ENCLOSURE TO SLNRC 81-62

COMPARISON OF FINITE ELEMENT AND LUMPED MASS SEISMIC ANALYSIS METHODS FOR SELECTED SNUPPS BUILDINGS

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I. Introduction

A seismic analysis utilizing a lumped mass model on an elastic half space with strain independent soil properties was performed for comparision with the FLUSH finite element results as requested in Reference 1. FLUSH is a finite element computer program based on a well founded method tailored to soil-structure interaction problems. This program is the basis for the seismic analysis of the power block and other seismic catagory I structures on SNUPPS.

The purpose of this comparison is to provide a check on the FLUSH analysis and to determine if similar results may be obtained between the finite element and lumped mass analyses. A one to one correspondence between the lumped mass and the more rigorous FLUSH analysis is not expected. The additional considerations provided in the FLUSH analysis, discussed below, are expected to result in local variations between the results of the FLUSH analysis when compared to the lumped mass model analysis. These variations may result in a lower response over local frequency ranges for the FLUSH analysis when compared to the lumped mass model results. Such variations are legitimate and do not necessarily reflect an unconservatism on the part of the FLUSH analysis. Rather, they are the result of the considerations included in a more rigorous analysis. The purpose of this comparison, therefore is not to demonstrate that the FLUSH analysis is at all locations and at all frequencies more conservative than the lumped mass model. Rather, the purpose is to provide evidence that the FLUSH analysis was properly conducted, in that no gross abnormalities exist between the results as compared with a simplier analysis.

Per Reference 1, this comparison is made for both a shell type and a frame type structure for one horizontal direction using the site specific earthquake "g" level and soil properties. Separate comparison analyses were prepared for the Callaway and Wolf Creek sites. For the shell type structure, the reactor building was analyzed, as suggested by the NRC. The auxiliary/control building was selected as the frame type structure. In accordance with Reference 1, three key points were selected in each building for comparison of results. These points for the reactor building include the polar crane support at elevation 2119'-0", operating floor at elevation 2047'-6", and reactor support structure at elevation 2012'-0". For the auxiliary/control building, the base slab, elevation 2000'-0", control room floor, elevation 2047'-6'", and the roof, elevation 2087'-2" were selected as key points in the building. These key points represent a wide range of elevations in each building.

II. FLUSH ANALYSIS

A detailed description of the FLUSH analysis procedure for the power block is provided in Section 3.7 of Reference 2, which will not be repeated here. However, some considerations included in the Flush analysis which create basic differences between this method as compared with the elastic half space method deserve mentioning.

Contrary to the representation of the soil medium by a relatively simple system of springs and dampers to simulate an elastic half space, the FLUSH analysis allows for the modeling of soil with a large finite element pattern. Unique soil properties may be identified with the various elements. This provides for a more detailed definition of the soil profile under the building, including accounting for variation in soil properties over the area and depth under consideration. Variation in soil properties as caused by the soil strain level are also considered. Since the entire power block is analyzed integrally in one model, the dynamic interaction between adjacent buildings is taken into account. Further, the model accounts approximately for the three dimensional effects of the soil.

To assure that proper modeling techniques were employed and an accurate idealization was obtained, the FLUSH models were developed with the direct aid of the program developers. Attention was given to assure that the models met restrictions on element size for wave propogation in a dynamic analysis required by the maximum frequency of interest in the analysis.

SNUPPS is a standardization concept which originally included four separate sites. To maintain standardization in design of the power block, separate FLUSH analyses were conducted for each site. The results from each site are enveloped so that the design is based on the upper bound result of all sites obtained from the FLUSH analyses. Since the soil properties varied from soft to stiff at the various sites, a range of soil properties were included in the overall analysis.

This approach added to the conservatism of the design by the tendency to eliminate effects in the analysis of a given site that normally would aid in reducing the seismic response. Therefore, a unique set of soil properties and site conditions which could adversely filter out response to the seismic input a' a specific frequency most likely will not control the design due to the enveloping approach.

III. LUMPED MASS ELASTIC HALF SPACE SEISMIC ANALYSIS

Analytical models used for the elastic half space seismic analysis are shown in Figures 1 and 2, respectively, for the reactor building and the auxiliary/control building. Identical models were used for both Callaway and Wolf Creek analyses. The models were developed to represent as closely as possible, those used in the FLUSH analysis.

The elastic half space analysis followed the requirements of Reference 3. Structure and soil properties were used in a modal analysis program to determine mode shapes, frequencies and participation factors, and to compute the composite modal damping. The same time history record used for the FLUSH analysis, scaled to the site specific SSE values was then used to obtain modal time histories for each site. These results were used to produce the response spectra at 3 percent damping, so as to agree with the lowest damping value curves for the SSE finite element analysis. This damping ratio was used since it would most likely amplify any discrepancies between the analyses beyond that obtained at higher SSE damping rates.

The same structural idealization employed for the FLUSH analysis was used in the elastic half space analysis.

The soil data source used for each of the sites is identical to that used in the FLUSH analysis. This data was transferred into equivalent soil springs using the methods outlined in Reference 3. An equivalent rectangular base was used in determining the equivalent soil springs.

IV. RESULTS

The response spectra from the lumped mass elastic half space analysis for Wolf Creek and Callaway are compared to the SNUPPS multi-site (i.e., four-site) envelope and to a three-site envelope (four-site envelope less Tyrone), based on the FLUSH analysis. These results are presented in Figures 3 thru 5 for the Wolf Creek reactor building, Figures 6 thru 8 for the Wolf Creek auxiliary/control building for the elevations identified in Section I. Similarly, Figures 9 thru 11 and Figures 12 thru 14 provide a similar comparison for the Callaway site reactor and auxiliary/control buildings.

The comparison of the Wolf Creek lumped mass response spectra curves to both the four-site and three-site envelopes shows that the lumped mass curves are enveloped within the limitations of the analysis. In the few instances where the lumped mass curves exceed either the three-site or four-site envelope curves, they do so only over a limited frequency range and by very minor amounts.

Comparison of the Callaway lumped mass model to both the three and four site envelopes shows the elastic half space results to be generally within the enveloping curves. Some exceptions occur, but they are minor in nature. All these exceptions occur over a limited frequency range and are within the variations to be expected in comparison of the more rigorous finite element method to the elastic half space method. The most significant of these occur in Figures 10 and 12. In no case does the maximum response exceed the four-site peak. The three-site peak is exceeded in Figure 12, over a limited frequency range by less than 20 percent.

V. CONCLUSION

It has been shown that the response spectrum curves obtained at various elevations on two power block structures on each of two sites developed utilizing elastic half space analytical techniques, compare favorably with the envelope curves developed for design use on the SNUPPS project. Although isolated instances exist where the elastic half space results exceed the design spectrum, they are limited in number and extend over a limited frequency range resulting only in minor amplitude variations. Although the comparison for both sites yield favorable results, the severity and frequency of these exceptions are less for the Wolf Creek site.

