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March 1996

US Army Corps of Engineers
Waterways Experiment Station

Los Angeles Harbor Pier 400 Long Wave Probability Analysis Data Summary

by James Rosati III, James P. McKinney

Prepared for U.S. Army Engineer District, Los Angeles

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U.S. Army Corps of Engineers
Waterways Experiment Station
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Vicksburg, MS 39180-6199

Final report

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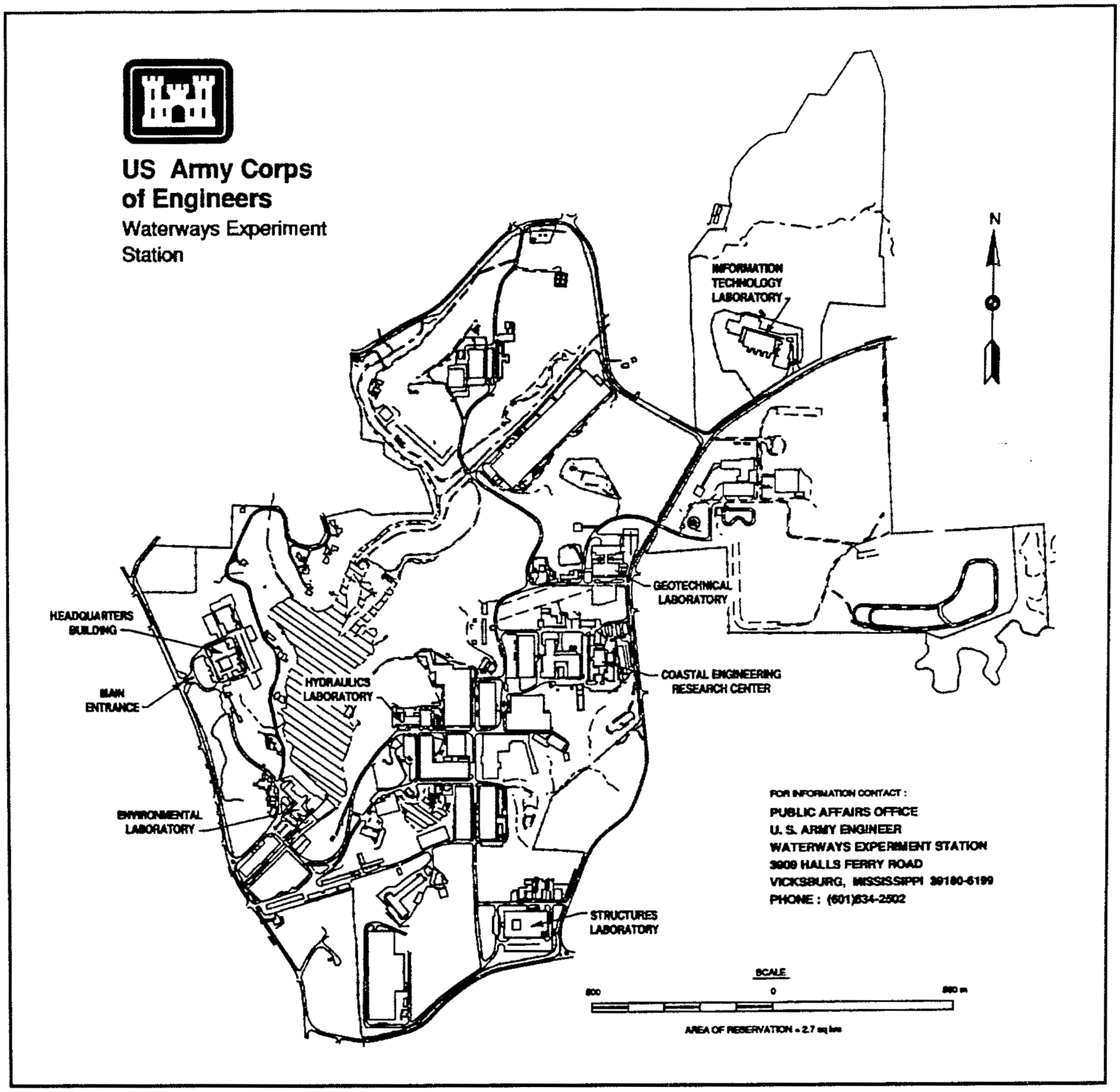
Prepared for U.S. Army Engineer District, Los Angeles
Los Angeles, CA 90053-2325



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Preface

This report was prepared by the Coastal Engineering Research Center (CERC), U.S. Army Engineer Waterways Experiment Station (WES), and is a product of a reimbursable study funded by the U.S. Army Engineer District, Los Angeles (SPL). The investigation was conducted during the period September 1993 to January 1994 by personnel of the Prototype Measurement and Analysis Branch (PMAB), CERC. This report was prepared by Messrs. James Rosati III and James P. McKinney, PMAB.

During the course of the study, significant liaison was maintained between WES, SPL, the Ports of Los Angeles and Long Beach, and the Pier 400 design team. Project management for SPL was administered by Ms. Jane Grandon under the supervision of Mr. Arthur Shak, Chief, Coastal Engineering Section. Messrs. Richard Wittkop and John Foxworthy were points of contact for the Port of Los Angeles and provided valuable input along with their Pier 400 design team contacts, Dr. Kimo Walker, Mr. Russ Boudreau, and Dr. Paul Szwetlot.

General supervision was provided by Dr. James R. Houston, Director, and Mr. Charles C. Calhoun, Jr., Assistant Director, CERC; direct supervision of the project was provided by Messrs. Thomas W. Richardson, Chief, Engineering Development Division, CERC, and William L. Preslan, Chief, PMAB.

During the publication of this report, Director of WES was Dr. Robert W. Whalin. COL Bruce K. Howard, EN, was Commander of WES.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
inches	2.54	centimeters
square inches	6.4516	square centimeters
miles (U.S. statute)	1.609347	kilometers

1 Introduction

As part of a reimbursable study for the U.S. Army Engineer District, Los Angeles, a long wave probability analysis has been performed. The purpose of this work is to supply the data needed to predict the magnitude and distribution of wave energy in the harbors after construction of the Los Angeles Harbor Pier 400 expansion. Prototype wave data have been collected at offshore Platform Edith as well as selected inshore sites within Los Angeles/Long Beach (LA/LB) Harbors since 1984 (Figure 1).[1] This gaging has occurred with the support of the Los Angeles District and the Ports of Long Beach and Los Angeles. Analysis and data collection methods, as

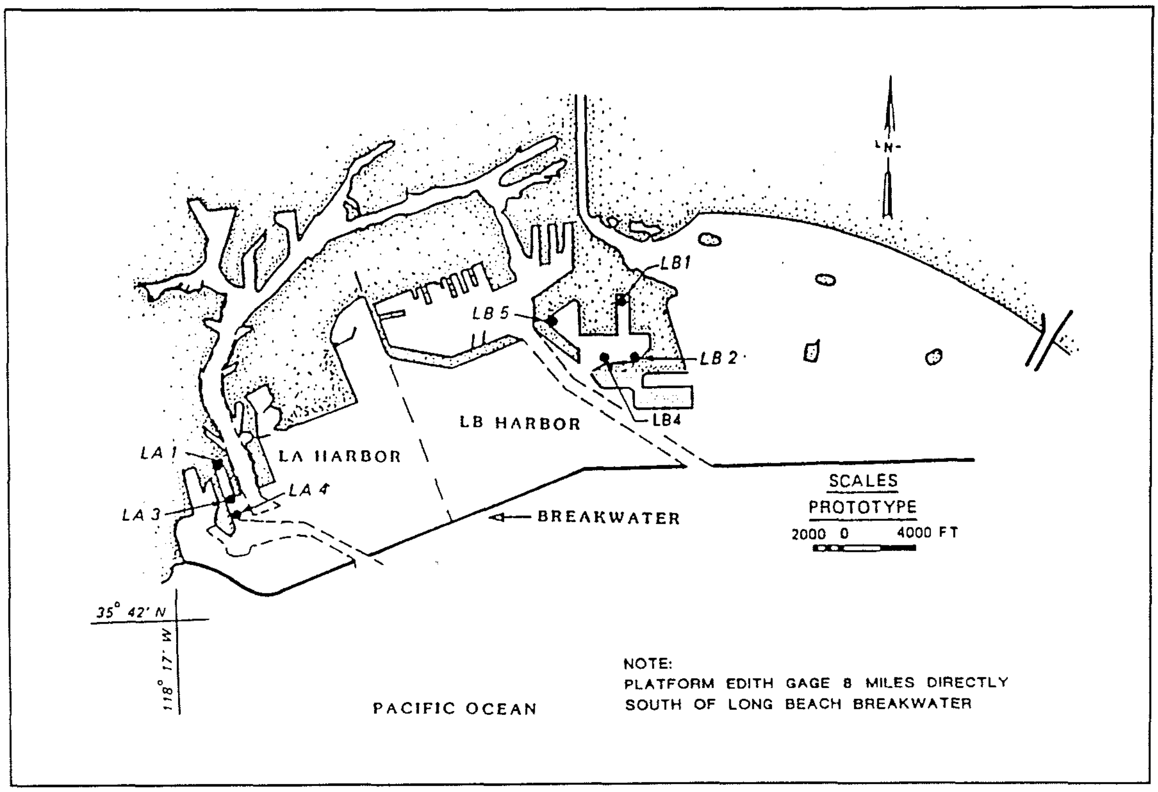

Figure 1. Prototype wave gage locations

[1]A table of factors for converting non-SI units of measurement to SI units is presented on page v.

well as data availability, are documented in a wave data summary report (Rosati, McKinney, and Puckette, in preparation). These wave data are used to document the waves occurring in the harbors due to the incident wave climate. The harbor response to incident wave energy affects ship motion and therefore the economic use of port facilities. This report documents how the probability analysis was performed and presents the results for use by the harbor resonance analysis performed by Seabergh and Thomas (1995).

2 Approach

Transfer Functions

The procedure for analyzing these wave data can be viewed as a sequence of transfer functions. The directional wave spectrum outside the harbor is transferred to short- and long-period waves inside the harbor. Long-period waves at each berthing site can be used to drive a ship motion model. Using these transfer functions and long-term wave statistics outside the harbor, probability of exceedance can be computed for ship motions at a berthing site. Prototype measurements inside and outside the harbor are used to empirically estimate the wave energy transfer function. However, prototype measurements are available for only a few gaging sites and are representative of only the harbor configuration existing while the gaging is occurring. Prototype data are used to calibrate and verify the performance of the model by comparing prototype measurements to model measurements at the same sites and for the same conditions as measured during prototype events (Figure 2).

The distorted-scale harbor physical model is used as the computational tool to estimate wave energy at all sites of interest, and for proposed new configurations. The collected prototype data can only describe the response of the current configuration of the harbors and therefore cannot predict harbor response when the configuration changes. Different expansion configurations were tested in the LA/LB physical model (Figure 3). The existing configuration is referred to as the base condition and the proposed configuration (the only one considered in this study) is termed POLA stage 1.

Physical Model Data

An example of the transfer function results obtained from the physical model is the amplification factor plot shown in Figure 4. Figure 4 describes the response of the harbor for a given incident wave condition. In this figure, if the response is greater than 1, the waves inside the harbor are larger than the waves outside the harbor for the periods of interest. This figure also shows good agreement with prototype data measured at the same location as in the physical model. The condition selected for this study is the "uniform" or "mean energy" spectrum with incident waves coming from the south. This is

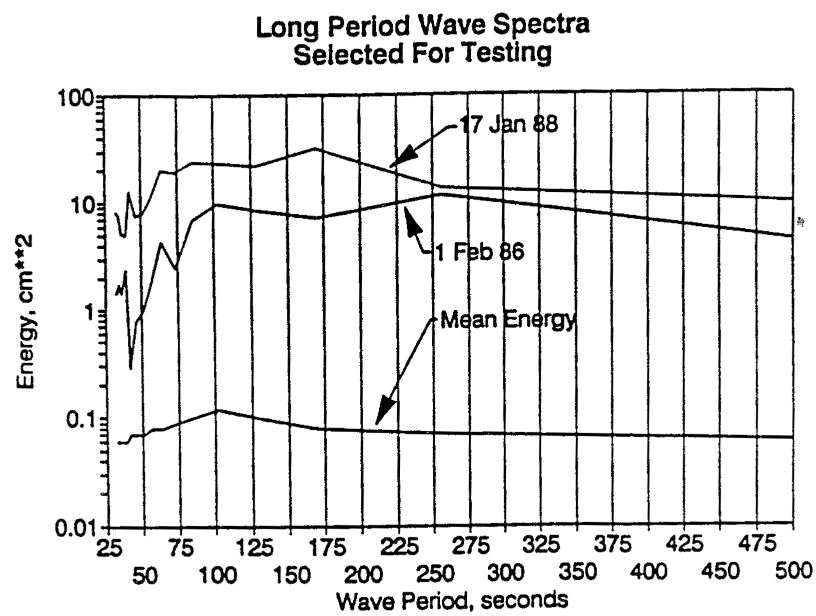

Figure 2. Long-period spectra events selected for model testing

the most frequent wave condition incident to the harbors, but this condition is not necessarily representative of extreme storm events. Physical model study results are described in Seabergh and Thomas (1993, 1995). They express amplification factors in terms of wave height. This study uses wave energy amplification factors. For this study, the conversion formula between energies and wave heights is

$$H = 4\sqrt{E} \tag{1}$$

where H is the wave height and E is wave energy.

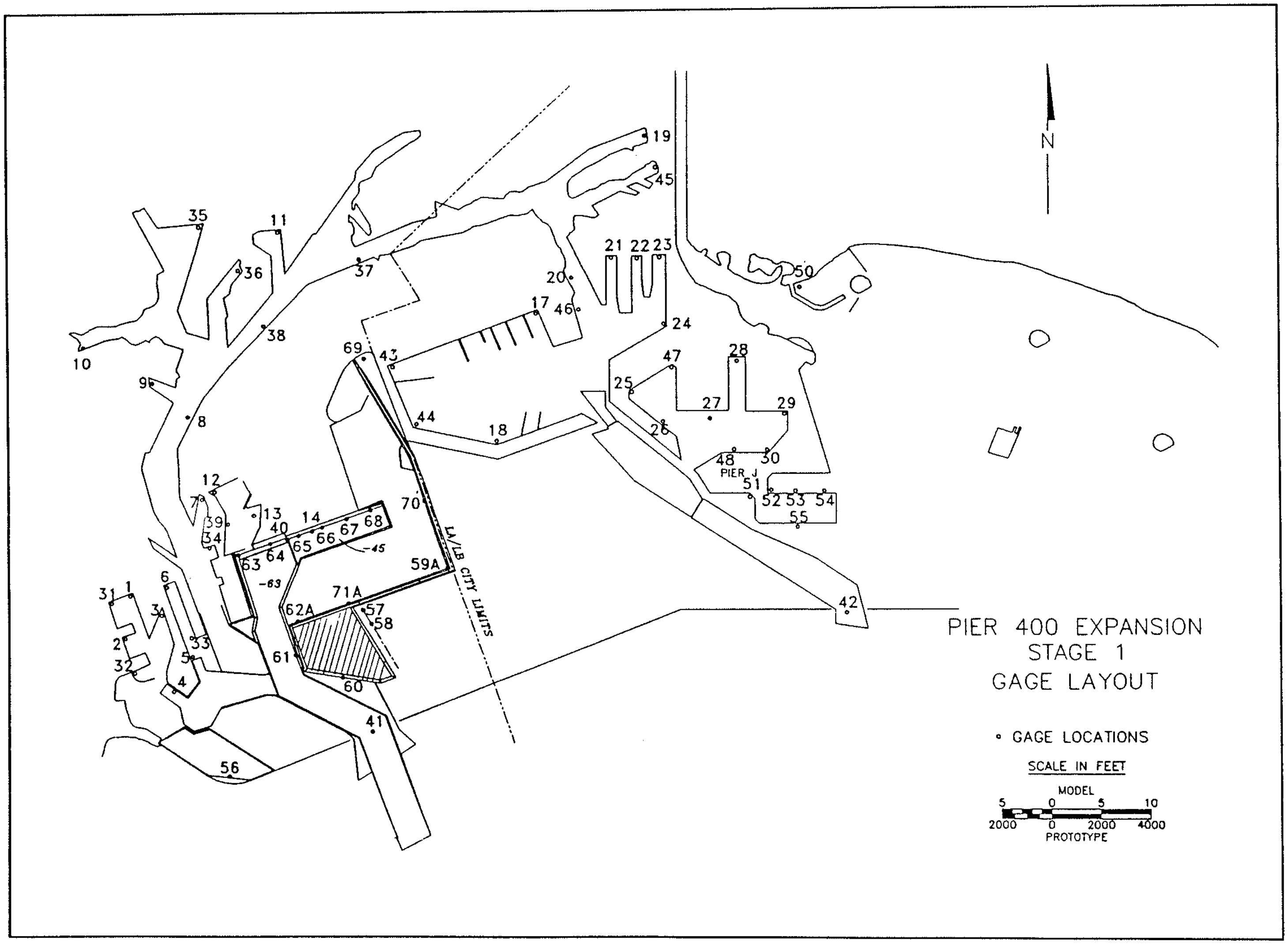

Figure 3. Pier 400 stage 1 model gage sites

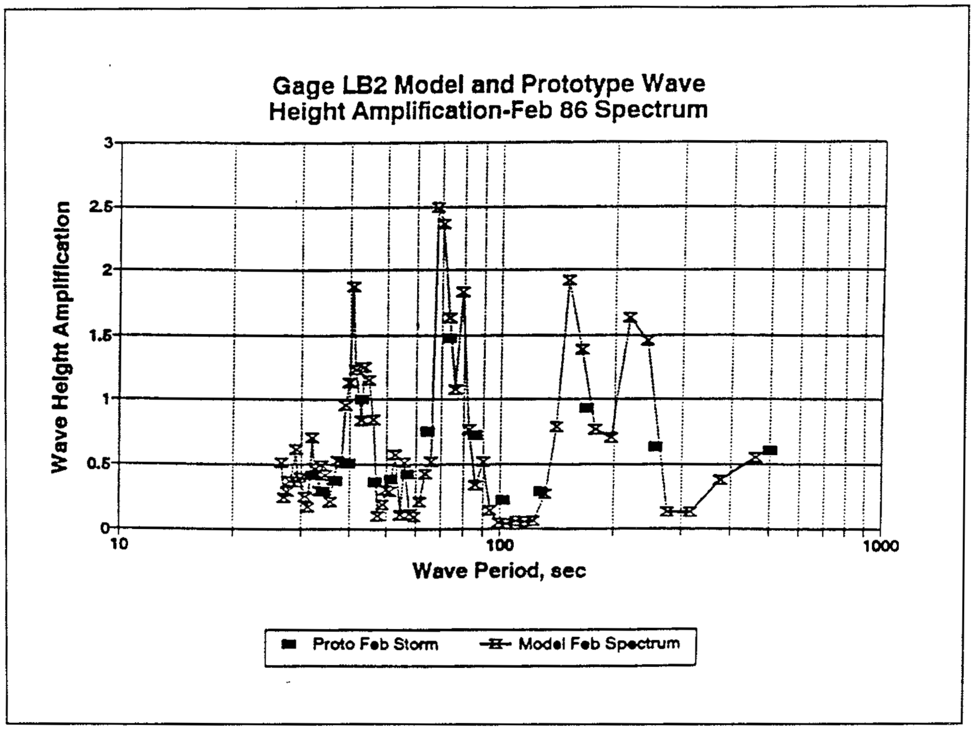

Figure 4. Comparison of prototype and model wave amplification factors

3 Methods

Platform Edith spectral information was used to construct probability distributions of recorded wave data. The data used for this study covered the time period from 1985 to August 1991. Although data subsequent to this time exist, it was most expedient for this study to utilize these data for which previously computed intermediate data products exist. These data products reduced the computational and data retrieval time needed to perform this study.

Other workers (Bowers (1992), for example), have defined the wave period range of 30-200 sec as the one that primarily affects ship motion in harbors. The data analysis was performed on two period ranges. One range uses the 512-sec and 256-sec center periods from the analyzed wave spectra, and another uses 42- to 170-sec center periods. With a spectral bandwidth of 0.00195 Hz, the 42- to 170-sec center period range is equivalent to the 41- to 204-sec period range and the 256- to 512-sec center period range is equivalent to a 204- to 1,022-sec period range. These period range selections were made in order to best describe the long wave probability distribution for the harbors in terms that are useful with existing ship-motion criteria (Seabergh and Thomas 1995). Probability of exceedance (PE) tables of wave energy were constructed for both base and stage 1 conditions.

Data Processing Procedure

a. Assume linear waves and transform each Platform Edith spectrum by multiplying each spectral value $S(f)$ by the corresponding amplification factor for each model site.

$$H_e(f) = AH(f)\,S(f) \tag{2}$$

where

$H_e(f)$ = harbor predicted energy spectrum

$AH(f)$ = model energy amplification factor

$S(f)$ = Platform Edith energy spectrum

f = frequency

b. Sum the energy belonging to each of the period ranges of interest for each transformed Platform Edith wave spectrum (H_e).

$$HS_{e1} = \sum_{t=512}^{256} H_e(t) \tag{3}$$

$$HS_{e2} = \sum_{t=170}^{42} H_e(t) \tag{4}$$

where

$H\,S_{e1,2}\,(t)$ = total harbor energy in period range

t = center period band

c. Update the tally of the number of occurrences of each energy value in the bins. This is done separately for each of the two period ranges. The number of occurrences N_r in a given bin is equal to the total number of wave records for which the value of $H\,S_e$ lies within the given bin energy interval.

d. Repeat steps 1 through 3 until all Edith wave spectra have been analyzed.

e. Compute the probability of occurrence for each site, each energy bin, and for each period range.

$$PO_1(j) = \frac{N_{r1}(i)}{N} \tag{5}$$

$$PO_2(j) = \frac{N_{r2}(i)}{N} \tag{6}$$

where

i = index of 0.35 cm^2 energy bin associated with energy value j

j = energy value associated with the i'th energy bin (0.35 $cm^2 \cdot i$)

$PO_{1,2}$ = probability of occurrence

N = total number of occurrences (wave records)

f. Compute the PE for each harbor site.

The PE for energy was determined by:

$$PE(j) = 1 - \sum_{k=1}^{i} PO(\Delta_e \cdot k) \tag{7}$$

where

PO = probability of occurrence

PE = probability of exceedance

e = bin size (0.35 cm^2)

k = bin index

g. Plots were constructed showing the base and stage 1 PE's on the same page.

This method is favored for several reasons. It minimizes the numerical roundoff or truncation errors associated with inserting the data into a finite number of probability of occurrence bins by performing this step only once for each Platform Edith spectrum. It is also the most straightforward realization of the linear transfer function approach. A variety of methods to compute the PE distributions were explored. For example, multiplying the period range average energy by the averaged amplification factors for that range produces very similar results.

A bin size Δ_e of 0.35 cm^2 was chosen in an attempt to satisfy the need of good probability resolution while representing the maximum energies with a reasonable number (in this case 80) of bins.

Prototype PE

Steps 2 through 7 of the data processing procedure were used on the harbor wave gage data. These prototype PE plots are presented in Appendix A.

4 Results

The standard approach in both numerical and physical harbor wave models is use of a linear, frequency-domain transfer function to transfer energy from outside to inside of a harbor. Since energy in the offshore wave spectrum can be low for harbor oscillation periods, large amplification factors result.

Results presented in the appendices include:

a. For each prototype inshore site which had a corresponding model site, PE tables were constructed for the energy in the two period ranges. The PE results for the prototype gage were plotted along with the base and stage 1 data computed using the Platform Edith wave data and the amplification factors from the physical modelling. These plots are contained in Appendix A.

b. Appendix B contains PE plots for all model sites that have both a base and stage 1 condition. These PE plots do not include prototype wave data.

c. For each model site, Appendix C presents a table of the energy and significant wave height at the 1-percent PE for both the base and stage 1 conditions. This PE value was selected as a comparative measure between the base and stage 1 conditions. For some model site PE tables, 80 of the 0.35-cm^2 bins did not reach the 1-percent level of wave energy. For these sites, the PE was recomputed using 350 of the 0.35-cm^2 bins. Even this number of bins was insufficient for some sites to reach the 1-percent level. Where this occurs, a "greater than" (>) sign is placed next to the maximum energy bin value.

5 Discussion

It is apparent from the plots and tabular results presented that POLA stage 1 harbor energies tend to be lower in most cases than the base condition. The plots in Appendix A show that prototype measured energies are less than predicted by the Platform Edith transform function approach (refer to Seabergh and Thomas (1995) for a more complete discussion of the harbor resonance analysis). The largest waves show the greatest disparity between the predicted and measured PE distributions. It is important to realize that the prototype harbor data were measured under all incident wave conditions and that the model amplification factors used in the predictions are for the uniform spectrum condition which most represents the prevailing wave climate. Large storms tend to come from a westerly direction that shelters the harbors from the largest waves and more directional spreading of wave energy occurs during storms (Seabergh and Thomas 1995). Different sets of amplification factors are available from the other long-period spectra tested in the physical model to more accurately describe these storm conditions.

For engineering purposes, the predicted energy values appear to be conservative: i.e., at a given probability level, the predicted energies are likely to be greater than those actually encountered.

Assumptions

Seabergh and Thomas (1995) discuss some of the assumptions made by this analysis and why these assumptions appear to be validated by the available data:

> ...the long wave energy measured for each frequency at the prototype wave gage in the ocean is the same energy transformed to the harbor entrance. ...However analysis of wave data indicates a good correlation between wave energy at Platform Edith and the harbors. At the harbor gages themselves a possible reduction in correlation of harbor response to offshore long wave conditions could be due to non-linear transfer of energy to other harmonics, but this does not appear to be a strong mechanism for a harbor of large depth like LA/LB harbors.

Additional Work

Additional work could be done to reduce the statistical variability associated with results and explore more aspects of the collected prototype data. Additional work could include using gages recently located near the entrances to the harbors as a basis for determining amplification factors. This would help to quantify any wave transformation effects between the harbors and the platform. Classifying Platform Edith and entrance gage data according to energy level, direction, and spectral shape along with other factors and comparing these data to the harbor wave data could provide further insight into the physical processes governing harbor response. Furthermore, recomputing the results presented in this report using prototype data collected after August 1991 would increase confidence in the results due to reduced statistical variability. Higher order spectral analysis can help to show the presence of nonlinear interactions in the prototype wave data.

