GENERAL ELECTRIC

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DIVISION

GENERAL ELECTRIC COMPANY, P.O. BOX 460, PLEASANTON, CALIFORNIA 94566

September 4, 1979

Mr. Chris Nelson
U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D.C. 20555

Subject: General Electric Test Reactor Safety Evaluation Report
Docket 50-70

Dear Mr. Nelson:

The General Electric Company has reviewed the letters from David B. Slemmons to Robert E. Jackson dated August 8, 1979 and August 9, 1979. We have determined that several points in these letters required clarification and have responded to both of these letters in the two enclosed attachments.

It is important that this information be forwarded to those reviewing the Safety Evaluation Report in order to have these points clearly understood.

Sincerely,

DL Gilliland for

R. W. Darmitzel
Manager
Irradiation Processing Operation

Attach.

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GENERAL ELECTRIC

AFFIRMATION

The General Electric Company hereby submits the attached response regarding geologic issues at the General Electric Test Reactor Site - Docket 50-70.

To the best of my knowledge and belief, the information contained herein is accurate.

By: D L Gilliland

D. L. Gilliland, Manager
Reactor Irradiations
Irradiation Processing Operation

Submitted and sworn before me this fifth day of September, 1979

Sandy Cleveland, Notary Public in and for the County of Alameda, State of California.

SANDY CLEVELAND
NOTARY PUBLIC
Alameda County, California
My commission expires June 4, 1982

928 253

External Distribution
Response to Dr. Slemmons' Letters to
Dr. Jackson (NRC)
Dated August 8 and 9, 1979

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(Attn: Neil Simon)

928 254

Attachment 1

RESPONSE TO LETTER FROM DAVID B. SLEMMONS TO ROBERT E. JACKSON
DATED AUGUST 8, 1979

The General Electric Company and its technical consultants have reviewed the letter from David B. Slemmons to Robert E. Jackson dated August 8, 1979. This letter summarizes Dr. Slemmons review of all available geologic data concerning the potential for surface faulting at the GETR site. Several of his statements appear to reflect a misunderstanding of some of the data and arguments that have been submitted, while other statements are inconsistent with his final conclusions. These statements are quoted as excerpts from his letter below, followed by our comments.

> "The overall appearance of the shears, their parallelism, their recurrent activity, and the presence of some strands well in front of the hill front, all support a tectonic origin. They appear to be part of a zone of shears or faults that does not conform exactly with the Verona fault as mapped by Herd (1977). The widespread development of dip-slip striations on fault planes suggest a major dip-slip component that appears to be anomalous for a fault that is both subparallel to and near the Calaveras fault zone. This orientation of striations could be the result of a combined faulting-folding mechanism, since many of the regional fault and fold structures are of similar strike and since the folding of late Cenozoic deposits is widespread in the vicinity of Livermore Valley. The possible development of shorter faults, or of smaller displacement values from either secondary distributed effects of folding, or from the detachment of surface faults by late Cenozoic deposits of the deeper, primary fault displacements appears to me to be possible, but is not verified or well documented for this area."

The overall appearance of the shears, their parallelism, their recurrent activity, and the presence of some strands well in front of the hillfront are not features that are unique to faulting nor do they alone support a tectonic origin. All of these features can result from landsliding and equally support a landslide origin, as pointed out in the ESA 1979 report, the responses to questions raised by the NRC staff, and in the recent report by California Division of Mines & Geology.

928 255

That the zone of shears does not conform to the Verona fault as mapped by Herd and that a major dip-slip component appears anomalous for a fault that is both subparallel to and near the Calaveras fault zone are important points that bear on the interpretation of the origin of the shears. One of the primary problems with interpreting the shears as part of a major thrust fault zone is the inconsistency of such a structure with the known regional geologic and tectonic setting.

The development of shorter faults, or of smaller displacements from secondary effects of folding is not only possible, but provides a more reasonable explanation for the origin of the shear features, in light of the regional setting and subsurface geology, than does a major thrust zone extending into basement rocks. The mechanism of secondary slip surfaces developing within late Cenozoic deposits in response to folding does not require detachment from deeper, primary faults.

> "The conclusion that the Verona fault is capable within the meaning of Appendix A to 10 CFR Part 100 is proved by the separations of the modern sola by the B-2, B-1/B-3, and H shears."

It is important for the interpretation of the origin of the shears and for the assessment of risk to emphasize that the organic horizon of the modern solum, judged about 8000 to 15000 years old, has not been offset by the shears.

