismology, and foundations. The meteorological program and associated analyses have been conducted by Teledyne Geotech of Garland, Texas and Meteorology Research Inc. of Altadena, California. Geography and demography consulting services were provided by Dr. D. Huff of the University of Texas. Special geological consulting was performed by C. O. Durham, Baton Rouge, Louisiana.

Other consultants retained by the applicant to perform or verify studies for this review are identified in the Preliminary Safety Analysis Report.

1.4 Summary of Principal Review Matters

This Safety Evaluation Report summarizes the results of the technical evaluation of the proposed Blue Hills site performed by the NRC staff. Our evaluation included a technical review of the information and data submitted by the applicant with emphasis on the following principal matters:

(1) We evaluated the population density and land use characteristics of the site environs and the physical characteristics of the site, including seismology, meteorology, geology, and hydrology to determine that these characteristics had been adequately describe and were given appropriate consideration to determine the significant site related plant design parameters, and that the site characteristics were in accordance with the Commission's siting criteria (10 CFR Part 100).

(2) We evaluated the hazards to a nuclear power plant which could result from man's activities; e.g., air crash, proximity of pipelines, etc.

(3) We evaluated the potential capability of the Blue Hills site to support the construction and operation of a nuclear power plant of the general type and size being proposed for other s es in the United States under the guidelines of 10 CFR Part 100.

During our review, several meetings (see Appendix A to this report) were held with representatives of the applicant and the applicant's contractors and consultants to discuss various technical matters related to our review of the Blue Hills site. We also visited the site to assess specific safety matters related to our review of the Blue Hills site.

2.0 SITE CHARACTERISTICS

The scope of the Blue Hills early site review does not include the design parameters for a specific nuclear power plant design. This information will be provided by Gulf States Utilities Company (the applicant) in a construction permit application in accordance with the requirements of 10 CFR Part 50 at a future date. However, the Blue Hills Station, Units 1 and 2 Preliminary Safety Analysis Report and this Site Safety Evaluation Report has established an envelope of meteorological, hydrological, seismological, geological, and foundation conditions for a nuclear power plant design. These conditions provide an indication, in advance of the development of a specific nuclear power plant design, of the site related design requirements for a nuclear power plant at the Blue Hills site. The applicant has presented the results of their site investigations and analyses in Chapter 2 of the Blue Hills Station Un 1 and 2 Preliminary Safety Analysis Report.

2.1 Geography and Demography

The 3016-acre Blue Hills site is located in the northeast corner of Newton County, Texas, two miles southwest of Toledo Bend Reservoir and 17 miles east of Sam Rayburn Reservoir. The site is about 25 miles east-northeast of Jasper, Texas. The Texas-Louisiana border is nine miles east of the site. State highway 87 is a north-south route about two miles west of the site. Farm-to-Market Road 255 runs east-west about two miles south of the site. This road ends at Farm-to-Market Road 692, which runs north-south, and is approximately 6.5 miles east of the plant site. Figure 2.1-1 shows the general location of the site, and Figure 2.1-2 shows the location of the designated exclusion area within the property boundary. No public highways, waterways, or railroads traverse the exclusion area. The site is totally owned by the applicant with the exception of the mineral rights within two parcels of land inside the exclusion area. The exclusion area (radius of 0.85 mile or 1369 meters as measured from the outside edge of the containment buildings) is entirely within the site boundary. When we resume our review of the application to build a nuclear power plant at the Blue Hills site, we will require that the applicant demonstrate that the mineral rights within those two parcels of land have been acquired so that they will have the authority to determine all activities within the exclusion area as required by 10 CFR Part 100.

The 1970 population within 10 miles of the site is stated by the applicant to be about 1500 people, and the 1970 population within 50 miles is given as about 155,000. The applicant projects that the population within these distances will double by the year 2020. Transient population resulting from recreational activities near the Toledo Bend Reservoir occurs between four and five miles, and reached a total of about 23,000 during 1973. The applicant estimates a growth to about 63,000 per year by the year 2020.

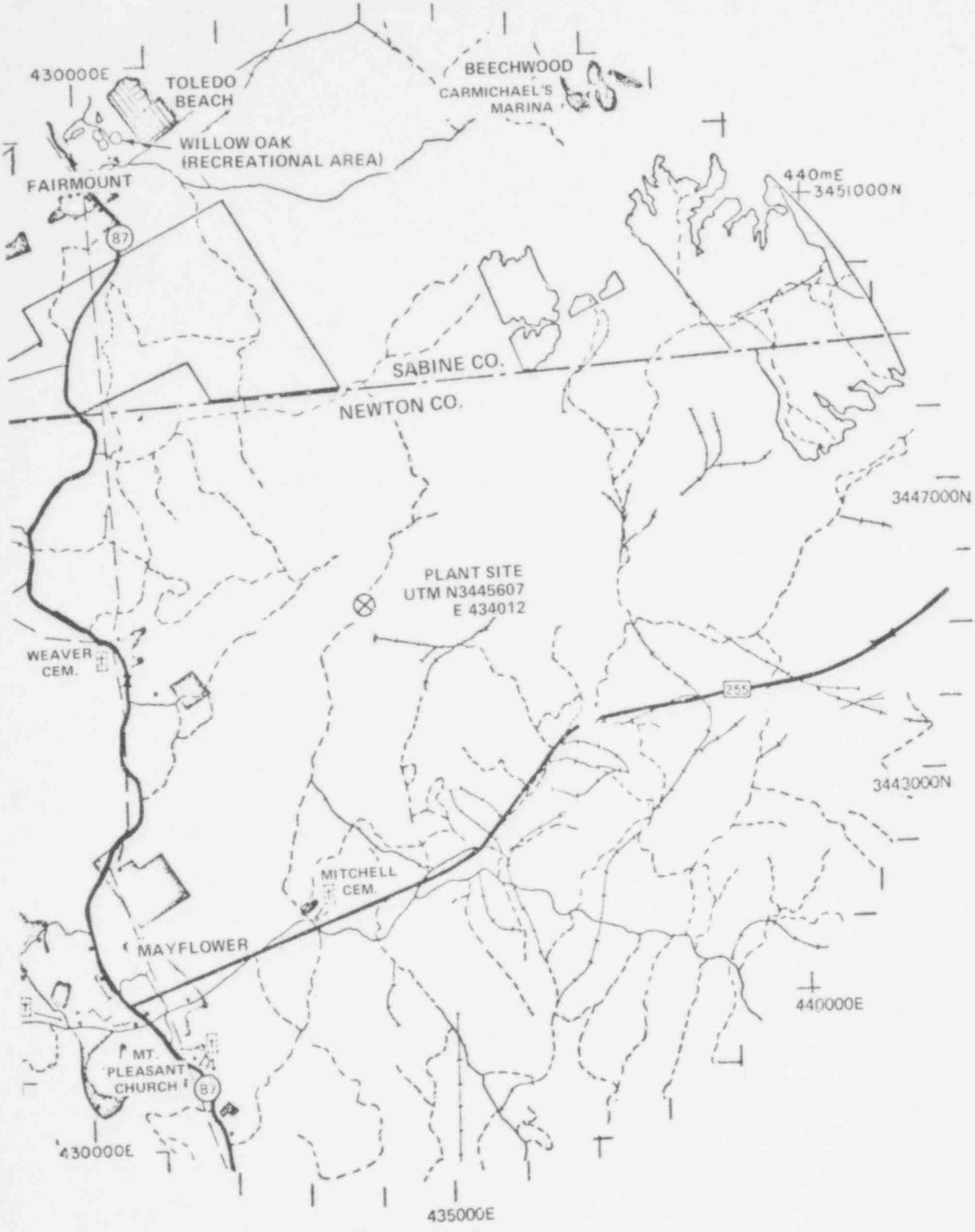

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Figure 2.1-1 Blue Hills Site Location

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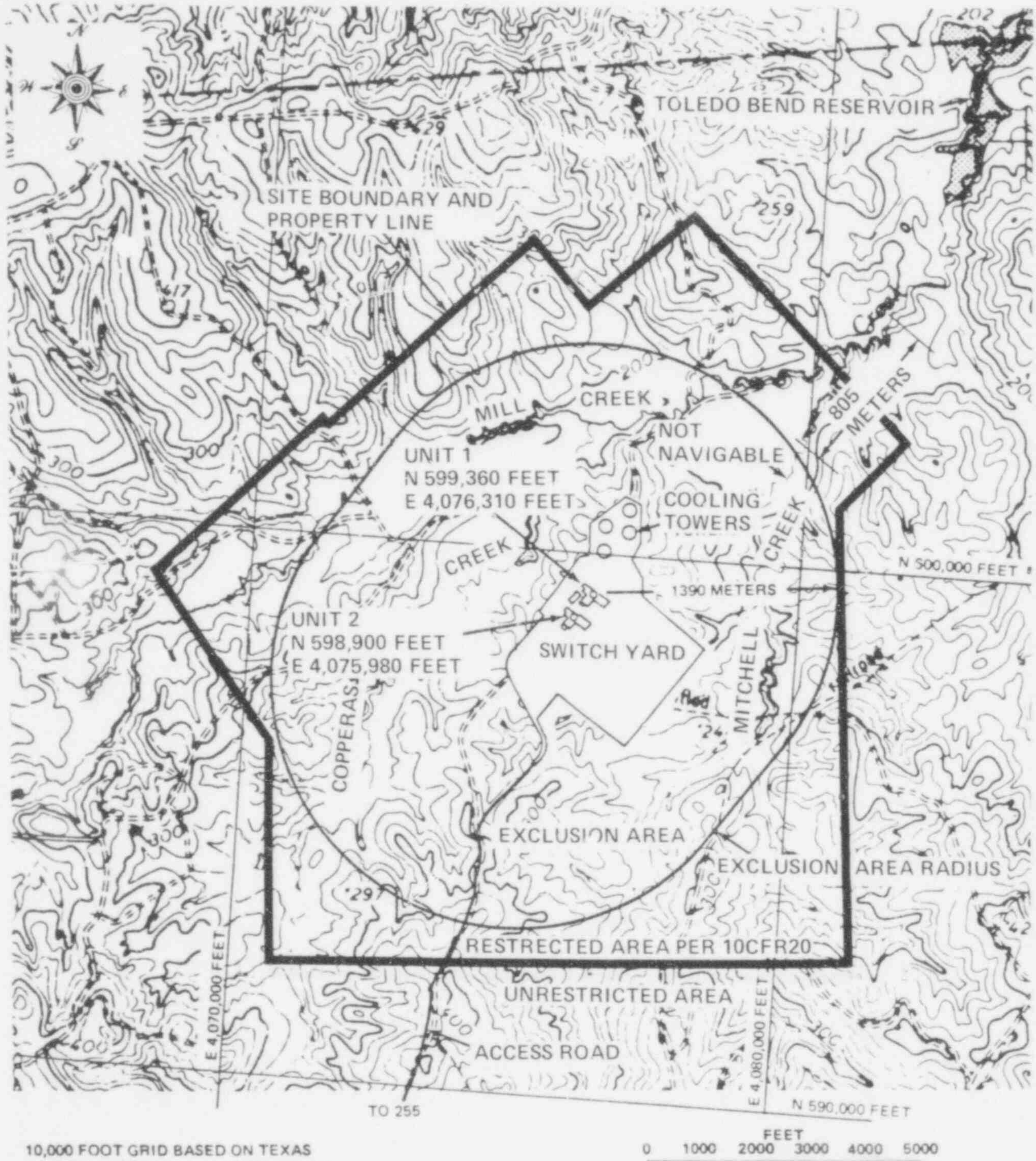

Figure 2.1-2 Blue Hills Site Exclusion Area

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The applicant has specified a low population zone of three miles radius. The population within that area is stated to be 10 for the 1970 census year, and the applicant estimates no more than 22 by the year 2020. No characteristics of the low population zone have been identified which would preclude the formulation of an acceptable emergency plan for the residents within the zone, as required by 10 CFR Part 100.