Within the scope of this study, as identified in Section 1, no gross abnormalities have been identified in the SNUPPS seismic analysis results.

REFERENCES

1. NRC letter dated 5-8-81 (Drumerick & Edison to Kansas Gas and Electric Company and Union Electric Company) - Summary of Meeting Held on May 5, 1981 with Wolf Creek and Callaway Applicants.

2. SNUPPS FSAR - NRC Docket Nos. STN 50-482, STN 50-483, and STN 50-486

3. Bechtel Topical BC-4A, Rev. 3, Seismic Analysis of Structures and Equipment for Nuclear Power Plants - Approved by AEC, October 31, 1974.

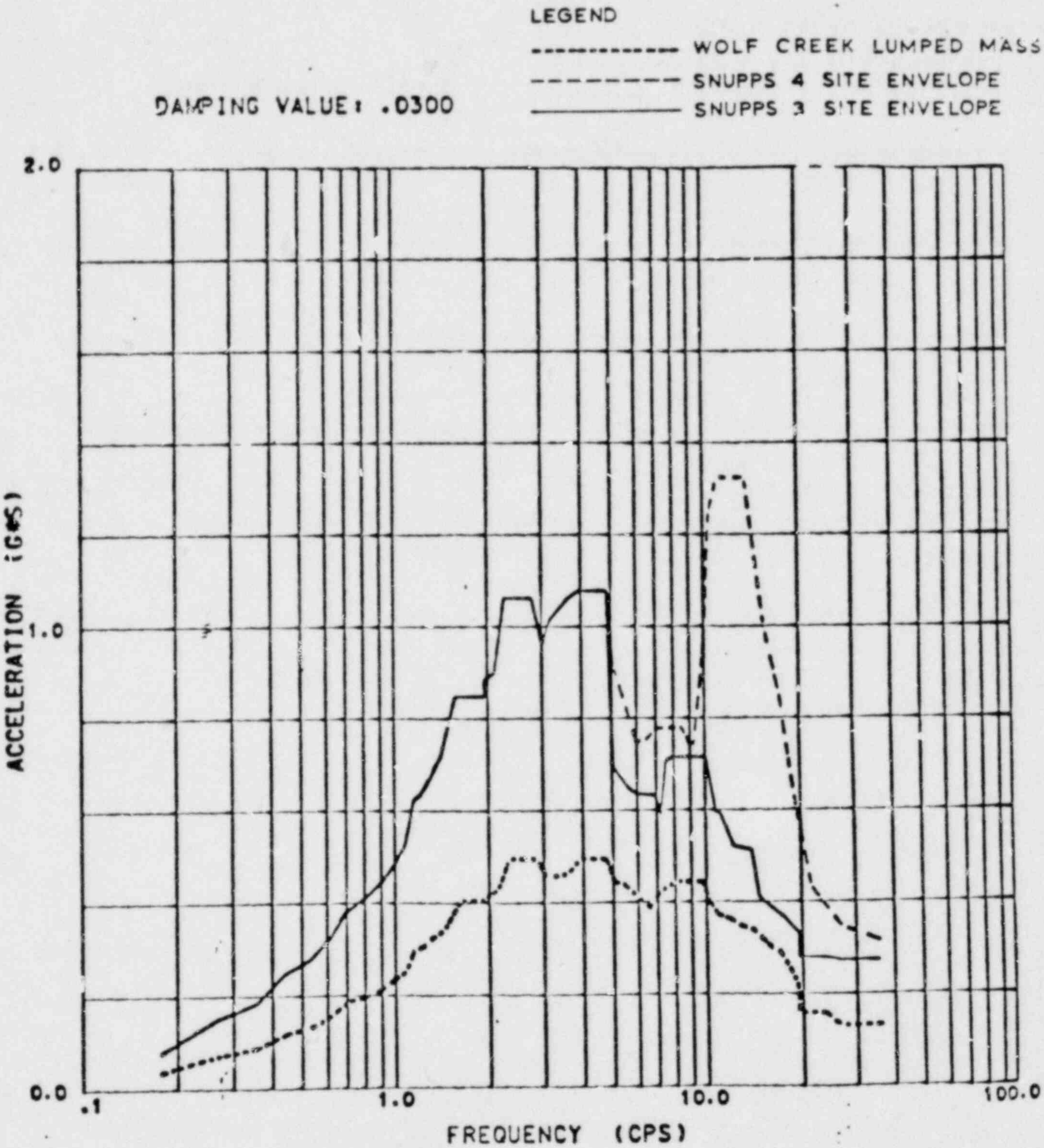

FIG. 3 SPECTRA REACTOR BUILDING
EL. 2012-0 NORTH SSE

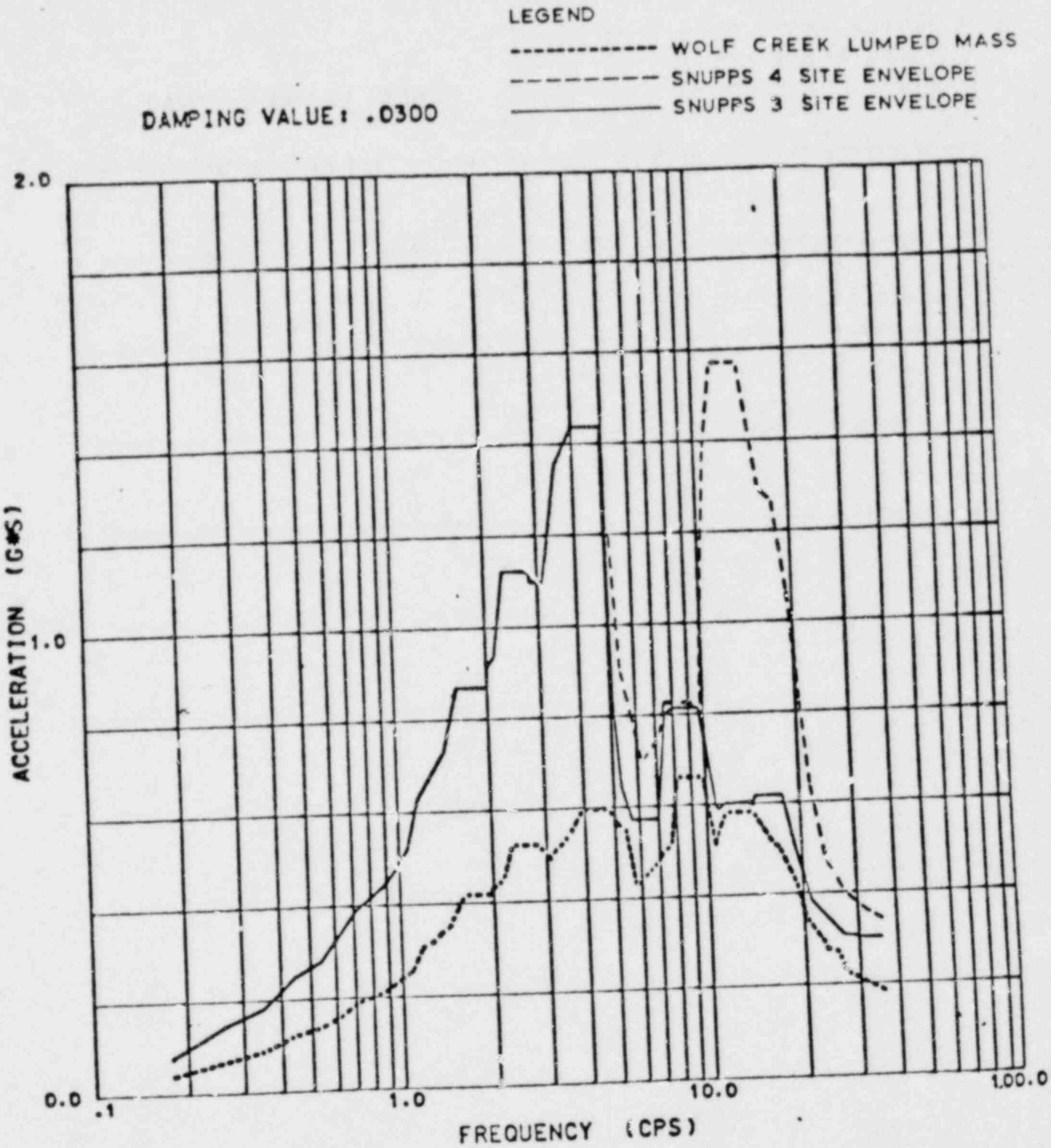

FIG. 4 SPECTRA REACTOR BUILDING
