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Lisa, Fred

Attached is a 1½ page progress report with 5 representative psd plots. Hope this is what you needed.

Alan

THIS TRANSMISSION CONSISTS OF 7 PAGES EXCLUDING COVER PAGE.

Progress Report

Ambient Ground Vibration Measurements at the Livingston, Louisiana LIGO Site

An analysis of ground vibration measurements taken at the Laser Interferometer Gravitational Wave Observatory (LIGO) site at Livingston, Louisiana, is underway to characterize the ambient seismic noise conditions, anthropogenic noise, and wind and acoustic noise sources.

Continuous seismic data were recorded at the LIGO site from October 26 to November 3, 1995. The equipment used was essentially identical to that used for the Hanford measurements, but additional equipment was obtained from PNNL and the IRIS consortium to make simultaneous, synchronized measurements at the Corner and two Ends of the LIGO site. The seismic systems at the South End and West End were installed on October 26. On October 27 the third seismic system was installed at the Corner, along with the infrasound microphone and wind measurement system. The data collection program produced valid seismic data measured simultaneously at all three sites for a 6-day period from mid-day Friday, October 27 to Thursday morning, November 2. Timing on all three seismic recording systems was synchronized to external GPS clocks that operated continuously at each site, and a timing precision better than 0.05 milliseconds was obtained.Wind measurements were made at the Corner throughout this period. The acoustic microphone operated for the first four days of this period.

On Wednesday, November 8, the systems were re-deployed at various distances from two pipelines that cross the West Arm of the LIGO site. Damage to the interconnecting cables from earlier flooding resulted in a loss of most of these data, but several half-hour samples of vertical-component noise were recorded at the Shell and Transcontinental pipelines, and three-component data were successfully recorded at two additional sites 0.1 and 0.3 miles east of the Shell pipeline

The data collected in the field was recovered and reviewed using computer systems and facilities provided by the Physics Department at Louisiana State University, Baton Rouge, prior to returning to Hanford. Simultaneous, synchronized seismic (only) measurements were made January 5, 1996, at the Hanford site; previous measurements had been made at one location at a time.

Spectra from all three components of all three sites for two nighttime and two daytime one-hour time series were provided to LIGO engineers January 5. Two examples of the spectra are attached (see Figure 1 and Figure 2). The Livingston seismic noise is notably higher than at Hanford from about 0.5 to 5 Hz, and the overall character of the low-frequency (0.1-1.0 Hz) microseism noise peak is broader. These results at Livingston are in good agreement with previous measurements make by Warren Johnson of LSU in 1988. Seismic noise at frequencies higher than 10 Hz is consistently below the LIGO design spectrum. As noted at Hanford, much of this higher-frequency noise is transmitted acoustically from a variety of anthropogenic sources. At Livingston, it was observed that a train passing twice daily about 1 1/2 miles south of the South End produced a significant increase in noise (see Figure 3).

Spectra from the usable seismic signals recorded near the Transcontinental and Shell pipelines have also been completed. Examples of these spectra (see Figures 4 and 5) indicate that there a detectable increase in the 40-60 Hz range directly over the Transcontinental pipelines, but that there is little effect observed over the Shell pipeline. Operational data such as flow rates and pump operating frequencies have been obtained from Transcontinental and is expected soon from Shell.

The differences in the low-frequency (0.1 to 1.0 Hz) between the Hanford and Livingston sites results in different effects on differential motion analyses. At Hanford, this noise can be highly correlated and can be identified as propagating Rayleigh waves approaching dominantly from the West (Pacific ocean wave phenomena are the dominant source). At Livingston, very little coherence is observed between the signals measured at the three locations. This results in the differential motions (e.g. the length change along one of the arms inferred from the difference in the corresponding seismic signals) being larger than the independently-measured displacements by a factor of approximately 1.4 (as expected from the sum of two random, un-correlated noise processes). At the Hanford site, the same calculations indicate that the differential motion is reduced by about 30%, depending upon the orientation of the arm relative to the propagation direction of the noise. This reduction occurs because the wavelength of the Rayleigh waves is significantly longer (20 km) than the maximum distance subtended by the arms of the LIGO facility.