There are no large communities in the vicinity of the site. The largest unincorporated area within 50 miles is the Fort Polk military base with a population of 24,000 and located 33 miles east of the site. There are no communities within 50 miles with a 1970 population of 25,000 or more. This satisfies the 10 CFR Part 100 requirement that a population center distance at least be one and one-third times the distance from the reactor to the outer boundary of the low population zone.

In accordance with 10 CFR Part 100, offsite doses from postulated design basis accidents are to be calculated at the exclusion area and the low population zone on the bases of the site meteorology, reactor thermal power level, and the safety features that are to be engineered into the nuclear power plant. Regulatory Guide 1.4 "Assumption Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors" specifies the allowable radiological consequences for the construction permit review. Since the applicant has elected to identify at a future date a reactor thermal power level and safety features that would be engineered into a facility, we are unable to conclude on these matters at this time.

However, based on past experience, we have found that a minimum exclusion area distance of 640 meters (0.4 mile), and a low population zone distance of 4800 meters (three miles), even with unfavorable atmospheric dispersion characteristics, usually provides assurance that engineered safety features can be provided to maintain calculated doses from postulated accidents within the guidelines of 10 CFR Part 100. We will require that the radiological dose consequences resulting from the design basis accidents be evaluated on the basis of the atmospheric dispersion factors presented in Section 2.3.4 of this report and the guidance of Regulatory Guides 1.4 "Assumption Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors" for the proposed facility design and reactor thermal power level.

On the basis of these considerations, we conclude that the Blue Hills site can be acceptable under the guidelines of 10 CFR Part 100 for the construction and operation of nuclear power plants of the general type and size being proposed for other sites in the United States.

2.2 Nearby Industrial, Transportation and Military Facilities

There are no significant industries, waterways, airports, mining activities, railroads, or military facilities within 10 miles of the Blue Hills site. The nearest major roadway is State Highway 87 which passes, at its closest approach, about two miles west of the site. The nearest pipeline is an eight-inch crude oil line passing about five miles southeast of the site, and the nearest railroad is a line of the Santa Fe Railroad 18 miles west of the site. Federal Airway V212 passes about five miles north of the site.

The nature and extent of activities at nearby industrial, military, and transportation facilities have been evaluated and we conclude that currently there are no activities in the vicinity which have the potential for adversely affecting safety-related structures of any nuclear power plant which may be proposed for the Blue Hills site nor which would require special design considerations for any plant proposed for the Blue Hills site.

2.3 Meteorology

Information concerning the atmospheric dispersion characteristics of a proposed nuclear power plant site is required in order that a determination may be made that postulated accidental, as well as routine operational, releases of radioactive materials are within NRC guidelines. Furthermore, regional and local climatological information, including extremes of climate and severe weather occurrences which may affect the safe design and siting of a nuclear plant at a proposed site, is required to insure that safety-related plant design and operating bases are within NRC guidelines. The design basis meteorological characteristics of a proposed site are determined by the NRC staff's evaluation of meteorological information in accordance with the procedures presented in Sections 2.3.1 through 2.3.5 of the Standard Review Plan.

2.3.1 Regional Climatology

The applicant has provided a sufficient description of the regional meteorological conditions of importance to the safe design and siting of a nuclear power plant at the Blue Hills site.

The region of east-central Texas and west-central Louisiana experiences a subtropical maritime climate, with occasional influences of polar air from the north. The semi-permanent high pressure system of the western Atlantic Ocean pushes the predominant south to southeast winds into the region, laden with warm, moist air from the Gulf of Mexico. Thus, summers are warm and humid, with average high temperatures near 90 degrees Fahrenheit and daytime humidities near 60 percent. Temperatures exceed 90 degrees Fahrenheit about 90 days each year. Occasional intrusions of polar air in the winter are usually of short duration. Thus, winters are mild with low temperatures averaging near 40 degrees Fahrenheit. Freezing temperatures occur about 30 days annually.

The proximity to the Gulf of Mexico also accounts for the abundant rainfall in the area, with annual amounts averaging about 50 inches. Rainfall varies slightly from month to month; however, small peaks in the rainfall occur in late spring due to airmass showers and in early winter due to frontal passages. Late summer-early fall generally has the least amount of rainfall. Thundershowers are possible any month of the year, occurring an average of 70 days annually.

Snowfall is a rarity in the region, averaging less than one inch per year. However, occasional storms have dumped up to 10 inches of snow on the ground (Leesville, Louisiana, February 13, 1960). One or two ice storms, some occasionally severe, may occur each year in the area. Similarly, the mean annual number of days of hail in the region is one or two.

We would consider a design load for roofs of safety-related structures of 30 pounds per square foot as proposed by the applicant, to be acceptable for loads due to snow at the Blue Hills site.

Between 1953 and 1974, 116 tornadoes occurred within a 10,000 square mile area containing the site. Using the methods of Thom (Reference 7), this results in a recurrence interval of 670 years for a tornado at the plant site. The design basis tornado proposed by the applicant is similar to the design basis tornado parameters for Region I, as described in Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants," which we find acceptable for the site. These parameters include a maximum wind speed of 360 miles per hour consisting of a maximum rotational speed of 290 miles per hour and a maximum translational speed of 70 miles per hour; a minimum translational speed of five miles per hour; a radius of maximum rotational speed of 150 feet; a pressure drop of three pounds per square inch; and a rate of pressure drop of two pounds per square inch per second.

Hurricanes and tropical storms also affect the site area. Between 1871 and 1974, the centers of five hurricanes and 18 tropical storms or hurricane remnants have passed within 50 miles of the site. Because the site is 95 miles inland from the Gulf of Mexico, the velocities of wind from these storms are less at the site than at the Gulf Coast. Thus we consider an operating basis wind speed (defined as the "fastest mile" wind speed at a height of 30 feet with a return period of 100 years) of 90 miles per hour, as proposed by the applicant for the site, to be acceptable. The "fastest mile" of wind recorded at Port Arthur, Texas (about 80 miles south of the site, near the Gulf Coast) has been 91 miles per hour (August 1940).

Between 1936 and 1970, the site area experienced about 20 cases of atmospheric stagnation totalling about 70 days. The autumn months had the highest frequency of cases.

The applicant has examined meteorological data from the region to select appropriate meteorological conditions in considering the design requirements for an ultimate heat sink as recommended in Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear

Power Plants." On this basis, we have evaluated this information and conclude that the meteorological data presented in Section 9.2.5 of the Preliminary Safety Analysis Report is acceptable for analysis of the ultimate heat sink design concept (i.e., mechanical draft cooling tower) described in Section 9.2.5 of the Preliminary Safety Analysis Report.

2.3.2 Local Meteorology

The applicant has provided sufficient information for us to make an evaluation of the local meteorological conditions of importance to the safe design and siting of a nuclear power plant at the Blue Hills site. Two years of data collected onsite are available to assess the local meteorological characteristics of the Blue Hills site as well as climatological data from Leesville, Louisiana (25 miles east of the site), Alexandria, Louisiana (75 miles east-northeast of the site), and Bronson, Texas 20 miles northwest of the site).

At Leesville the average daily maximum and minimum temperatures range between 93 degrees Fahrenheit and 70 degrees Fahrenheit in July, the warmest month, and between 61 degrees Fahrenheit and 38 degrees Fahrenheit in January, the coolest month. The extreme maximum temperature recorded at Leesville was 107 degrees Fahrenheit; however, Bronson has recorded the extreme maximum temperature of 114 degrees Fahrenheit. The extreme minimum temperature recorded at Leesville has been zero degrees Fahrenheit.

Leesville receives about 54.4 inches of rain annually. Precipitation is usually abundant each month of the year, ranging from 5.5 inches in December, the wettest month, to 3.2 inches in October, the average driest month. The maximum 24-hour rainfall recorded at Leesville was 11.0 inches in February 1966. However, in June 1886, a location near Alexandria received a torrential amount of 21.4 inches within a 24-hour period. Annual snowfall averages 0.7 inches at both locations. The maximum 24-hour snowfalls have been 10 inches at Leesville (February 1960) and 8.2 inches at Alexandria (January 1940). Heavy fogs (visibility of 1/4 mile or less) occur on about 40 days annually at Alexandria, with the majority occurring in the winter months.

For the two year period of October 15, 1973 through October 14, 1975, about 26 percent of the time the windflow over the site, as measured at the 33-foot level of the onsite meteorological tower, was from the south and south-southeast. Figure 2.3-1 shows the directional frequency of onsite winds. Winds were calm (windspeeds less than 0.6 mph) three percent of the time at the 33-foot level.

2.3.3 Onsite Meteorological Measurements Program

The onsite meteorological measurements program has been compared with the recommendations and intent of Regulatory Guide 1.23, "Onsite Meteorological Programs." We conclude that the meteorological measurements program has produced data which, in turn, have been summarized to provide sufficient meteorological description of the site and its vicinity for the purpose of making atmospheric dispersion estimates for