EL. 2047-6 NORTH SSE

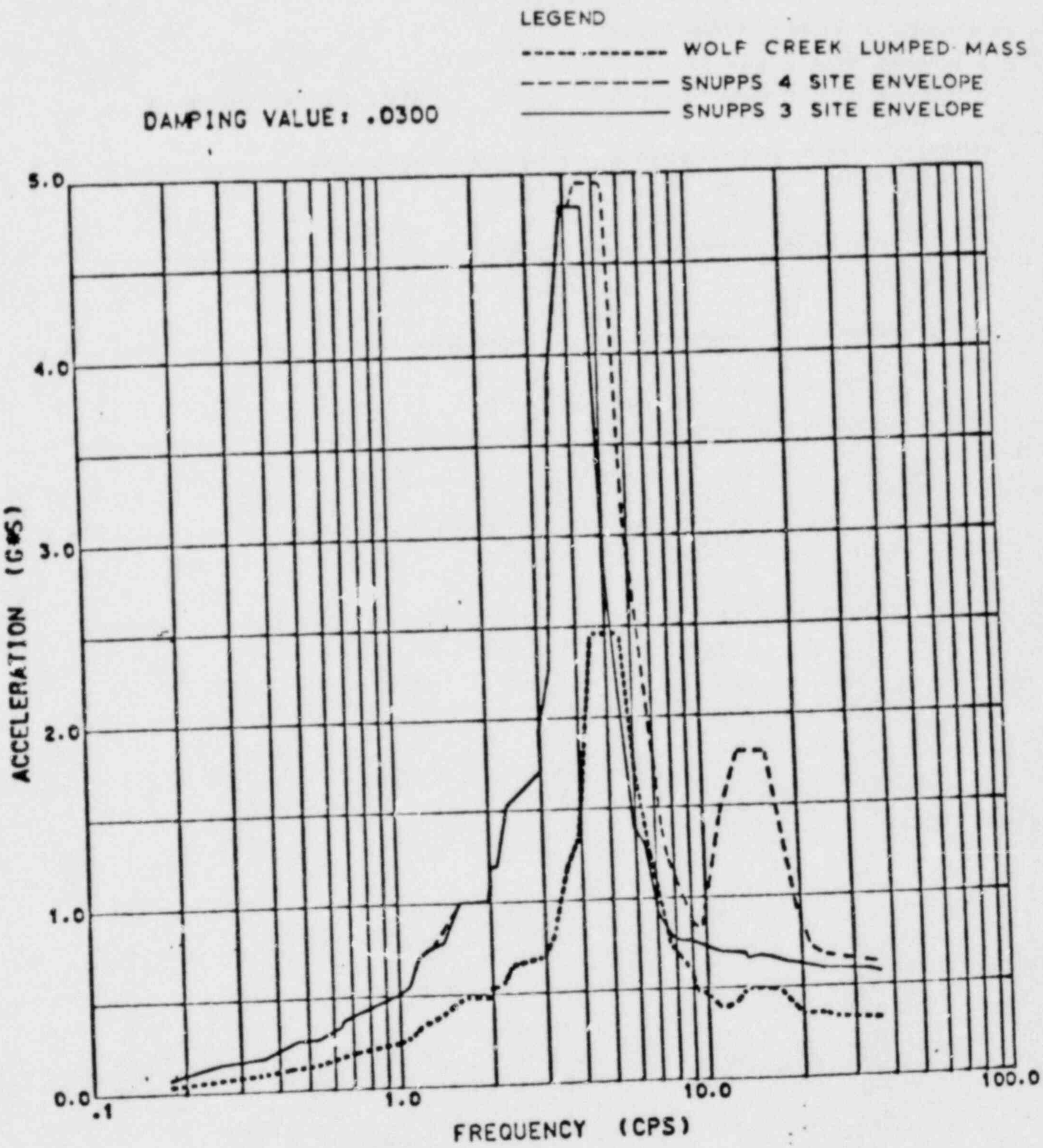

FIG. 5 SPECTRA REACTOR BUILDING
EL. 2119-0 NORTH SSE

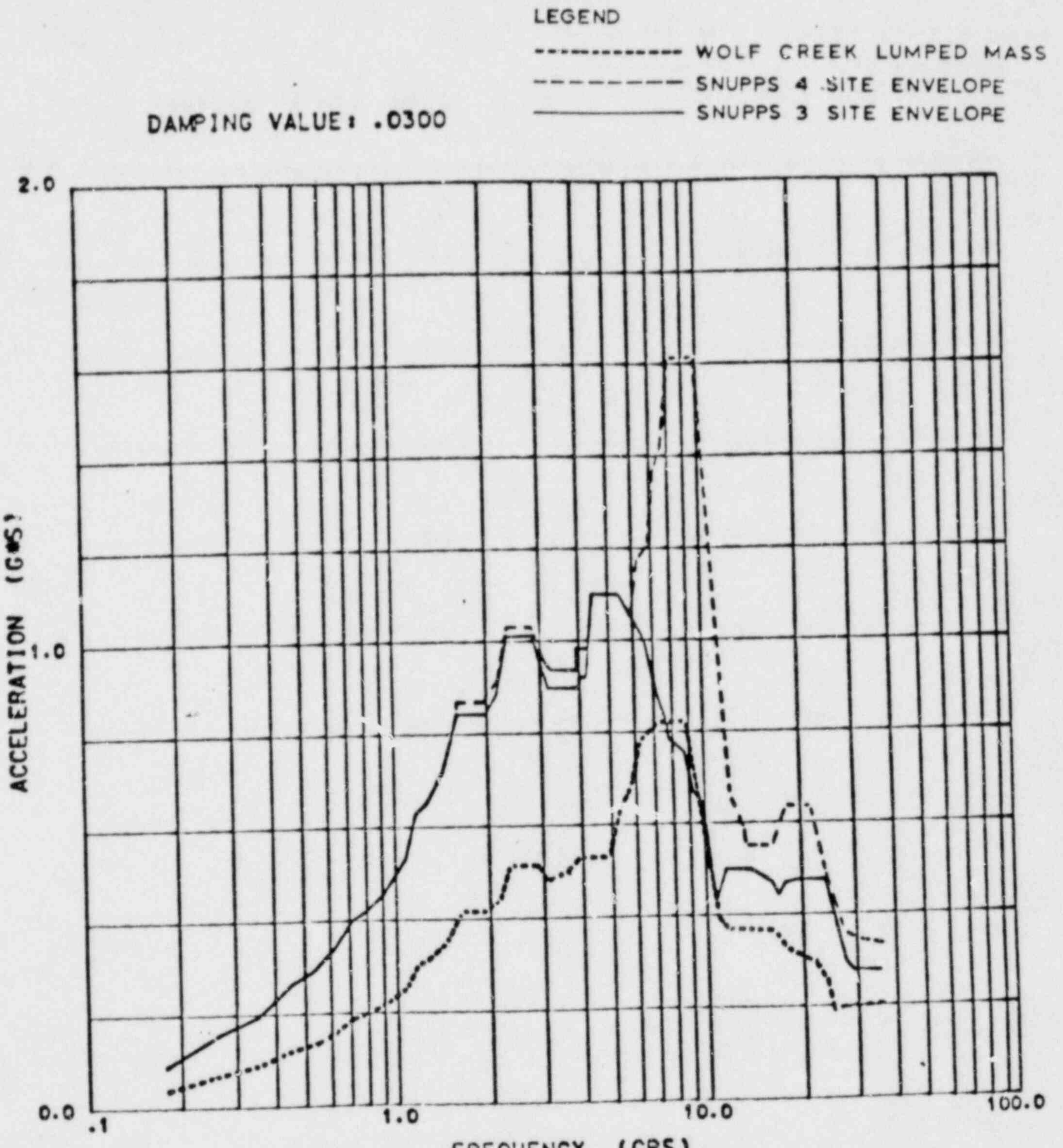

FIG. 6 SPECTRA AUXILIARY CONTROL
EL. 2000-0 NORTH SSE

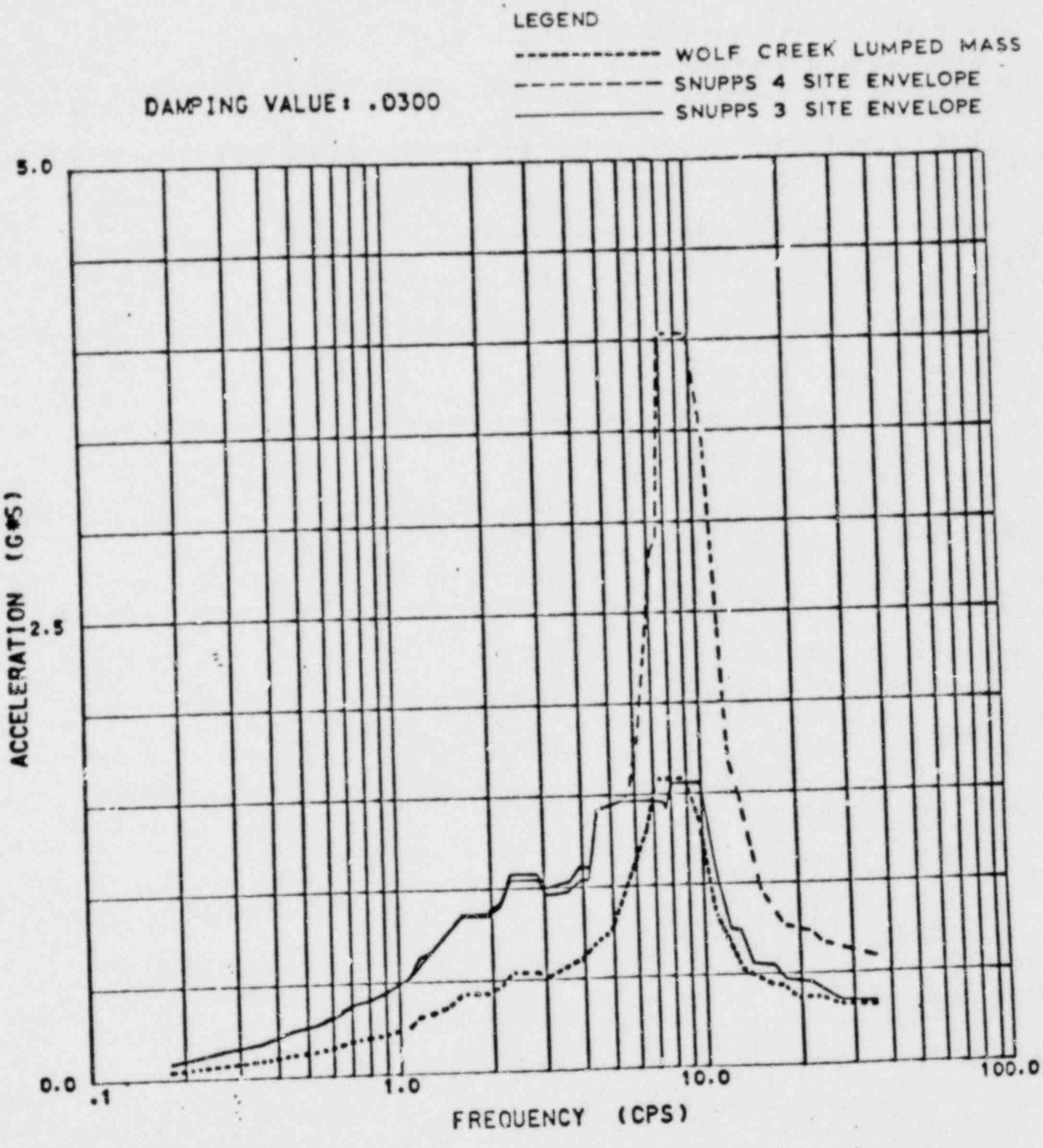