In order to complete this study, a calibration and correction of the phase response of the third seismometer relative to the two LIGO seismometers is needed. Although the amplitude response is not affected significantly above 0.1 Hz, the group delay of the 30-s seismometer is significantly different than the group delay for the 20-s seismometers for measuring differential motions in the frequency range near 0.1-0.2 Hz. Otherwise, most of the analysis tools developed for the previous Hanford measurement can be directly applied to the Livingston data. A draft report is expected to be produced by April 15, and the final report is expected to be completed May 15.

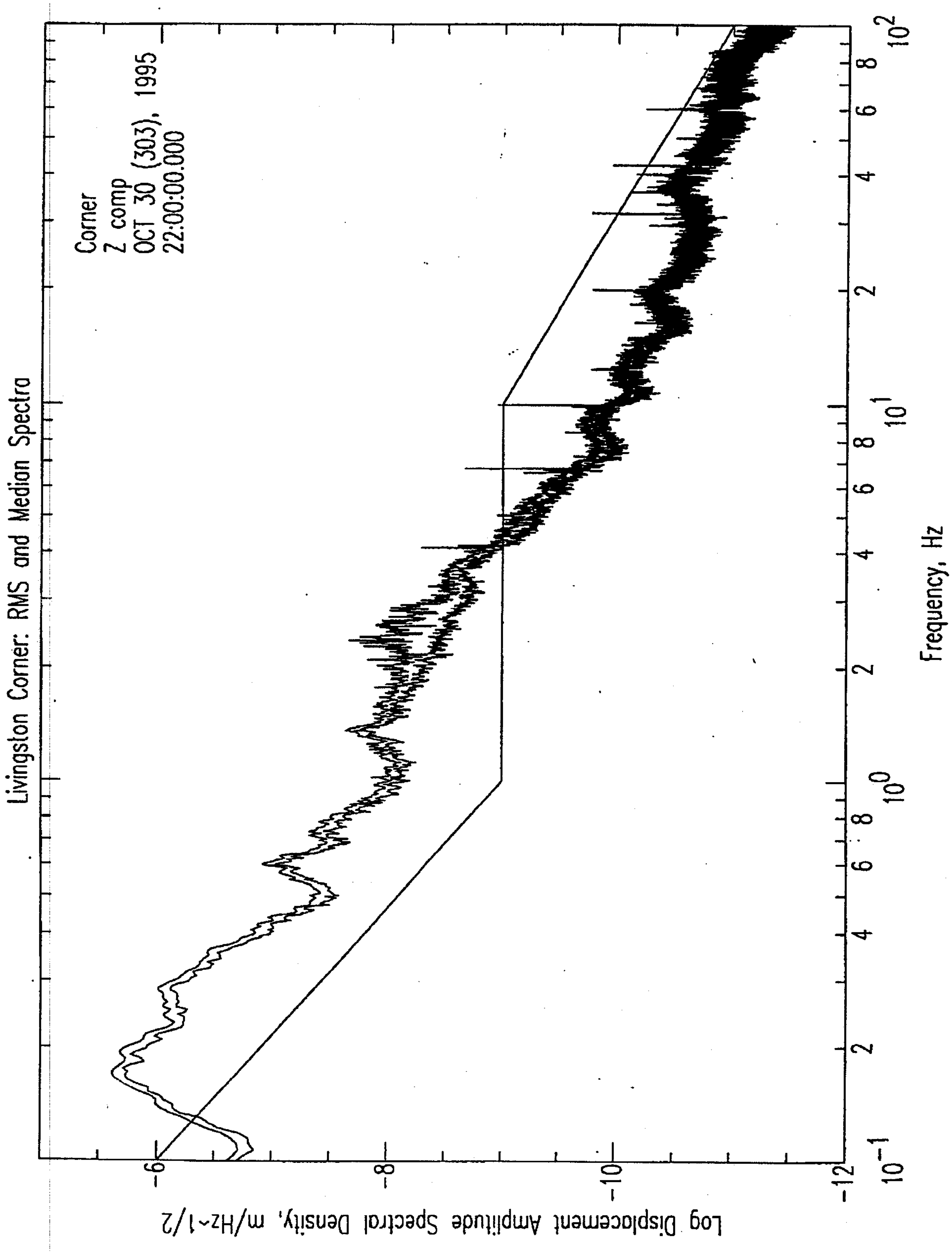

Figure 1. Daytime seismic noise.