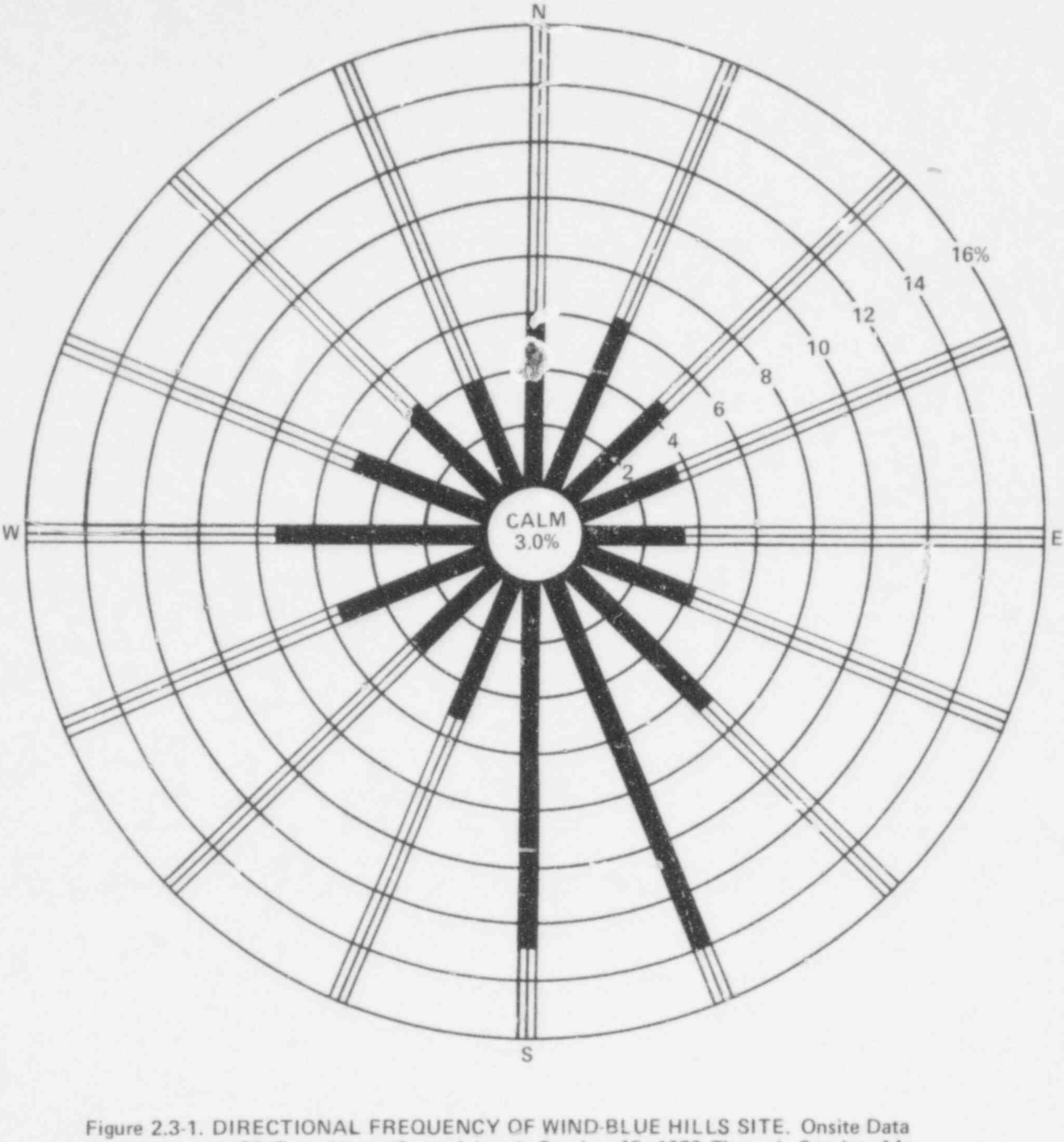

Figure 2.3-1. DIRECTIONAL FREQUENCY OF WIND-BLUE HILLS SITE. Onsite Data at 33 Feet Above Ground Level, October 15, 1973 Through October 14, 1975. Bars Show the Direction From Which the Wind Blows. Calms are Those Winds With Hourly Average Speeds Less Than 0.6 MPH.

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use in determining the radiological consequences of accidental and routine airborne releases of effluents from a nuclear power plant.

A 180-foot high meteorological tower, erected about 8500 feet west-southwest of the proposed reactor site, became fully operational on October 15, 1973. Wind speed and direction, standard deviation of direction, and dewpoint temperature are measured at both the 33 and 180-foot levels of the tower. Vertical temperature difference measurements are made between the 33 and 180-foot levels. Ambient air temperature is taken at the 33-foot level. Precipitation is measured at 10 feet above ground level. In January 1974, additional wind sensors were added at the 67 and 100-foot levels to provide intermediate data to describe the vertical wind profile.

The applicant has provided joint frequency distributions of wind speed and direction by atmospheric stability class, based on the vertical temperature gradient data collected onsite during the period October 15, 1973 to October 14, 1975. The distributions were for wind speed and direction measured at both the 33 and 180-foot levels with the vertical temperature difference between the 33 and 180-foot levels.

We have concluded that the applicants' onsite meteorological program conforms to the provisions of Regulatory Guide 1.23, "Onsite Meteorological Program," and has produced two years (October 15, 1973 - October 14, 1975) of onsite meteorological data which provides an acceptable basis to determine site atmospheric dispersion conditions, and is therefore acceptable.

2.3.4 Short-Term (Accident) Dispersion Estimates

The Blue Hills site is located in a forested terrain. The applicant has proposed a meteorological model which considers the "sheltering" effect of the trees surrounding the meteorological tower in their calculations of atmospheric dispersion factors (X/Q's) for the site. These X/Q's are smaller than those calculated which do not consider the "tree sheltering" effect. As a result of our evaluation of the applicant's meteorological model, we find that the quantitative reduction of the X/Q's proposed by the applicant due to the "tree sheltering" effect is unwarranted based upon the limited information available on this phenomenon at this time.

The following provides the basis for our conclusions on this matter:

(1) The applicant concluded in their dispersion factor analysis that the effects of "tree sheltering" were observed primarily for Stability Class G. According to their method of analysis the other stability classes they reviewed; i.e., Stability Class E and F, showed little sheltering effect. It is our assessment that if "tree sheltering" is occurring, the effects should be apparent for all stabilities.

We have observed decoupling of upper and lower-level winds at other sites where no trees are present. It is possible that the low-level wind reduction noted at the Blue Hills site may be a combination of the effects of "stability-decoupling" and "tree sheltering." The degree of X/Q reduction due to "tree sheltering" effects alone would need to be quantified before credit for it in our X/Q evaluation could be allowed.

(2) The applicant concluded in their analysis that the proposed cleared area surrounding the finished plant would be significantly larger than the clearing surrounding the meteorological tower. Thus, we would expect the meteorological tower data to reflect lower wind speeds, and thus higher X/Q values, than predicted by the applicant to occur at the "as built" plant complex.

It is our assessment that the addition of buildings and attendant structures may significantly reduce the effective area of the clearing surrounding the plant. Thus, comparison of meteorological data collected at the present tower location and that at the future plant clearing may not differ significantly; this difference would need to be quantified before credit could be allowed in the X/Q's.

In summary, the NRC staff agrees in principle with the applicant that some "tree sheltering" may be occurring at the lower levels of the present meteorological tower. However, we do not believe that the magnitude of this phenomenon attributed to occur at the present tower location has been fully quantified, nor has it been correlated to the meteorological conditions which would occur within the "as built" plant complex. On this basis, we have not used the applicants analysis of "tree sheltering" effects in our development of acceptable X/Q estimates for the Blue Hills site.

In our calculation of short-term dispersion estimates, we used a dispersion model modified from that described in Regulatory Guide 1.4, "Assumption Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors." This modified model has incorporated results from recent field experiments in atmospheric dispersion. This model considers the following effects:

(1) lateral plume meander, as a function of atmospheric stability, wind speed, and distance from the source, during periods of light winds and stable atmospheric conditions,

(2) boundary distance as a function of direction from the plant,

(3) the atmospheric dispersion conditions when the wind is blowing in a specific direction, and

(4) the fraction of time the wind can be expected to blow into each of the 16 compass directions.

In our development of short-term atmospheric dispersion estimates for the Blue Hills site we have modified the atmospheric dispersion model (Reference 6) and the assessment of short-term dispersion estimates described in Section 2.3.4 of the Standard

Review Plan. These deviations represent a substantial change in the procedures used for determining atmospheric dispersion conditions appropriate in assessing the potential offsite radiological consequences resulting from a range of postulated accidental releases of radioactive materials. These changes are based on our review of relatively recent experimental data of atmospheric dispersion during stable atmospheric and light wind conditions, and on a recognition that our procedures should reflect variations in relative concentrations that occur as a function of wind direction and varying site boundary distance with direction. We did not formulate these changes specifically for the Blue Hills site; rather, we derived them on a generic basis to be applicable to most sites. Because the topographic and vegetative characteristics of several of the test sites, noted in the subsequent text, were similar to those of the Blue Hills site, we consider these changes appropriate for our analysis of the atmospheric dispersion conditions of the Blue Hills site.

Recently collected experimental data have established a basis for more realistic evaluations of atmospheric dispersion conditions during light wind and relatively stable atmospheric conditions. Quantitative atmospheric tracer studies representing ground level releases without the effects of buildings have been performed at the River Bend, Three Mile Island, and Clinch River power reactor sites and at the Idaho National Engineering Laboratory. These tests have shown that during stable atmospheric conditions (as defined by the vertical temperature difference criteria in Regulatory Guide 1.23, "Onsite Meteorological Program") when the wind speed is light, measured effluent concentrations are usually substantially lower than those predicted by the use of the traditional prediction curves (Reference 17) of lateral and vertical plume spread.

Preliminary data from recent atmospheric dispersion tests at the Rancho Seco power reactor site, conducted to determine the combined effects of meander and building wake on relative concentrations, also indicate that during light wind and relatively stable atmospheric stability conditions, measured concentrations are generally lower than those predicted by the use of the traditional prediction curves. Further, the contribution of building wake cavity mixing for reducing effluent concentrations is masked by the plume meander during these conditions.

Using these test data, we have formulated a generalized and reasonably conservative, yet more realistic, assessment methodology for the relative concentration (X/Q) calculations used in design basis accident evaluations. This method is applicable to assumed vent releases, or releases from other building penetrations, at most sites.

The NRC Reactor Site Criteria, i.e., 10 CFR Part 100, specify the limiting doses to an individual located at any point on the boundary of the exclusion area. Part 100 also references Technical Information Document TID-14844 (Reference 16) for further guidance on siting practices of the Commission. However, these two documents are mute on how the impact of directional dependent factors (exclusion boundary distance, dispersion rate, and wind frequency) should be assessed. To assess these directionally dependent factors, the model provides X/Q values at a constant probability level for individuals at different locations on the exclusion boundary. It considers directionally variable exclusion boundary distances and site specific directional frequencies of atmospheric dispersion conditions.

Using the modified dispersion model, we have made conservative assessments of post-accident atmospheric dispersion conditions for the Blue Hills site. In the model, we used the applicant's meteorological data for two years of onsite data collection (October 15, 1973 - October 14, 1975) with wind direction and speed measured at the 33-foot level. Data recovery for this period and this level was 93 percent.

We have calculated values for the various time periods following an accidental release. We assumed a ground-level release with a building wake factor, cA, of 1000 square meters, a value suggested by the applicant. If buildings are constructed on this site that result in a different building wake factor, we will adjust our X/Q values in our construction permit review.

The relative concentration for the 0-2 hour time period which is exceeded no more than five percent of the time is 1.1×10^{-3} seconds per cubic meter at an exclusion distance of 1369 meters (measured from the outside edge of the containment buildings and suggested in the Preliminary Safety Analysis Report).

The relative concentration values for various time periods at the outer boundary of a Low Population Zone of 4800 meters are:

Time Periods	X/Q (seconds per cubic meter)
0-8 hours	1.7×10^{-4}
8-24 hours	1.2×10^{-4}
1-4 days	4.8×10^{-5}
4-30 days	1.4×10^{-5}

For purposes of comparison, the following are the X/Q values calculated using the model described in Standard Review Plan Section 2.3.4.

The relative concentration for the 0-2 hour time period which is exceeded no more than five percent of the time is 1.4×10^{-3} seconds per cubic meter at an exclusion distance of 1369 meters (measured from the outside edge of the containment buildings and suggested in the Preliminary Safety Analysis Report).

