KANSAS GAS AND ELECTRIC COMPANY
THE ELECTRIC COMPANY

GLENN L. KOESTER
VICE PRESIDENT - NUCLEAR

October 1, 1981

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U.S. NUCLEAR REGULATORY COMMISSION

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

KMLNRC 81-114
Re: Docket No. STN 50-482
Ref: Letter dated 8/7/81 from RLTedesco, NRC, to GLKoester, KG&E
Subj: Seismology

Dear Mr. Denton:

The Referenced letter requested additional information in the area of seismology. Transmitted herewith are responses to questions 230.1 WC and 230.4 WC in the Referenced letter. The outstanding responses to questions 230.2 WC and 230.3 WC will be forwarded to you on October 9, 1981. This information will be formally incorporated into the Wolf Creek Generating Station, Unit No. 1, Final Safety Analysis Report in Revision 6. This information is hereby incorporated into the Wolf Creek Generating Station Unit No. 1,Operating License Application.

Yours very truly,

Glenn L Koester

GLK:bb

cc: Dr. Gordon Edison (2)
Division of Project Management
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Mr. Thomas Vandel
Resident NRC Inspector
Box 311
Burlington, Kansas 66839

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OATH OF AFFIRMATION

STATE OF KANSAS)
) SS:
COUNTY OF SEDGWICK)

I, Glenn L. Koester, of lawful age, being duly sworn upon oath, do depose, state and affirm that I am Vice President - Nuclear of Kansas Gas and Electric Company, Wichita, Kansas, that I have signed the foregoing letter of transmittal, know the contents thereof, and that all statements contained therein are true.

KANSAS GAS AND ELECTRIC COMPANY

ATTEST:

By Glenn L Koester
Glenn L. Koester
Vice President - Nuclear

W.B. Walker
W.B. Walker, Secretary

STATE OF KANSAS)
) SS:
COUNTY OF SEDGWICK)

BE IT REMEMBERED that on this 1st day of October, 1981, before me, Evelyn L. Fry, a Notary, personally appeared Glenn L. Koester, Vice President - Nuclear of Kansas Gas and Electric Company, Wichita, Kansas, who is personally known to me and who executed the foregoing instrument, and he duly acknowledged the execution of the same for and on behalf of and as the act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my seal the date and year above written.

EVELYN L. FRY
NOTARY PUBLIC
STATE OF KANSAS

Evelyn L. Fry
Evelyn L. Fry, Notary

My Commission expires on August 15, 1985.

Q230.1WC Provide a figure to illustrate the geographic regions used in the probability calculations discussed on FSAR page 2.5-144.

R230.1WC Figure 2.5-75 of the FSAR illustrates the geographic regions used in the probability calculations. The Nemaha Anticline, as shown on Figure 2.5-75 represents Region I, and the remaining area on this figure represents Region II as used in the probability calculations discussed starting on revised FSAR page 2.5-144.

During review of the FSAR for this question, an inconsistency was noted between the earthquake data shown on Figure 2.5-75 and those which were used for the probability calculations. Whereas earthquake intensities and epicentral locations shown on Figure 2.5-75 had been revised from those in the PSAR where necessary to reflect recent publications, the probability calculations discussed on original FSAR pages 2.5-144 through 2.5-146 had not been revised. In order to correct this inconsistency, the tabulated data presented on pages 2.5-145 and 2.5-146, and the probability calculations have been revised to reflect the data presented on Figure 2.5-75.

HORIZONTAL ACCELERATION (a, as percent gravity)	RETURN PERIOD (years)
0.02g	100
0.03g	300
0.04g	800
0.05g	2,000
0.075g	20,000
0.10g	4,000,000

The method described above has been used successfully for a variety of problems. For completeness, more conventional recurrence relationships are also provided below.

The area between latitudes, 35°N and 41°N, and longitudes, 92°W and 100°W, was selected for a study of intensity-recurrence relationships. This region covers epicenters within a distance of at least 200 miles from the site and has an area of about 180,000 square miles (Figure 2.5-75).

Nuttli (1974) examined the magnitude-recurrence relation for the central Mississippi River Valley seismic region for the interval 1833 through 1972. As expected, the earthquake data set was found to be incomplete for the interval, 1833 to 1972, especially for the smaller events. Applying a test described by Stepp (1972), the available earthquake data for the past 100 years appear to be complete for events of approximately body wave magnitude, m_b, 4.1 (corresponding to maximum intensity of about MMI V) and larger. While examining seismicity of the southeastern United States, Bollinger (1973) arrived at a similar conclusion regarding the reporting of MMI V events over the last 100 years. Therefore, it may be assumed that all or nearly all events of MMI V and greater have also been included in Table 2.5-19 for the interval, 1873 to 1981.