Figure

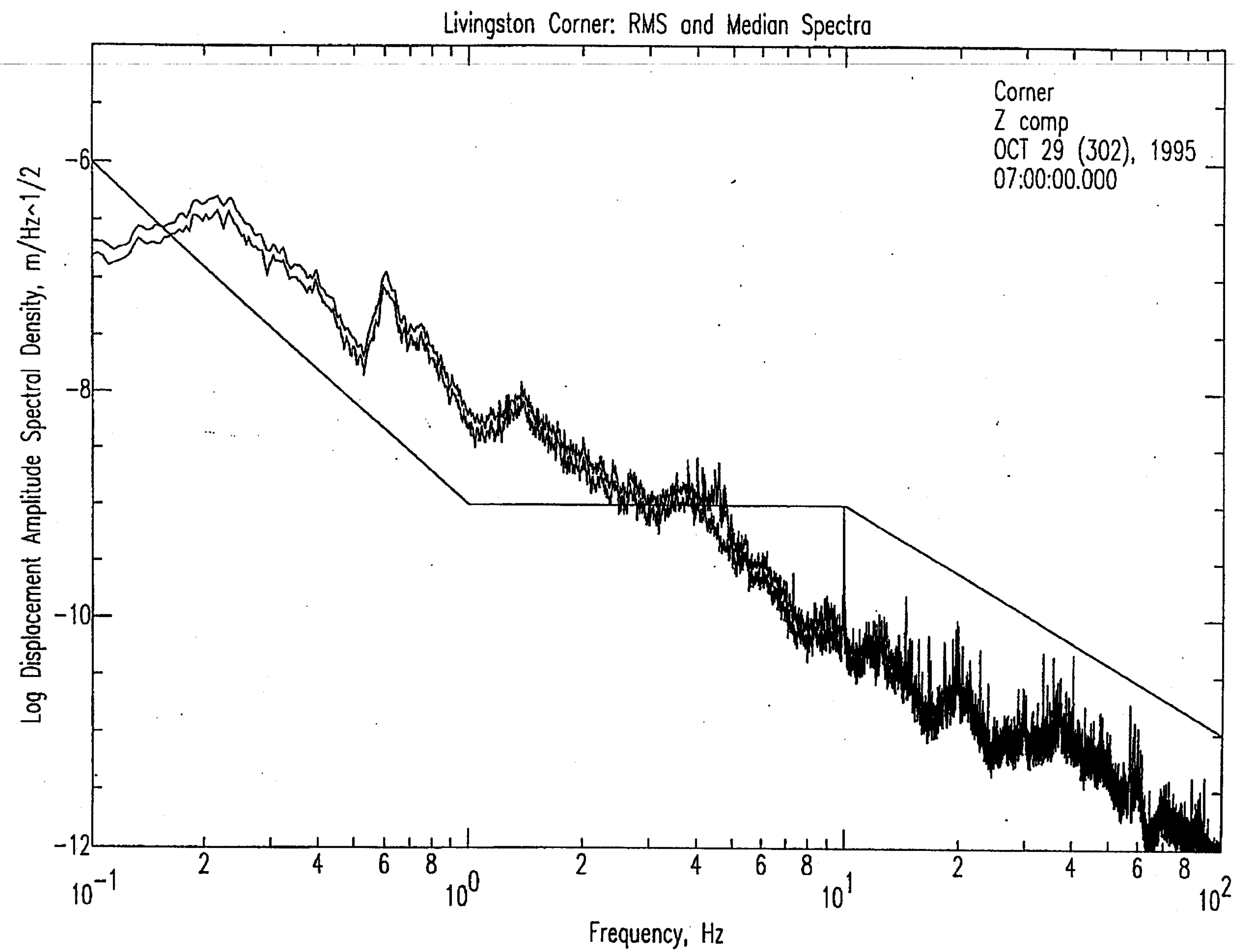

Figure 2. Nighttime seismic noise.