The relative concentration values for various time periods at the outer boundary of a Low Population Zone of 4800 meters are:

Time Period	X/Q (seconds per cubic meter)
0-8 hours	1.8×10^{-4}
8-24 hours	1.2×10^{-4}
1-4 days	4.8×10^{-5}
4-30 days	1.4×10^{-5}

2.3.5 Long-Term (Routine) Dispersion Estimates

We have made reasonable estimates of average atmospheric dispersion conditions for the Blue Hills site using our atmospheric dispersion model for long-term releases (Reference 15). This model is based on the "Straight-Line Trajectory Model" described in Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactor." We assumed a ground-level release only and considered the effects of airflow recirculation and stagnation. Neglecting plume depletion and radioactive decay, the highest offsite annual average relative concentration of 4.1×10^{-5} seconds per cubic meter would occur at the east boundary 1369 meters from the reactor complex, as described in the Preliminary Safety Analysis Report.

2.3.6 Conclusions

The applicant has provided sufficient information concerning those meteorological conditions which are of importance to the safe design and siting of a nuclear power plant at the Blue Hills site. The design basis tornado parameters proposed for the site conform to the provisions of Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants." The applicants' onsite meteorological program conforms to the provisions of Regulatory Guide 1.23, "Onsite Meteorological Program," and has produced two years (October 15, 1973 - October 14, 1975) of onsite meteorological data which provides an acceptable basis to determine site atmospheric dispersion conditions and which was used by us to make both conservative and realistic estimates of atmospheric dispersion characteristics for accidental and routine gaseous releases, respectively, for the Blue Hills site.

2.4 Hydrology

2.4.1 Hydrologic Description

The Blue Hills site is located in the Mill Creek basin eight miles west-southwest of the Toledo Bend Dam. The lower portion of the Toledo Bend Reservoir is between the site and the dam. When the water level is at the top of the spillway gates, the closest point of the reservoir is just over one mile from the site. The site lies on a ridge between two small creeks. Copperas and Mitchell Creeks are approximately a mile apart at the site. The proposed plant grade is 270 feet above mean sea level; 97 feet above the top of the dam spillway gates, more than 50 feet above the higher creek bed (Mitchell Creek) near the site.

Copperas Creek, which is northwest of the site, flows into Mill Creek approximately 0.3 miles downstream of the proposed location for plant cooling towers (Preliminary Safety Analysis Report Figure 2.4-1), has a drainage area of approximately four square miles and an estimated average flow of 4.4 cubic feet per second.

Mitchell Creek, which is southwest of the site, flows into Mill Creek about 0.8 miles downstream of the mouth of Copperas Creek (Preliminary Safety Analysis Report Figure

2.4-1), has a drainage area of approximately five square miles and an estimated average flow of 5.5 cubic feet per second.

Mill Creek, which follows a northeasterly course to the point where it empties into Toledo Bend Reservoir approximately two miles from the site, has a drainage area of approximately 20 square miles. A stream gage, a device to measure stage, located below Mitchell Creek about one half mile upstream from Toledo Bend Reservoir, has been in operation since July 1974. The annual average flow estimated from the first nine months of data was 26.5 cubic feet per second. This is more than the 19.7 cubic feet per second estimated for Mill Creek using data from several nearby streams that have been gaged for about 20 years. These nearby streams, however, show higher than average flow for the period of the Mill Creek gage record.

Toledo Bend Dam is located on the Sabine River at river mile 156.5, where the drainage area is 7178 square miles. The top of the dam is 185 feet above mean sea level, the top of the power pool (that portion of the reservoir used for hydroelectric power generation) 172 feet above mean sea level, and the top of the gates 173 feet above mean sea level. At elevation 172 feet above mean sea level, the reservoir covers 182,000 acres and contains almost 4.7 million acre-feet of water. Water from the reservoir is used for irrigation, municipal and industrial water supplies, hydroelectric power generation and recreation. The entire water supply for normal plant operation would be obtained from Toledo Bend Reservoir.

2.4.2 Probable Maximum Flood on Streams and Rivers

There are no recorded data on floods in the Mill Creek Basin. The probable maximum flood elevation is estimated to be 243 feet above mean sea level near the site; this is well below plant grade of 270 feet above mean sea level. Because of this large freeboard we concluded that the probable maximum flood does not constitute a threat to the Blue Hills site.

The probable maximum flood in the Mill Creek basin was based on the probable maximum precipitation (from U.S. Weather Bureau Hydrometeorological Report No. 33) during a 24-hour storm. Due to the small size of the basin, longer storm periods did not need to be considered. The basin was divided into 14 runoff areas and the probable maximum flood flow for each was computed using a nondimensional unit hydrograph developed from regional data. An initial loss of 1.0 inch, followed by a continuous loss of 0.05 inch per hour was used. Due to the proximity of the Blue Hills site to the Toledo Bend Reservoir, ba. ater computations were made using a conservative water level of 190 feet above mean level in the reservoir. Using these conservative assumptions the applicant calculated the water levels in the two creeks adjacent to the site; i.e., Copperas Creek and Mitchell Creek. Near the site, water levels are higher in Copperas Creek than in Mitchell Creek, but the maximum level of 243 feet above mean sea level for the probable maximum flood is well below plant grade. Because of this large freeboard, wind wave runup was not calculated.

On the basis of our review of the applicant's analysis, we conclude that a probable maximum flood does not constitute a threat to the Blue Hills site.

2.4.3 Other Potential Floods

Since no dams exist in the Mill Creek basin, the Blue Hills site is not susceptible to a dam failure flood.

Surges and seiches on Toledo Bend Reservoir will not affect the site because it is more than a mile away and almost 100 feet above the normal reservoir water level. There is no other large water body near the site.

Due to its inland location, the Blue Hills site is not susceptible to tsunami flooding.

Relatively mild winters in the site area preclude the possibility of ice flooding and associated damage to safety-related facilities.

2.4.4 Cooling Water Canals and Channel Diversions

The proposed cooling water canals (which are not safety related), designed for a flow of 1200 cubic feet per second with 3.5 feet of freeboard for wind wave effects, are well above the probable maximum flood level.

Channel diversions in the Mill Creek basin will not affect plant operation because none of this water is used. The proposed ultimate heat sink design for a nuclear power plant; i.e., mechanical draft cooling tower, at the Blue Hills site is not dependent upon Toledo Bend Reservoir water level. In the extremely unlikely event of the loss of water to the plant from the Toledo Bend Reservoir, the applicant has stated that a nuclear power plant could be safely shut down and maintained in safe shutdown for at least 30 days, using the ultimate heat sink design (Section 2.3.1 of this report) proposed by the applicant.

2.4.5 Flooding Protection Requirements

The site, at elevation 270 feet above mean sea level, is well above the level of the probable maximum flood. The applicant has committed to design the roofs of all safety-related buildings and the site grading and drainage to prevent a threat to safety-related facilities by the localized probable maximum precipitation.

2.4.6 Low Water Considerations

The normal water supply for the station will be taken from the Toledo Bend Reservoir which has a total storage of 4.7 million acre-feet. Average annual regulated inflow is 2.7 million acre-feet and the 100-year low annual inflow is estimated by the applicant to be 0.25 million acre-feet. Since the initial filling of the reservoir, in 1968, the lowest level was at 166.5 feet above mean sea level, on September 29 1972. The ultimate heat sink design proposed by the applicant (Section 2.3.1 of this report) will not be dependent on the water level in the Toledo Bend Reservoir.

2.4.7 Environmental Acceptance of Effluents

At our request, the applicant provided an analysis of an accidental spill of liquid radioactive wastes. A postulated failure of a boron management system holdup tank releasing 124,000 gallons to the groundwater was evaluated. This tank is expected to contain the highest total quantity of activity in a proposed plant. The analysis showed that all radionuclides will be below the maximum permissible concentration listed in the 10 CFR Part 20 Appendix B at the point where Mitchell Creek leaves the site exclusion area. In addition, there is no present or projected future use of any of the surface waters in the Mill Creek basin. We conclude that there is little likelihood of contamination of potable water supplies outside the site exclusion area from an accidental spill.

2.4.8 Groundwater

The site is located in sediments of the Gulf Coastal Plain, which contain large quantities of water commonly occurring under confined conditions. The permeable sands containing the groundwater are interbedded with less permeable clays, silts and silty clays which act to confine the water in the sands. In Newton and Jasper counties the major aquifers are the Chicot, Evangeline and Jasper with an aquiclude, the Burkeville, sep[illegible]ing the Jasper from the other two overlying aquifers.

The total estimated use of groundwater in Newton and Jasper counties was 52 million gallons per day in 1965 of which more than 40 million gallons per day were produced in one well field to supply a paper mill 60 miles from the site. Of the balance, about five million gallons per day were for domestic and agricultural use and the rest was uncontrolled discharge from flowing wells.

Groundwater beneath the site occurs in two zones, both part of the Jasper Aquifer. A perched water table, within 20 feet of the surface, is present above localized lenticular clay interbeds. The main water zone is at a depth of 70 to 80 feet below the site. Recharge is by percolation of water flowing around the overlying lenticular clay bodies and by infiltration from Copperas Creek. Groundwater movement is to the northeast apparently toward Toledo Bend Reservoir.

Nearly all the wells within 10 miles of the site extract less than 10 gallons per minute. There are no wells downgradient of the plant between the site and Toledo Bend Reservoir. Groundwater will not be used for plant operation; all the water used [illegible] come from Toledo Bend Reservoir.

Groundwater levels at the site are at elevations ranging from 190 to 210 feet above mean sea level, excluding the perched water tables. To prevent groundwater hydrostatic loading due to perched water tables, the applicant has stated that during construction, the upper clay stratum will be removed in the plant area and replaced by compacted sand backfill. We find this to be acceptable.

Based on our evaluation of the present groundwater levels, topography at the site and the applicant's commitment to remove the higher perched water table during construction, we conclude that the proposed design basis groundwater level of 215 feet above mean sea level is conservative and acceptable for use in the design of a nuclear power plant at the Blue Hills site.

2.4.9 Conclusions

On the basis of our review, we conclude that the flood analysis for the Blue Hills site meets the criteria in Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants," and that flooding does not constitute a threat to the site. We also conclude that there is little likelihood of contamination of potable water supplies outside of the site exclusion area from an accidental release of liquid effluents.

2.5 Geology and Seismology

The seismology and geology review of this site addressed the geologic history of the region including physiographic, lithologic, stratigraphic and tectonic settings as well as the subregional and site-specific geology and seismology. In addition to reviewing data submitted in the Preliminary Safety Analysis Report, NRC staff geologists and seismologists visited the site and its environs. During this visit we examined the regional geology. We also conferred with the applicants consultants concerning problems of geologic interpretation in the site region.

On this basis we conclude that investigations performed by the applicant have been sufficient to adequately assess site geologic conditions in accordance with "Seismic and Geologic Siting Criteria for Nuclear Power Plants," Appendix A, 10 CFR Part 100.

In our review we have followed the tectonic province approach as described in 10 CFR Part 100 Appendix A to determine the vibratory ground motion corresponding to the safe shutdown earthquake. The seismicity and structural features of the site region are not clearly distinct from those found generally throughout the major portion of the Gulf Coastal Plain Tectonic Province. Therefore, we have concluded as a result of our review that an earthquake producing intensity VI on the Modified Mercalli (MM) scale at the site, i.e., an acceleration of 0.07g should be considered in evaluating the safe shutdown earthquake. We concur with the applicant that the safe shutdown earthquake of 0.13g represents an appropriate and conservative reference acceleration for seismic design of structures at the Blue Hills site.