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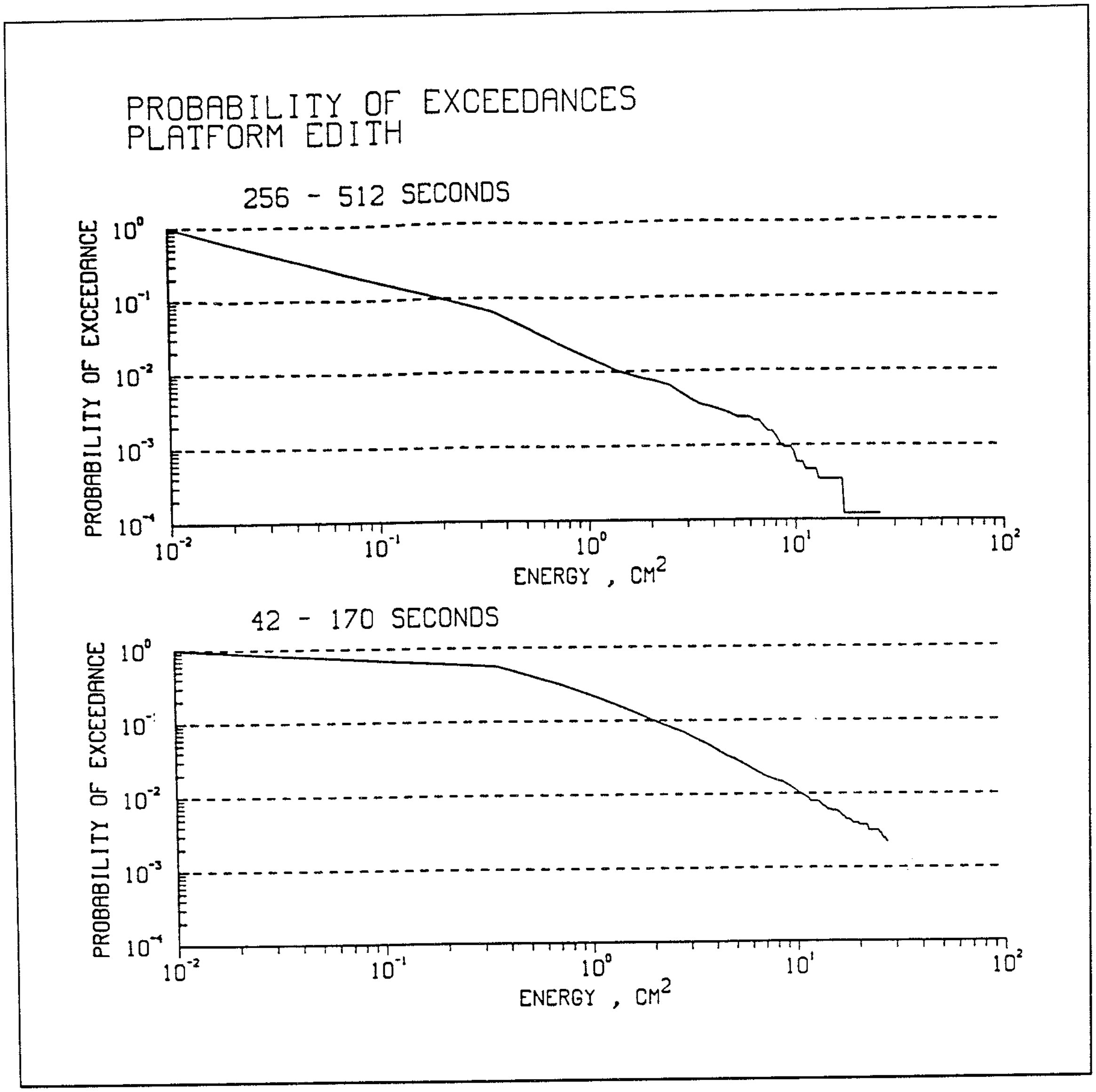
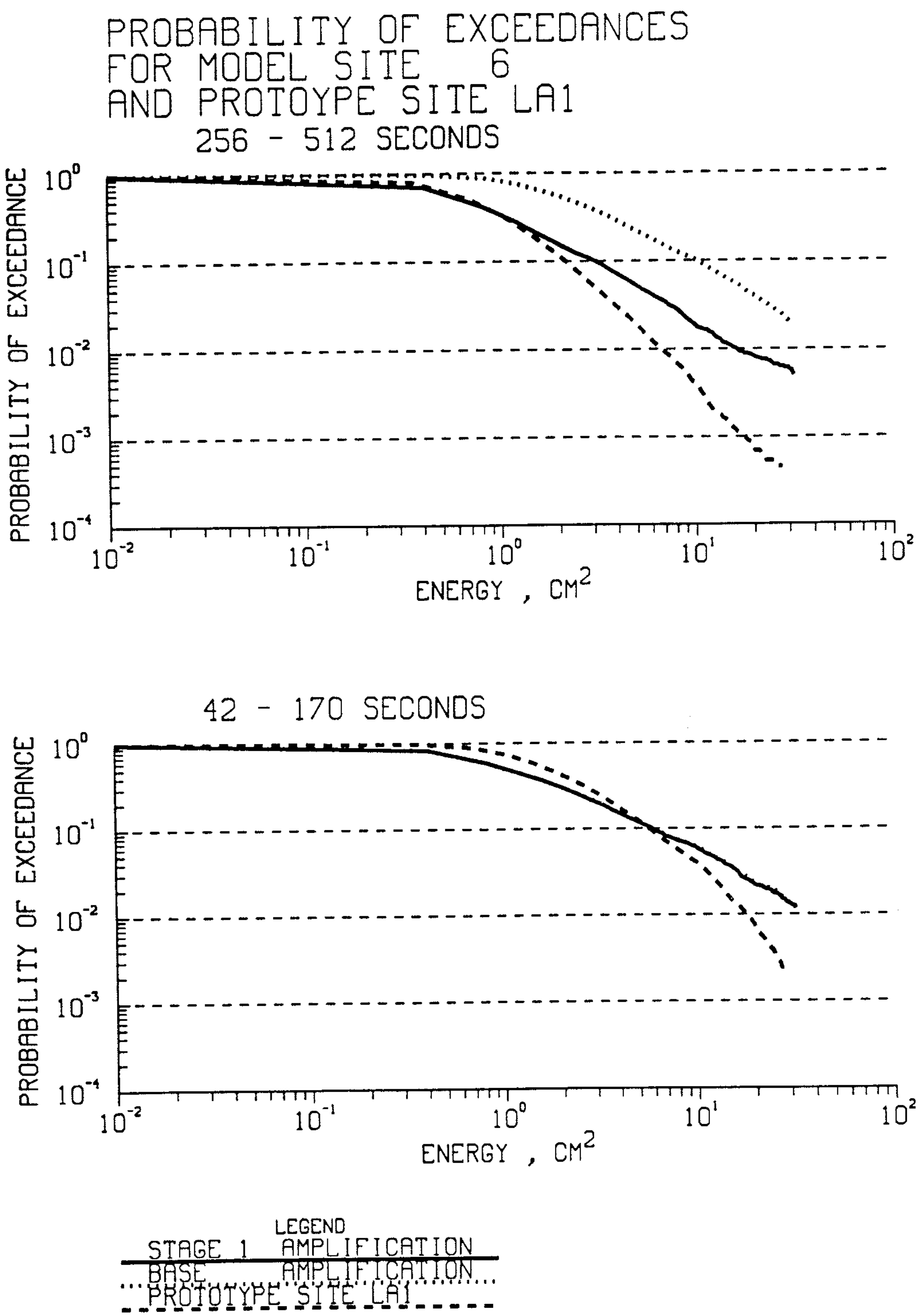
Seabergh, W. C., and Thomas, L. J. (1993). "Los Angeles and Long Beach Harbors Model Enhancement Program, improved physical model harbor resonance methodology," Technical Report CERC-93-17, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1995). "Los Angeles Harbor Pier 400 harbor resonance model study," Technical Report CERC-95-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

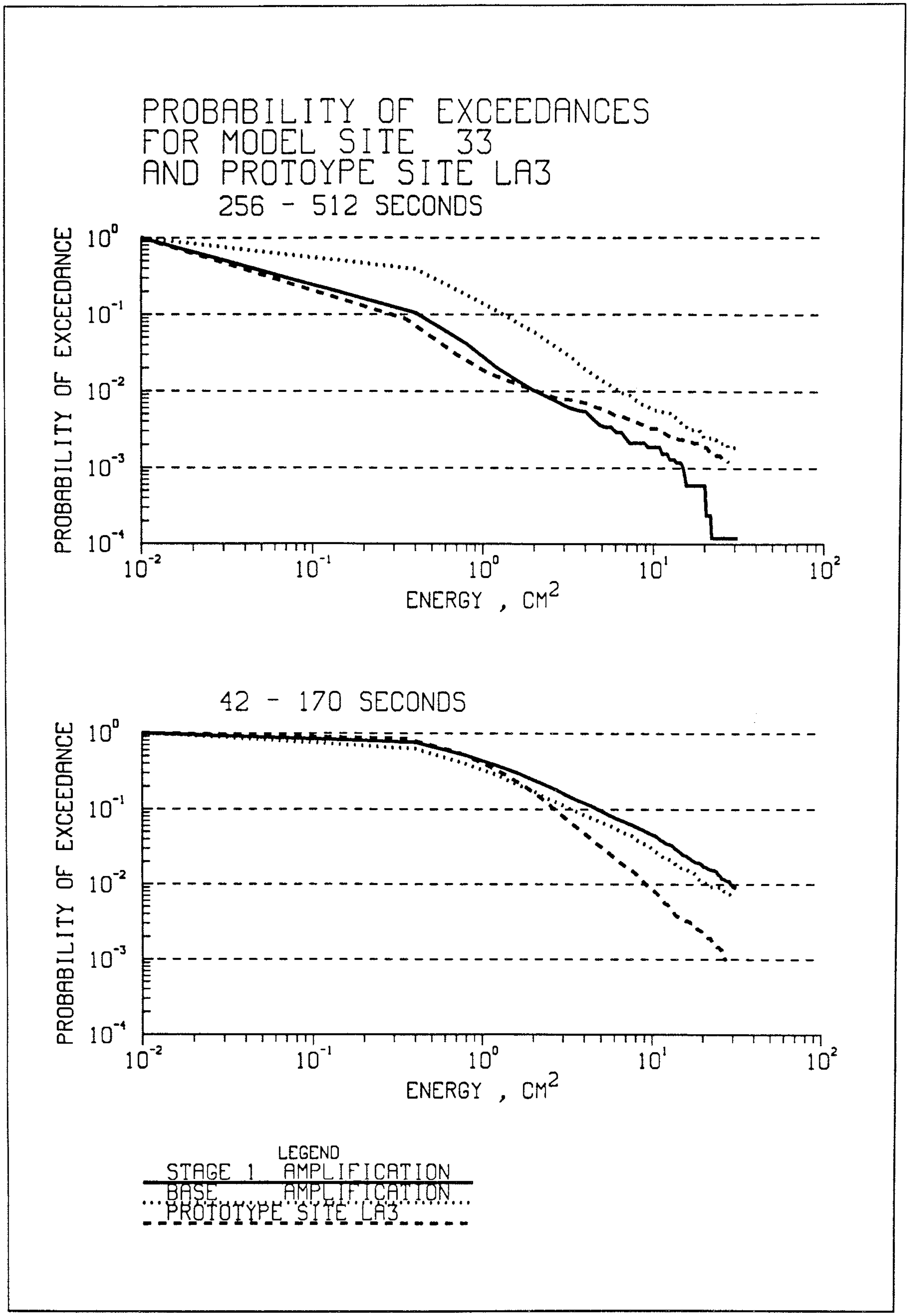
Appendix A
Prototype Site PE Plots

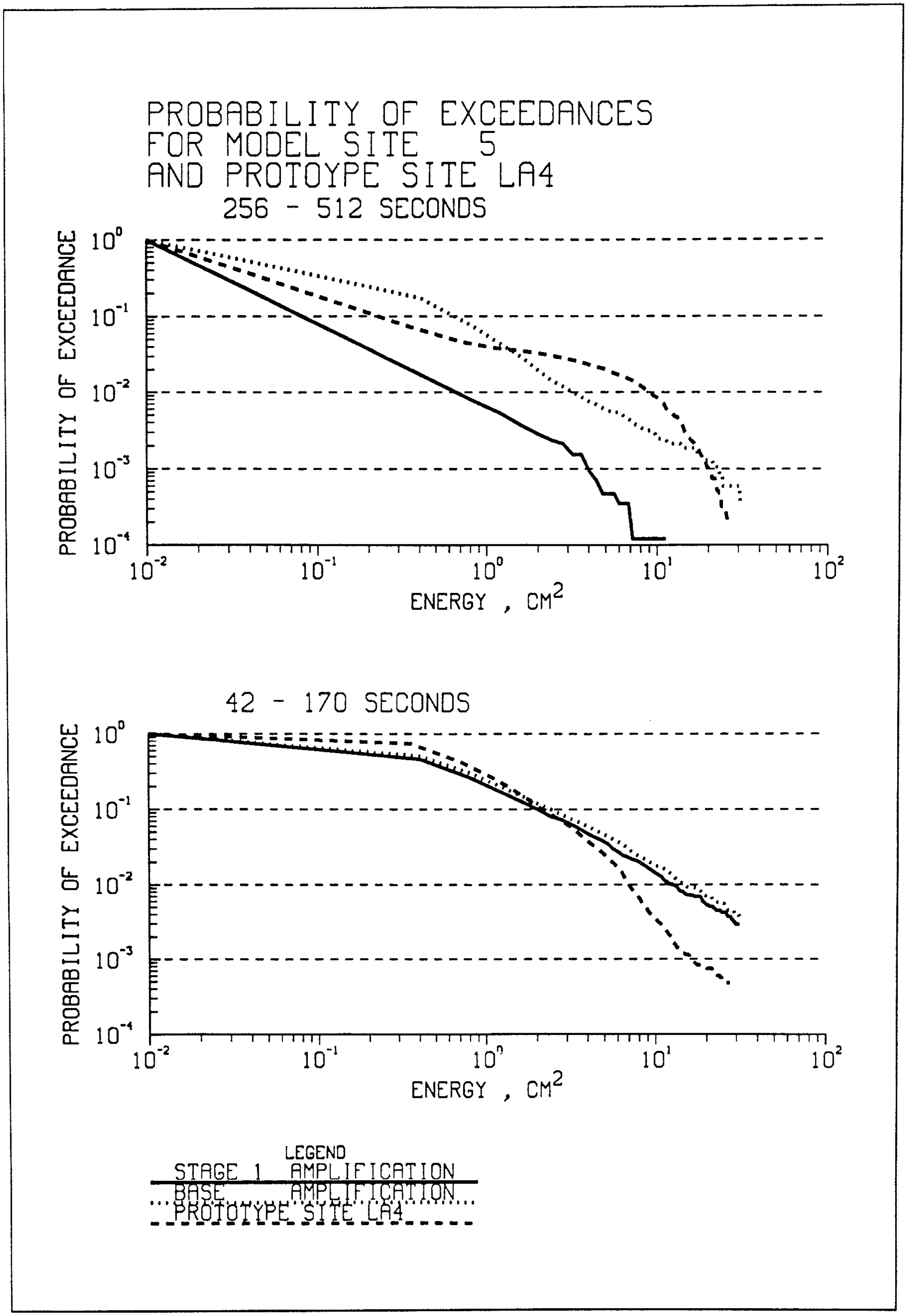


PROBABILITY OF EXCEEDANCES
PLATFORM EDITH
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2

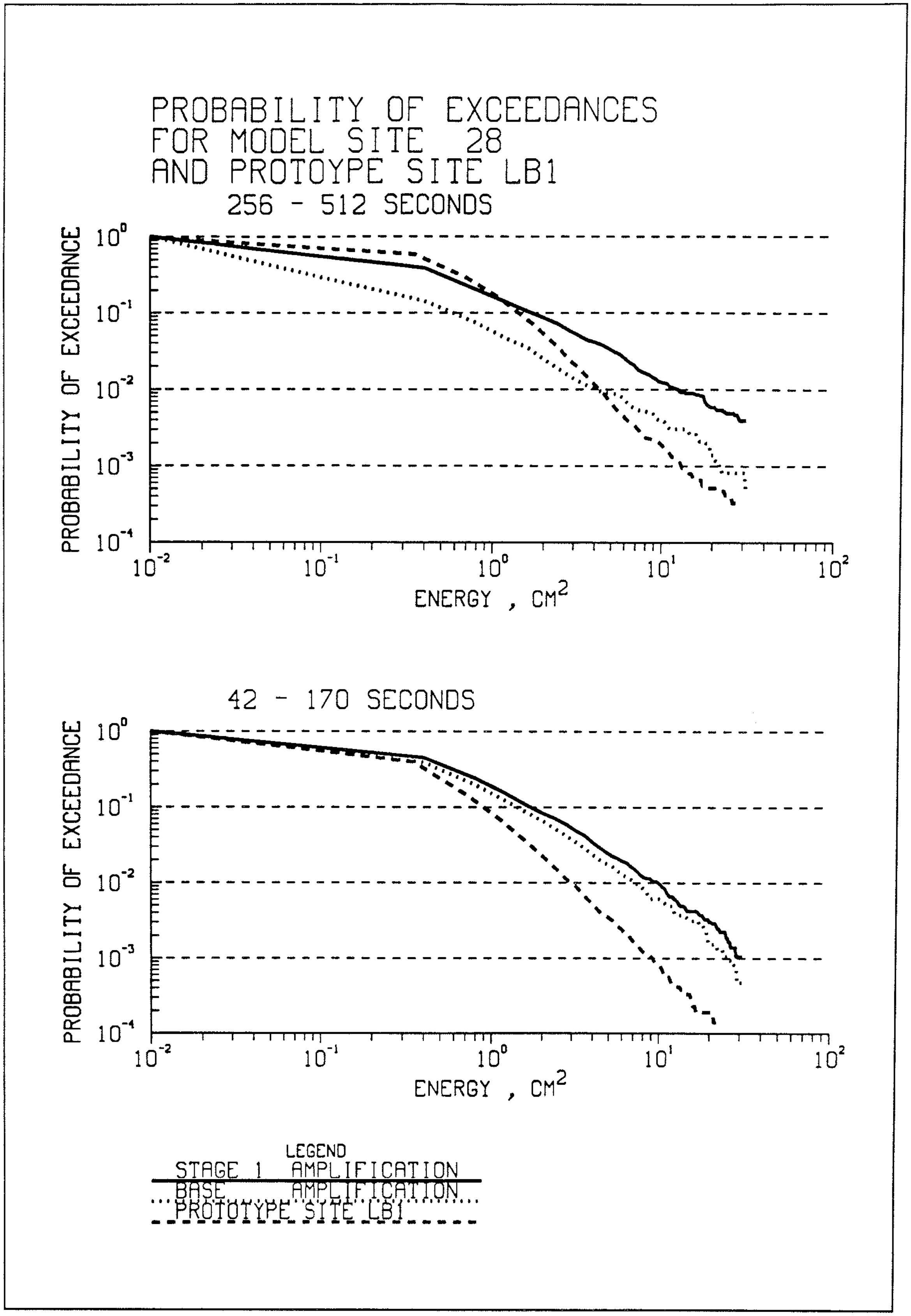


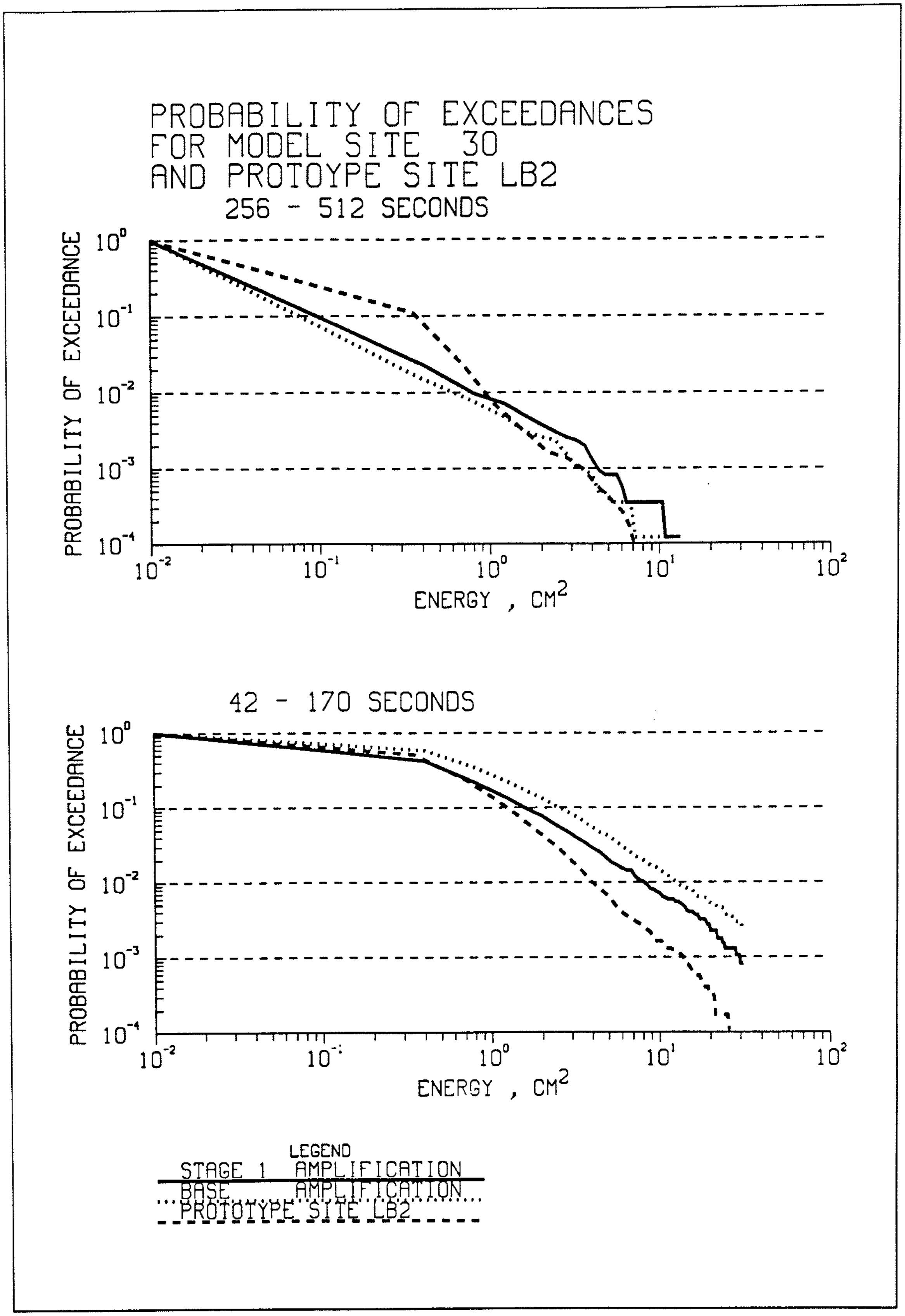
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 6
AND PROTOTYPE SITE LA1
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
STAGE 1 AMPLIFICATION
BASE AMPLIFICATION
PROTOTYPE SITE LA1


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 33
AND PROTOYPE SITE LA3
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM^2
LEGEND
STAGE 1 AMPLIFICATION
BASE AMPLIFICATION
PROTOTYPE SITE LA3



PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 5
AND PROTOYPE SITE LA4
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
STAGE 1 AMPLIFICATION
BASE AMPLIFICATION
PROTOTYPE SITE LA4


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 28
AND PROTOTYPE SITE LB1
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
STAGE 1 AMPLIFICATION
BASE AMPLIFICATION
PROTOTYPE SITE LB1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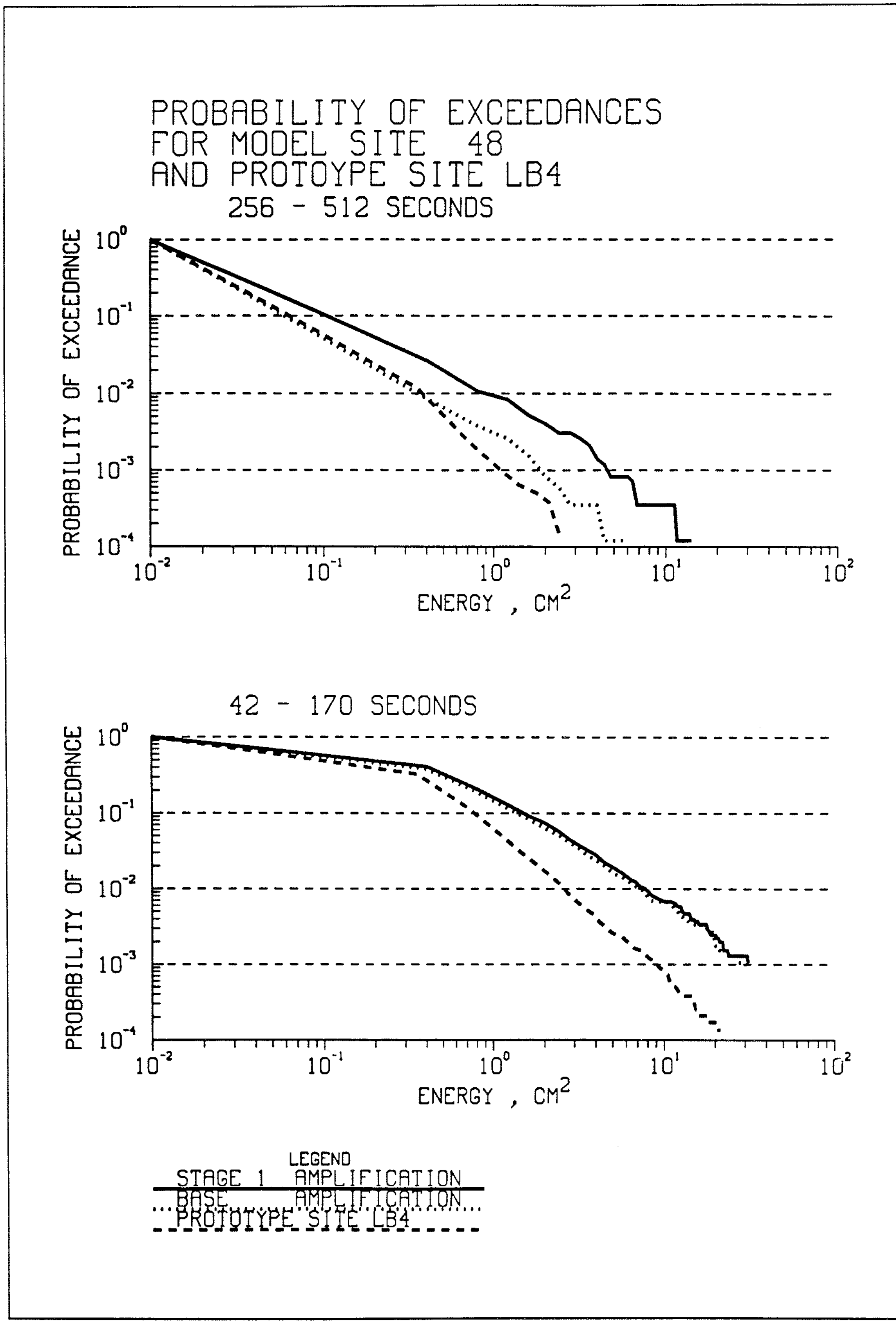
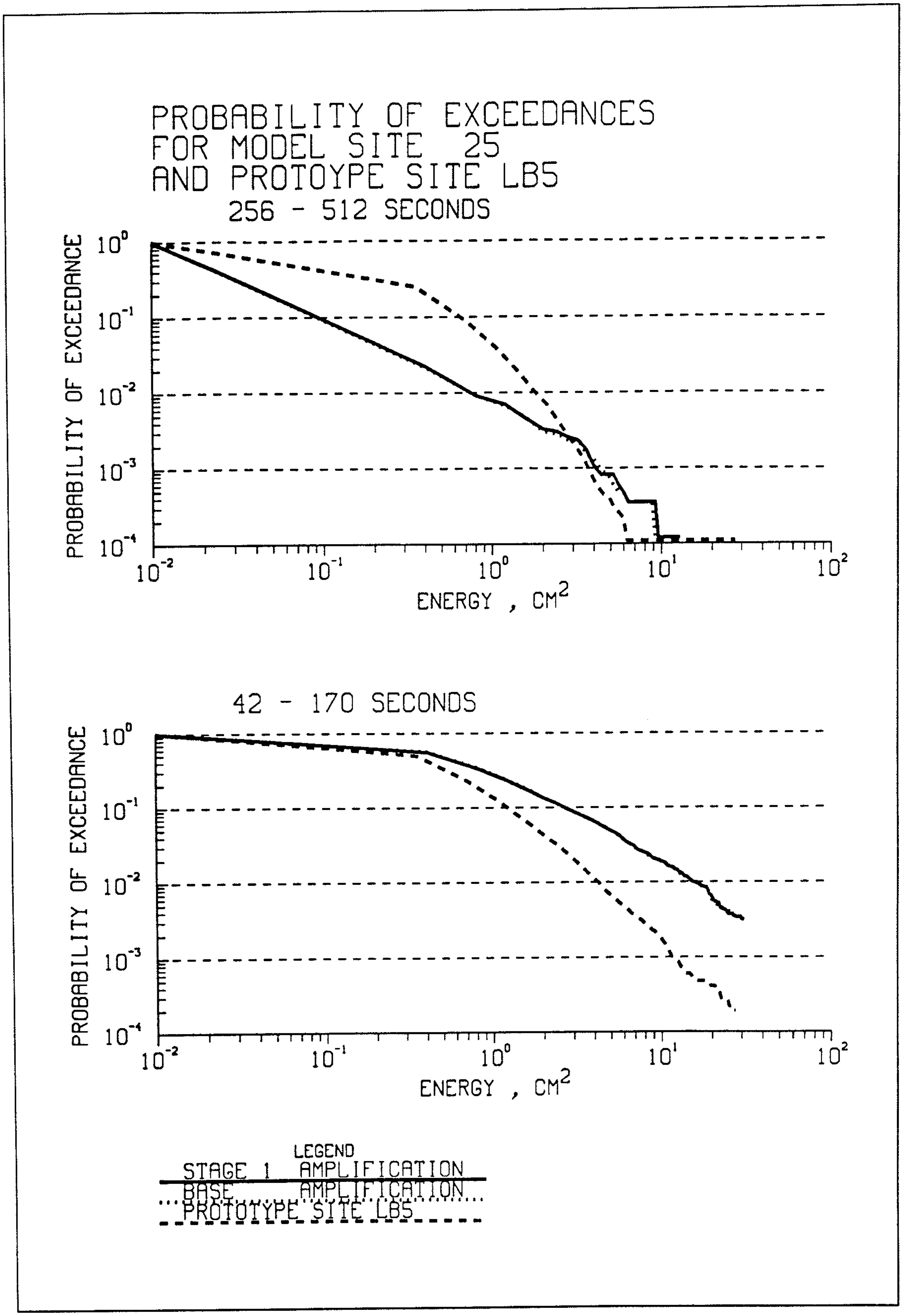
FOR MODEL SITE 30
AND PROTOTYPE SITE LB2
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM^2
LEGEND
STAGE 1 AMPLIFICATION
BASE AMPLIFICATION
PROTOTYPE SITE LB2