The region around the site may be divided into two distinct zones on the basis of their vastly different seismic histories. Most epicenters of large and small earthquakes lie along the Nemaha trend, a zone about 50 to 60 miles in width and located about 50 miles west of the site. Within this area, the seismic zone (called Region I) has an area of about 30,000 square miles. The remaining zone (called Region II) has much lower seismic activity and an area of about 150,000 square miles.

The distribution of seismic events of MMI V or larger during the interval, 1873 to 1981, for Regions I and II (as obtained from Table 2.5-19) is as follows:

MAXIMUM MMI (I_o)	NUMBER OF EVENTS IN REGION I	NUMBER OF EVENTS IN REGION II	TOTAL
VII	3	2	5
VI - VII	0	1	1
VI	4	1	5
V - VI	2	3	5
V	6	9	15
IV - V	1	1	2

It should be noted that one MMI VII event which was included in Region II is not a random event. This event, the 1882 western Arkansas (Bonham, Texas) event, occurred approximately 240 miles south of the site along the Ouachita trend. It was included for the sake of completeness in Region II, because it was felt at the site and did not occur along the Nemaha trend. With the exception of this event, there have been no events in Region II definitively greater than MMI VI. In order to present a conservative analysis the 1956 Catoosa, Oklahoma earthquake has been included as an MMI VI-VII rather than an MMI VI.

A least-squares, straight-line fit has been applied to an equation of the following form:

$$\log N = a - b\, I \qquad [2.5\text{-}6]$$

where:

N = The number of events per year of MMI I and greater; a and b are constants.

Therefore,

$$\log N = 0.963 - 0.357\, I \text{ (for Region I)}$$

and

$$\log N = 1.211 - 0.410\, I \text{ (for Region II)}$$

where:

N = The number of events per year within the areas of the two seismic regions.

It can be seen from the attenuation curves on Figures 2.5-77 through 2.5-80 that the average MMI within a radius, R, of 10 miles from the epicenter is the same as the epicentral intensity, which can be expressed in the following:

$$I \text{ site} = I \text{ epicenter for } R \leq 10 \text{ miles} \qquad [2.5\text{-}7]$$

It may be noted that this relationship has also been obtained by Cornell and Merz (1974) in their study of northeastern earthquakes near Boston.

Considering the number of events, n, per year within a radius of 10 miles, the above equations provide the following results for various MMI values:

I_o	n (Region I)	n (Region II)
I	4.2×10^{-2}	1.3×10^{-2}
II	1.9×10^{-2}	5.2×10^{-3}
III	8.2×10^{-3}	2.0×10^{-3}
IV	3.6×10^{-3}	7.8×10^{-4}
V	1.6×10^{-3}	3.0×10^{-4}
VI	6.9×10^{-4}	1.2×10^{-4}
VII	3.0×10^{-4}	4.6×10^{-5}
VIII	1.3×10^{-4}	1.8×10^{-5}
IX	5.9×10^{-5}	6.9×10^{-6}

These results demonstrate that for very small intensity earthquakes, the number of events per unit area per unit time in the Nemaha Trend region (Region I) is only slightly greater than that in Region II. For large intensity events, Region I shows many more earthquakes than Region II.

Therefore, the maximum credible earthquake, or maximum earthquake, to affect the site is postulated as an event considerably larger than that which has occurred historically (10 to 15 times the energy release of the largest historical earthquake). This earthquake may be defined as an MMI VIII event some 75 miles from the site, the nearest approach of Docekal's seismogenic area associated with the location of mafic intrusives in the CNARS or at the probable location of events on Merriam's proposed westward dipping Nemaha reverse faults. Alternately, this earthquake may be defined as an MMI VII event occurring 50 miles from the site at the nearest approach of the Nemaha Uplift (Humboldt fault zone). As discussed in Section 2.5.2.3 and in this section, the whole length of the Nemaha Uplift cannot be considered as a major seismogenic structure. The postulation of an MMI VIII event on the eastern margin of the Nemaha Uplift 50 miles from the site introduces an appropriate degree of conservatism by selection of an intensity that is much greater than any historic event.

An MMI VII event occurring along the western margin of the Nemaha Uplift at its closest approach to the site (75 miles) appears to be reasonable as a maximum probably earthquake. Such an event would be approximated by the Manhattan, Kansas

Q230.4WC Discuss the following recent studies and their significance to the Wolf Creek site:

a. Yarger, H. L., 1981, Aeromagnetic Survey of Kansas, EOS Transactions, v. 62, n. 17 173-178.

b. Steeples, D. W., and M. E. Bickford, 1981, Piggyback Drilling in Kansas: An Example for the Continental Scientific Drilling Program, EOS Transactions, v. 62, n. 18, 473-476.