> "The N.R.C. (1978) description of the faults exposed in the exploratory trenches as having the potential for an estimated 2.5 meter net slip offset on a reverse-oblique fault with a dip of 10^0 to 60^0 is obtained by several methods and is supported by both the new exploratory trench data and by the current worldwide data bank of information on the relationships between earthquake magnitude to fault rupture length and maximum surface displacement. The estimate is compatible with the current estimates of total fault length (8.2 km to 12 km), the observed striations along the shears exposed by the exploratory trenches, with striations that vary from reverse-slip to strike-slip, and the worldwide fault rupture data (Slemmons, 1977) and the field data for the San Fernando earthquake of 1971 and the El Asnam, Algeria earthquake of 1954. The excellent documentation of offsets of up to 1.0

meter for the modern sola exposed by the trenches defines the most probable dimension for a future offset. The lack of definitive offset data for earlier displacements on these shears, and the historic variations between earthquake magnitude and associated amount of offset that occurs during each new event, required that a larger displacement value be used to provide a conservative estimate of potential offset. The 2.5 meter net slip value of the N.R.C. report (1978) is reasonable for a fault with a length of between 8.2 and 12 km and the observed 1 m offset of the modern solum; it is consistent with the dispersion of data shown on the worldwide data for earthquake magnitude to maximum displacement relations (Slemmons, 1977, Figure 25)."

The new exploratory trench data do not support a potential 2.5 meter net slip, but, on the contrary, support the conclusion that maximum offsets have been on the order of 1 meter or less, if one reasonably assumes a uniform rate of strain relief over the last several hundred thousand years. Geologic constraints limit the length of the assumed fault to 8 km, not 12 km. No strike-slip striations were observed on any of the shears in the T, B-1/B-3, B-2, or H series trenches. We question the indiscriminate use of worldwide fault rupture data without comparing the local tectonic setting of the various faults in the data bank. As discussed in several of the reports which have been submitted by G.E., all of the data thus far presented indicate that the rate and magnitude of tectonic activity at the GETR site are much less than those of many of the faults in the worldwide data bank, including faults associated with the San Fernando earthquake of 1971. By any comparison, expected net-slip offset on the assumed faults at the GETR site should be much less than the dispersion of data for worldwide earthquake magnitude to maximum displacement relations would indicate. The excellent documentation of maximum offsets of 1 meter, not only for the older horizons of the modern solum, but for earlier displacements of the paleosols as well, support this conclusion.

"The maximum earthquake magnitude described for the Verona fault zone is listed as 6 to 6½. My review of the possible fault parameters, the 8.2 to 12 km length, the surface displacement of 1 to 2.5 m, and the San Fernando and El Asnam case histories of 6.4 and 6.7 magnitude, respectively, all indicate a potential magnitude of about 6.5 ± 0.5, for an earthquake generated by faulting that is limited to the Verona fault zone."

928 257

An independent estimate of the earthquake magnitude to be expected from rupture of an assumed Verona fault can be made based on recent work by Wyss (1979). If one makes the extremely conservative assumption that the entire fault surface (about 60 km^2 maximum) all ruptures in a single event, the corresponding magnitude would fall in the range of M 5.5-6.4. If a more reasonable assumption of about half of the surface area rupturing in a single event is made, the estimated magnitude is about M 5.7. This value is in good agreement with the estimate of M 5-5.6 presented in ESA (1978d).

As noted by Jahns (1979), "It (the assumed Verona fault) must be considerably shorter than faults that have been judged capable of generating M 6.5 earthquakes (e.g., Raymond and Sierra Madre as comparable thrust faults), and its activities in late Quaternary time cannot have been nearly as great. In my judgment, assignment of 5.5 as a maximum value for magnitude of an earthquake generated along a Verona thrust fault represents an extremely conservative assumption." (p 15-16).

Rice and others (1979) infer a magnitude of about M 6 based on their interpretation of the geologic evidence and historical data in Slemmons (1977).

> "The matter of earthquake recurrence is important if a probabilistic analysis is used for assessming the earthquake risk. Table A-1 of the report by Engineering Decision Analysis Company (1979, Probability analysis of surface rupture offset beneath reactor building, General Electric Test Reactor: for General Electric Co.) indicates that the three shears, B-2, B-1/B-3, and H, have cumulative offsets of more than 80, 40 and 20 feet respectively. This amount of offset, if it occurred in the inferred 70 to 195,000 yr. period implies a high frequency of earthquakes if each event involves an average displacement of 1 m. Alternatively, if longer recurrence intervals are used, then the average offset is likely to be much greater than 1 m, or the offset at depth could be much greater."