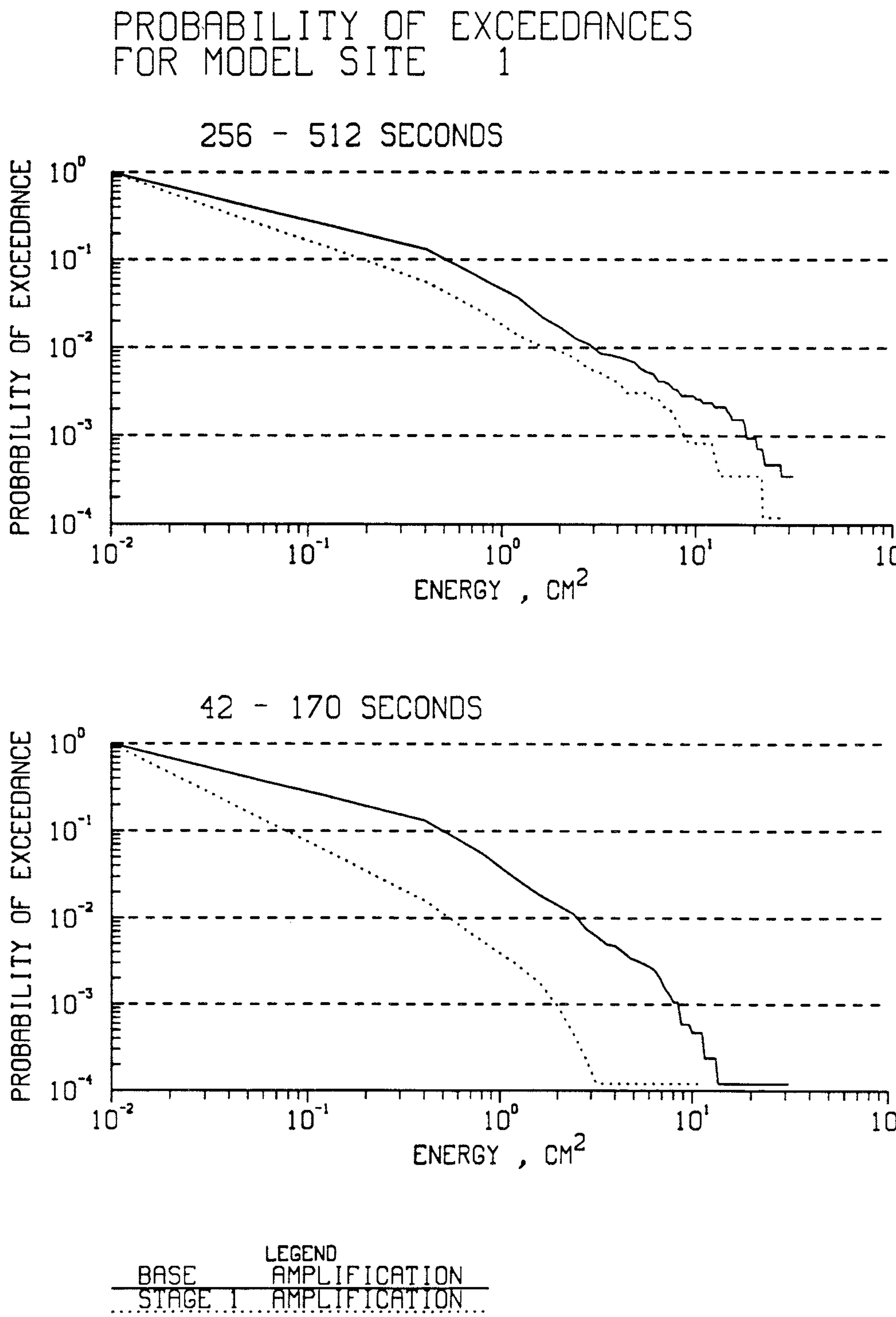


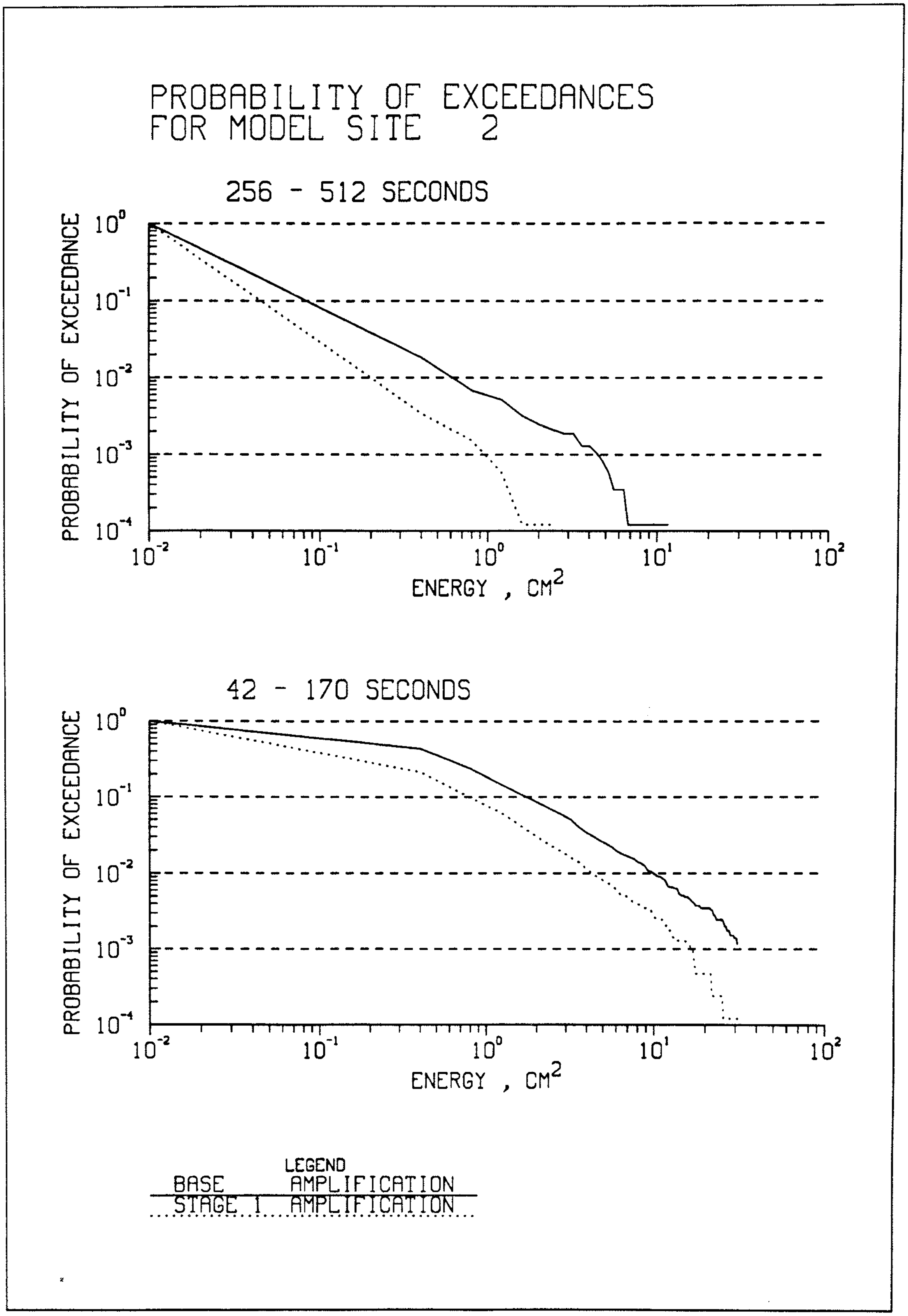
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 48
AND PROTOTYPE SITE LB4
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
ENERGY , CM^2
LEGEND
STAGE 1 AMPLIFICATION
BASE AMPLIFICATION
PROTOTYPE SITE LB4

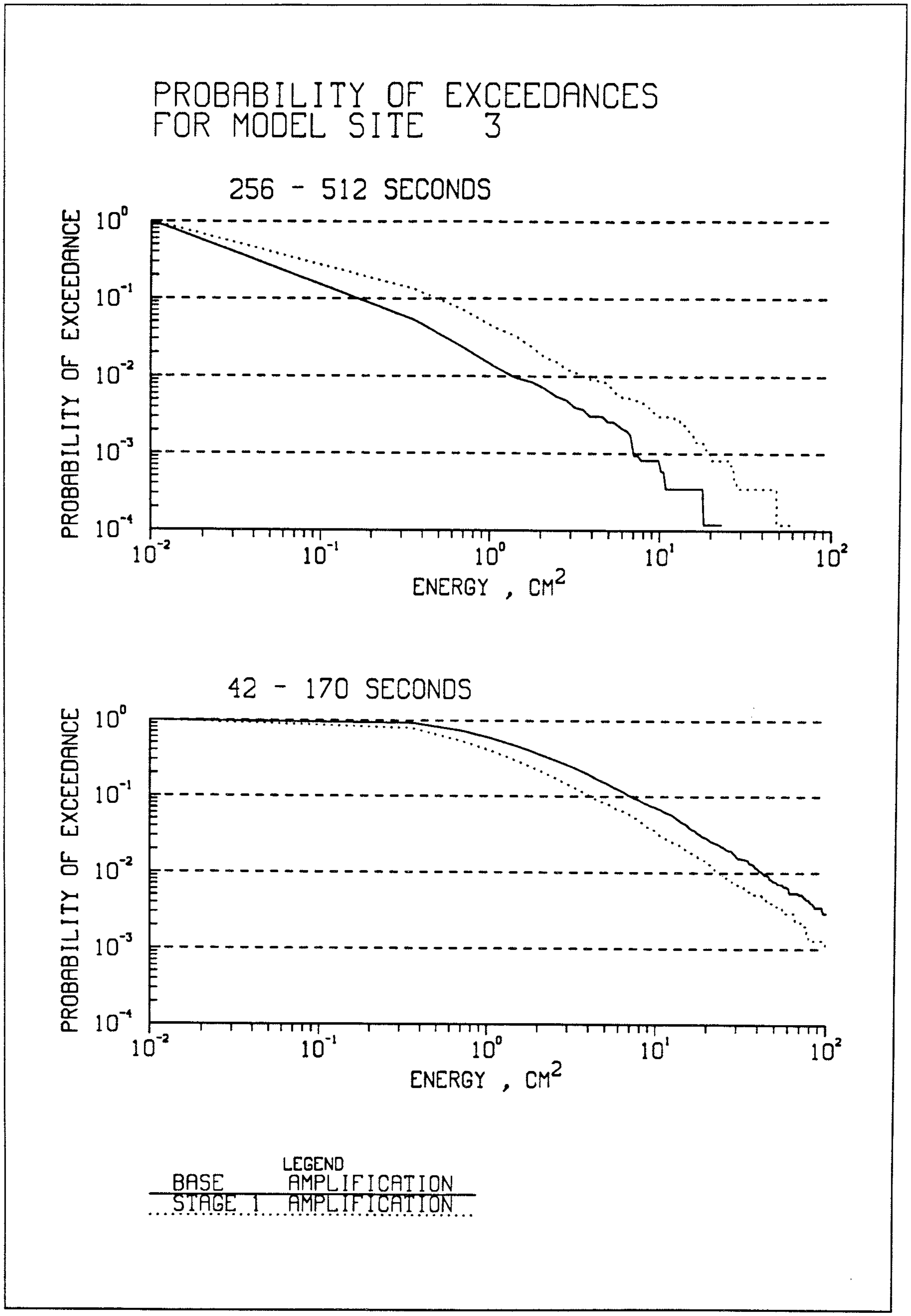


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 25
AND PROTOYPE SITE LB5
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM^2
LEGEND
STAGE 1 AMPLIFICATION
BASE AMPLIFICATION
PROTOTYPE SITE LB5

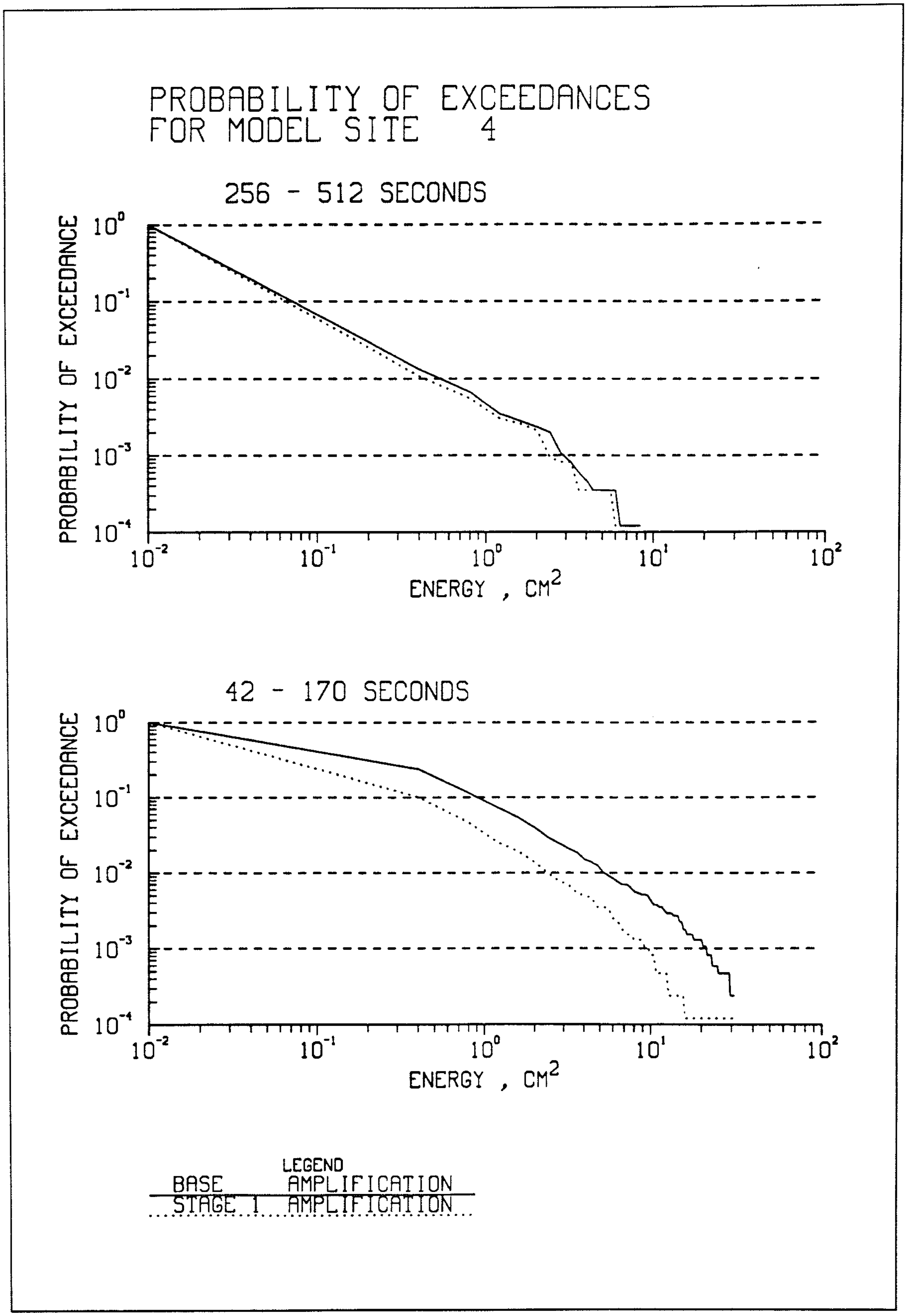
Appendix B
Model Site PE Plots


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 1
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 2
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

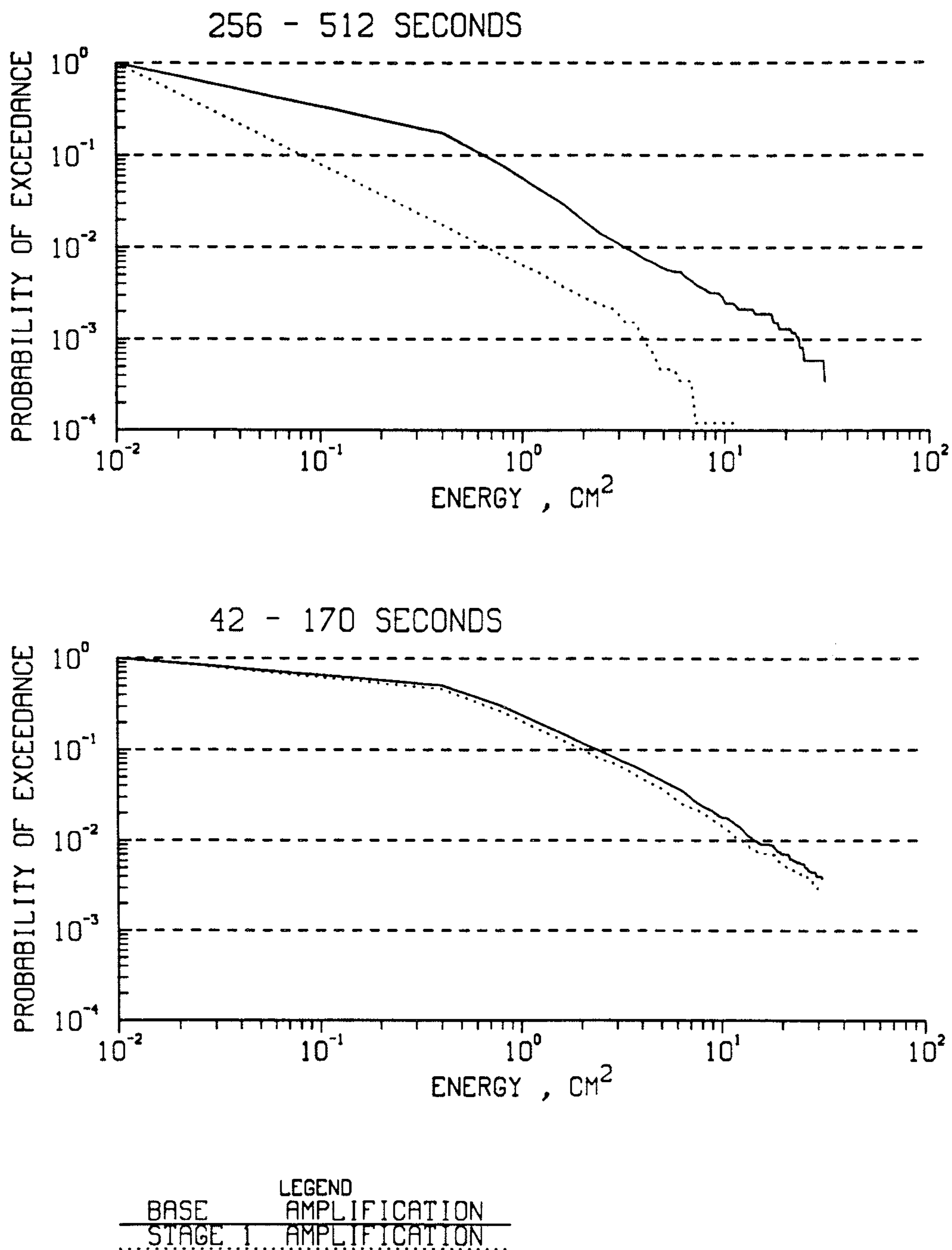


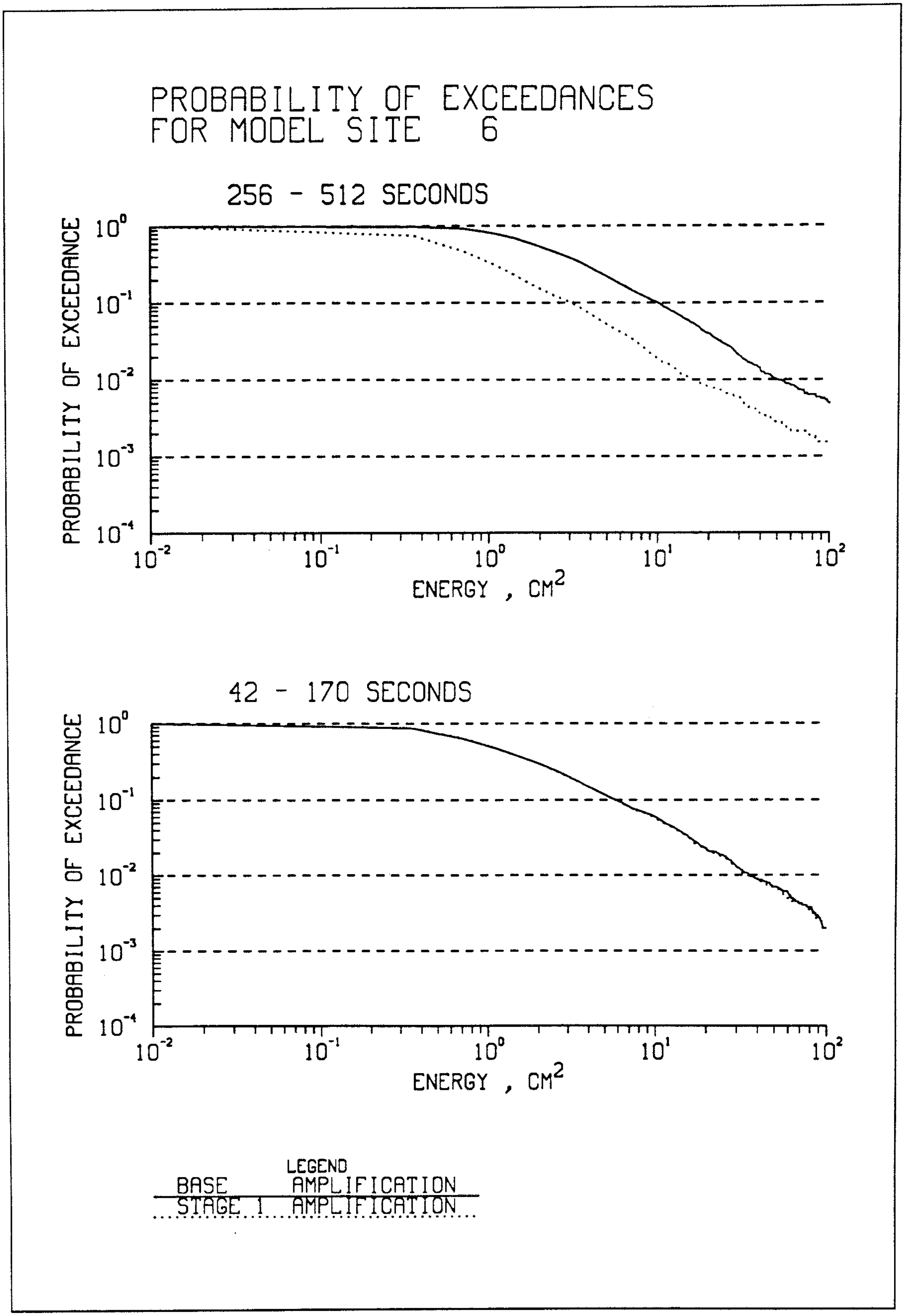
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 3
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