R230.4WC Yarger (1981) and Steeples and Bickford (1981) document the results of investigations performed to define more precisely geological and geophysical characteristics of the buried Precambrian basement of Kansas. These publications strongly support the Applicant's earlier interpretations, presented in the WCGS-FSAR, of several features within the basement and, therefore, do not affect the previous conclusions regarding site safety.

Both of these publications have been referred to in Sections 2.5.1.1.5.1.17 and 2.5.1.1.5.1.18 of the WCGS-FSAR. Yarger (1981) discusses the aeromagnetic survey and the resulting aeromagnetic anomaly map. The aeromagnetic map of eastern Kansas, available from the Kansas Geological Survey, has been reproduced as Figure 2.5-9 and is referred to in Section 2.5.1. The three major features described by Yarger (1981) are the Central North American Rift System (CNARS), a large east-west trending negative anomaly and the group of strongly positive, circular aeromagnetic anomalies in the Forest City Basin.

The buried CNARS is reflected by northeast-trending positive aeromagnetic anomalies and closely spaced contour lines in the north central portion of Figure 2.5-9 (see Section 2.5.1.1.5.1.17). Several lineaments visible on LANDSAT imagery appear to correspond with features on the aeromagnetic and basement surface maps that are apparently associated with the CNARS (Lineament Group No. 2 - Figures 2.5-14a and 2.5-14b). Lineament Group No. 3 appears to be associated with the Nemaha Uplift (Section 2.5.1.1.5.1.18, Figures 2.5-14a and 2.5-14b).

Yarger (1981) confirms interpretations stated in Sections 2.5 1 and 2.5.2 that the CNARS appears to extend southward into southern Kansas and Oklahoma and that mafic volcanics did not reach the Proterozoic surface in southern Kansas. In southern

R230.4WC (continued)

Kansas, the CNARS appears to be represented by prominent magnetic lineaments. Yarger (1981) indicates that the rift in southern Kansas may not have progressed beyond the stage of block faulting and possibly dike intrusion. Yarger (1981) also supports the hypotheses inferred in Section 2.5.2.2 that the Nemaha block and bounding faults might be related to the formation of the CNARS (i.e., the Nemaha block was topographically higher and not involved in subsequent foundering). These data do not alter interpretations presented in Section 2.5.2.

The second major feature, an east-west trending aeromagnetic low centered about Wichita, may, according to Yarger (1981), reflect a crustal boundary between a northern 1,625 million-year-old (m.y.) mesozonal granitic terrane and a southern 1,4000 m.y. epizonal granite and rhyolite terrane. Precambrian basement lithologies are discussed in Section 2.5.1.1.4.1. This anomaly had previously been discussed by Lidiak and Zietz (1976) and by Wilson (1979). Structure contour maps on the top of Cambro-Ordovician Arbuckle rocks, Silurian-Devonian "Hunton" rocks, Mississippian rocks, the Upper Pennsylvanian Lansing Group and on the base of the Upper Pennsylvanian Kansas City Group do not indicate a geologic structure associated with this large negative anomaly (Merriam and Smith, 1961; Merriam and Kelley, 1960; Merriam, 1960; Merriam, Winchell and Atkinson, 1958; Watney, 197). In addition, this large negative magnetic anomaly is not marked by a concentration of historic macro- or microearthquake epicenters. Although the source of these magnetic lows is not clear, this basement feature does not appear to be significant to site safety.

The third major geophysical feature discussed by Yarger (1981) and by Steeples and Bickford (1981) is the group of circular, strongly positive magnetic anomalies in the Forest City Basin (see Section 2.5.1.1.5.1.17). These features and the aeromagnetic survey of Kansas were also discussed at a hearing in the NRC offices (Docket No. 50-482, April 20, 1976). Earlier interpretations which indicated that these features are the results of density-magnetic (i.e., lithologic) contrasts within the Precambrian basement were confirmed by two deep borings (Steeples and Bickford, 1981). These circular, strongly-positive, magnetic anomalies appear to result from Precambrian

R230.4WC (continued)

granitic intrusives (containing approximately 2 percent magnetite) which intruded older Precambrian granitic crust (see FSAR Section 2.5.1.1.5.1.17 and Figure 2.5-14a; Steeples and Bickford, 1981; Yarger, 1981). These data provide further confirmation that the magnetic highs do not represent upfaulted basement blocks. These anomalies, therefore, are not significant to site safety.