2.5.1 Regional Geology

The site is located within the Gulf Coastal Plain physiographic province which is the onshore portion of the Gulf Coast Geosyncline which extends under the Gulf of Mexico to the edge of the continental shelf. The sedimentary deposits in the region range in age from Jurassic to Recent and consist mainly of unconsolidated sands, silts, clays, limestone, and chalk with minor amounts of salt. The sediments form a wedge that diverges seaward, exceeding 50,000 feet in total thickness. At least 20,000 feet of sediments underlie the Blue Hills site.

Due to consolidation of the thick sedimentary section, the general dip of the strata increases gulfward at slightly greater angles than the present landsurface. Differences in resistance to erosion of the sediments resulted in a series of linear topographic belts which are parallel to the Gulf Coastline. The more resistant formations form landward facing cuestas with relief up to 400 feet or more. Salt domes which are common to the east Texas region are not known to occur closer than approximately 55 miles from the site.

The pre-Mesozoic history of events in the site region is unknown because the Paleozoic rocks are buried beneath thick Mesozoic and Cenozoic strata beyond reach of investigatory methods presently known. Evidence indicates that the Gulf Coastal Plain Province was initiated from late Paleozoic orogenies. The discontinuous Triassic sediments in the region underlie more than 8,000 feet of Jurassic sediments, which in turn are overlain by more than 9,000 feet of calcareous sediments of Cretaceous age.

The Tertiary sediments in the region include marine, continental, and deltaic deposits consisting of fine-grained clastic material with relatively little carbonate content in contrast to the Cretaceous sediments. In excess of 8,000 feet of Tertiary sediments underly the proposed site.

The Pleistocene terraces in the region, presumed to have developed during inter-glacial high sea levels, consist of four distinct terraces overlying the Miocene and early Pliocene strata. They decrease in age and altitude going seaward. The names of the terraces from oldest to youngest are: the Willis (or Williana), the Bentley, the Montgomery, and the Prairie (or Beaumont). They range in age from approximately 1,000,000 years for the Willis to as young as 60,000 years for the Prairie.

2.5.2 Tectonic Structures

One of the structural features most significant to the site is the Sabine Uplift which is flanked on the west by the East Texas Basin and on the east by the North Louisiana Basin. It is a structural high up to 100 miles in extent, and is located approximately 90 miles north of the proposed site. The Sabine Uplift appears to have undergone differential arching during Mesozoic and Cenozoic time. The Sabine Uplift, superimposed on the sediments of the Gulf Coastal Plain, was manifested in these sediments with the development of the Angelina-Caldwell Flexure or monocline. This flexure is located on the southern flank of the Sabine Uplift approximately 10 miles north of the proposed site. It is readily distinguishable by the abrupt change from the essentially flat-lying strata of the domal uplift to the steeply dipping strata on the flank of the uplift. Anderson (Reference 1) describes the flexure as a zone two to five miles wide, along which the dip of the Tertiary and older sediments increases from 45 feet to 250 feet per mile with an occasional dip as great as 316 feet per mile. The width of the flexure increases to the east and west away from the Sabine River.

The Fisher Fault Zone trends along the Angelina-Caldwell Flexure and is concentrated where the transition or flexure in the bedding is most pronounced, a point where the potential for normal faulting would be expected to be greatest. Tensional stresses in the near-surface strata, resulting from bending of the strata over the Angelina-Caldwell Flexure, would be expected to develop shallow, normal faults, such as are found in the Fisher Fault Zone. The fault zone is five to 10 miles wide and the overall length of the zone may be as much as 60 miles; if projected the fault zone would pass about 10 miles north of the site. Fault displacement ranges from 250 feet on faults in Sabine Parish, where the greatest flexure occurs, to tens of feet in Sabine County, where flexure is less pronounced.

In the site vicinity there may be faults (none are known to exist within a five mile radius of the site) of non-tectonic origin characterized by steep, near surface dips which become less steep with depth and eventually pass into bedding planes. Another characteristic of these faults is the thicker strata on the downthrown side, where accumulation occurred simultaneously with fault movement. They are referred to as growth faults and are predominantly of low stress, since they are shallow rooted. They typically do not develop large strain and sudden stress releases which are characteristic of damaging earthquakes, and therefore, are not considered to present a hazard to the proposed site.

We have questioned the capability of the faults in the Fisher Fault Zone and their significance to the site. The following served as the bases for our concern on this matter.

(1) Holdahl and Morrison (Reference 2) investigated vertical crustal movements by means of precise level surveys in the Gulf Coast States, including the site region, and reported that the region north and northwest of the site is rising at a rate of one to five millimeters per year, while the coastal zone south of the site is subsiding at a rate of one to five millimeters per year.

(2) Faults in the Fisher Fault Zone appear on geologic maps to cut to the ground surface and to be capped by Pleistocene terrace deposits. The fault zone is not dated in the literature.

(3) Lineations observed in Earth Resources Technology Satellite photos, which could have structural origin, trend in the direction of the site.

In response to our concerns the applicant provided new precise level data (Preliminary Safety Analysis Report Figure 2.5-53) which demonstrated that the axis of the vertical movement is occurring in a northeast-southwest, rather than the originally reported east-west direction, which obliquely crosses the axis of the Angelina-Caldwell Flexure. On the basis of this later information on vertical crustal movements in the site region, the applicant concluded that present-day vertical movements do not fit the known structural framework of the site region and, therefore, are not considered a threat to the site.

The Sabine Uplift and Angelina-Caldwell Flexure have not had significant movement since the Williana terrace (early Pleistocene in age) was deposited across the uplift and flexure areas. Doering (Reference 3) shows that the terraces overlying both structures have not been significantly uplifted or warped. On the basis of lack of evidence of vertical movement the applicant concludes and we agree that insofar as the Sabine Uplift, the Angelina-Caldwell Flexure, and the Fisher Fault Zone are structurally interrelated, lack of activity on the Sabine Uplift and the Angelina-Caldwell Flexure during the greater part of Pleistocene time suggests a similar inactiveness of the Fisher Fault Zone.

Seismic reflection surveys taken across the Fisher Fault Zone produced profiles having inconclusive information as to depth and age of faulting. The record became obscure at the elevations where they might have been used to determine with confidence whether faulting terminated at a shallow depth, and whether the faults were capped by dateable strata.

At our request, the applicant investigated whether terraces which cross the regional lineaments observed on Earth Resources Technology Satellite photos that trend toward the site could be utilized to help establish the age and significance of the lineaments. As a result of the investigation, the applicant determined that in the site area the older terraces are too badly eroded to be of any use for dating, and that the Beaumont (age: 150,000 to 60,000 years) is the oldest terrace useful for age dating the lineaments. After evaluating the Beaumont and older terraces near the site and in other areas, the applicant concluded that "Field examination of terrace surfaces and of outcrops of terrace deposits and underlying strata along Earth Resources Technology Satellite lineaments trending southwesterly toward the site has verified that these deposits display no evidence of deformation or offset."

Another fault system that trends within approximately 28 miles of the site is the Bancroft-Mamou fault system, located to the south and consisting of en echelon, down-to-basin faults, having a total length of about 200 miles. The fault system is considered to be the result of compaction of great thickness of sediments. The faults in the system are growth faults which are shallow rooted and typically do not develop damaging earthquakes.

On the basis of the above evidence, we have concluded that there are no geologic faults or other tectonic structures that present a potential hazard to the proposed site.

2.5.3 Site Geology

The Blue Hills site is located in the eastern part of the West Gulf Coastal Plain. The Mississippi Alluvial Plain divides the Gulf Coastal Plain province into east and west segments. The proposed site is characterized by cuesta-like low rolling ridges which have broad tops and steep sites, and which parallel the regional strike of the bedding. The ground surface elevation at the site ranges between 200 and 290 feet above mean sea level.

The site is located on the slope of the Kisatchie wold, which is an out-cropping of Catahoula formation more resistant to erosion than the surrounding strata. The wold is a significant physiographic marker which delineates the belted terrain of the Gulf Coastal Plain province.

The lithologic units underlying the plant site, beginning with the uppermost unit, are a 15-foot thick sand stratum underlain by 17 feet of thick clay, which in turn is underlain by the 113-foot thick middle sand stratum of the Catahoula formation. The middle sand overlies the 77-foot thick lower clay stratum, which in turn overlies the lower sand stratum of undetermined thickness. The water table is in the middle sand at average elevation 203 feet above mean sea level.

As the result of the applicant's comprehensive investigatory program, the applicant states in the Preliminary Safety Analysis Report that:

(1) "No deformational zones, such as folds, fissures, slips, faults, and shears, have been found at the site."

(2) "The nearest known salt dome is approximately 55 miles south of the site."

(3) "No oil, gas, or other mineral extraction has been or is presently being conducted within a five mile radius of the site, and ground water extraction in the vicinity of the site is not sufficient to cause subsurface subsidence. Also there is no record of subsurface mining or other similar underground workings in the area which might create a subsidence problem at the site."

(4) "All lineaments recognized in a ten-mile radius of the site on small-scale infrared and large-scale panchromatic photography were investigated in the field.... No indication of fault offset was observed."

On the basis of our review of the information in the literature and field evidence developed by the applicant, we conclude that there are no geologic structures, or conditions resulting from man's activities, such as mining or oil extraction, that present a hazard to the site. In addition, the problem of subsidence, such as is characteristic of the Houston, Texas area is not a factor at the Blue Hills site.

2.5.4 Tectonic Provinces

King (Reference 4) in his discussion of the tectonic map of North America defines the Atlantic and Gulf Coastal Plains as platform deposits (Mesozoic and younger) that were laid over the deformed Paleozoic and older rocks of the Appalachian and Ouachita fold-belts. The platform deposits thicken and slope seaward from the exposed parts of these fold-belts, the basement descending beneath them. From the State of New Jersey to the Llano uplift in central Texas the landward border of the platform deposits on Paleozoic basement is drawn at the edge of Cretaceous and (or) Tertiary deposits of the coastal plains, where they overlap on older rocks. These limits define the Coastal Plain. The Gulf Coastal Plain Tectonic Province, in which the Blue Hills site is located, is that part of the Coastal Plain extending from west Florida westward and southward into Mexico (Reference 5).

2.5.5 Earthquake Activity and Geologic Structure

The historical earthquake activity nearest the site occurred about 15 miles northwest of the site in the vicinity of the towns of Yellowpine, Hemphill, and Pineland, Texas (References 6, 7, 8, 9). Numerous earthquakes occurred in the Hemphill area in 1964. Five of these earthquakes had Richter magnitudes in the range 3.4 to 4.4 and epicentral intensities near V (MM) (Reference 9). Several additional smaller events were recorded on a high sensitivity seismograph installed at Hemphill in 1964. No other earthquakes besides those occurring in 1964 have been reported in this area. The earthquake activity is coincident with a projection of a zone of small faults, the Fisher Fault Zone, and with the Angelina-Caldwell Flexure, a monocline involving rock units as young as Tertiary. As discussed in the geology section of this report, geologic evidence supports the conclusion that the faulting in the Fisher Fault Zone is related to the development of the Angelina-Caldwell Flexure and is not capable. Since the earthquake activity near Hemphill occurred prior to the start of filling at either Lake Sam Rayburn or Toledo Bend Reservoir (Reference 9), the earthquake activity is not reservoir related.