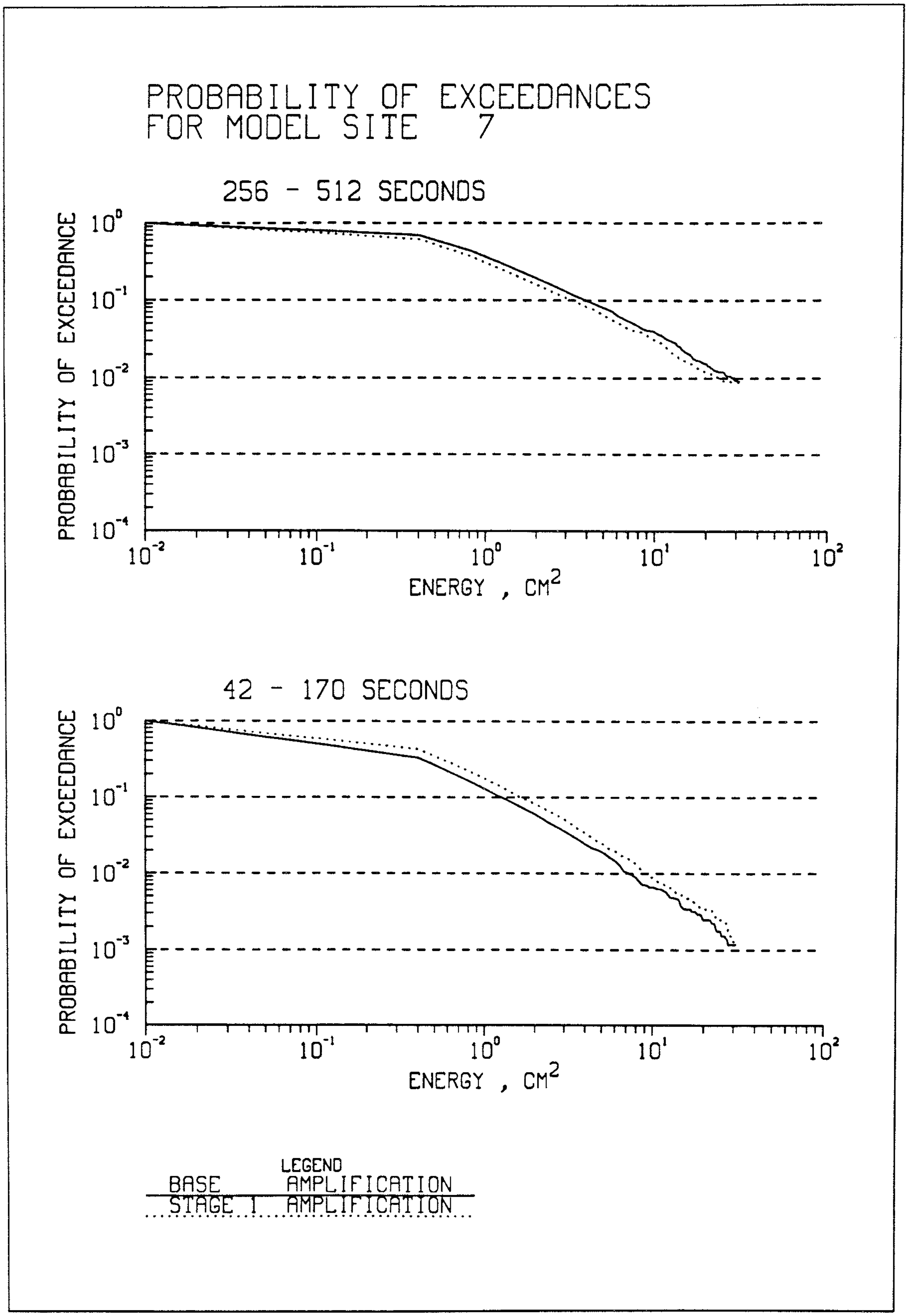


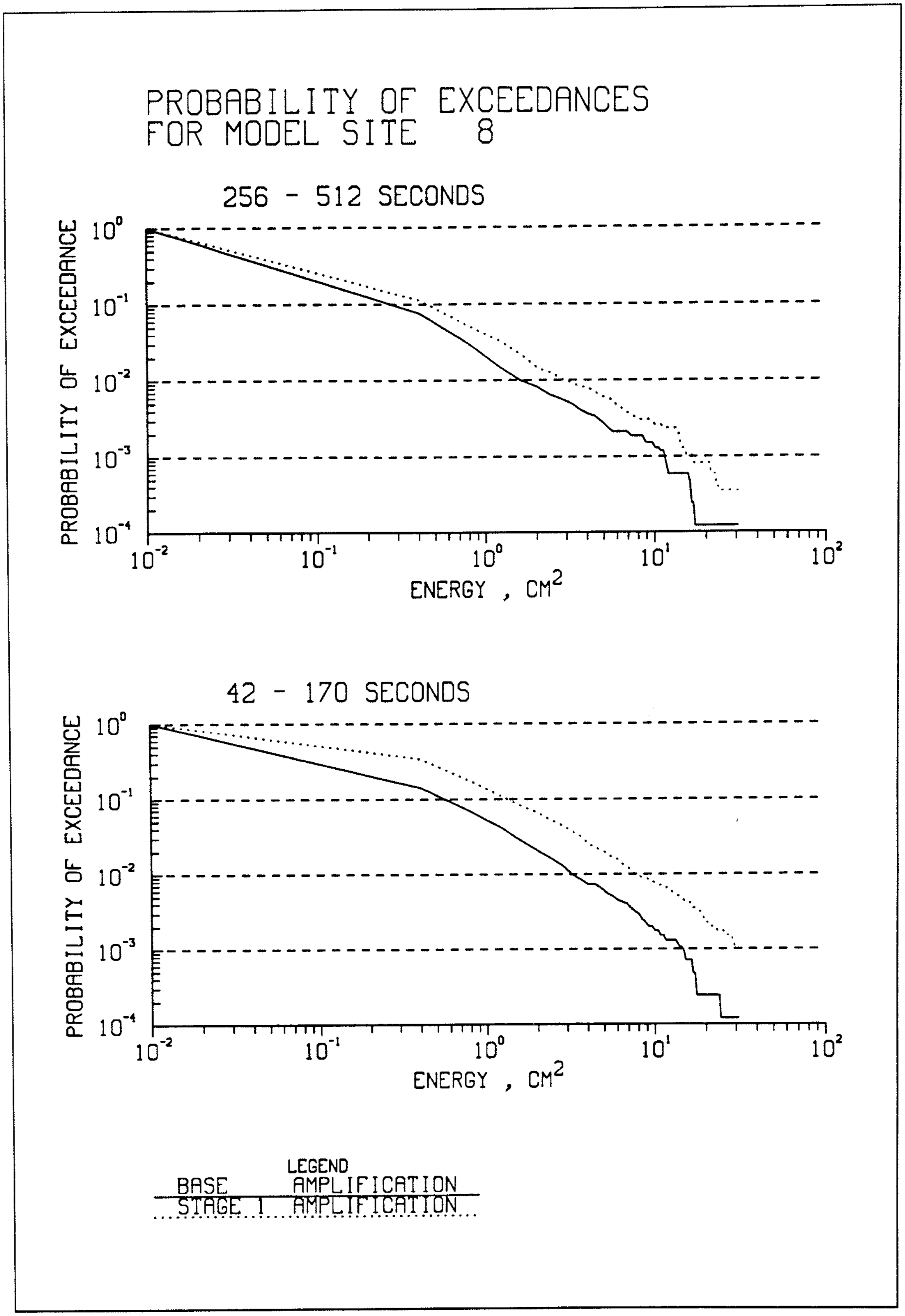
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 4
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

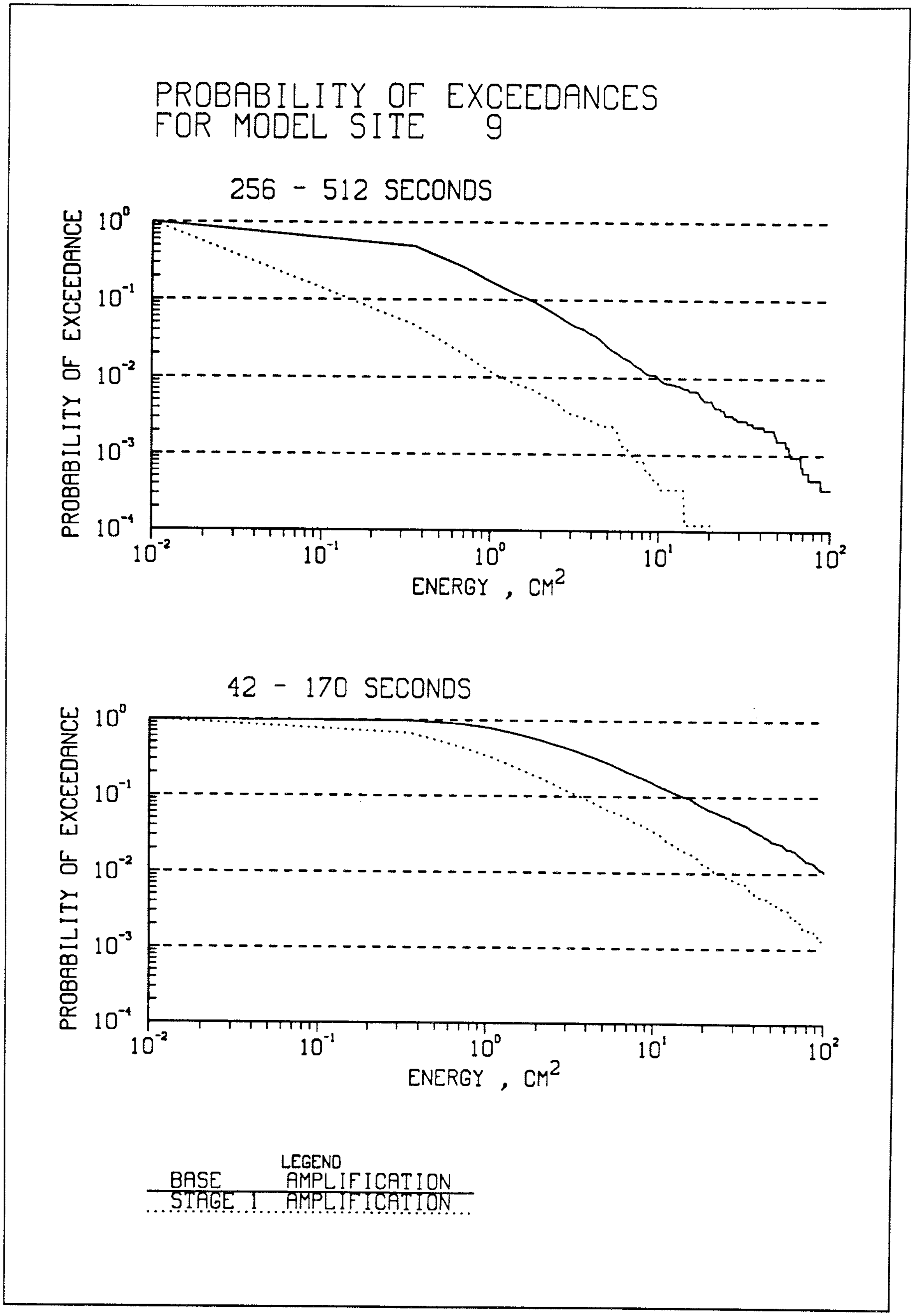
PROBABILITY OF EXCEEDANCES FOR MODEL SITE 5



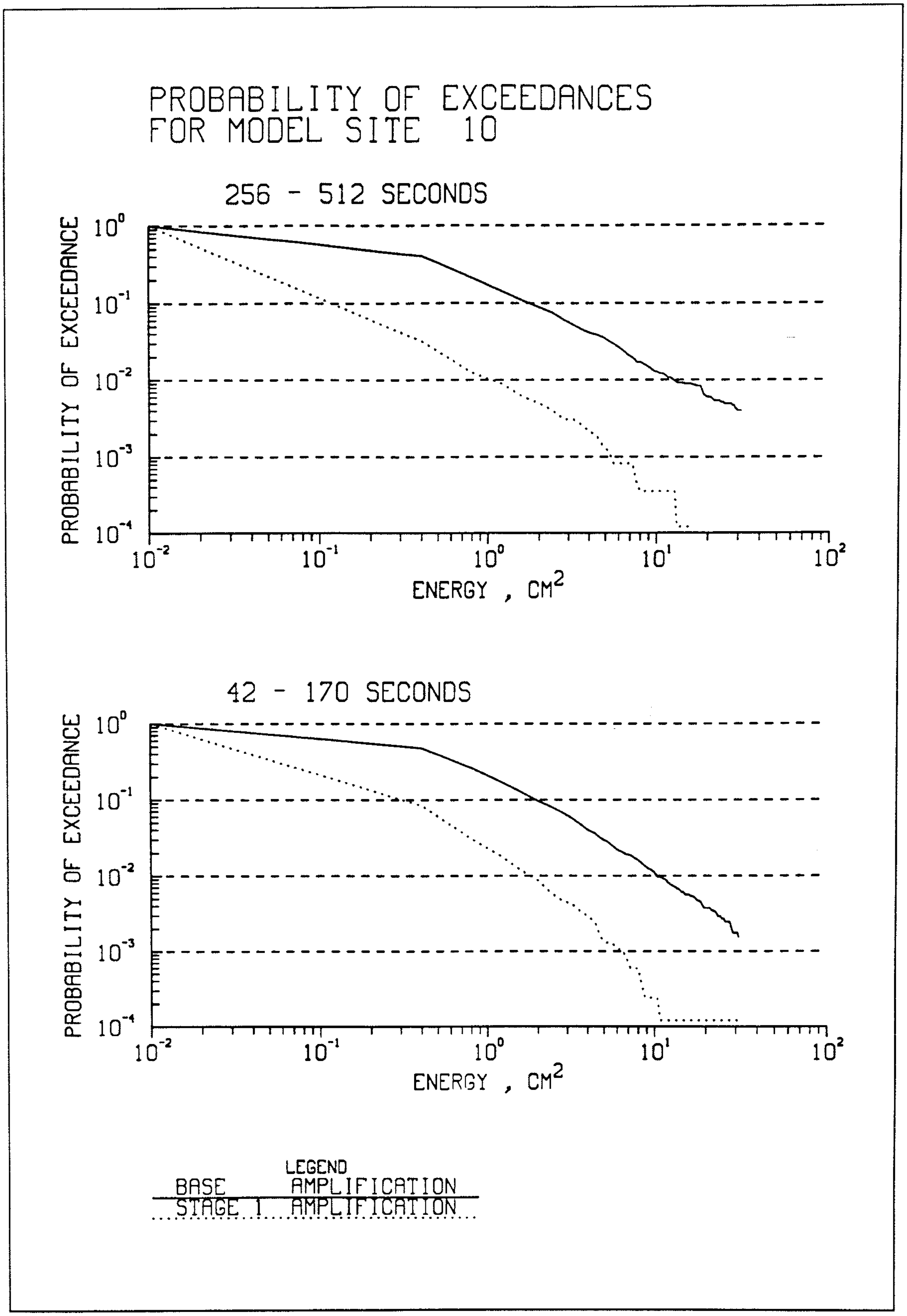

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 6
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

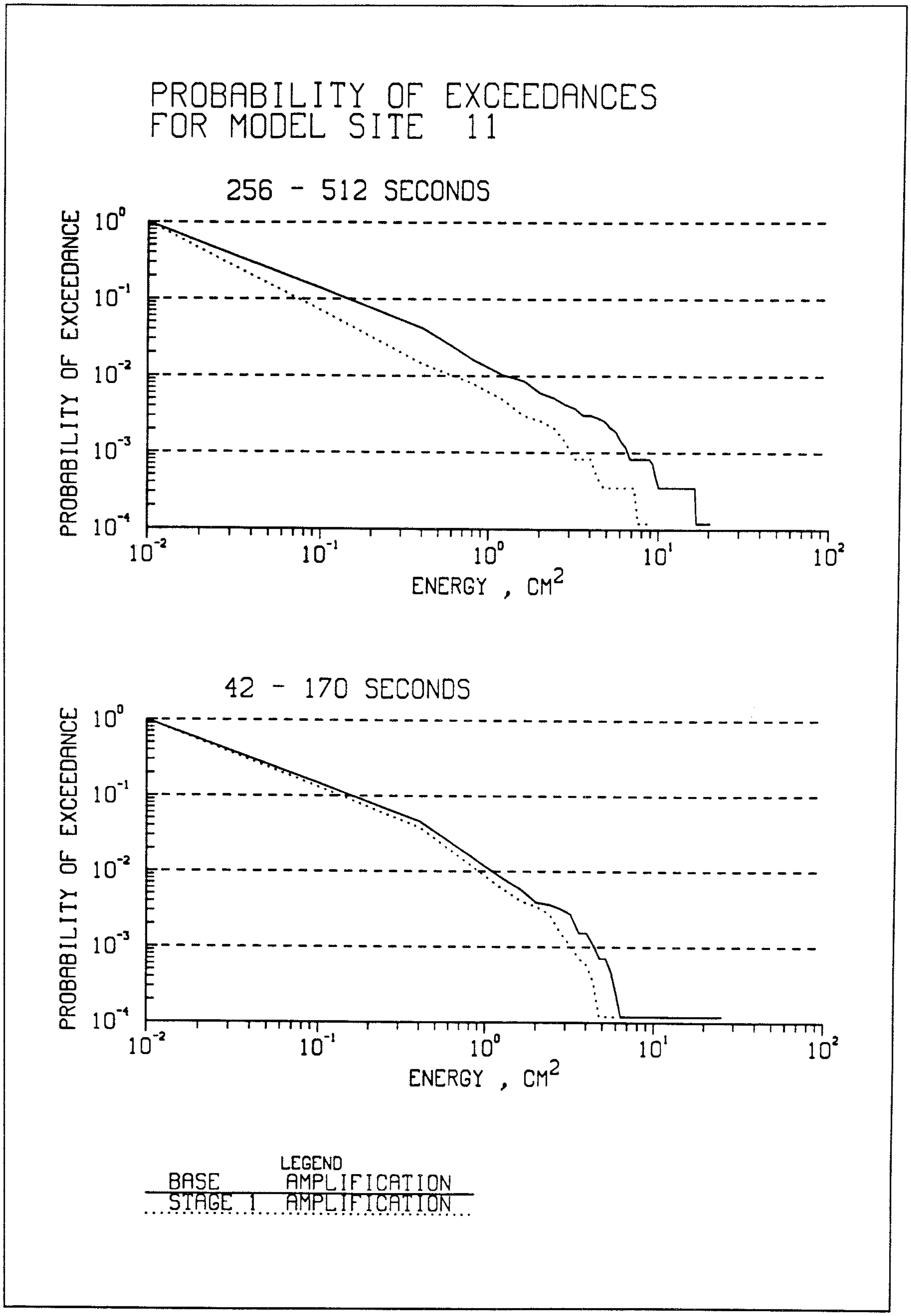

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 7
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE I AMPLIFICATION

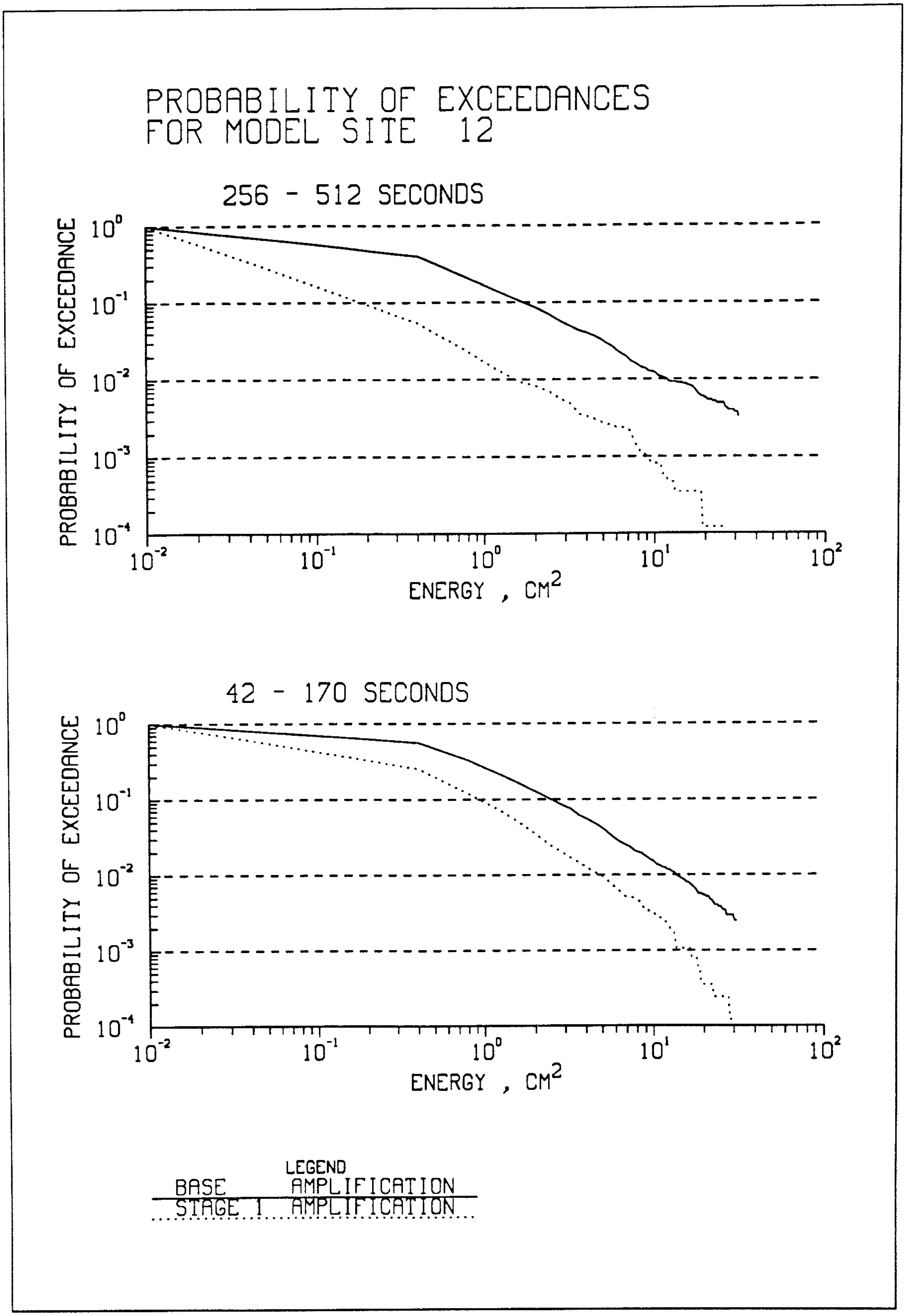

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 8
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

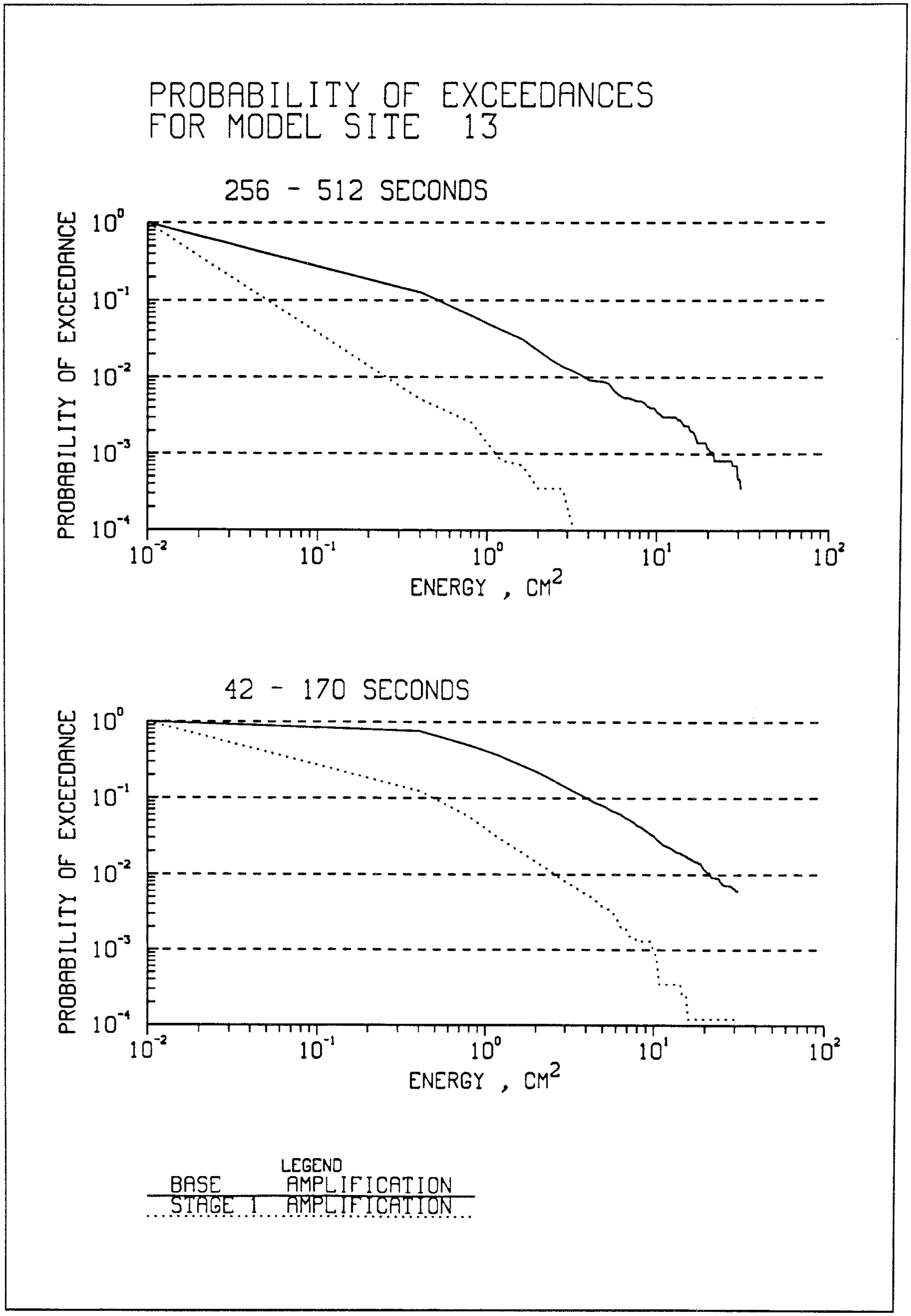


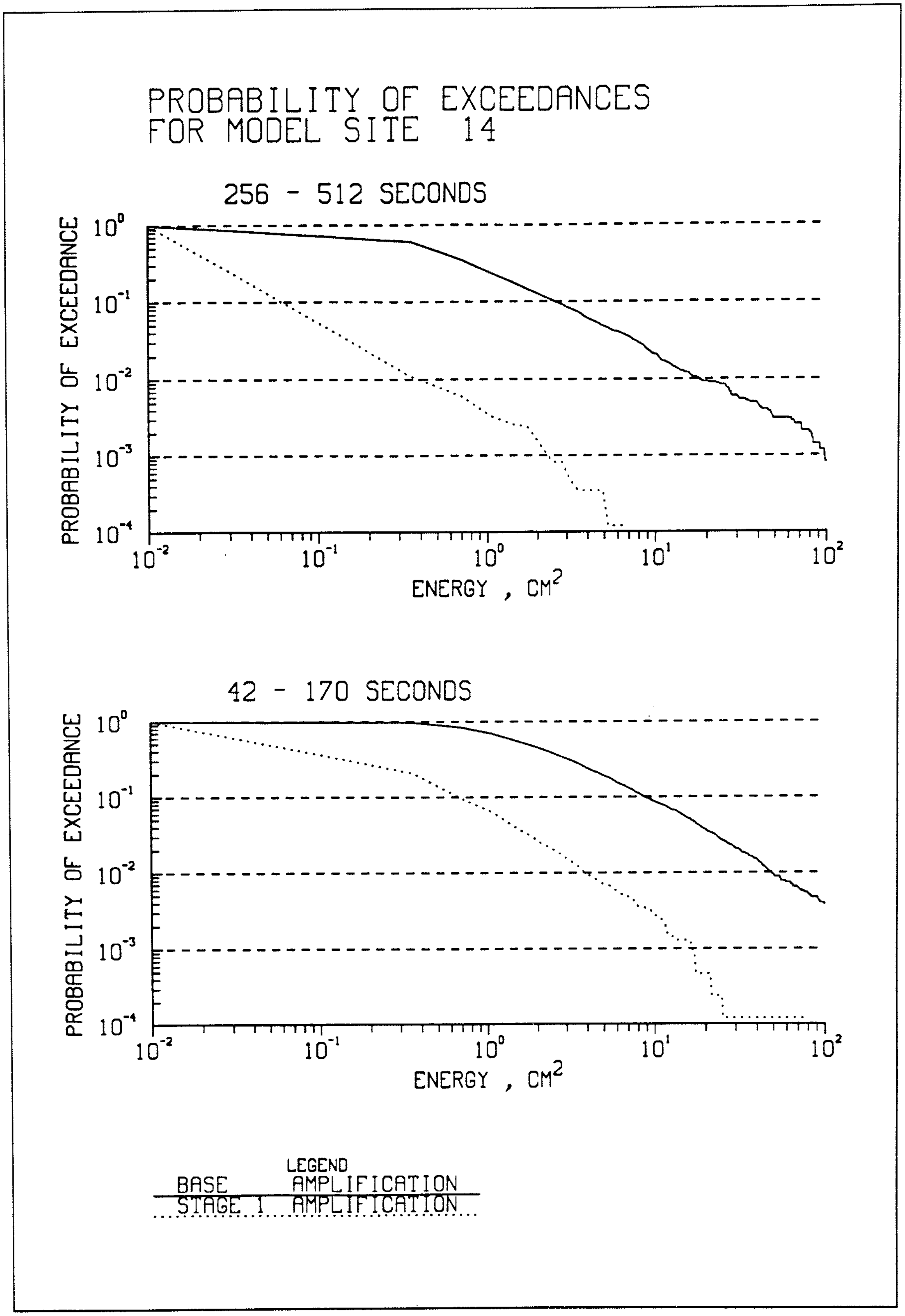
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 9
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 10
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^0
10^1
10^2
ENERGY , CM²
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^0
10^1
10^2
ENERGY , CM²
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