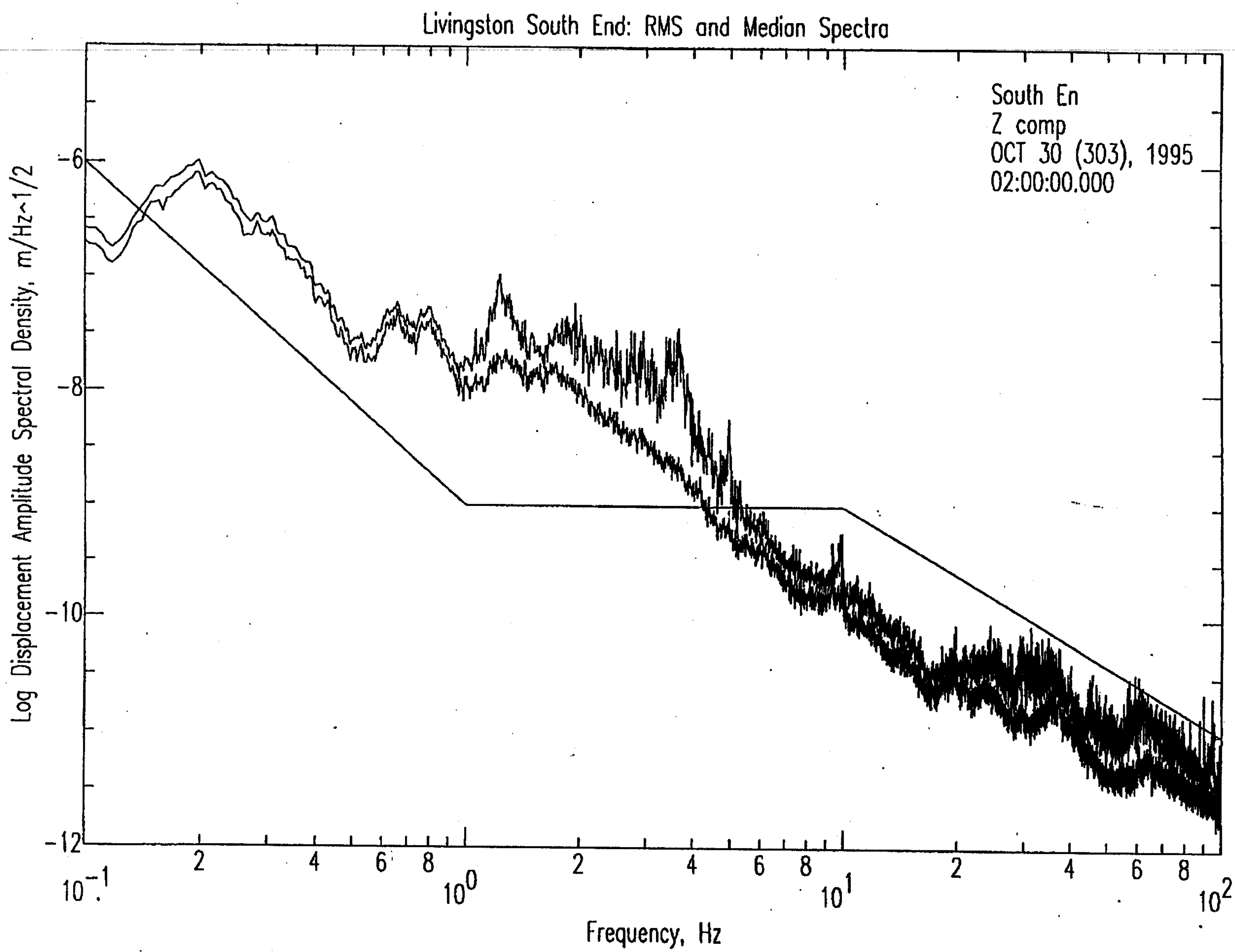

Figure 3. Daily train noise.