The largest earthquakes (References 6, 7, 9) within 200 miles of the site were an earthquake with epicentral intensity VII (MM) in the town of Rusk, Texas about 100 miles northwest of the site in 1891, an earthquake with epicentral intensity VI (MM) at Donaldsonville, Louisiana about 190 miles from the site in 1930, and an earthquake with epicentral intensity V-VII (MM) near the towns of Mexia and Wortham, Texas about 180 miles from the site in 1932. It should be noted that the applicant has posed the hypothesis that the damage at Rusk, Texas in 1891 was due to severe weather and not an earthquake as reported. The damage reports from all three of these events were very sparse (References 6, 7, 9). The felt areas were 18,500 square miles for the Donaldsonville earthquake, 100 square miles for the Mexia-Wortham earthquake, and the Rusk earthquake was felt only in the town of Rusk. Based on an empirical relation between earthquake magnitude (measured on a regional magnitude scale developed by Nuttli.) and felt area (Reference 10), the Donaldsonville earthquake had a felt area no greater than that for a typical earthquake of magnitude 4.5, epicentral intensity V-VI (MM). Based on this analysis the Mexia-Wortham and Rusk earthquakes were much smaller than a typical earthquake of epicentral intensity VI (MM), i.e., the energy released by these events was less than that released by an average event of epicentral intensity VI (MM).

For the purpose of establishing the safe shutdown earthquake for nuclear power plants in the Gulf Coastal Plain, we recognize that different regions of this large province exhibit vastly different levels of seismicity. In particular, to arrive at the appropriate choice of the safe shutdown earthquake for the Blue Hills site, we recognized four seismic zones: (1) the Mississippi Embayment Earthquake Zone, (2) the Southern Cordilleran Front Zone, (3) the zone at the intersection of the Ouachita Tectonic Belt and the Wichita Structural System, and (4) a Gulf Coast Seismic Zone.

The Mississippi Embayment Earthquake Zone is a region of much higher seismic activity than the remainder of the eastern United States. It has also been the source region of the largest earthquakes in the eastern United States, the 1811-1812 New Madrid earthquakes. The closest approach to the site of the Mississippi Embayment Earthquake Zone was established at the Monroe Uplift during our review of the Grand Gulf site and the closest approach of earthquakes similar to the 1811-1812 series is considered to be near Memphis, Tennessee, over 340 miles from the site.

The Southern Cordilleran Front consists of a belt of Laramide folds and thrust faults extending southward from New Mexico and Texas into central and eastern Mexico (References 4, 5). Several earthquake epicenters are located along this zone including the Valentine, Texas earthquake of 1931 which had an epicentral intensity of VIII (MM). The epicentral intensity of the largest reported historical earthquake in this zone would be less than X (MM). This zone apparently intercepts the Gulf Coastal Plain and has its closest approach to the Blue Hills site approximately 520 miles southeast of the site.

Within the remainder of the Gulf Coastal Plain (the region between west Florida and where the Gulf Coastal Plain is narrowed and partly intercepted by the outer folds of the Cordillera in Mexico) there is very little seismic activity. Few small earthquakes, none larger than VII (MM), have been recorded.

One of the two intensity VII (MM) earthquakes that have occurred in the general area of interest, is the 1882 earthquake located near Paris, Texas. This earthquake was recently relocated by Docekal (Reference 7) based on a reevaluation of its effects and characteristics. The region of maximum intensity is located at the intersection of the Ouachita Tectonic Belt and the Wichita Structural System. This is a complex region where various complex tectonic forces have acted (Reference 4). The Ouachita Tectonic Belt is recognized in this area as a region of intense folding and thrust faulting which developed principally in Pennsylvanian time. The Wichita Structural System includes a number of block uplifts and fault-bounded basins and strikes northwest-southeast in southern Oklahoma and north-central Texas. The segmentation of the Wichita System into the various crustal blocks of its present configuration came during several stages of Pennsylvanian orogeny. Further adding to the tectonic complexity of this area is the Nemaha Uplift, a nearly north-south structure of sharply uplifted and faulted Precambrian basement material which also formed during the Pennsylvanian orogeny (Reference 5). The Nemaha Uplift apparently trends into the Wichita System and terminates in the vicinity of the Arbuckle Mountains.

Numerous earthquake epicenters, none larger than epicentral intensity VII (MM), coincide with each of these three tectonic units. Therefore, we consider the 1882 earthquake to be located in a tectonic province separate from the remainder of the Gulf Coastal Plain as suggested by Docekal (Reference 7) who relates the earthquake to the buried structures associated with the Arbuckle Mountains. The closest approach of these structures to the site is about 200 miles.

Active surface faults are recognized in the Gulf Coast. In the Gulf of Mexico, active slump faulting or growth faulting is also occurring. There are various models proposed for the mechanisms of this faulting; however, in view of the low level of seismicity for the region, we conclude that the typical movement on these faults is a fault creep process and does not release significant seismic energy in the form of earthquakes. We have, therefore, not considered such faults to be capable of generating significant earthquakes.

2.5.6 Safe Shutdown Earthquake

As discussed in Section 2.5.5 of this report, we recognize four seismic zones within the large Gulf Coastal Plains Tectonic Province: (1) the Mississippi Embayment Earthquake Zone, (2) the zone in which the 1882 Paris, Texas earthquake occurred, (3) the Southern Cordilleran Front Zone, and (4) the remainder of the Gulf Coastal Plain (the Gulf Coast Seismic Zone) which includes the Blue Hills site. Of the former three zones, the Southern Cordilleran Front Zone and the zone in which the Paris, Texas earthquake occurred are so remote from the site, that the resulting intensity at the site from the largest historical earthquakes located in these zones is less than would occur at the site from a random earthquake located in the Gulf Coast Seismic Zone, assuming a conservative relation between intensity and epicentral distance (References 11, 12, 13). Nuttli (References 11, 12) has taken a critical look at the epicentral intensities of the larger earthquakes in the Mississippi Embayment Earthquake Zone and has found that the earthquake of February 7, 1812 was the largest. He has estimated the epicentral intensity of this earthquake to be

XI-XII (MM). If we accept this assessment and use a conservative relation between intensity and epicentral distance (References 11, 12, 13), the intensity from an earthquake of epicentral intensity XI-XII (MM) assumed to occur 340 miles from the site could reach VII (MM) at the site. Though this earthquake might be expected to produce a site intensity as great as or greater than a local earthquake in the Gulf Coast Seismic Zone, we believe the acceleration level would be greater for the latter event. Several lines of evidence lead to this conclusion. First, existing data on accelerations recorded at various distances from earthquakes reveals that high accelerations are unlikely at such large epicentral distances (Reference 14). This observation is in agreement with the theoretical considerations which predict more rapid spatial attenuation of the higher frequency waves responsible for higher acceleration levels. Furthermore, studies by Nuttli (References 11, 15) on attenuation and ground motion in the midcontinent would indicate that much lower acceleration levels are appropriate. Finally, much of the damage produced by the New Madrid earthquakes may have been the result of soil failure (Reference 16), and studies on various types of soil failure indicate that long duration motions with relatively low accelerations can produce such failure (Reference 17).

The largest historical earthquakes in the Gulf Coast Seismic Zone were the Rusk, Texas earthquake of 1891, the Donaldsonville, Louisiana earthquake of 1930, and the Mexia-Wortham, Texas earthquake of 1932. Based on the discussion provided above, these earthquakes were no larger than typical earthquakes of epicentral intensity VI (MM). Following the tectonic province approach described in Appendix A to 10 CFR Part 100, this intensity was assumed to occur at the site in determining the safe shutdown earthquake.

Empirical relationships between intensity and acceleration were used in assessing the ground motion corresponding to a Modified Mercalli intensity VI earthquake occurring near the site. In 1954 Neumann (Reference 18) developed an empirical relationship between earthquake intensity and ground acceleration. More recently Trifunac and Brady (Reference 19) have published a relation between intensity and acceleration which was developed using many additional observations. Trifunac and Brady's data essentially corroborate the relationship published by Neumann. Utilizing either the Neumann or the Trifunac-Brady relation between intensity and acceleration, the mean acceleration corresponding to a Modified Mercalli intensity of VI is about 0.07g.

The applicant for the Blue Hills site has conservatively proposed to use 0.13g for the safe shutdown earthquake acceleration level. Based on the Neumann or the Trifunac-Brady relationship, the intensity corresponding to a mean acceleration of 0.13g is VII (MM). As discussed above, earthquakes as large as this have not been observed in the historical record of seismicity for the Gulf Coastal Plain except in the area of the Southern Cordilleran Front, the complex region at the intersection of the Ouachita Tectonic Belt, the Wichita Structural System, and the Nemaha Uplift, and in the highly seismic area of the nor ern Mississippi Embayment.

Neither the high seismicity nor the structural complexity found in these areas where large earthquakes have occurred is present in the vicinity of the Blue Hills site. However, the proximity of the site to the location of the Hemphill earthquake activity may warrant the additional conservatism proposed by the applicant.

Therefore, we concur with the applicant that for the safe shutdown earthquake 0.13g represents an appropriate and conservative reference acceleration for seismic design of structures at the Blue Hills site. The applicant has proposed to use Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," response spectra scaled to this maximum acceleration for the design of a nuclear power plant at the Blue Hills site.

2.5.7 Operating Basis Earthquake

The applicant has proposed to use 0.07g for the acceleration level corresponding to the operating basis earthquake. Based on the Neumann or Trifunac-Brady relationship between intensity and acceleration, an acceleration of 0.07g is representative of intensity VI (MM). Considering the low seismicity of the Gulf Coast Seismic Zone, the proposed operating basis earthquake appears conservative. The applicant has proposed to use Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," response spectra scaled to this maximum acceleration of 0.07g for the operating basis earthquake to be used for the design of a nuclear power plant at the Blue Hills site.

2.5.8 Stability of Soils and Foundations

The topography of the proposed plant site is gently rolling with elevations varying from 290 to 250 feet above mean sea level. Plant grade is at elevation 270 feet above mean sea level. The proposed plant site is to be located next to Mill Creek about two miles southwest of the Toledo Bend Reservoir. The geologic setting is described in Section 2.5.1 of this report.

The soils investigations for the proposed plant site included 84 preliminary borings up to 250 feet in depth, and 126 additional borings for engineering purposes up to 252 feet in depth. The latter borings included 88 undisturbed sample borings and 12 continuous borings from which samples for testing were obtained. These investigations reveal that the sedimentary soils at the proposed plant site occur in five sequences, characterized as follows:

(1) Elevation 270 to 264 feet above mean sea level is an upper sand stratum consisting of a medium to fine sand, which is poorly graded, as well as some silty and clayey sands.

(2) Elevation 264 to 247 feet above mean sea level is an upper clay stratum consisting of a hard, high plasticity clay which evidences overconsolidation.

(3) Elevation 247 to 134 feet above mean sea level is a middle sand stratum consisting of medium to fine sands with silt, and with some scattered clay seams. The water table is at an elevation of 203 feet above mean sea level.

(4) Elevation 134 to 57 feet above mean sea level is a lower clay stratum consisting of hard clays of low to high plasticity which also evidence overconsolidation.

(5) Elevation 57 feet above mean sea level to depth is a lower sand stratum apparently extending beyond a depth of 250 feet and consists of medium to fine sands with some silt.