928 258

This statement implies a misunderstanding of the data in Table A-1 of the EDAC report, the bases for which are explained in the Appendices to that report and discussed further in the Phase II Geologic Report (ESA, 1979). The cumulative offsets of more than 80, 40, and 20 feet, respectively, represent the measured offsets of pre-70,000 to 125,000 year old units (stage 5 paleosol), which include 128,000 to 195,000 year old sediments (stage 6) and the underlying Livermore Gravels. Based on the measured offsets of the 70,000 to 125,000 year old stage 5 paleosol and younger units, and the minimum cumulative offsets of the pre-stage 5 units, the recurrence interval for offset events of 1 m is in the range of 10,000-20,000 years. This is certainly not a high frequency of earthquakes and reflects the low degree of assumed tectonic activity at the GETR site.

References Cited

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Attachment 2

RESPONSE TO LETTER FROM DAVID B. SLEMMONS TO ROBERT E. JACKSON
DATED AUGUST 9, 1979

INTRODUCTION

General Electric Company (GE) and its technical consultants have reviewed the letter from David B. Slemmons to Robert E. Jackson dated August 9, 1979. This letter contains the findings of the review by Dr. Slemmons of EDAC report 117-217.13, entitled: "Probability Analysis of Surface Rupture Offset Beneath Reactor Building, General Electric Test Reactor". GE and its consultants believe that comments made by Dr. Slemmons present an inaccurate evalution of the report. The following response restates the findings and pertinent bases of the probabilistic analysis and presents a critical review of Dr. Slemmons' letter.

This response is organized in two sections. The first section addresses a general misunderstanding evident in Dr. Slemmons' letter concerning the basis and findings of the probabilistic analysis. Based on the background material presented in the first section, the individual comments made by Dr. Slemmons in his letter are discussed in the second section.

GENERAL RESPONSE

A significant finding of the model (detailed) probabilistic analysis is that the annual probability of a future offset beneath the reactor building is very insensitive to the number of offsets which have occurred in the past on the two existing shears. The analysis presents a conservative estimate of the probability of occurrence of a future offset of <u>any</u>* size beneath the reactor building. Such an occurrence is independent of the number of past offsets. The probability of occurrence was calculated based on a mathematical model starting with the Poisson assumption for occurrence of offset events. Of equal significance was the finding that

*All offsets greater than zero

928 260

probabilities of future offsets of <u>any</u> size could be calculated directly using an alternate (simplified) probability analysis which does not depend on any assumption concerning the occurrence of any offset events. This result was not surprising since the detailed probabilistic analysis, which was performed first, led to the conclusion that the number of past offsets does not affect the probability values. In other words, a detailed model and a simplified model produced the same results.

Dr. Slemmons' comments concerning the validity of the Poisson model and interpretation of geologic data are not applicable to the analysis which was performed. It is true that if a strain rate-dependent model is used (such as filtered Poisson model), which reflects the process of gradual or sporadic strain accumulation and subsequent energy release due to offsets, the estimate of the number of offsets which have occurred in the past would change. However, this result would not affect the probability values, since the probability of a future offset beneath the reactor building is not affected by the number of offsets which have occurred in the past.

This conclusion (i.e., the probability values do not depend on the history of past offsets) also can be reached directly by the following intuitive argument which perhaps can be more easily understood than the analyses described earlier. It was found in the trench excavations that there is an area which includes the reactor building that is 1,320 feet long and which has not been intersected by an offset for at least 128,000 years which is the minimum age of the soil at the bottom of the trench (a very conservative interpretation of the data). In addition, past offsets have occurred on two existing shears (which bound the 1,320 feet) for a period of at least 128,000 years and probably much longer. A conservative estimate of the probability of an offset somewhere in the 1,320 foot long area in a one year time period is 1/128,000. Since the reactor building is 72 feet wide the probability of an offset intersecting its foundation given that an offset occurs in this region is approximately 72/1320. The total probability of an offset beneath the reactor building is the product of of these two values which is 4×10^{-7}. This is a simplified approach, but is instructive since it is intuitively understandable and again demonstrates the point that the number and size of past offsets on the existing shears does not affect the results of the analysis.

Even if the strain accumulation is currently high, which is unlikely, or if an offset occurs on the existing shears tomorrow, which is even more unlikely, the probability values for future offsets beneath the reactor building would not change. This is true since all offset events have occurred on the existing shears.