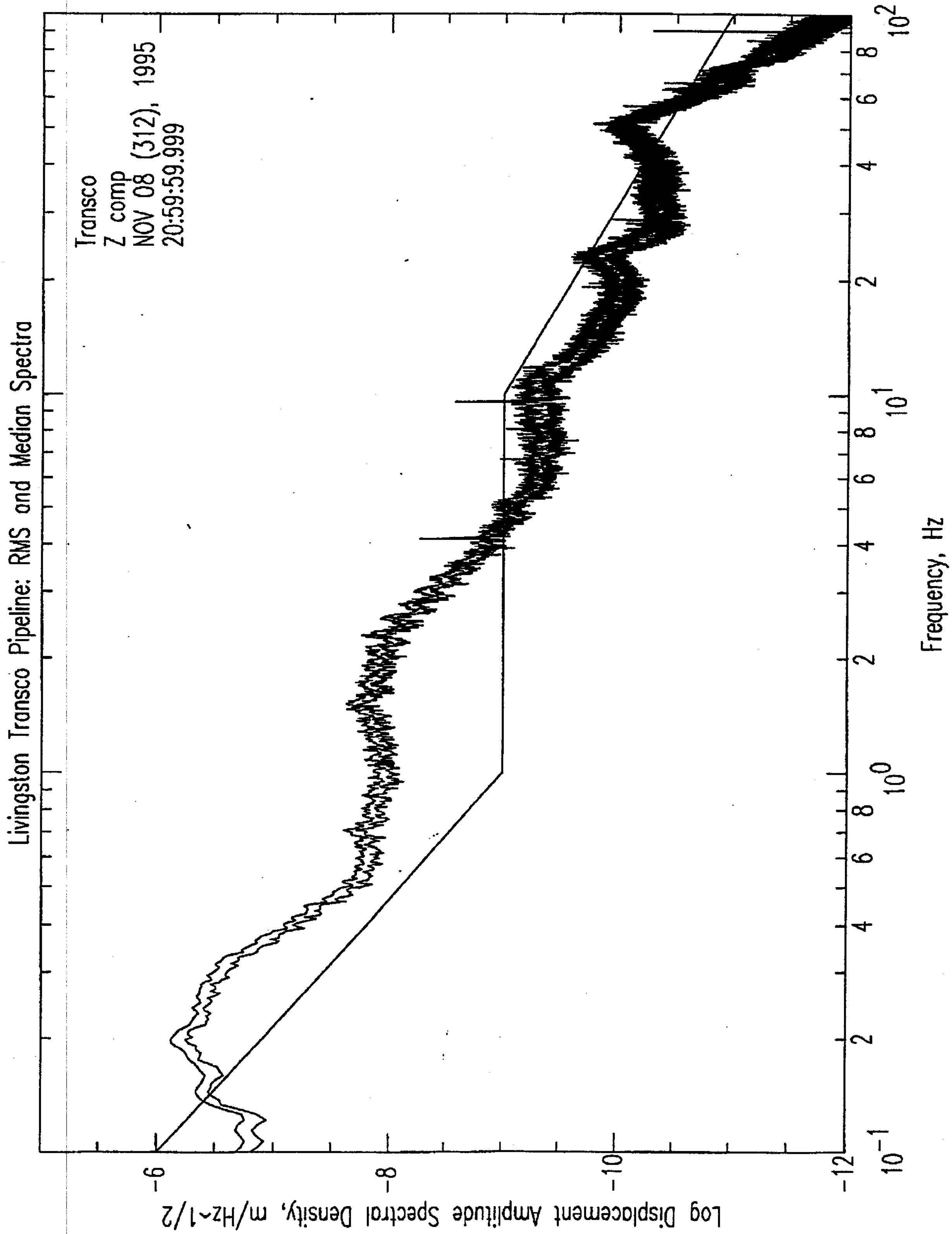

Figure 4. Noise at Transco Pipeline.