Laboratory tests on soil specimens retrieved during the investigation program included determinations of shear strength, consolidation, dynamic properties, and seismic resistance to earthquake effects. The only unusual behavior noted was the amount of expansion of the clay samples when extruded from the sample tubes; some samples expanded up to 16 percent.

On the bases of our review of the geologic investigations and the laboratory analyses performed on the soil specimens by the applicant, we conclude that this information is adequate to serve as the basis for the design of safety-related plant structures.

2.5.9 Foundations

The plan for the support of safety-related plant structures is uncomplicated. The applicant has stated that upper clay and upper sand strata will be excavated. Deep plant foundations will rest directly on or in the middle sand stratum, i.e., the third sequence. Shallower plant foundations will rest on compacted granular backfill supported by the middle sand stratum.

Deeply founded structures will be the reactor building, auxiliary building, control building, and ultimate heat sink-nuclear service water cooling towers. Structures founded on backfill will be the fuel building, cooling water building, radwaste building, and diesel generator building. The applicant has stated that all foundations will be individual mats.

Our review and acceptance of the foundation design proposed by the applicant is based on an envelope of dimensions, structure depths, loadings, and stated assumptions. Therefore, at the construction permit application stage, we will require that the applicant validate the applicability of the foundation design that we have reviewed to the specific nuclear power plant design proposed as follows:

(1) Table 2.5-1 of this report lists the parameters which serve as the bases for acceptability of the foundation design. The applicant will justify that for the specific nuclear power plant design proposed these parameters are satisfied.

Table 2.5-1

FOUNDATION DESIGN PARAMETERS

Structures	Values expressed as feet		Values expressed in thousand pounds per square foot	
	Plan Dimensions	Depth Below Grade	Total Bearing Pressure[a]	Net Bearing Pressure[b]
Reactor Building	140 diameter	35	6.6	2.4
Auxiliary Building	140 x 201	30 to 58	2.8 to 5.0	-4.2 to 1.4 (c)
Control Building	120 x 154	25	3.1	0.2
Ultimate Heat Sink and Nuclear Service Water Towers	120 x 294	30	2.9	-0.8 (c)
Fuel Building	75 x 125	5 to 10	3.1	1.9 to 2.5
Radwaste Building	143 x 213	5	3.1	2.5
Diesel Generator Building	63 x 85	5	4.8	4.2

Notes:

(a) Total bearing pressure is the weight of the structure divided by the bearing area of the foundation

(b) Net bearing pressure is the total bearing pressure less the effective pressure exerted by the soil to be removed by excavation to the foundation elevation

(c) Negative values of net bearing pressure indicate that the effective pressure before excavation is greater than the pressure applied by the foundation of the structure

(2) The applicant must submit for our review and approval its criteria for construction control during (a) excavation and backfilling of the foundations, (b) remedial foundation treatment, (c) proof-rolling of the foundation, and (d) removal of unsuitable materials from the middle sand stratum.

(3) Standard Penetration Test data in the middle sand strata should be provided for our review as comparative plots of blowcount and effective pressure.

Criteria for backfill supporting safety-related structures is presented in Section 2C.10.4 of the Preliminary Safety Analysis Report. The applicant has stated that backfill materials will be classified and compacted according to accepted standards of the American Society for Testing and Materials. For clean, sandy materials, a relative density greater than 80 percent will be attained. For material with more than 12 percent fines, at least 93 percent of the Modified Proctor density will be attained. Test fills will be constructed to assure that the method of compaction during construction (type of equipment, number of coverages, etc.) will satisfy the backfill criteria set forth in Section 2C.10.4 of the Preliminary Safety Analysis Report.

On the bases of our review of the applicant's proposed foundation design we conclude that it is acceptable. The applicability of this foundation design to a specific nuclear power plant design will be demonstrated by satisfaction of the validation requirements stated herein at the construction permit stage.

2.5.10 Bearing Capacity and Settlement

The large mat foundations supporting plant structures impose relatively low net bearing pressures on the structural fill and soils of the middle sand stratum. Table 2C-3 of the Preliminary Safety Analysis Report indicates that net dynamic bearing pressures due to the safe shutdown earthquake are also relatively low, and that the site soils have adequate bearing capacity. We agree with this conclusion.

As a result of excavation into the middle sand stratum for the foundations of the plant structures, this stratum may be expected to rebound, i.e., heave, about 1.5 inches. As the structural loads and backfill is placed during construction, the middle sand stratum will be recompressed about 1.5 inches, plus an additional 0.5 inch due to the net loads imposed by the proposed plant structures. The estimated earthquake induced settlement is about 0.1 to 0.2 inches.

Although these estimated settlements are small and the soil conditions are seemingly well understood, the impact upon a specific nuclear power plant will be dependent upon the arrangement of the safety related structures and the differential settlement between safety related structures. Consequently, when we resume our review of the construction permit application, we will review the physical arrangement and loading of the applicant's safety related structures and the criteria for differential settlement between these structures. This review of a specific plant design will enable us to determine the need, if any, for monuments to be set in the middle sand and lower clay strata to measure heave due to excavation.

In addition, we will also determine the need for settlement and tilt monuments to be established on safety related structures. Such measurements could help to explain the unusual amount of expansion of the apparently overconsolidated clays, confirm the preload of the middle sand stratum and insure that long-term settlement and differential settlement effects will not pose an unexpected hazard to the plant.

2.5.11 Lateral Earth Pressures

Criteria for the lateral earth pressure acting on subsurface foundations has been established. For static conditions, the active earth pressure coefficient is 0.27, the at rest coefficient is 0.7, and the passive coefficient, considering limiting strains, is 1.58. For earthquake conditions, the dynamic passive pressure coefficient, is based on the Mononabe - Okabe method, as discussed in the Preliminary Safety Analysis Report (References 73, 74, 75, and page 2.5-174). The unit weight of the backfill (moist) is assumed to be 126 pounds per cubic foot.

On the basis of our review we consider the design criteria for lateral earth pressures to be acceptable.

2.5.12 Liquefaction Potential

The applicant analytically evaluated the liquefaction potential of the middle sand stratum by comparing the computed dynamic stresses induced in the site soils by the safe shutdown earthquake to the resistance of these same soils to cyclic stresses during tests in the laboratory. An earthquake motion having a duration of 24 seconds, a peak acceleration of 0.13g, and a response spectrum enveloping that given in Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," was assumed to represent the particle motion at the ground surface. Conservative assumptions regarding water table elevation and soil layering were made. The SHAKE program, as described in the Preliminary Safety Analysis Report (page 2.5-174, and Reference 68) was used to compute dynamic soil stresses. Undisturbed samples of soil were used for the undrained cyclic triaxial tests.

Based on our review, we conclude that the assumptions that the applicant has used in the analysis is conservative that the margins of safety determined by the applicant for the various conditions are considered to be adequate, and that risk of liquefaction due to seismic effects is remote at the Blue Hills site.

2.5.13 Dynamic Soil Properties

The dynamic properties of the soils at the site were measured by cross hole seismic surveys and small strain cyclic loading triaxial tests. The shear modulus of the in-situ middle sand stratum (for deeply founded plant structures identified in Section 2.5.9 of this report) at small strains varies from about 21,000 to 150,000 pounds per square inch. The shear modulus of the granular backfill (for backfill founded structures identified in Section 2.5.9 of this report) at small strains will be estimated from the relationships given in Table 2C-2 of the Preliminary Safety Analysis Report. For design purposes, the change in modulus and damping of the sand and clay with increasing strain was assumed to agree with values published by the University of California, as discussed in Preliminary Safety Analysis Report (Reference 67 and page 2.5-174). We find this assumption to be acceptable for soils at the Blue Hills site.

Based on our review, of the field and laboratory tests we conclude that the dynamic properties of the soils used in the applicant's analyses are reasonable for this site and are therefore acceptable.

2.5.14 Slope Stability

The applicant has performed stability analyses for permanent slopes surrounding the proposed plant area. All slopes will be constructed at two horizontal to one vertical. None of the slopes is, itself, seismic Category I. The location of these slopes with respect to the proposed location of safety-related structures is such that slope failure will not affect proposed safety related structures.

On the bases of our review we have determined that none of the proposed slopes are near proposed safety related structures, so slope failures would not endanger these proposed structures. Therefore, we conclude, that the applicant's consideration of slope stability at the site is acceptable.

18.0 REVIEW BY ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The Blue Hills site is expected to be reviewed by the Advisory Committee On Reactor Safeguards. We intend to issue a supplement to this Safety Evaluation Report after the receipt of the Committee's report to the Commission relative to its review of the Blue Hills site. The supplement will append a copy of the Committee's report and will address each of the comments made by the Committee, and will also describe steps taken by the staff to resolve any issues raised as a result of the Committee's review.

21.0 CONCLUSIONS

Based on our analysis of the proposed Blue Hills site, we have reached the following conclusions, subject to the conditions discussed in this report, for the site related issues covered in the Blue Hills Station Units 1 and 2 Preliminary Safety Analysis Report:

(1) Gulf States Utilities Company has described, analyzed and evaluated the proposed Blue Hills site to establish the acceptability of the site for the construction and operation of a nuclear power plant. This description and our evaluation have included a definition of site parameters which we would find to be acceptable for a nuclear power plant at the proposed Blue Hills site.

(2) On the basis of the foregoing, we conclude that the Blue Hills site is acceptable under the guidelines of 10 CFR Part 100 for the construction and operation of nuclear power plant of the general type and size being proposed for other sites in the United States.

APPENDIX A

CHRONOLOGY OF THE EARLY SITE REVIEW FOR THE BLUE HILLS SITE

This appendix presents a chronology of the principal actions during the processing of the Blue Hills Station Units 1 and 2 construction permit application and its subsequent conversion to an Early Site Review. The following abbreviations are used in this appendix:

GSU	Gulf States Utilities Company
NRC	United States Nuclear Regulatory Commission
ACRS	Advisory Committee on Reactor Safeguards
CP	Construction Permit
ESR	Early Site Review
PSAR	Preliminary Safety Analysis Report
BHS	Blue Hills Station Units 1 and 2

June 27, 1974	GSU tenders CP application for BHS.
June 28, 1974	Letter to GSU: Acknowledgement of application and initiation of acceptance review.
July 30, 1974	Letter to GSU: BHS PSAR accepted for docketing; including requests for additional information.
August 8, 1974	Meeting with GSU: Discussion of additional information required at docketing. (Meeting summary dated August 18, 1974).
August 22, 1974	Letter from GSU: PSAR submitted for docketing.
August 29, 1974	Letter to GSU: Review suspended due to lack of seismology information in docketed PSAR.
September 6, 1974	Letter from GSU: BHS inservice dates slip 2 years. CP not needed until July 1976, GSU will support licensing review.
September 26, 1974	Letter from GSU: Information on anticipated transients without scram.
September 26, 1974	Letter from GSU: Notice that GSU will submit additional seismological information by November 1, 1974.