FIG. 7 SPECTRA AUXILIARY CONTROL
EL. 2047-6 NORTH SSE

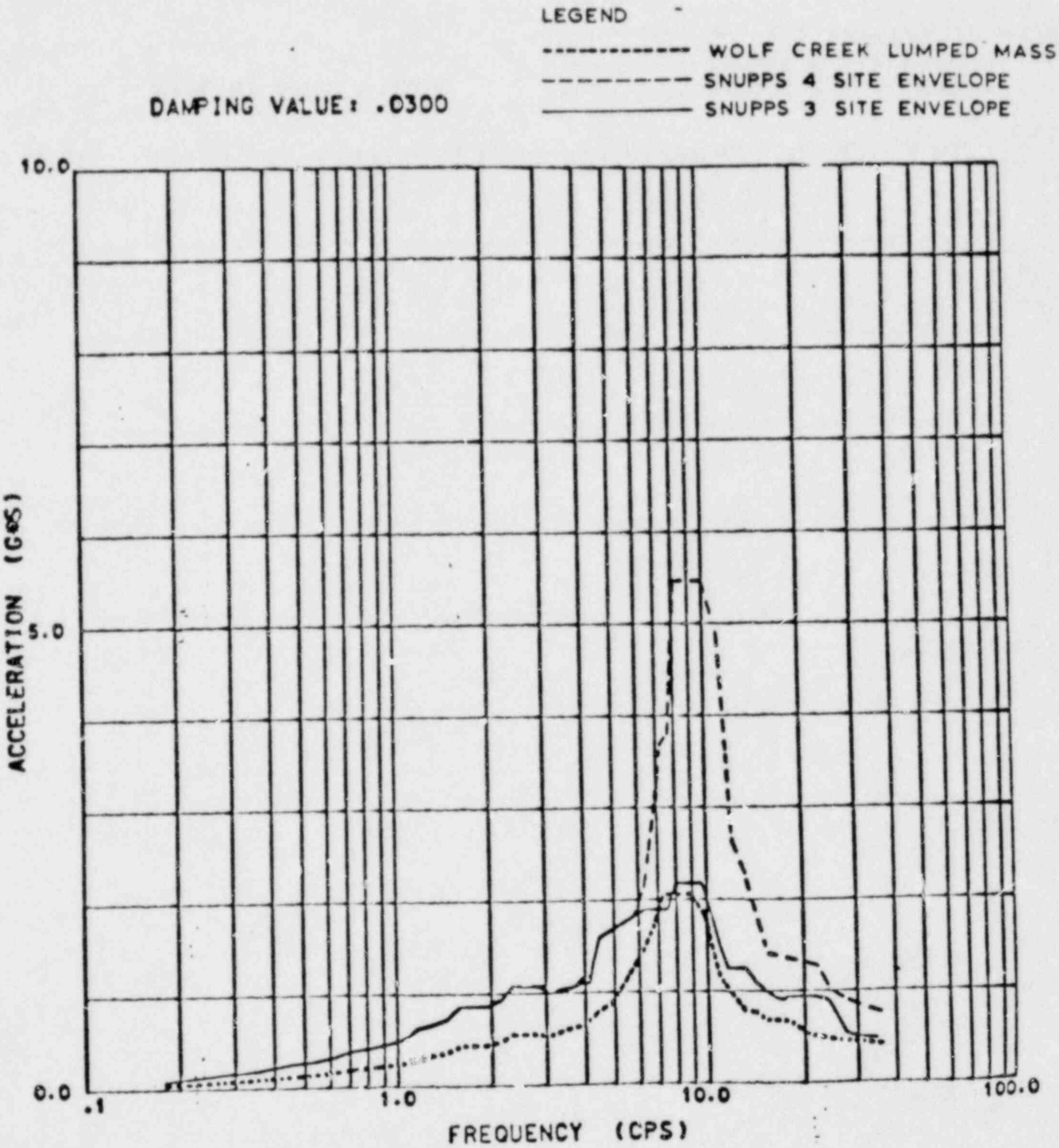

FIG. 8 SPECTRA AUXILIARY CONTROL
EL. 2087-2 NORTH SSE

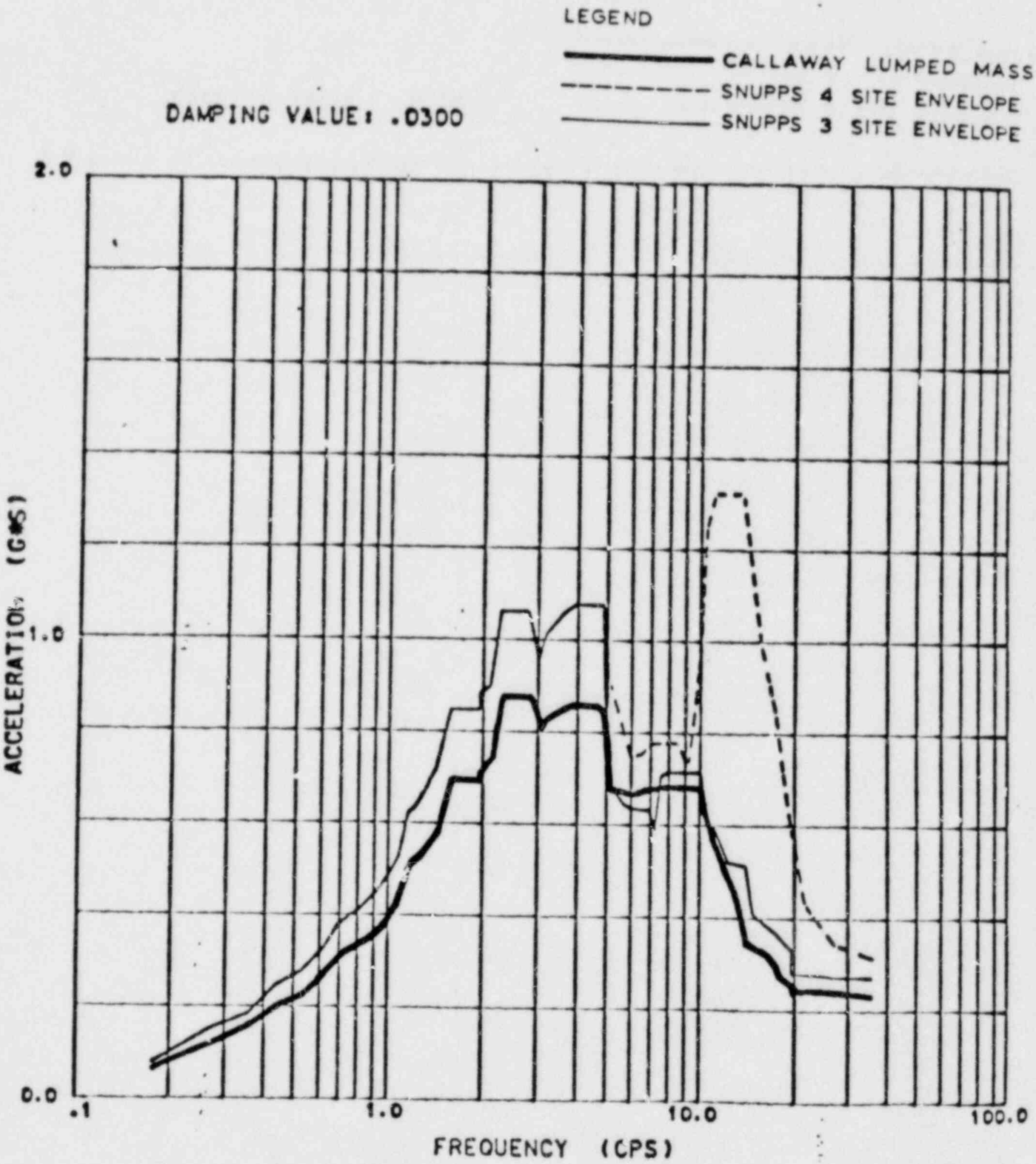

FIG. 9 SPECTRA REACTOR BUILDING
EL. 2012-0 NORTH SSE