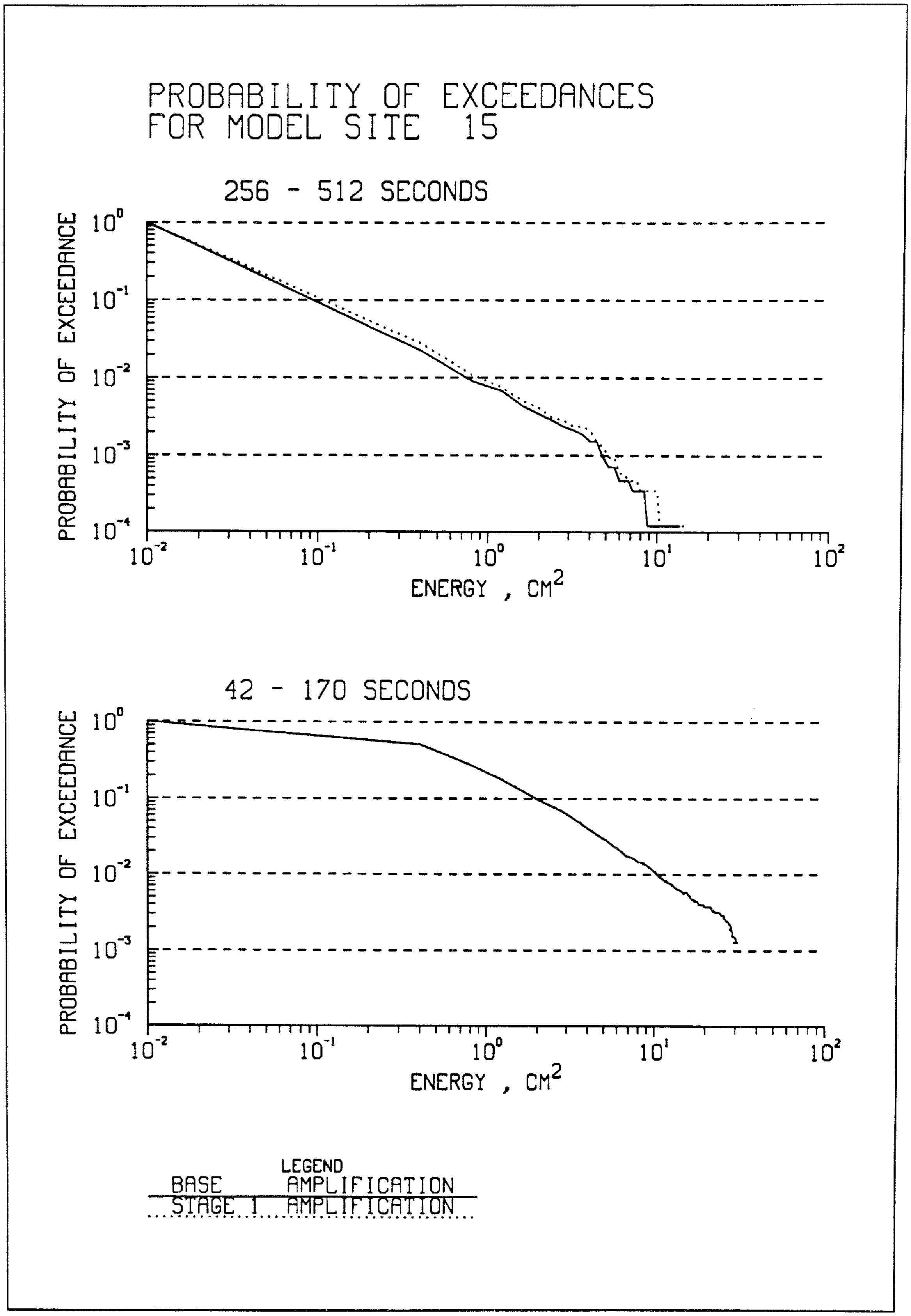

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 11
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 12
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

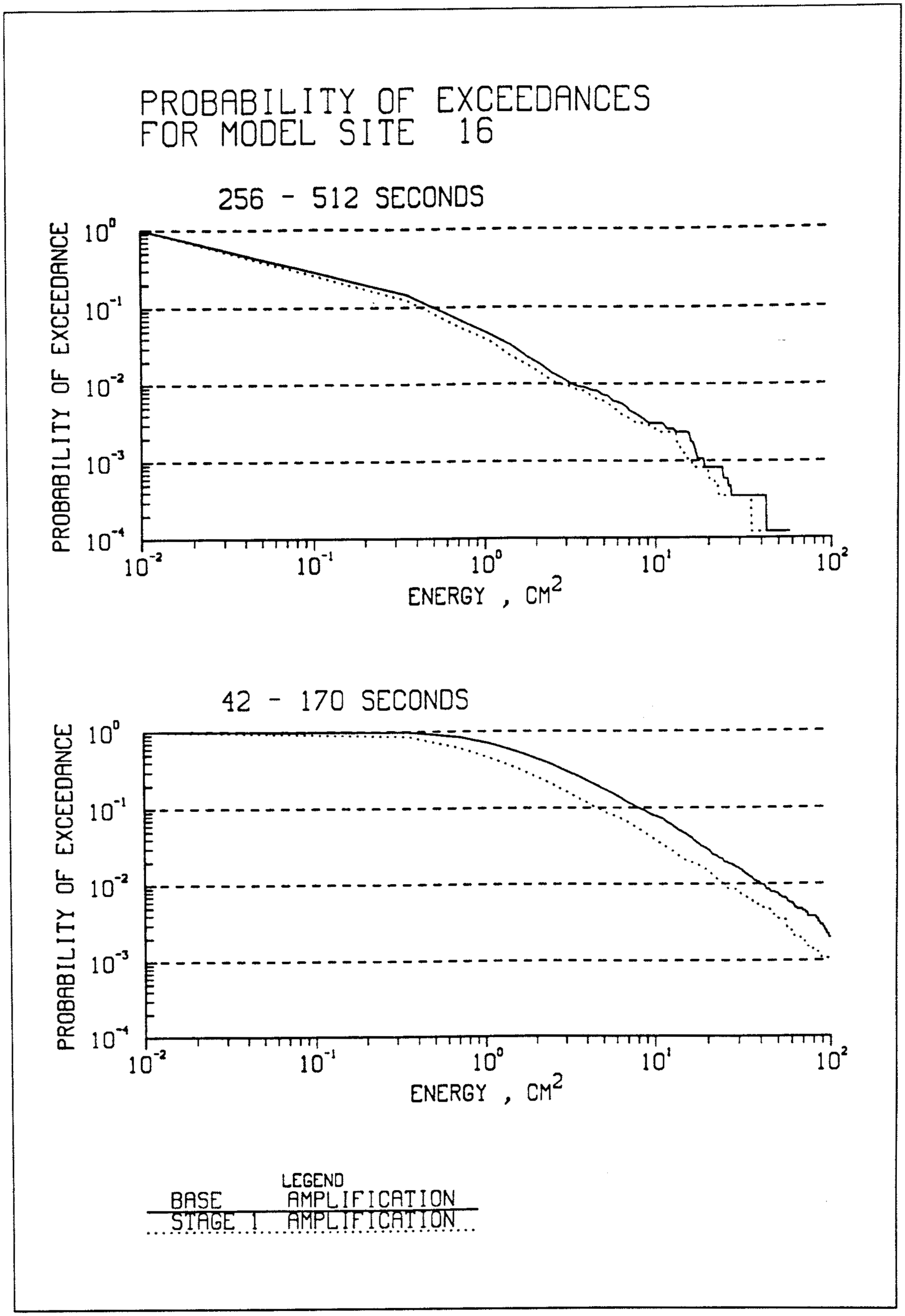

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 13
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

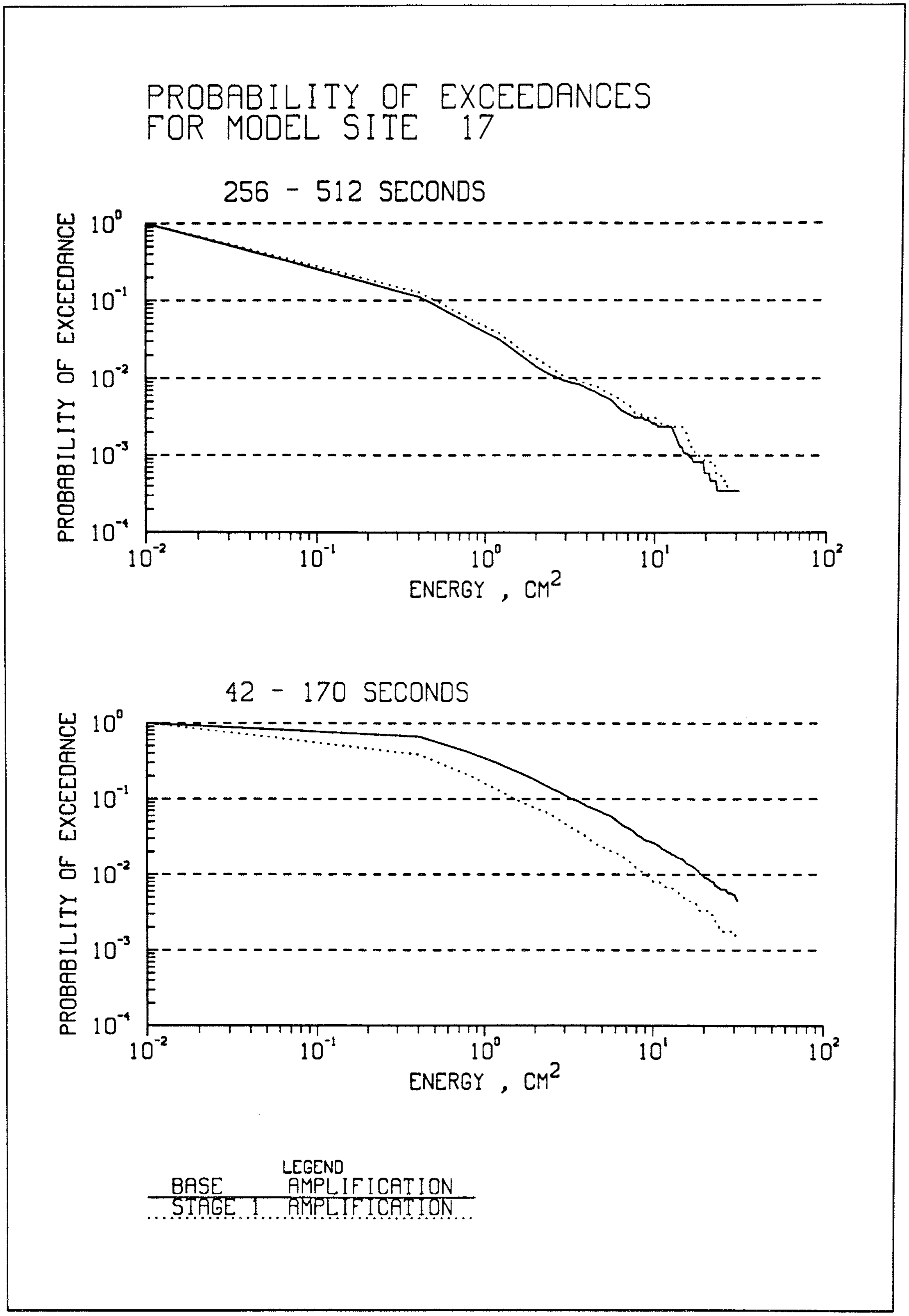


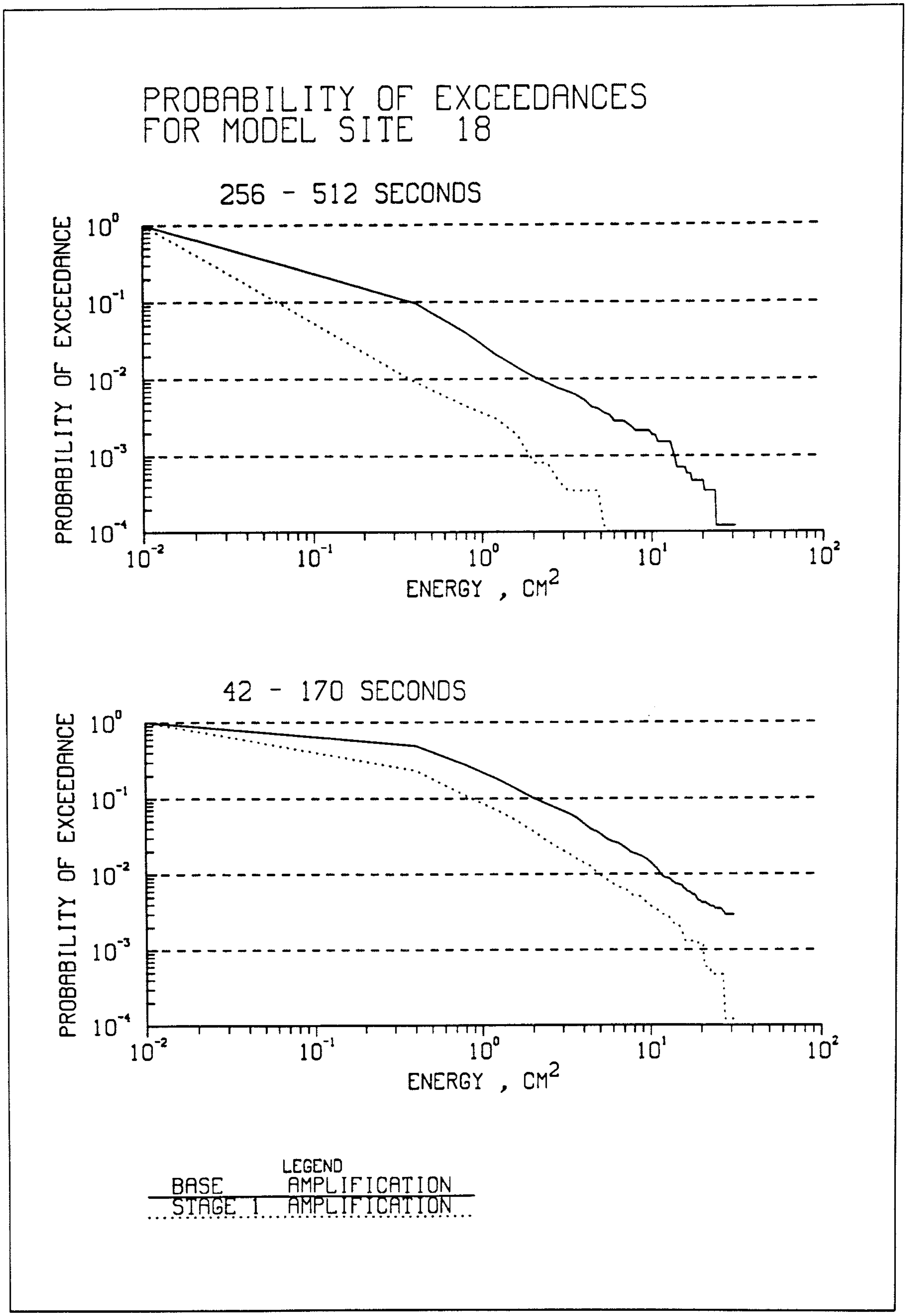
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 14
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE I AMPLIFICATION



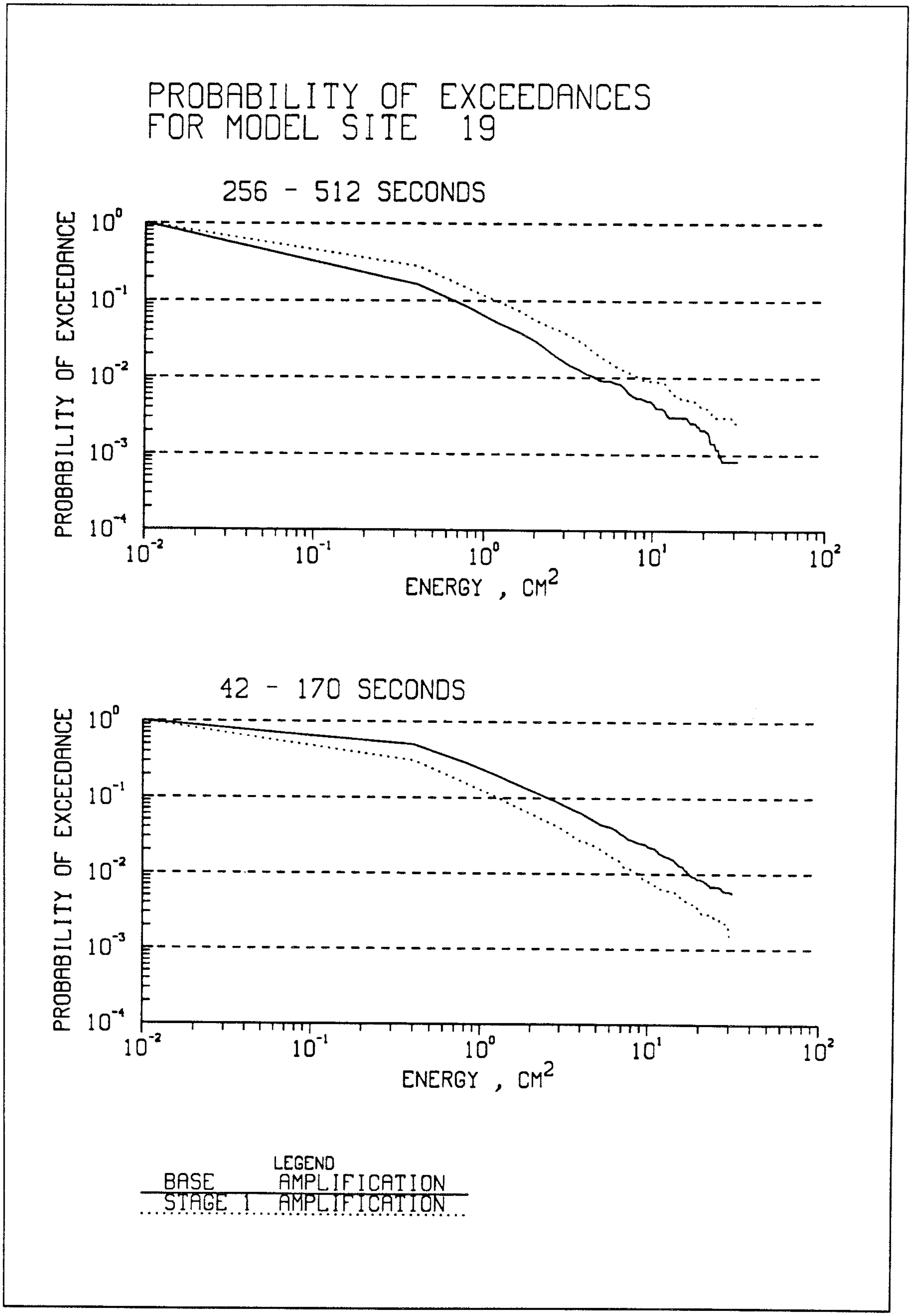
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 15
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

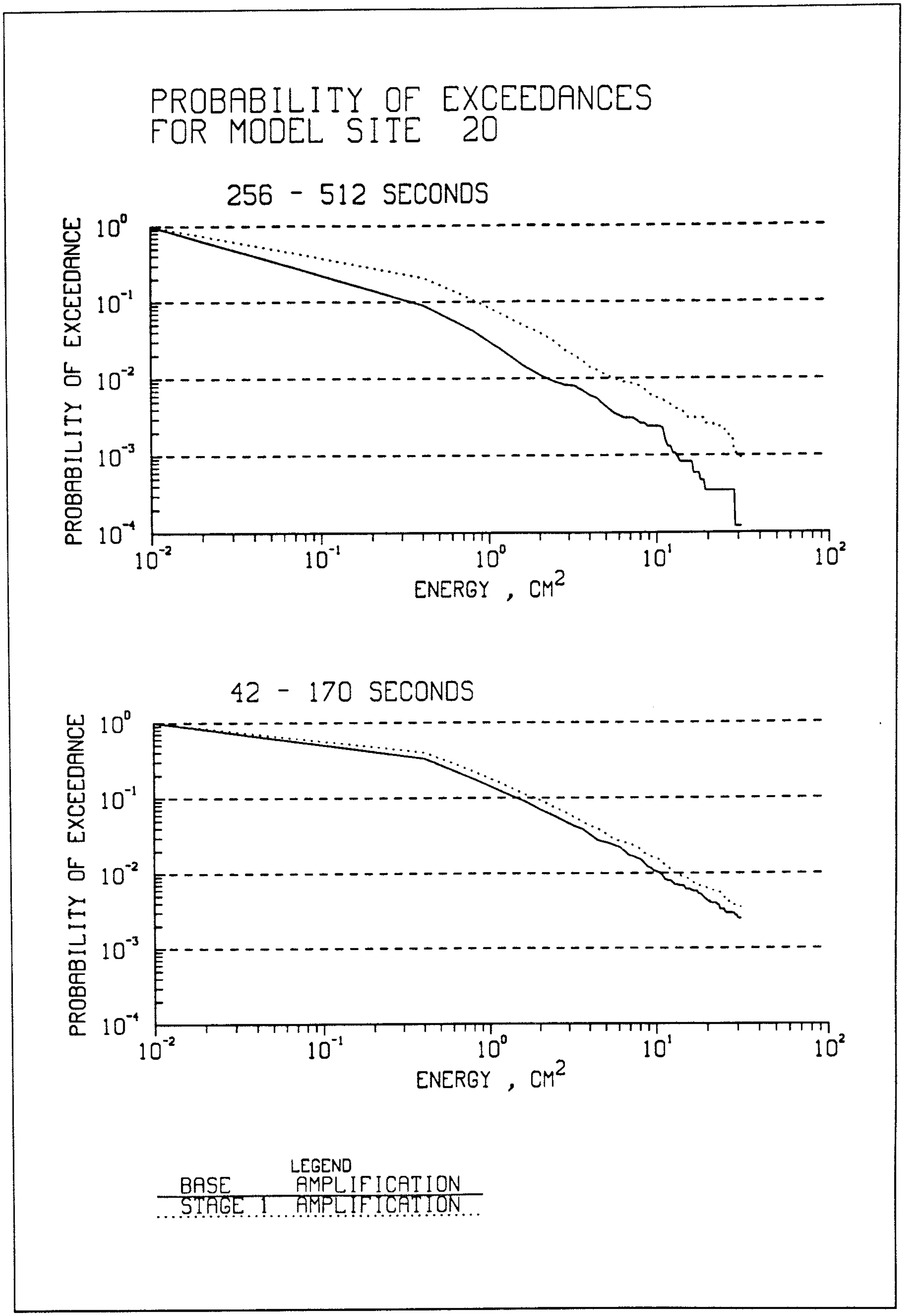

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 16
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