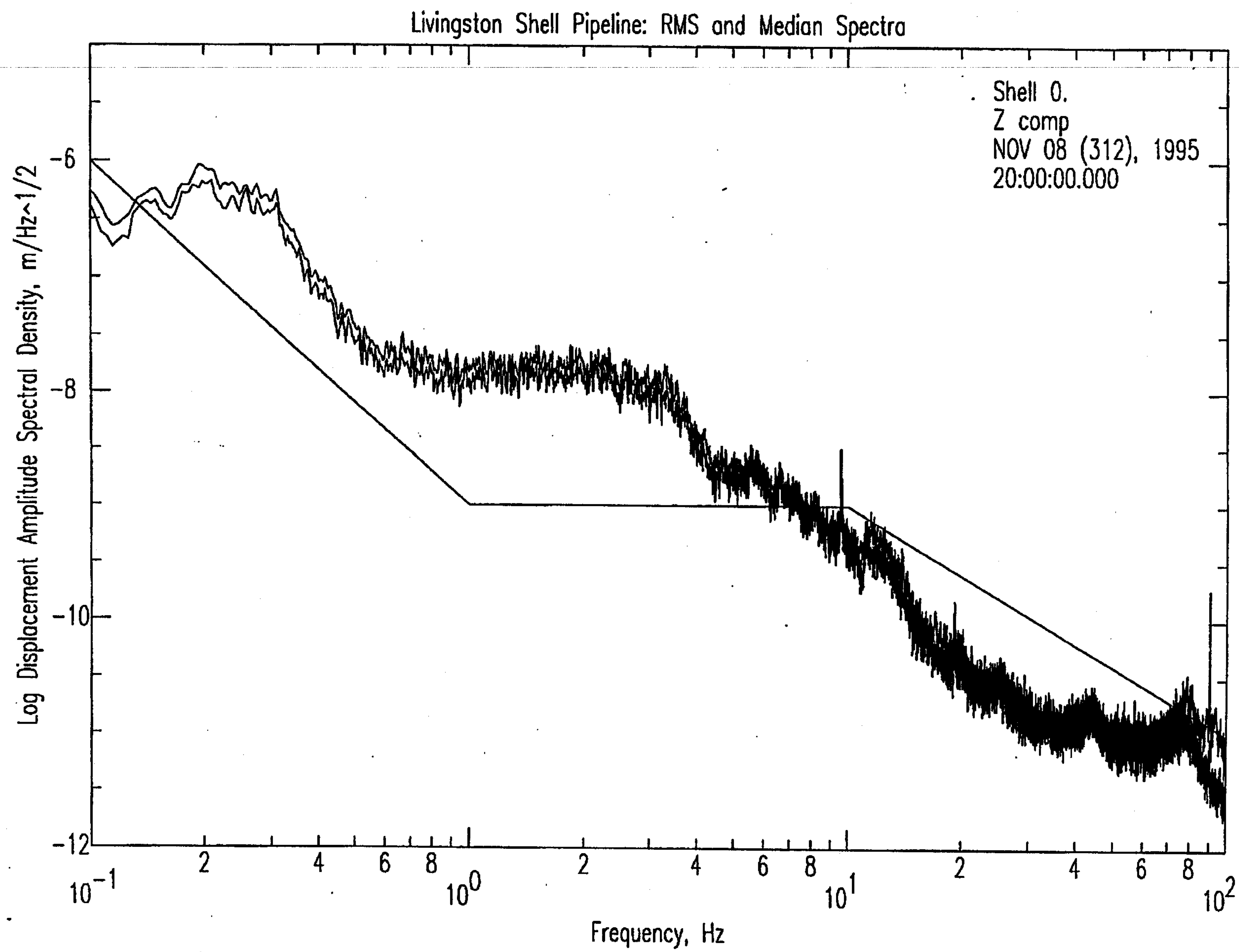

Figure 5. Noise at Shell Pipeline.