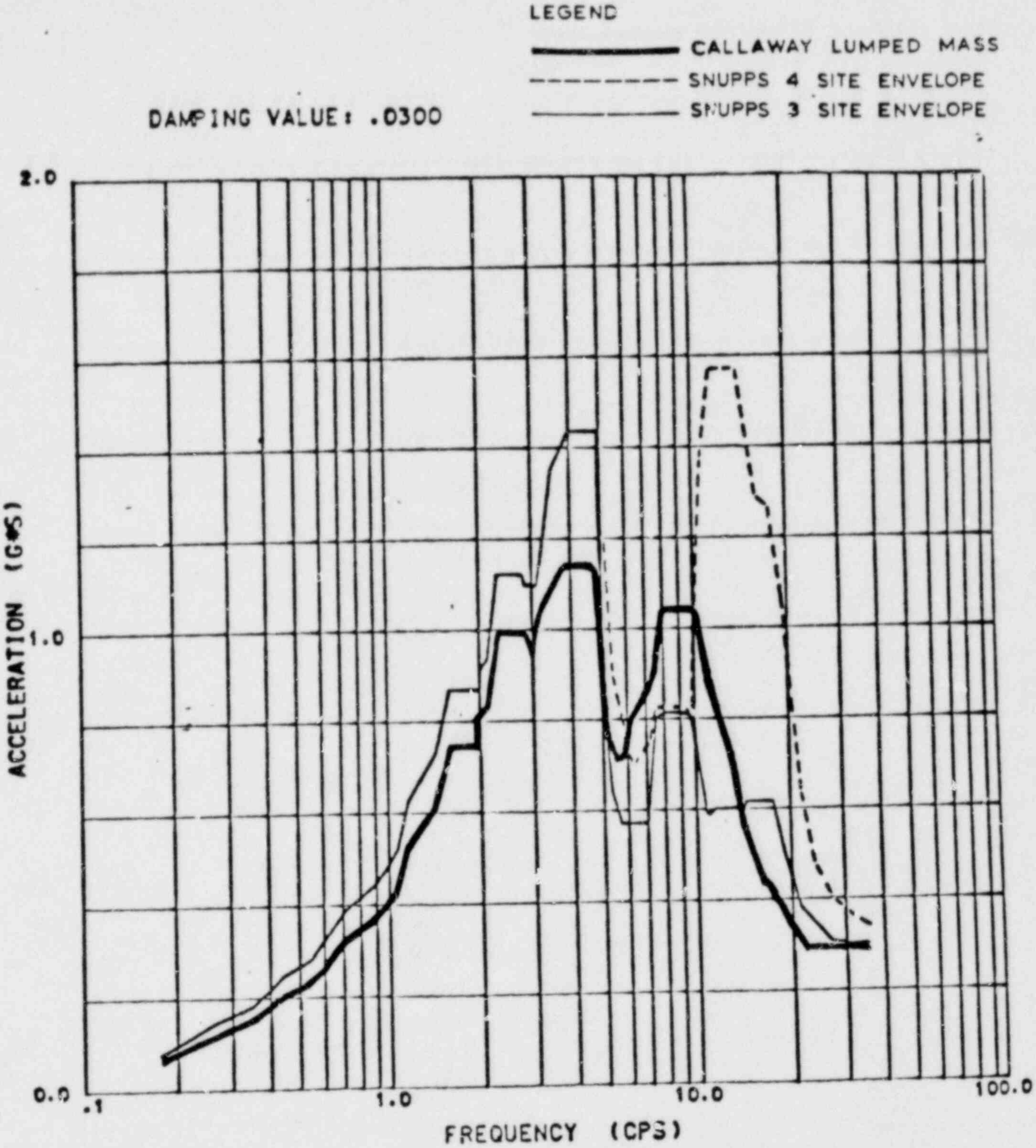

FIG. 10 SPECTRA REACTOR BUILDING
EL. 2047-6 NORTH SSE

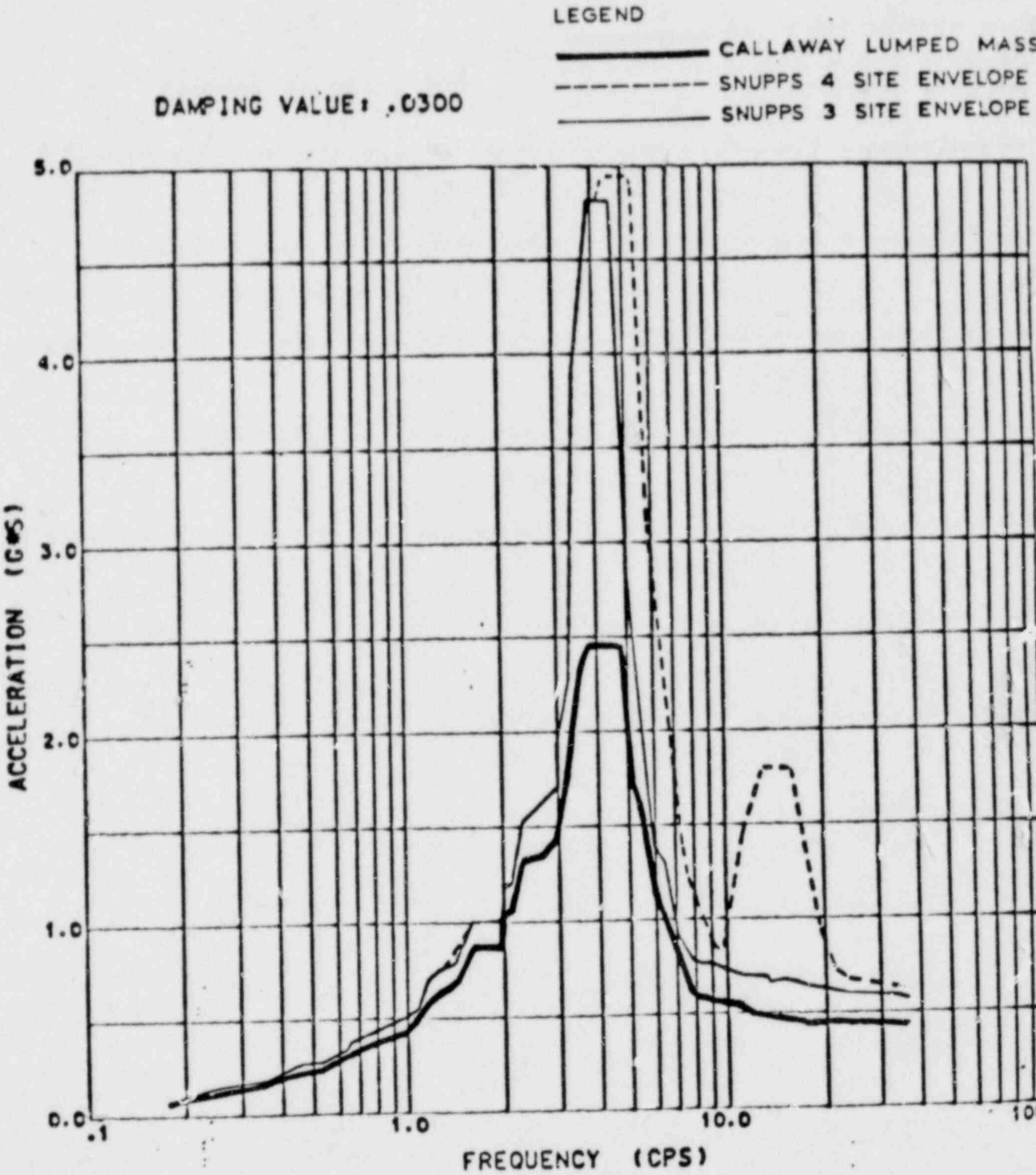

FIG. 11 SPECTRA REACTOR BUILDING
2119-0 NORTH SSF

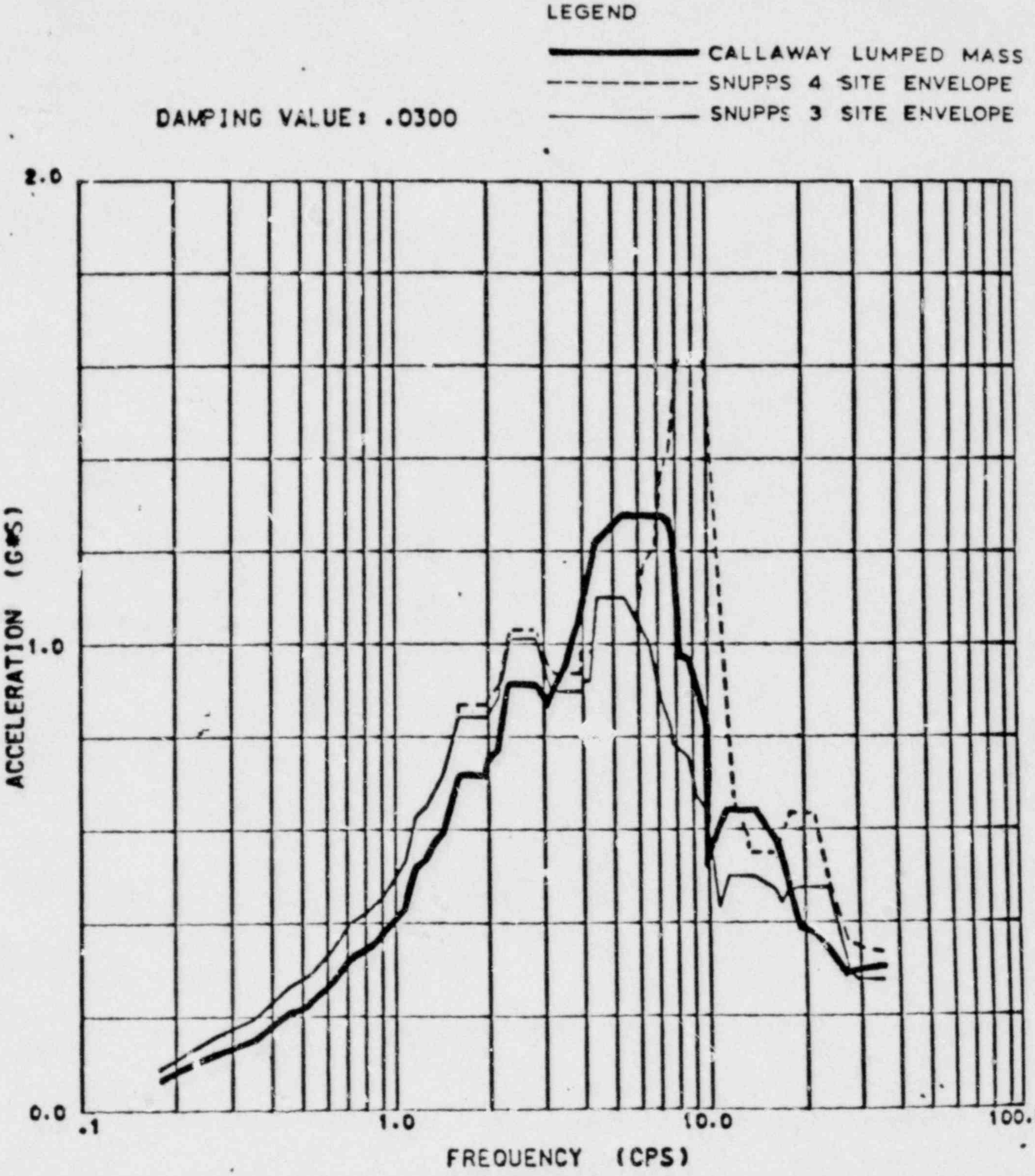