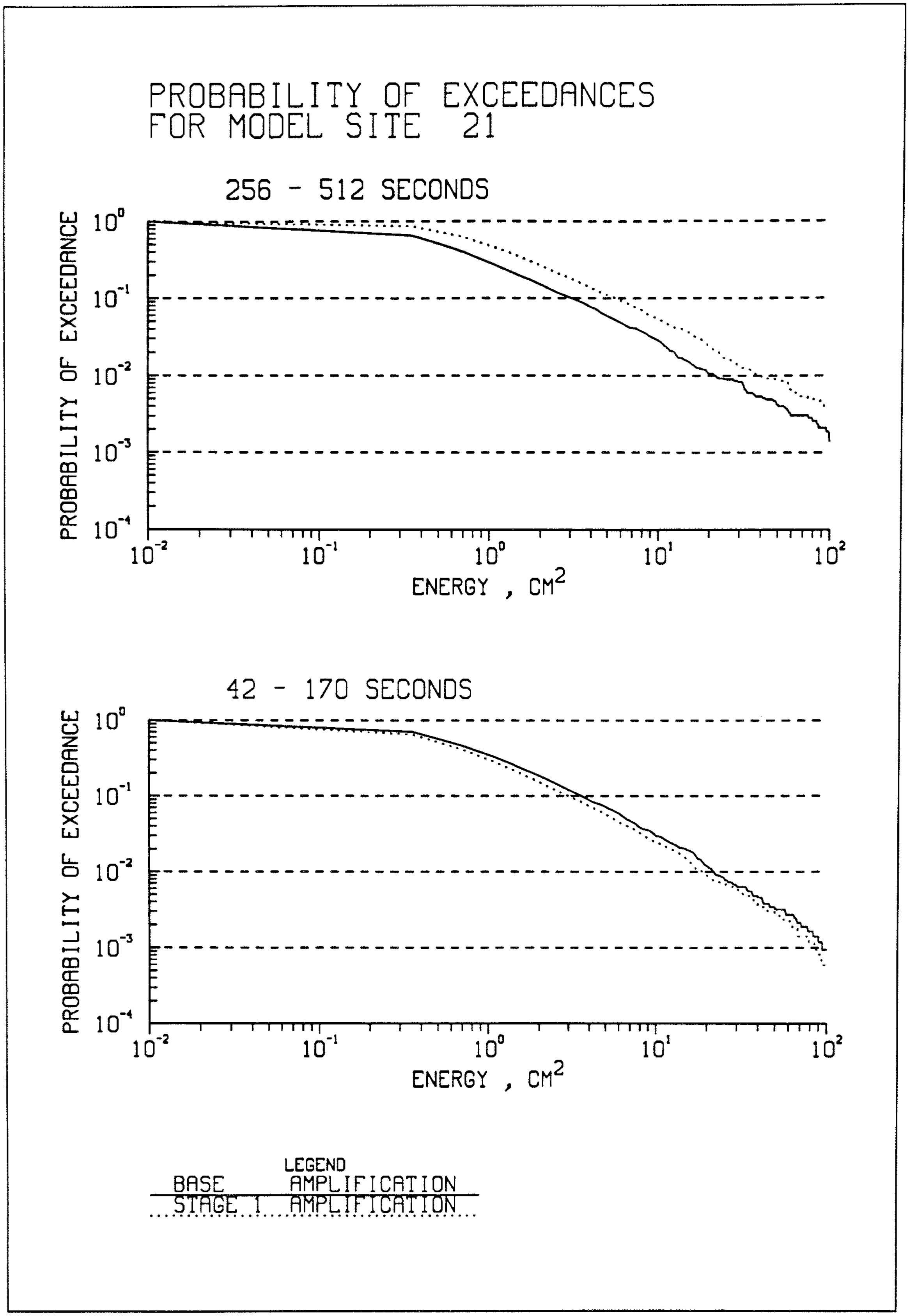

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 17
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

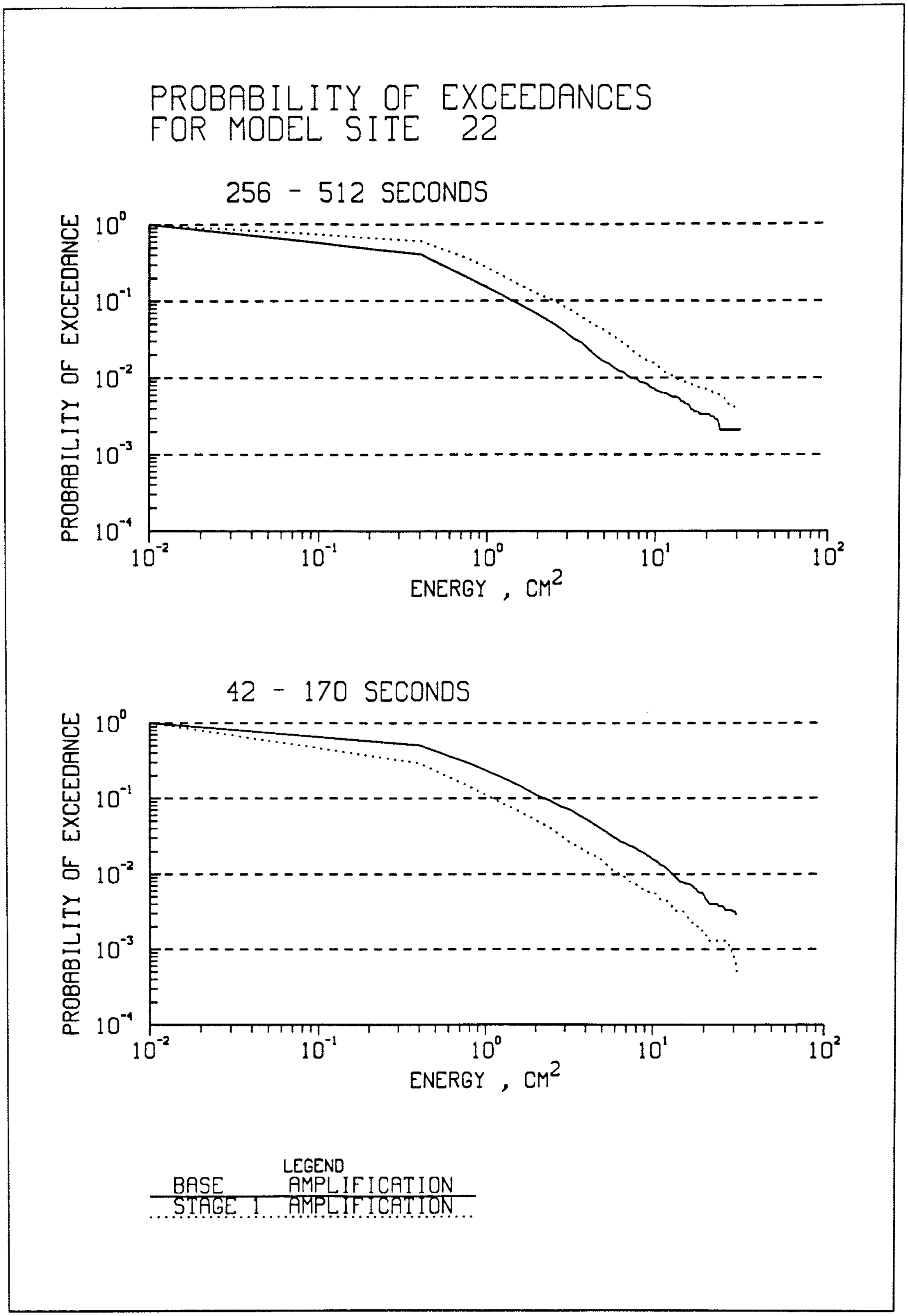


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 18
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

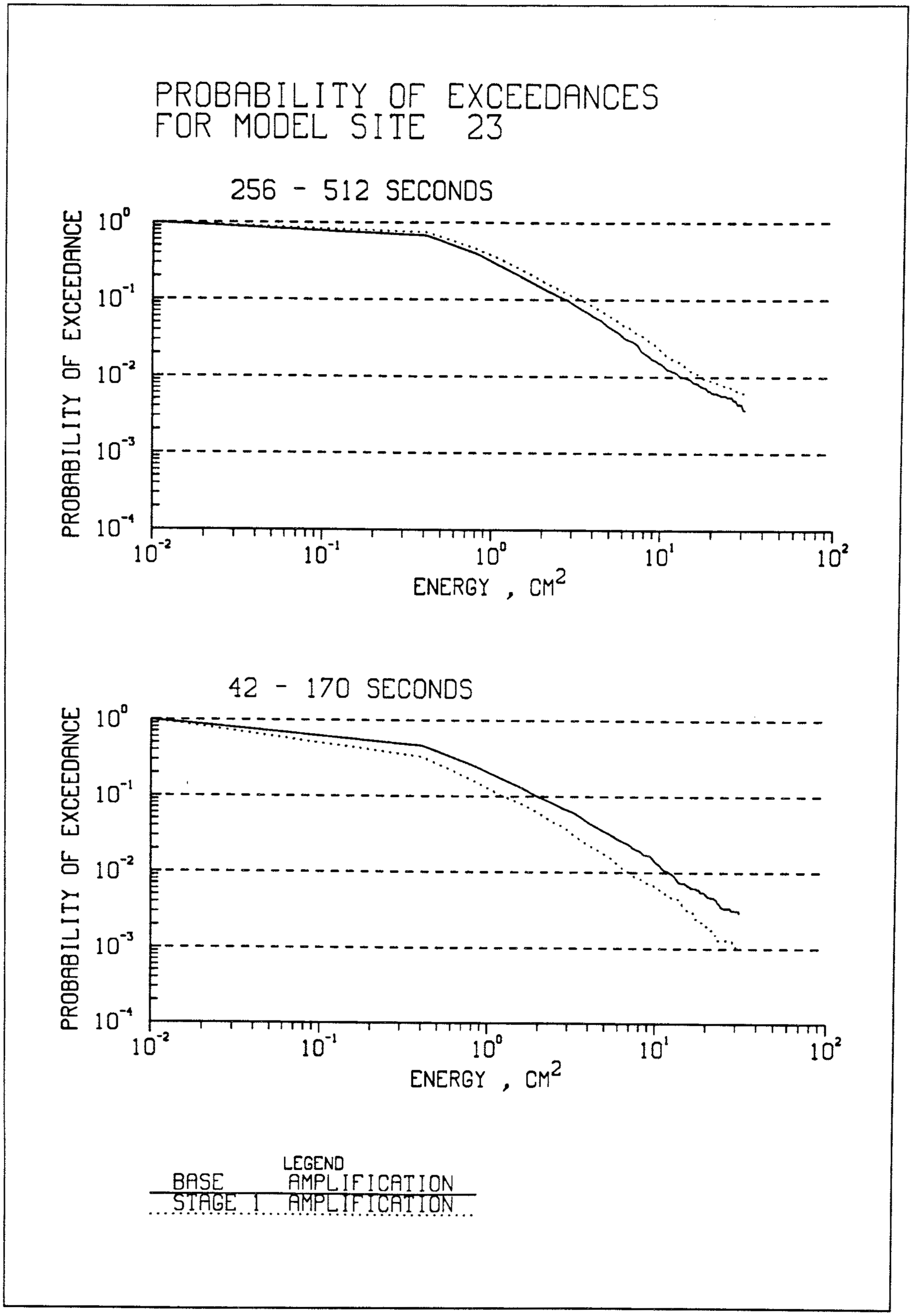

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 19
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 20
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

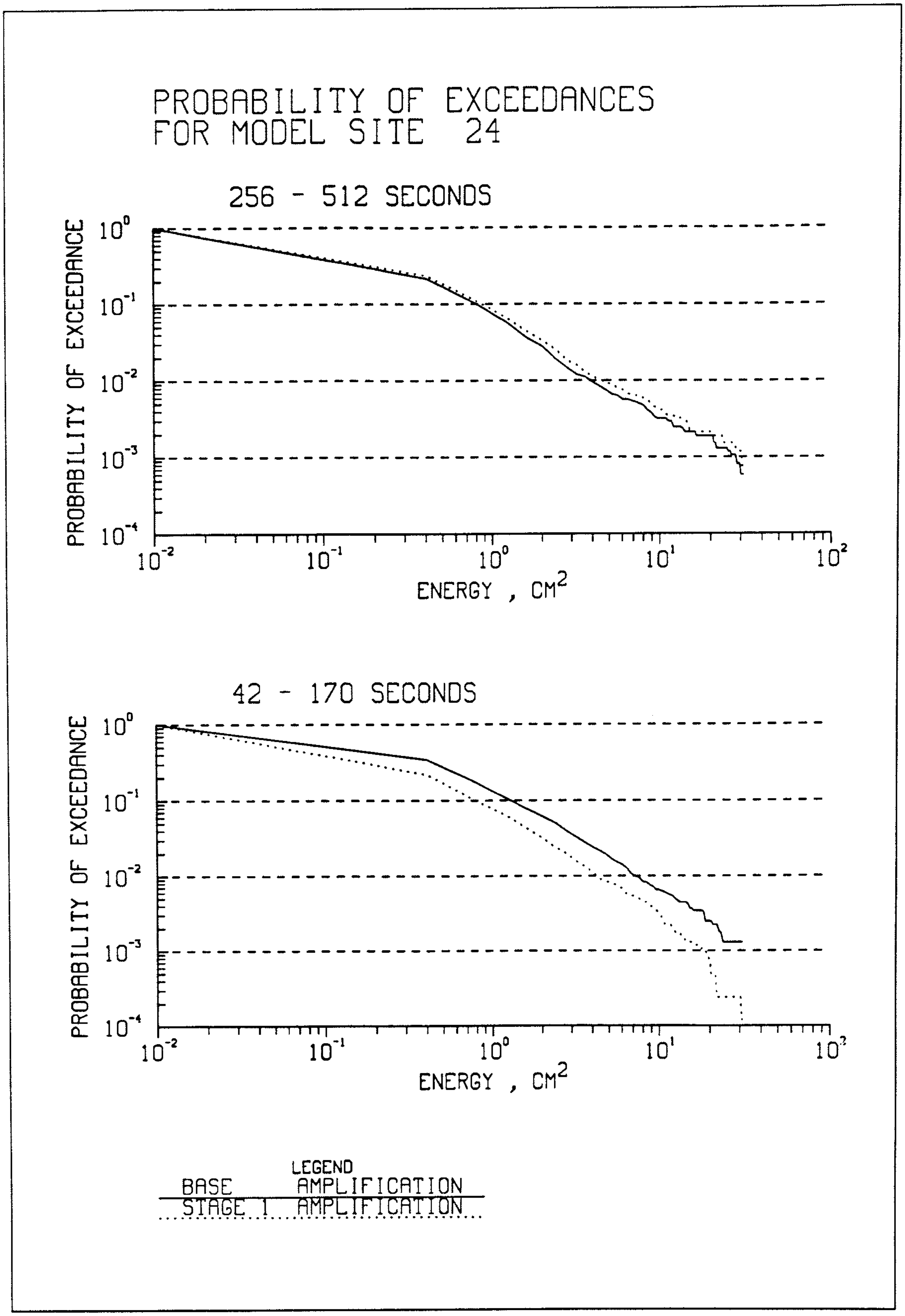

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 21
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE I AMPLIFICATION

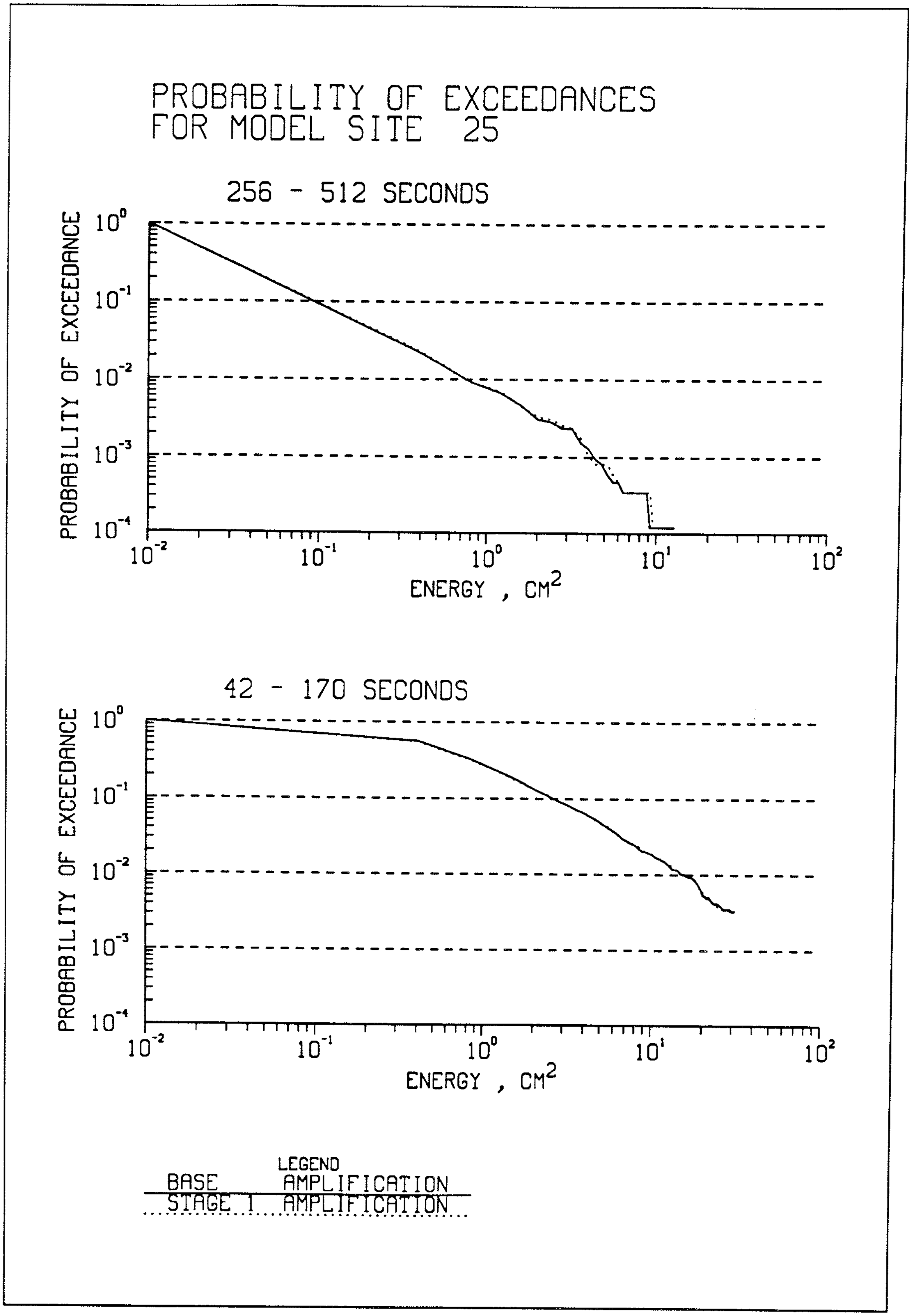


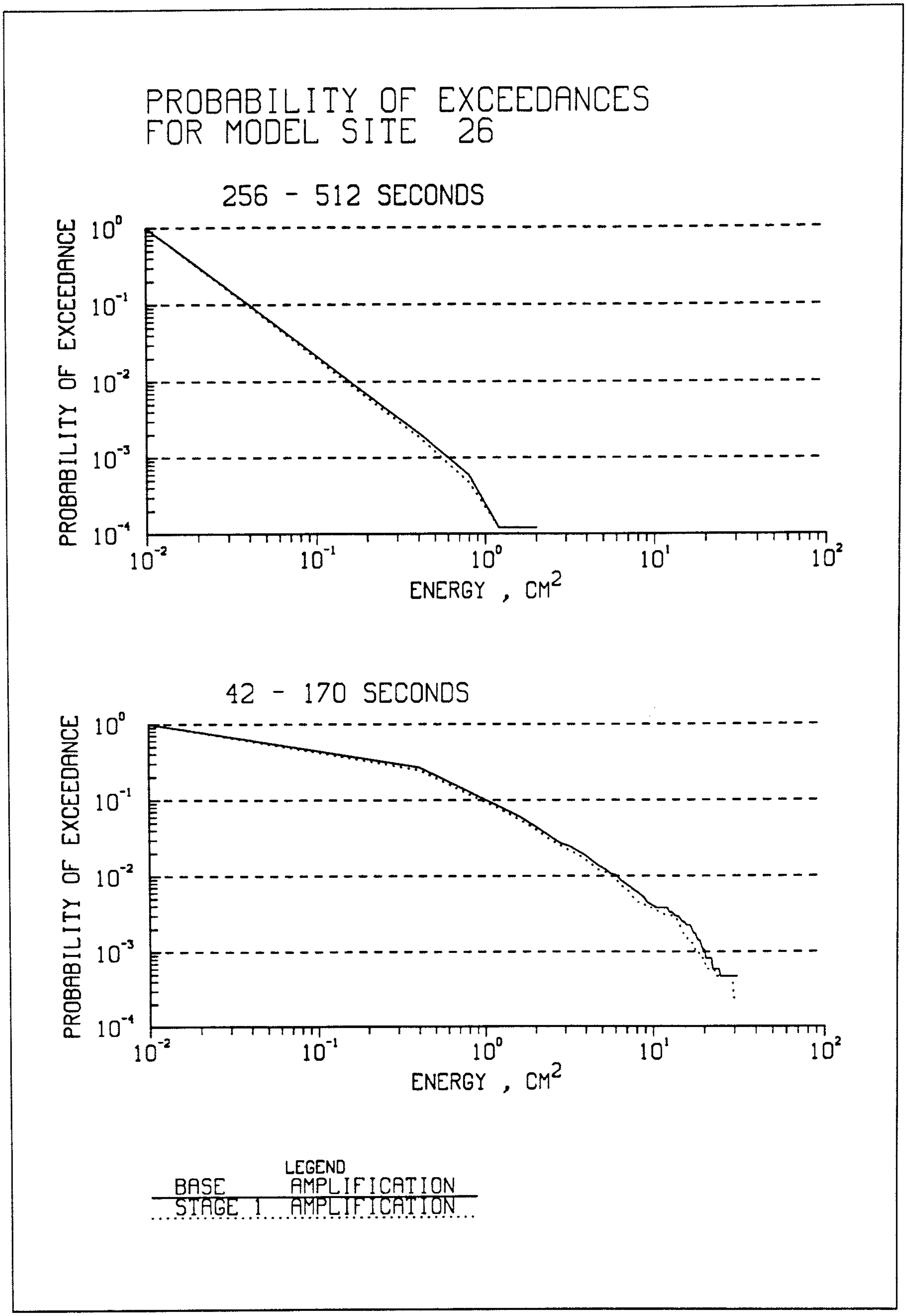
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 22
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION



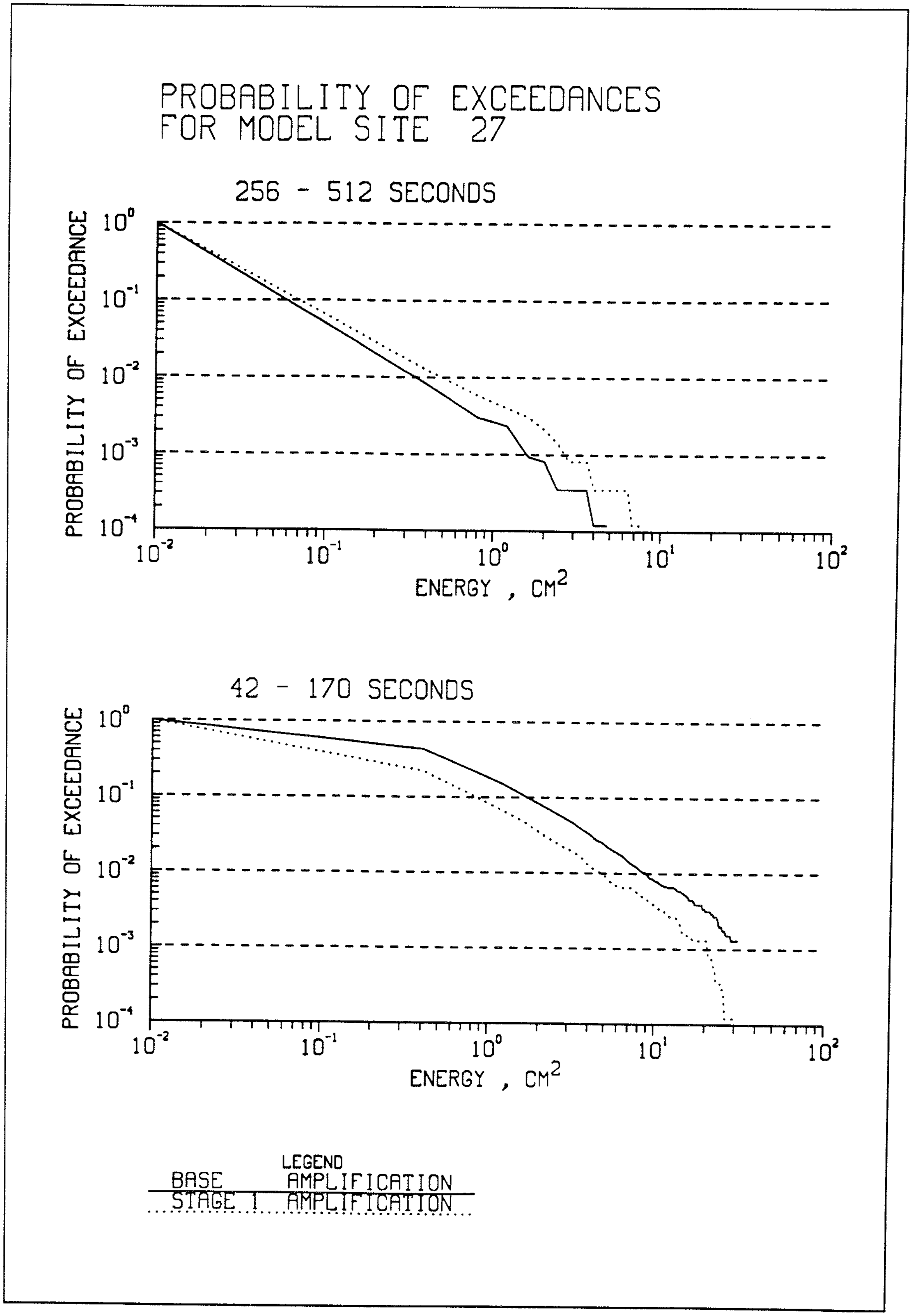
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 23
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 24
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

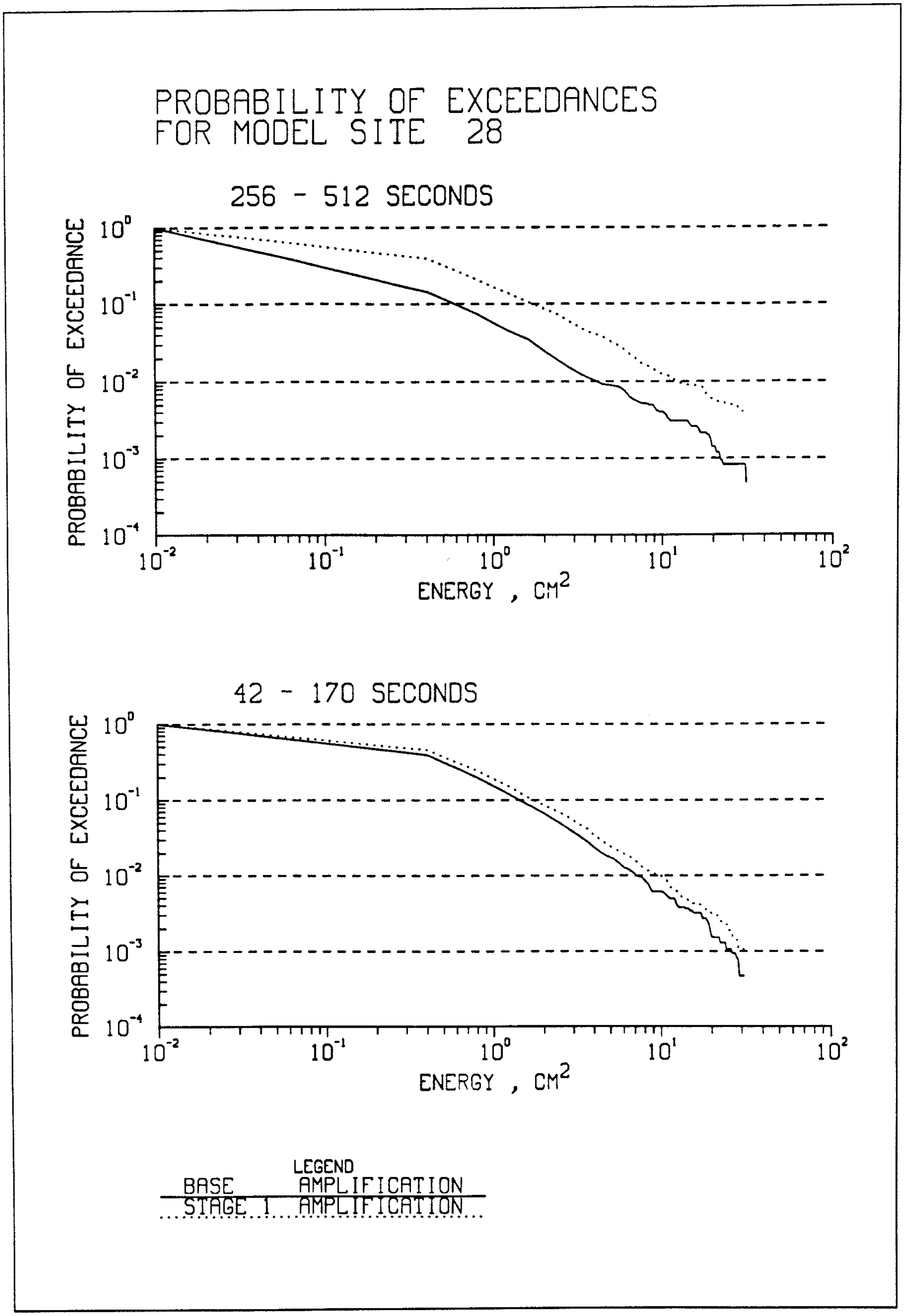

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 25
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