The physical characteristics of surface rupture offset have one important difference when compared to vibratory ground motion. If an earthquake occurs which results in an offset, the ground motion may reach the reactor building, but the surface offset will not impact the reactor building with high probability. This conclusion is based on data which show that for at least the last 128,000 years (and probably much longer) all offsets have occurred on the existing shears. Not only is it unlikely that the next offset will occur off the existing shears, it is even more unlikely that it will intersect the reactor building since there is a 1,320 foot wide area where it can occur.

In conclusion, Dr. Slemmons' comments are not applicable to the analysis which was performed -- namely, the determination of the annual probability of <u>any</u> size offset occurring beneath the reactor building. If the analysis had been stated in terms of the probability of exceeding a specific displacement (e.g., 1 ft., 2 ft., etc.) or if the probability of a future offset on the existing shears was calculated, then the detailed history of past offsets would be applicable to the analysis. Note, however, the probability of an offset with a displacement greater than a specific size is always smaller than the probability of occurrence of <u>any</u> size offset. Thus it is conservative and required less dependence on interpretation of data and the formulation of the model to compute the probability of occurrence of <u>any</u> size future offset.

RESPONSE TO SPECIFIC COMMENTS

The following responses are made in regard to specific comments given in Dr. Slemmons' letter to Dr. Jackson. The responses are keyed to the organizational format of the letter.

Introductory Paragraphs

The reference to the seismological cycle is not pertinent to the analysis which was performed, since variations in the underlying geological parameters would only affect the number of offsets, n, which have occurred in the past. However, since a conservative estimate of the probability of a future offset of any size beneath the reactor building does not depend on n the details of the seismological cycle are not important.

Dr. Slemmons is incorrect in criticizing the use of probability theory as a basis to determine the likelihood of future offsets. The probabilistic approach reflects reality in which it is assumed that the future is uncertain and not deterministic. Note that in estimating future offset activity, conservative rather than mean centered estimates were used in the probabilistic analysis which was performed.

The statement: "This is a deterministic process...," is not correct since the time and location of future events is not known with certainty.

The probabilistic analysis was reported to two significant figures, which properly reflects the accuracy and precision attributed to the analysis. Age data are given to three significant figures, but were given as a range. No inference, that a higher level of assurance exists than is truly appropriate, was made. Rounding the age data to two significant digits would not change the results of the probabilistic analysis.

Basic Assumptions

1. Dr. Slemmons questions the use of the Poisson model and identifies various factors that affect the characteristics of earthquake faulting.

As discussed above, these factors (except location) do not affect the results of the analysis. Event location is important and has been conservatively included in the probabilistic analysis. As shown by the alternate probabilistic approach given in the EDAC report and the simplified intuitive analysis cited above, the results of the analysis do not depend on the use of the Poisson model.

2. Knowing the parameters of time since the last displacement, recurrence interval, or amount of the displacement will not change the results of the analysis. It is evident from the final sentence, quote: "I do not believe that the present data base permits this type of analysis," that Dr. Slemmons does not understand the analysis which was performed.

   The probability model was constructed on the basis of data that were available. In every case where the available data indicated a range of values, the most conservative value was used, even though geologic considerations suggested that less conservative values were the more reasonable. Because of the conservative assumptions used in the model, the available data are adequate for the probabilistic approach.

3. Dr. Roy J. Shlemon will respond to this comment under separate cover.

4. Dr. Slemmons makes the point that it is possible to have simultaneous occurrence of displacement on more than one fault strand. This possibility does not affect the results of the probabilistic analysis. If offsets have occurred on several shears at the same time in the past, this result would affect the number of offsets, n. As shown in the probabilistic analysis, the probability of <u>any</u> size offset greater than zero beneath the reactor building is not significantly affected by the total number of offsets during the last 128,000 to 195,000 years.

Age of Solum and Paleosols

1. Only the oldest time (i.e., 128,000 to 195,000 years) is significant to the analysis, since the effect of displacements during earlier periods is reflected in the number of offsets, n. As discussed above, the parameter n does not affect the results of the analysis.

   Dr. Roy J. Shlemon will also provide additional response under separate cover.