October 28, 1974	Letter from GSU: Additional seismological information submitted.
November 18, 1974	Letter to GSU: Seismological information acceptable; request for additional information.
November 26, 1974	Letter from GSU: Advising that additional information would be submitted by December 21, 1974.
December 2, 1974	Submittal of Amendment 1: Includes additional information requested in NRC letter dated July 30, 1974 and in August 8, 1974 meeting (meeting summary dated August 18, 1974).
December 18, 1974	Letter from GSU: Submitted additional information requested in NRC letter dated November 18, 1974.
January 10, 1975	Letter to GSU: Transmitting radiological safety review schedule for PSAR.
January 13-14, 1975	Meeting with GSU in Houston and Beaumont, Texas to discuss Quality Assurance questions, utility staffing, and design review effort.
January 22, 1975	Letter from GSU: Additional meteorological data submitted.
January 23, 1975	Site visit by meteorology, foundations, seismology, geology, hydrology, and accident analysis reviewers. (Meeting summary dated February 19, 1975.)
January 29, 1975	Letter to GSU: Confirmation of telephone call regarding inservice dates for BHS and request for information regarding GSU project plans.
February 11, 1975	Transmittal from GSU indicating the availability of deep seismic reflection profiles near BHS site.
February 11, 1975	Letter from GSU: Summary report by GSU on proposed BHS project plans and a GSU proposed PSAR review schedule.
February 13, 1975	Letter to GSU: Transmitting Round One Questions.
February 18, 1975	Submittal of Amendment 2: Additional information requested in August 8, 1974 meeting and in July 30, 1974 letter.
March 3, 1975	Letter to ACRS: Identification of potential problem areas by NRC staff.

March 21, 1975	Letter to GSU: Acceptability of GSU proposed PSAR review schedule.
April 7, 1975	Letter to GSU: Transmitted a notice to the Office of the Federal Register relating to acceptance of the BHS PSAR for NRC staff review.
June 6, 1975	Letter from GSU: Submittal of seismic reflection profile and request for withholding from public disclosure.
June 17, 1975	Submittal of Amendment 3: Organizational changes within GSU.
July 21, 1975	Submittal of Amendment 4: Responses to Round One Questions.
July 25, 1975	Letter from GSU: Errata Sheet for PSAR Amendment 4.
August 6, 1975	Letter to GSU: Approval of request to withhold seismic reflection profiles from public disclosure.
September 15, 1975	Letter from GSU: Notice of termination of meteorological program at BHS.
September 26, 1975	Letter from GSU: Transmitting emergency core cooling system analysis.
October 27, 1975	Letter from GSU: Transmitting additional information on site ownership.
October 30, 1975	Meeting with GSU to discuss the seismic reflection profiles provided to NRC by letter dated June 6, 1975. (Meeting summary dated November 10, 1975).
November 10, 1975	Letter to GSU: Transmitting Notice of Hearing on BHS.
December 16, 1975	Letter to GSU: Transmitting Round Two Questions on site safety issues.
January 14, 1976	Letter from GSU: Requesting that the NRC proceed with review of site safety issues only as an ESR.
February 2, 1976	Letter from GSU: Transmitting seismic reflection profiles (revision of those sent in a June 6, 1975 letter) and requesting they be withheld from public disclosure.
February 19, 1976	Letter to GSU: Stating that the NRC staff will proceed with a review of site safety issues for BHS ESR.

February 27, 1976	Letter from GSU: Confirmation of the review schedule for site safety issues for BHS ESR.
March 31, 1976	Letter from GSU: Submitted topography map of the reservoir area.
April 19, 1976	Letter from GSU: Submitting seismic reflection profiles and requesting they be withheld from public disclosure.
April 26, 1976	Submittal of Amendment 5: Responses to Round Two Questions on site safety issues.
May 10, 1976	Letter to GSU: Procedural changes for submission of amendments to NRC.
June 21, 1976	Letter to GSU: Granting a request that the seismic reflection data submitted by April 19, 1976 letter be withheld from public disclosure.
August 19, 1976	Letter to GSU: Changing schedule for completion of BHS ESR due to NRC workload priorities.
August 25, 1976	Letter to GSU: Procedural changes for submission amendments to safety evaluation reports.
September 15, 1976	Letter from GSU: Update on control of mineral rights within site boundary.
October 5, 1976	Meeting with GSU to discuss our conclusion on the GSU meteorological model (Meeting summary dated October 14, 1976).

APPENDIX B

BIBLIOGRAPHY FOR BLUE HILLS SITE SAFETY EVALUATION REPORT

Documents referenced in or used to prepare this Safety Evaluation Report, excluding those listed in the applicants Preliminary Safety Analysis Report, may be obtained at the source stated in the Bibliography or, where no specific source is given, at most major public libraries. Documents submitted by the applicant and Commission Rules and Regulations and Regulatory Guides may be inspected at the Commission's Public Document Room, 1717 H Street, N. W., Washington, D. C. or at the Newton County Public Library, Newton, Texas 77034. Specific documents replied upon by the NRC staff and referenced in this Safety Evaluation Report are as follows:

METEOROLOGY

1. American National Standards Institute, 1972: ANSI A58.1-1972, Building Code Requirements for Minimum Design Loads in Buildings or Other Structures. New York, N.Y.

2. Baldwin, J. L., 1973: Climates of the United States. U. S. Department of Commerce, Environmental Data Service, Washington, D. C.

3. Cry, G. W., 1965: Tropical Cyclones of the North Atlantic Ocean. Technical Paper No. 55, U. S. Department of Commerce, Weather Bureau, Washington, D. C.

4. Korshover, J., 1971: Climatology of Stagnating Anticyclones East of the Rocky Mountains, 1936 - 1970. NOAA Technical Memorandum ERL ARL-34. Silver Spring, Maryland.

5. National Severe Storms Forecast Centers, 1975: Listing of Tornadoes for the Period 1953 - 1974. National Oceanic & Atmospheric Administration. Kansas City, Mo. (Unpublished).

6. Sagendorf, J. F., 1974: A Program for Evaluating Atmospheric Dispersion from A Nuclear Power Station. NOAA Technical Memorandum ERL ARL-42. Air Resources Laboratory, NOAA, Idaho Falls, Idaho.

7. Thom, H. C. S., 1963: Tornado Probabilities. Monthly Weather Review, October-December 1963, pp. 730-737.

8. Thom, H. C. S., 1968: New Distributions of Extreme Winds in the United States. Journal of the Structural Division, Proceedings of the American Society of Civil Engineers - July 1968. pp. 1787-1801.

9. U. S. Department of Commerce, Environmental Data Service, 1974: Local Climatological Data, Annual Summary with Comparative Data-Alexandria, Louisiana, National Climatic Center, Asheville, N. C.

10. U. S. Department of Commerce, Environmental Data Services, 1974: Local Climatological Data, Annual Summary with Comparative Data-Port Arthur, Texas. National Climatic Center, Asheville, N. C.

11. U. S. Department of Commerce, Environmental Data Service, 1975: Climatography of the United States No. 20, Climate of Leesville, Louisiana. National Climatic Center, Asheville, N. C.

12. U. S. Department of Commerce, Environmental Data Service: Tropical Storm and Atlantic Hurricane Articles from the Monthly Weather Review. Monthly Review published through December 1975.

13. U. S. Department of Commerce, Weather Bureau, 1964: Climatography of the United States No. 86-14, Supplement for 1951 through 1960, Louisiana. Washington, D. C.

14. U. S. Department of Commerce, Weather Bureau, 1965: Climatography of the United States No. 86-36, Supplement for 1951 through 1960, Texas. Washington, D. C.

15. Sagendorf, J. F. and J. T. Goll, 1976: XOQDOQ, Program for the Evaluation of Routine Effluent Releases at Nuclear Power Stations, (DRAFT). U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D. C.

16. DiNunno, J. J., et al, 1962: Calculation of Distance Factors for Power and Test Reactor Sites, AEC - Available as TID-14844 from NTIS, Springfield, Va., 22151.

17. Gifford, F. A., Jr., 1968: An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere, Chapter 3 in Meteorology and Atomic Energy 1968, (D. H. Slade, Ed). Available as TID-24190 from NTIS, Springfield, Va., 22151.

SEISMOLOGY/GEOLOGY

1. Anderson, H. V., 1960, Geology of Sabine Parish, Louisiana, Louisiana Geological Survey Bulletin 34, Baton Rouge, Louisiana, p. 164.

2. Holdahl, S. R. and Morrison, N. L., 1974 Regional Investigations of Vertical Crustal Movements in the U. S., Using Precise Releveling and Mareograph Data, Tectonophysics, Vol. 23, pp. 373-390.

3. Doering, J., 1956, Review of Quaternary Surface Formations of Gulf Coastal Region, American Association of Petroleum Geologists Bulletin 40, pp. 764-786.

4. King, P. B., 1969, The Tectonics of North America - A Discussion to Accompany the Tectonic Map of North America Scale 1:5,000,000, Geological Survey Professional Paper 628, Washington, D. C.

5. Eardley, A. J., 1962, Structural Geology of North America, Harper & Row, New York.

6. Coffman, J. L. and C. A. Von Hake, 1973, Earthquake History of the United States, NOAA-U. S. Department of Commerce Publications 41-1.

7. Docekal, J., 1970, Earthquakes of the Stable Interior, with Emphasis on the Midcontinent, Ph. D. Dissertation University of Nebraska.

8. Henley, A. D., 1966, Seismic Activity Near the Texas Gulf Coast, Bulletin of the Association of Engineering Geologists, Vol. 3, pp. 33-39.

9. Preliminary Safety Analysis Report for the Blue Hills Station.

10. Nuttli, O. W. and J. E. Zollweg, 1974, The Relation Between Felt Area and Magnitude for Central United States Earthquakes, Bulletin of the Seismological Society of America, Vol. 64, pp. 73-86.

11. Nuttli, O. W., 1973, The Mississippi Valley Earthquakes of 1811 and 1812: Intensities, Ground Motion and Magnitudes, Bulletin of the Seismological Society of America, Vol. 63, pp. 227-248.

12. Nuttli, O. W., 1976, Comments on "Seismic Intensities, 'Size' of Earthquakes and Related Parameters" by Jack F. Evernden, Bulletin of the Seismological Society of America, Vol. 66, pp. 331-338.

13. Gupta, I. N. and O. W. Nuttli, 1976, Spatial Attenuation of Intensities for Central U. S. Earthquakes, Bulletin of the Seismological Society of America, Vol. 66, pp. 743-752.

14. Donovan, N. C., 1973, A Statistical Evaluation of Strong Motion Data Including the February 9, 1971, San Fernando Earthquake, Proceedings of the Fifth World Conference on Earthquake Engineering.

7100556

15. Nuttli, O. W., 1973, Seismic Wave Attenuation and Magnitude Relations for Eastern North America, Journal of Geophysical Research, Vol. 78; pp. 876-885.

16. Fuller, M. L., 1912, The New Madrid Earthquake, U. S. Geological Survey, Department of the Interior - Bulletin 494.

17. Seed, H. B., 1968, Landslides During Earthquakes Due to Soil Liquefaction, Journal of the Soil Mechanics and Foundation Division, ASCE, Vol. 94, pp. 1053-1122.

18. Neumann, F., 1974, Earthquake Intensity and Related Ground Motion, University Press, Seattle, Washington.

19. Trifunac, M. D. and A. G. Brady, 1975, On the Correlation of Seismic Intensity Scales with Peaks of Recorded Strong Ground Motion, Bulletion of the Seismological Society of America, Vol. 65, pp. 139-162.