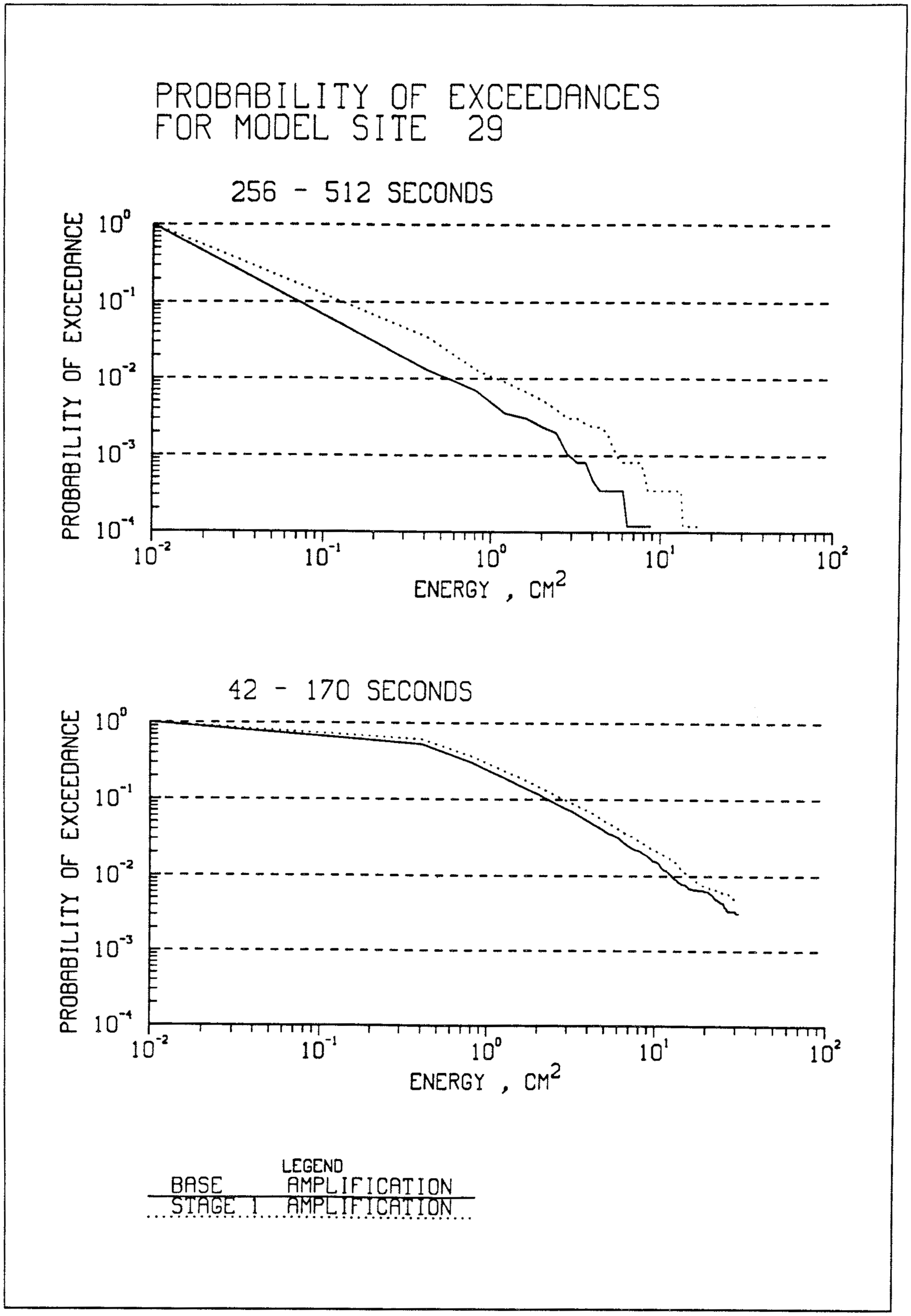


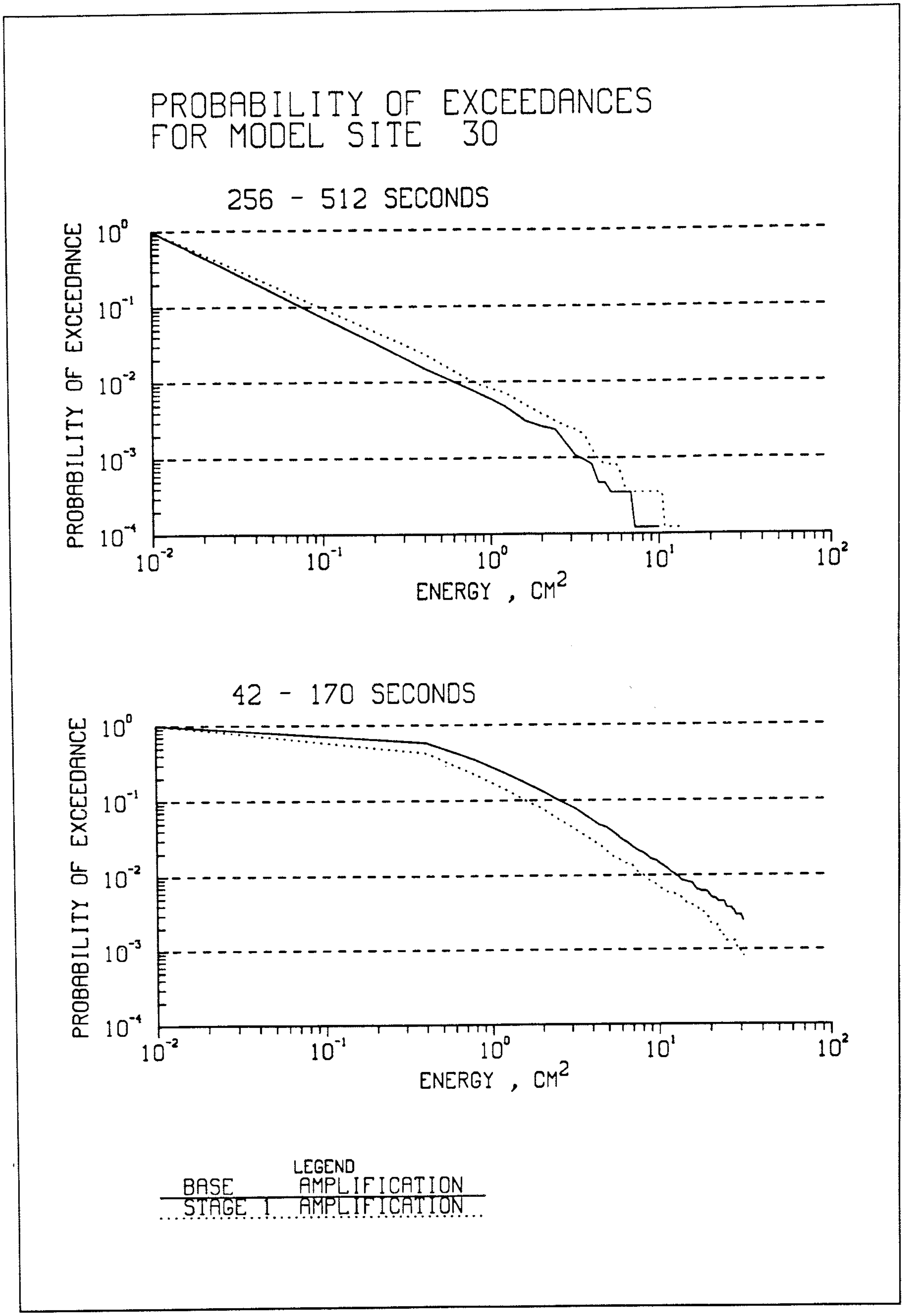
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 26
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION



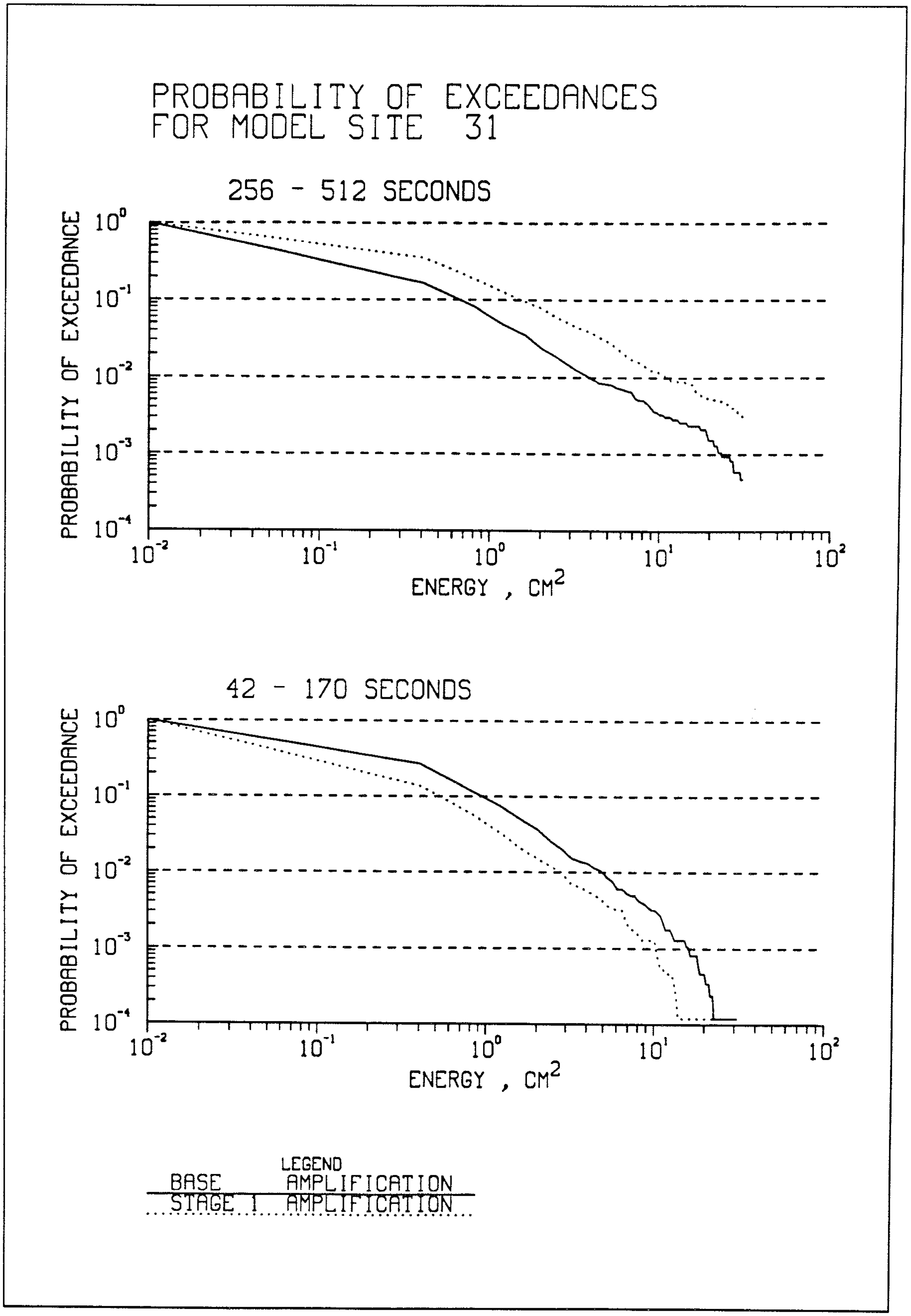
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 27
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 28
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE I AMPLIFICATION

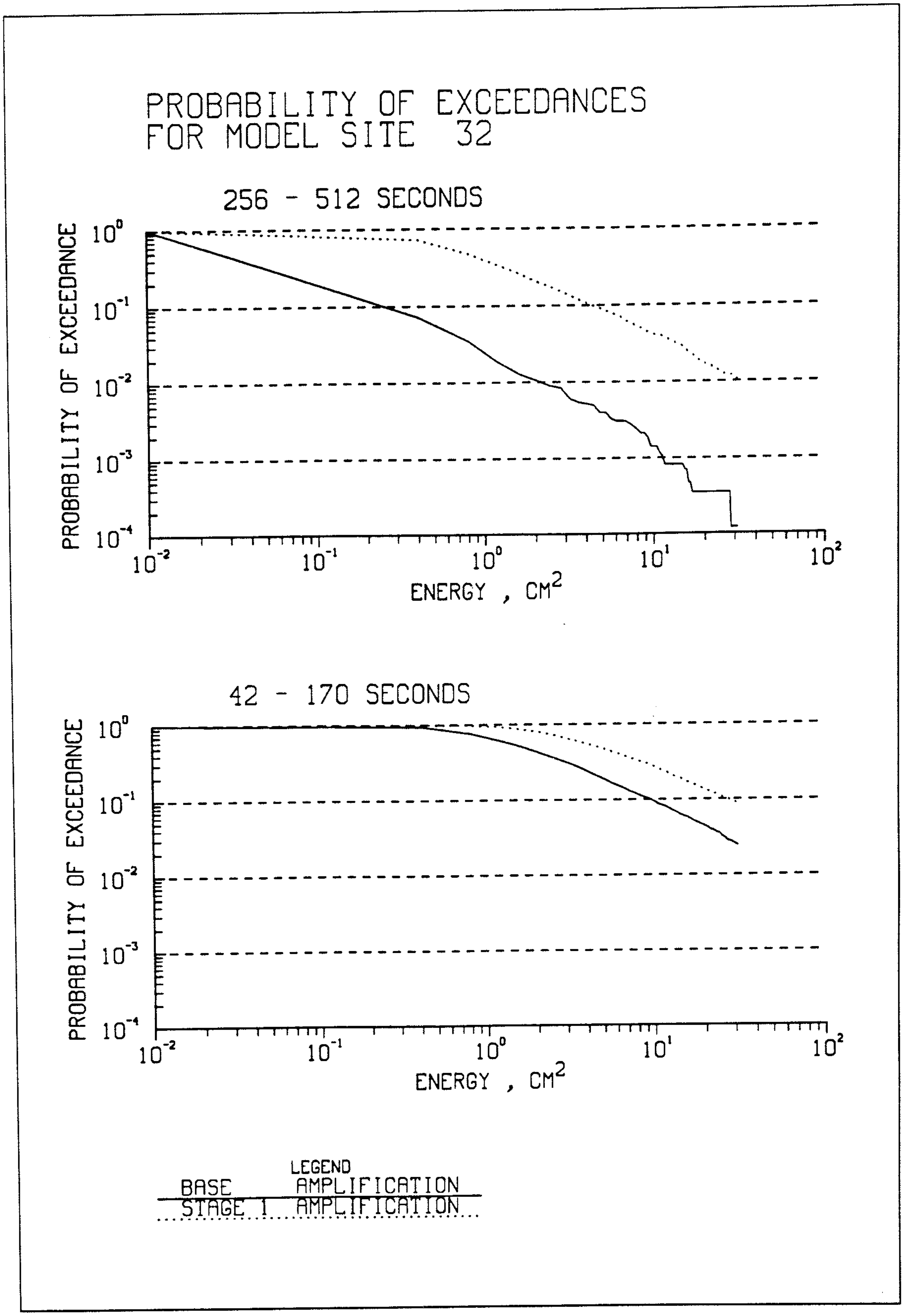

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 29
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION



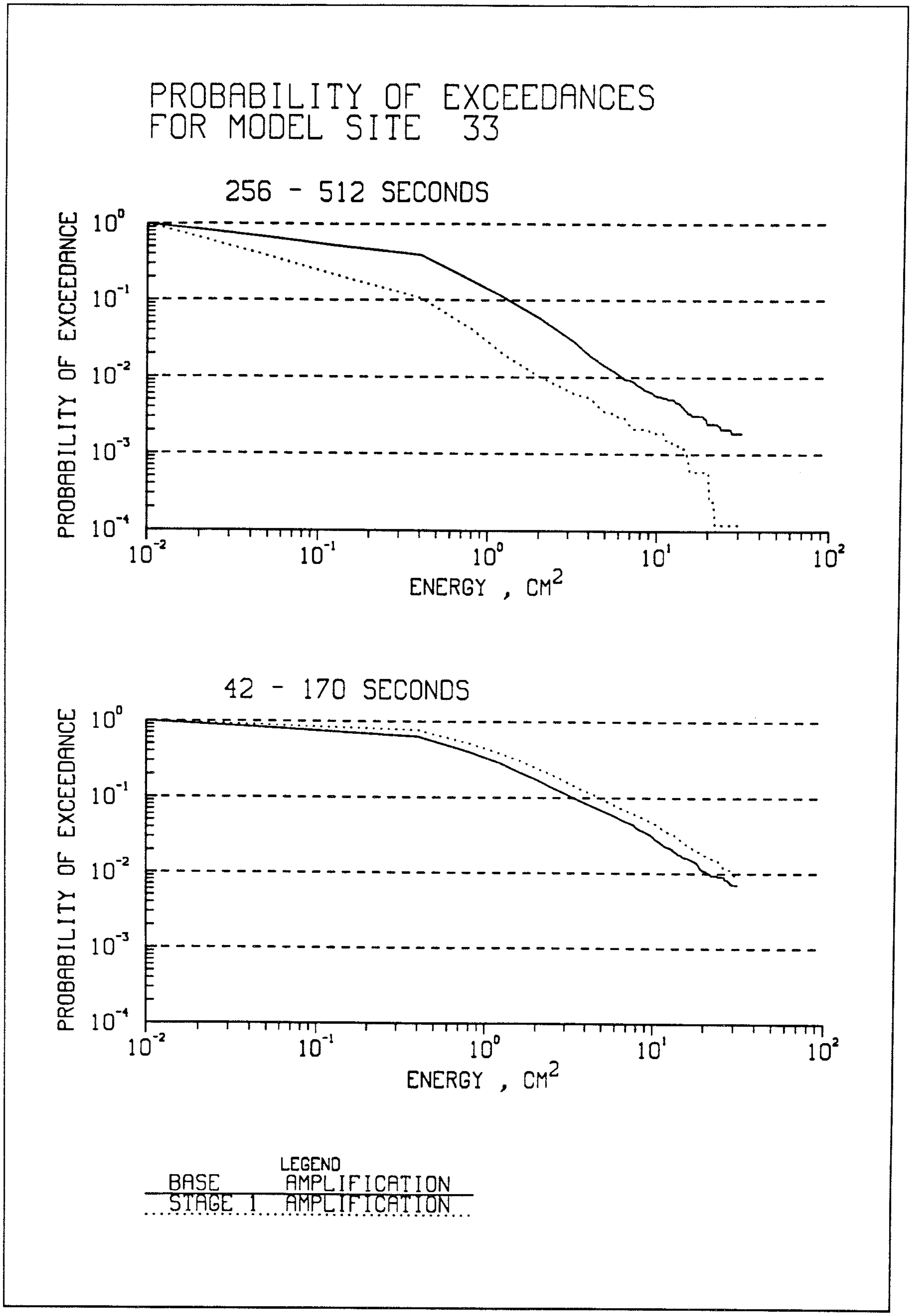
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 30
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

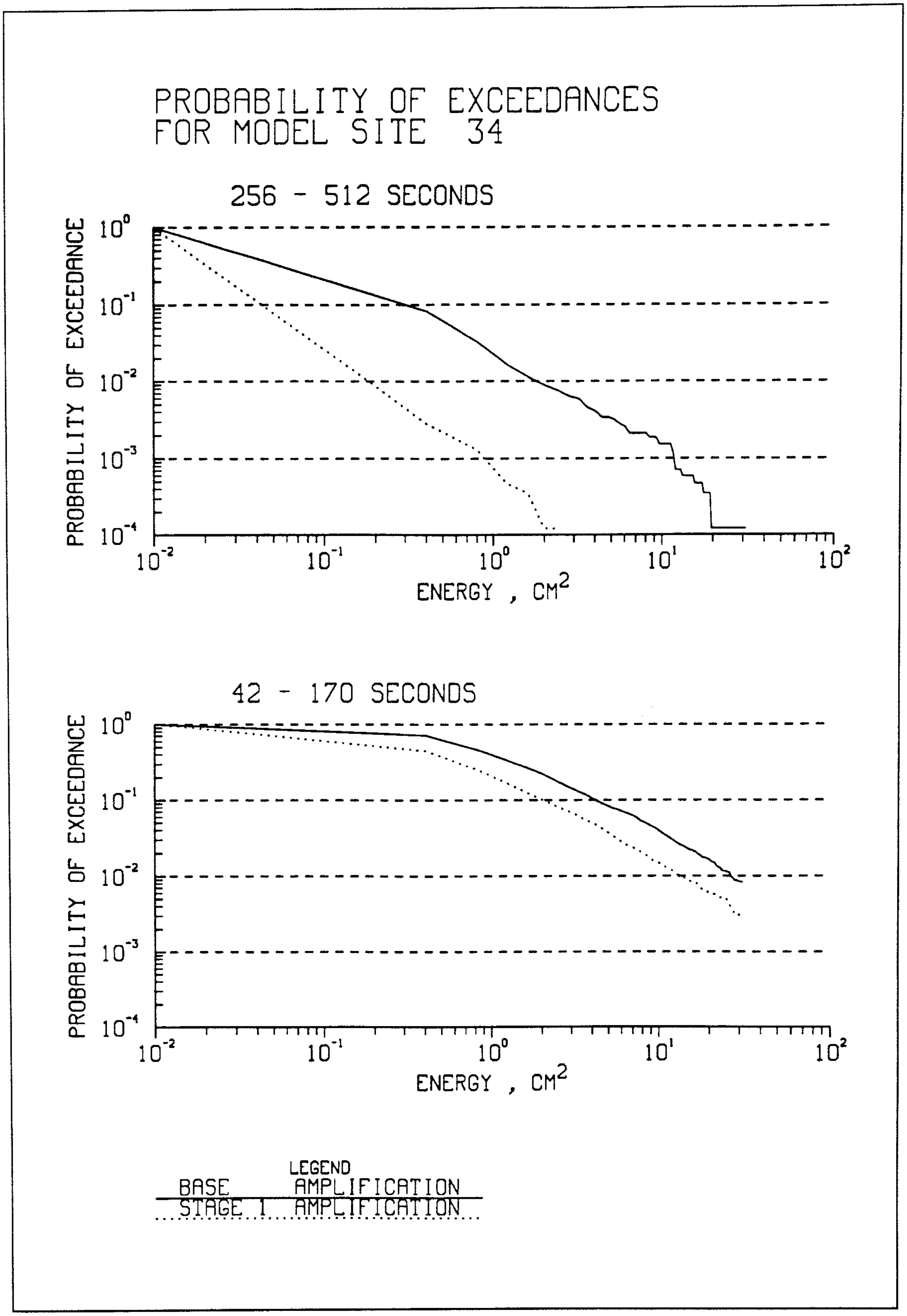


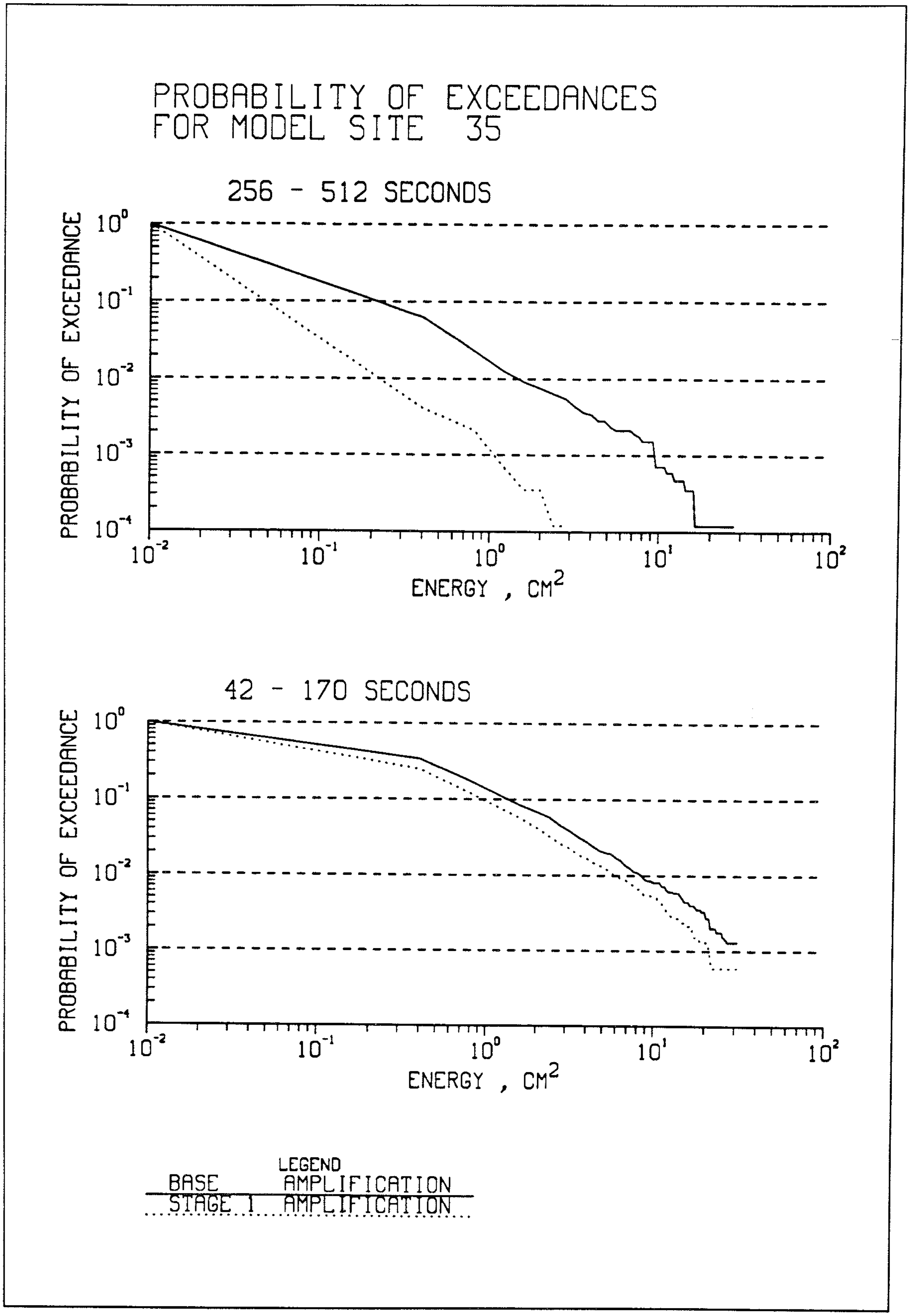
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 31
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