FIG. 12 SPECTRA AUXILIARY CONTROL
EL. 2000-0 NORTH SSE

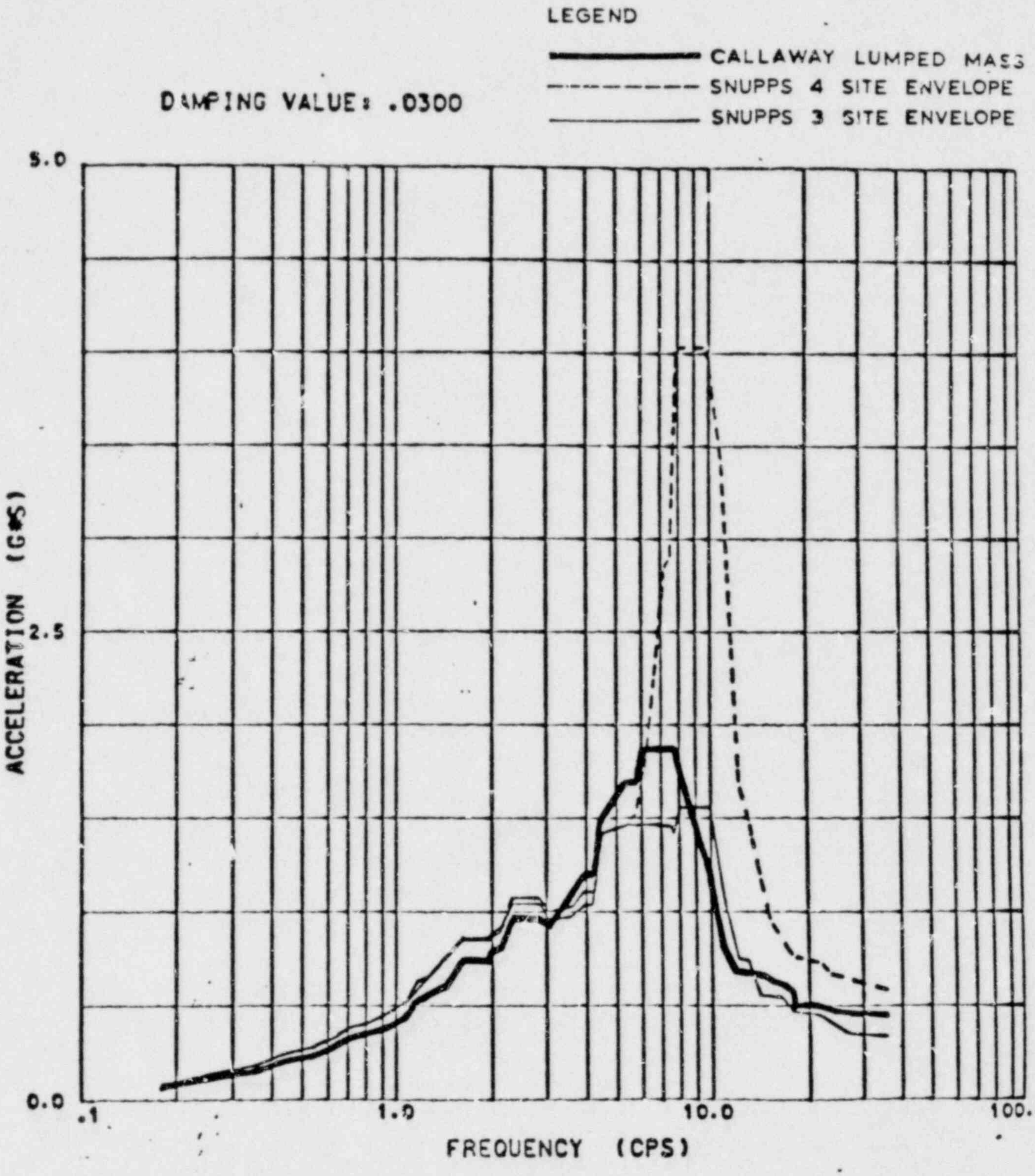

FIG. 13 SPECTRA AUXILIARY CONTROL
EL. 2047-6 NORTH SSE

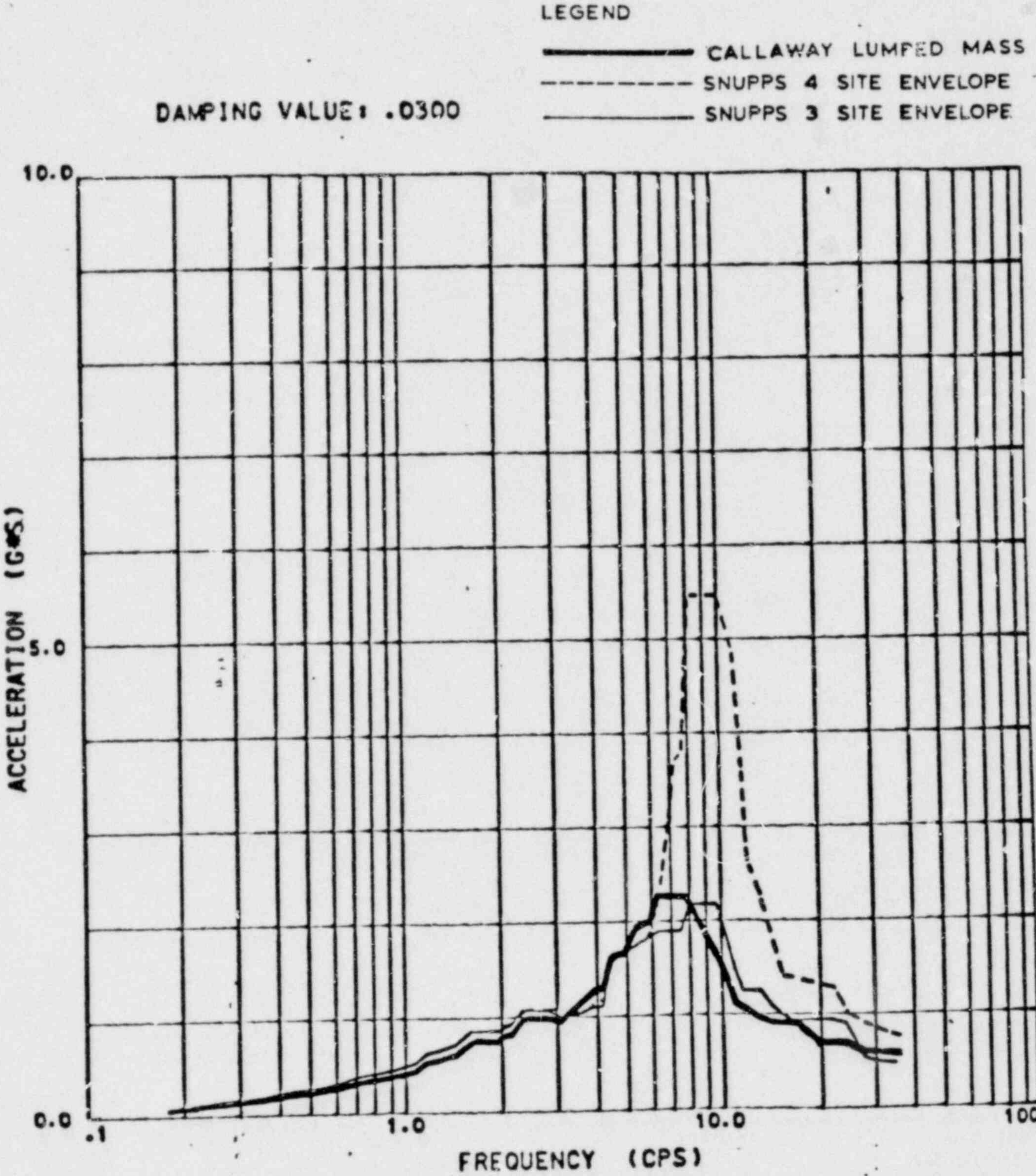

FIG. 14 SPECTRA AUXILIARY CONTROL
EL. 2087-2 NORTH SSE