2. Dr. Roy J. Shlemon will respond to this comment under separate cover.

Displacement Data

1. Dr. Slemmons states: "The known tendency of reverse faults to rupture with new, short-cut paths (Slemmons, 1977, p. A33 to A37) suggests the potential for future faulting in the 1,320 ft. interval between B-2 and B-1/B-3 faults." Although Dr. Slemmons cites examples of thrust faults which exhibit imbricate faults that have taken short-cut paths to the surface within the upthrown block (Slemmons, 1977), such is not always the case. Some thrust faults exhibit a tendency to break progressively outward from the main topographic expression of the fault zone. An example is the White Wolfe fault in California which ruptured in 1952. Trenching across this fault zone revealed that the youngest breaks, rather than taking short-cut paths, broke outward from the main fault zone and topographic scarp (Cotton et al., 1977).

   A more recent study of worldwide historical fault rupture events (Bonilla, 1979) supports the commonly accepted position that faults have a tendency to rupture along pre-existing breaks rather than rupture new ground. As stated by Bonilla: "Of the main faults in 108 examples of worldwide historic surface faulting on land, 91 percent occurred or probably occurred on pre-existing faults, 8 percent are indeterminate in this regard based on available data, and 1 percent (1 example) apparently occurred where no fault existed previously." (pp 11-12).

At the Vallecitos site, the tendency for rupture along new short-cut paths is not supported by the field data. On the contrary, trench exposures revealed that repeated contemporaneous movements have occurred on both the B-2 and B-1/B-3 shears over the past several hundred thousand years, and no short-cut ruptures have occurred in the 1,320 ft. interval between these shears for at least 128,000 years and most likely for a much longer period.

Based on this historical record, and the fact that the shear planes mechanically provide existing paths of weakness along which rupture can occur, it is more likely that future ruptures will propagate along one or more of the existing shears, rather than take a short-cut path to break new ground between the shears. As shown in Figure 5-1 of the EDAC report the probability density function for offsets between the shears is weighted toward the existing shears, which is conservative. Since the reactor building is located near the quarter point between the shears, increasing the probability density even more near the shears will not significantly affect the probability of occurrence at the reactor building.

The statement: "... the 80+ ft. displacement of the paleosols suggests a recurrence interval measured in thousands of years and a higher risk than proposed by the analysis" is incorrect and reflects a misunderstanding of the data that have been submitted.

No paleosols have been offset 80+ feet. The maximum offset of any of the paleosols is exhibited by the Stage 5 paleosol (70,000 to 125,000 years old), which was 10 to 11 feet in trenches B-1 and B-3, and 14 feet in Trench T-1. The 80+ feet offset represents the minimum amount of cumulative offset of the Livermore Gravels underlying the paleosols on the B-2 shear. As discussed in Appendix A of the EDAC report, the presence of three well developed paleosols above Livermore Gravels in Trenches H and B-3 indicates that the Gravels are at least

928 266

older than 350,000 years. Geologic considerations strongly imply that the Gravels are much older, more likely at least a million years.

Spread over this time period, the 80+ feet displacement of the Livermore Gravels suggests a recurrence interval measured in tens of thousands of years, which is consistent with a recurrence interval of 10,000 to 20,000 years for 3 foot displacements as determined from the measured displacements of younger paleosols. If events had occurred with displacements larger than 3 feet, as suggested by Dr. Slemmons, then the recurrence interval would be proportionately longer. When compared to recurrence intervals estimated in hundreds of years for other known "capable faults", the recurrence interval determined from the geologic record at the GETR site is extremely long and represents a low degree of risk. Regardless of the conclusion concerning the recurrence interval, the size and timing of past displacements do not affect the results of the probabilistic analysis.

Summary

1. Dr. Slemmons' comments given in this section are not germane. The form of the faulting mechanism, size, frequency, and time histories of activities do not affect the results of the analysis. The location of offset does affect the analysis. However, this factor has been conservatively accounted for in the probabilistic analysis. The Poisson distribution is appropriate for the detailed analysis since it was shown that the form of the model does not affect the results of the analysis.

2. (1) Dr. Roy J. Shlemon will respond to this comment under separate cover.

   (2) The statement: "The only exact displacement for the faults is the recent event,..." is not true. The fact that no displacement of the Post-Cambic Horizons of the Modern Solum

(6,000-15,000 years old) was observed is an important consideration in assessing rates of displacement. In addition, displacements of the stoneline (17,000 to 20,000 years old) and the Stage 5 paleosol (70,000 to 125,000 years old) were recorded. In any event, the number or size of past offsets does not affect the results of the probability analysis.

(3) The number and size of past offsets does not affect the results of the analysis.

(4) The mode of origin of the shears and relationship at depth does not affect the results of the analysis. The possibility of "short cut" faults has been included in the model in a conservative manner as discussed above.

References

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