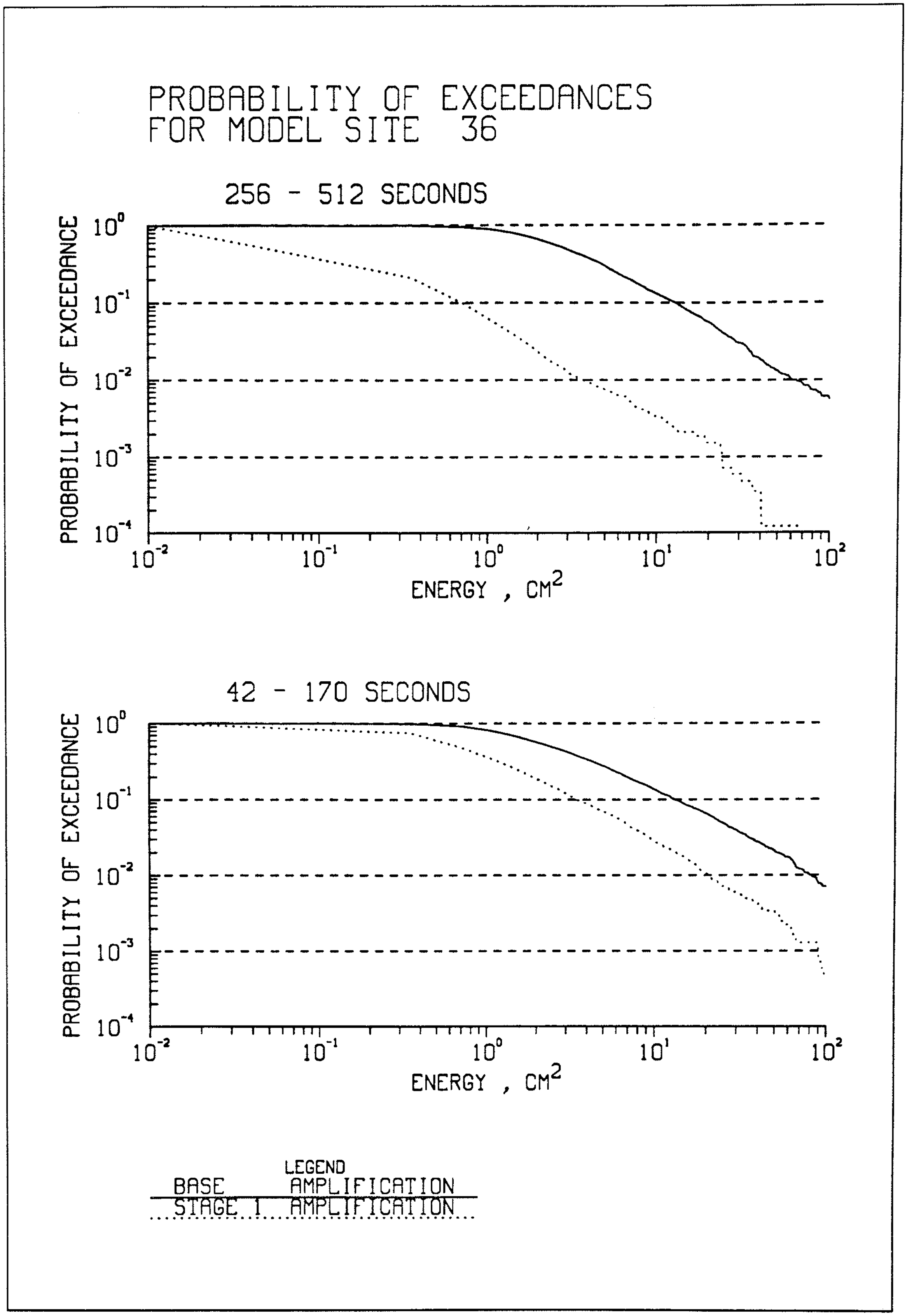


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 32
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

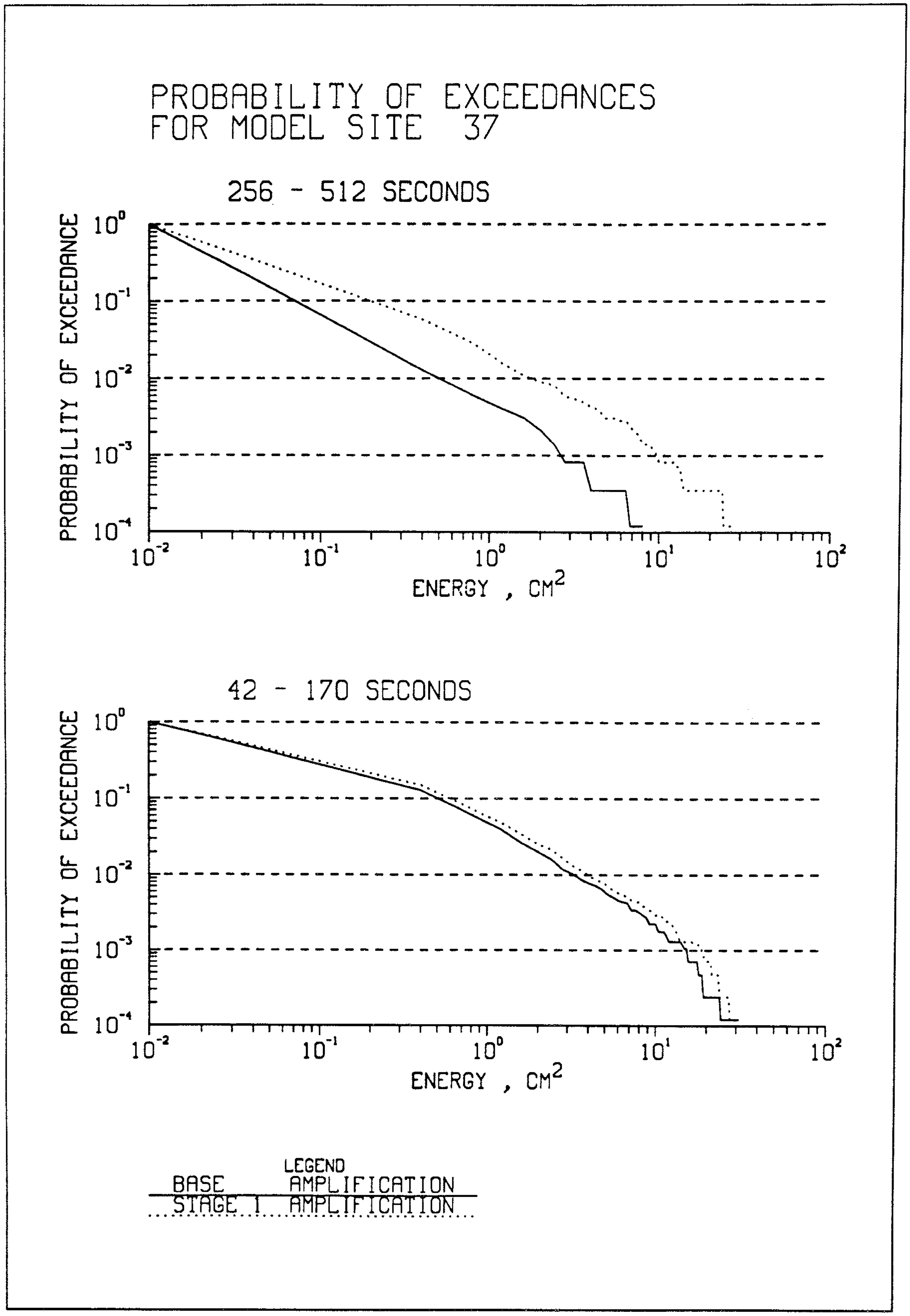

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 33
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM²
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM²
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 34
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE I AMPLIFICATION

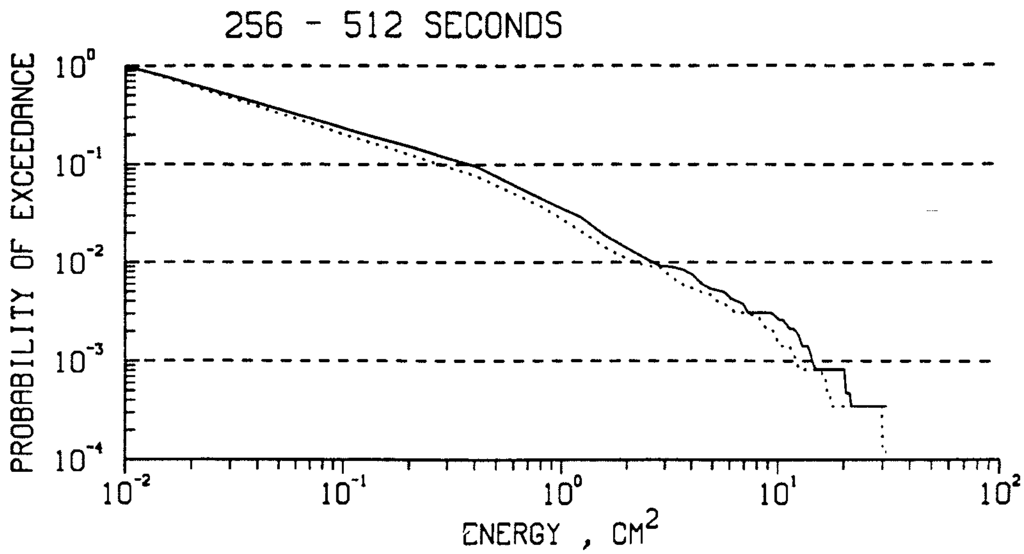

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 35
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

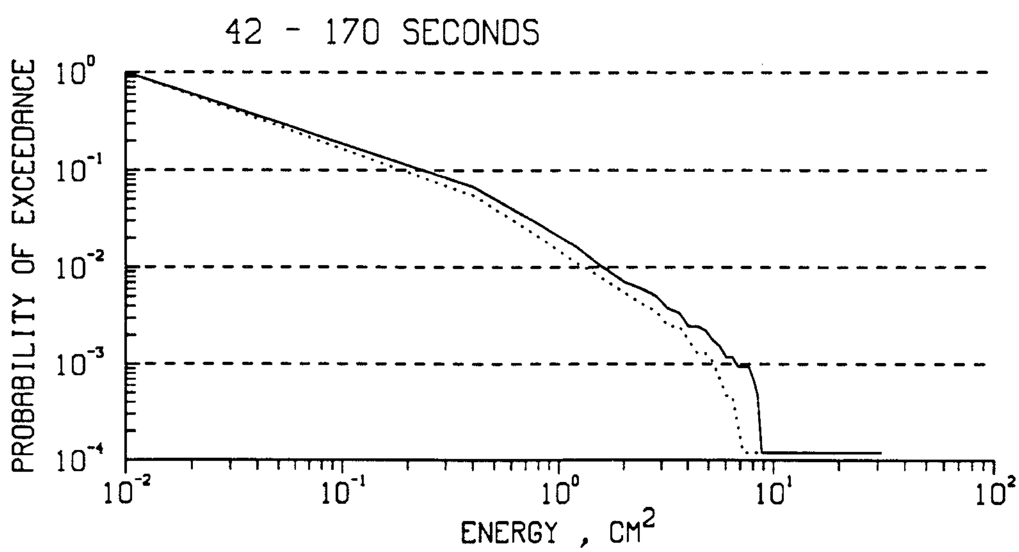


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 36
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

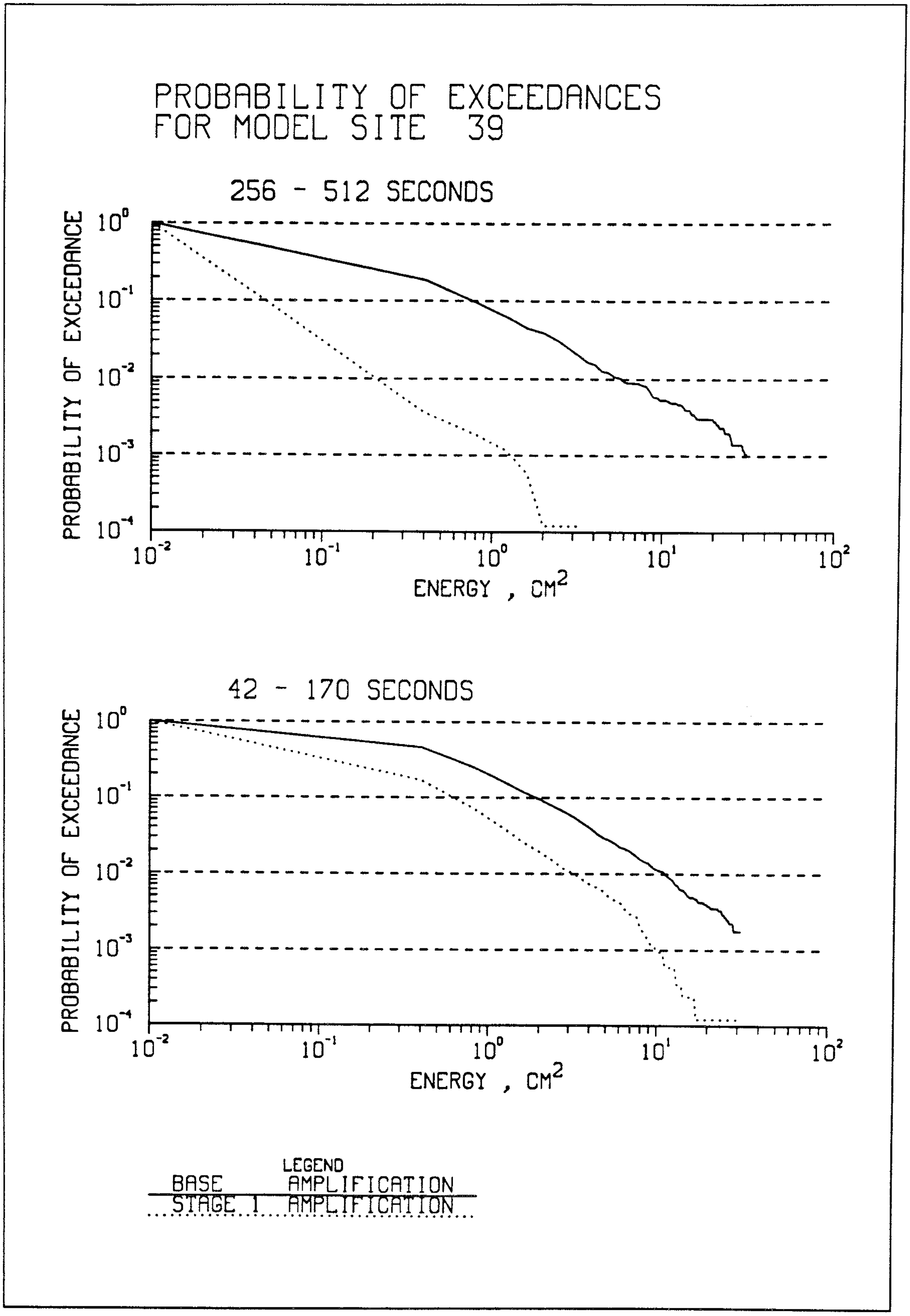

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 37
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
10^0
10^-1
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM^2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

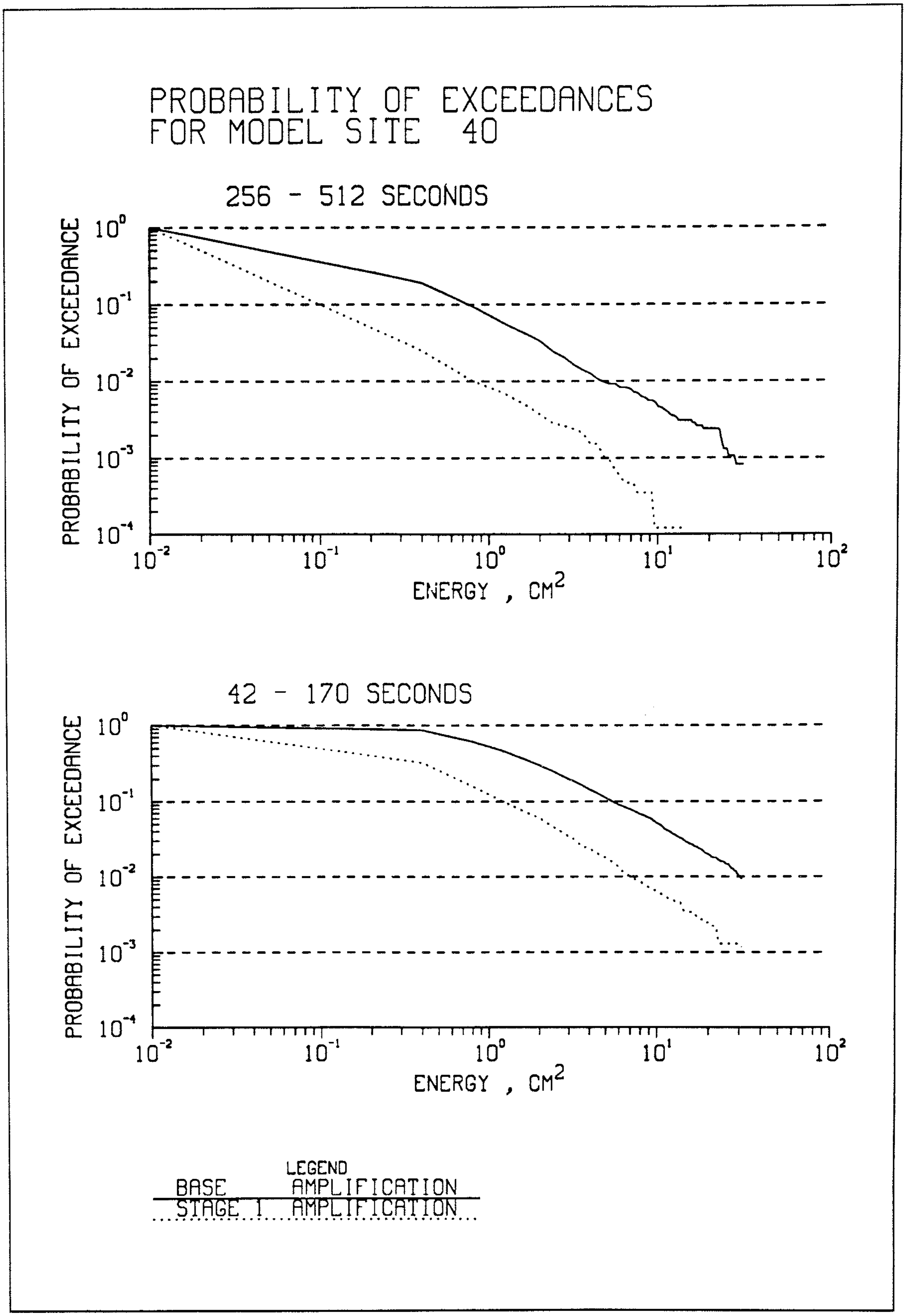
PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 38

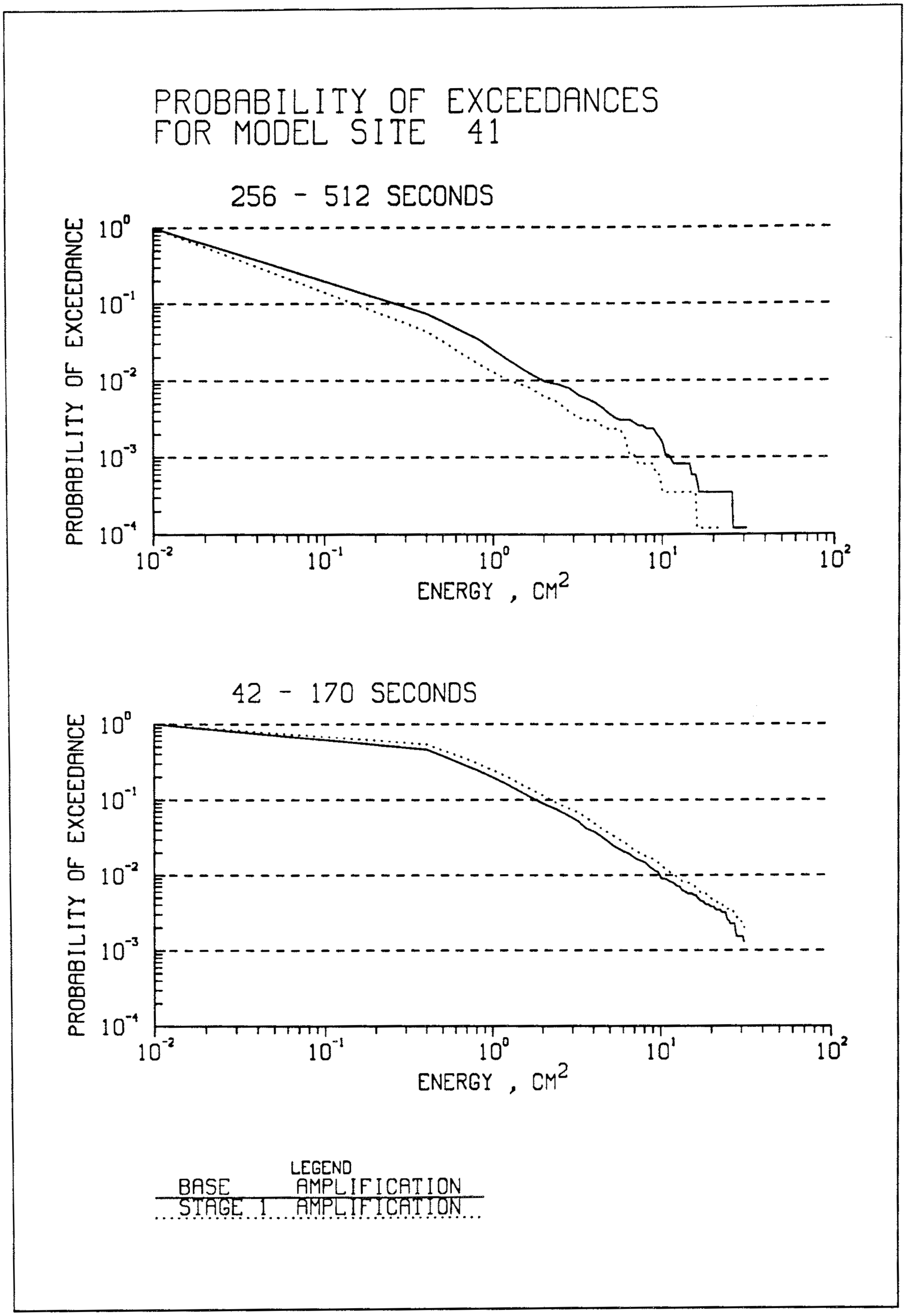


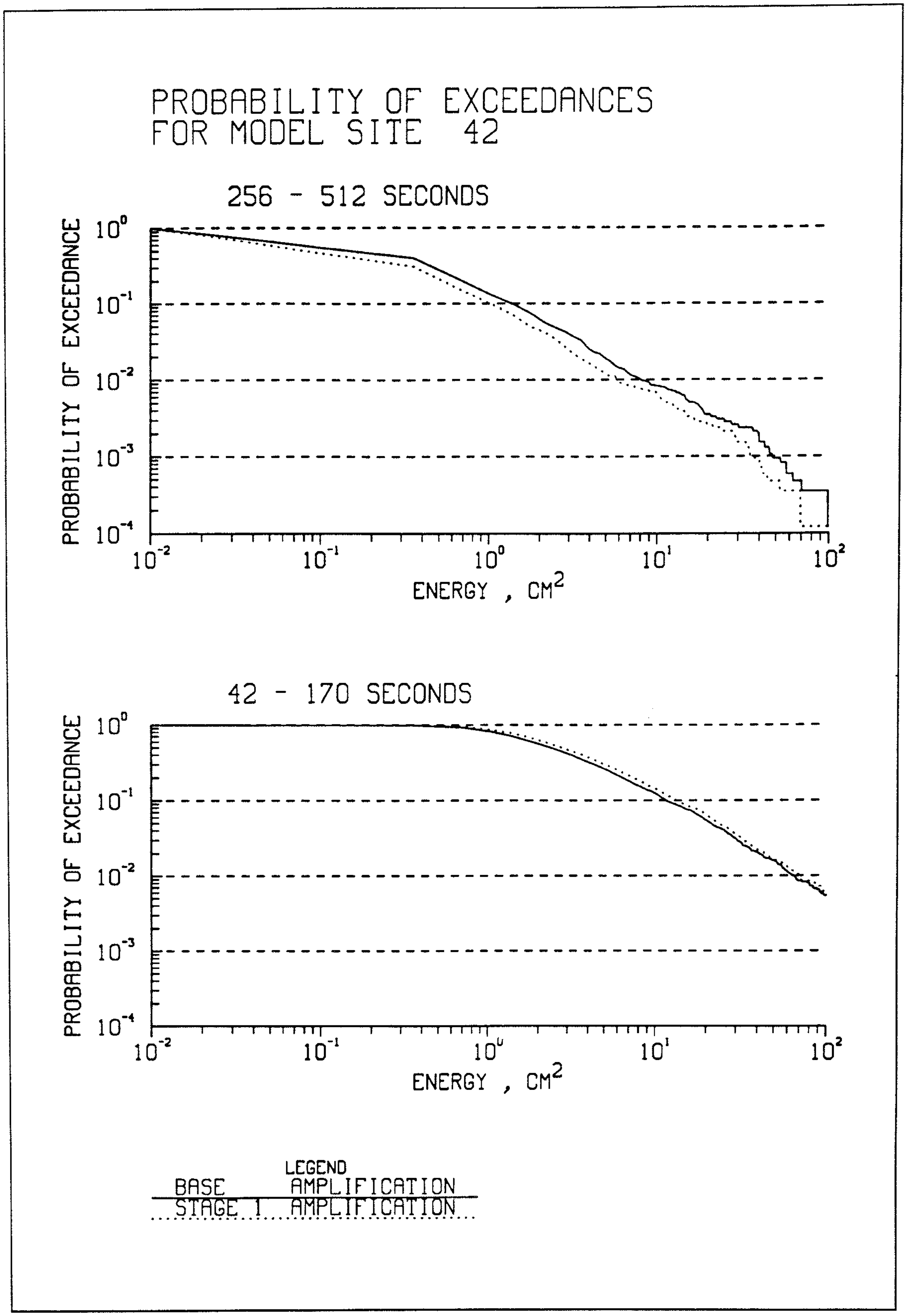


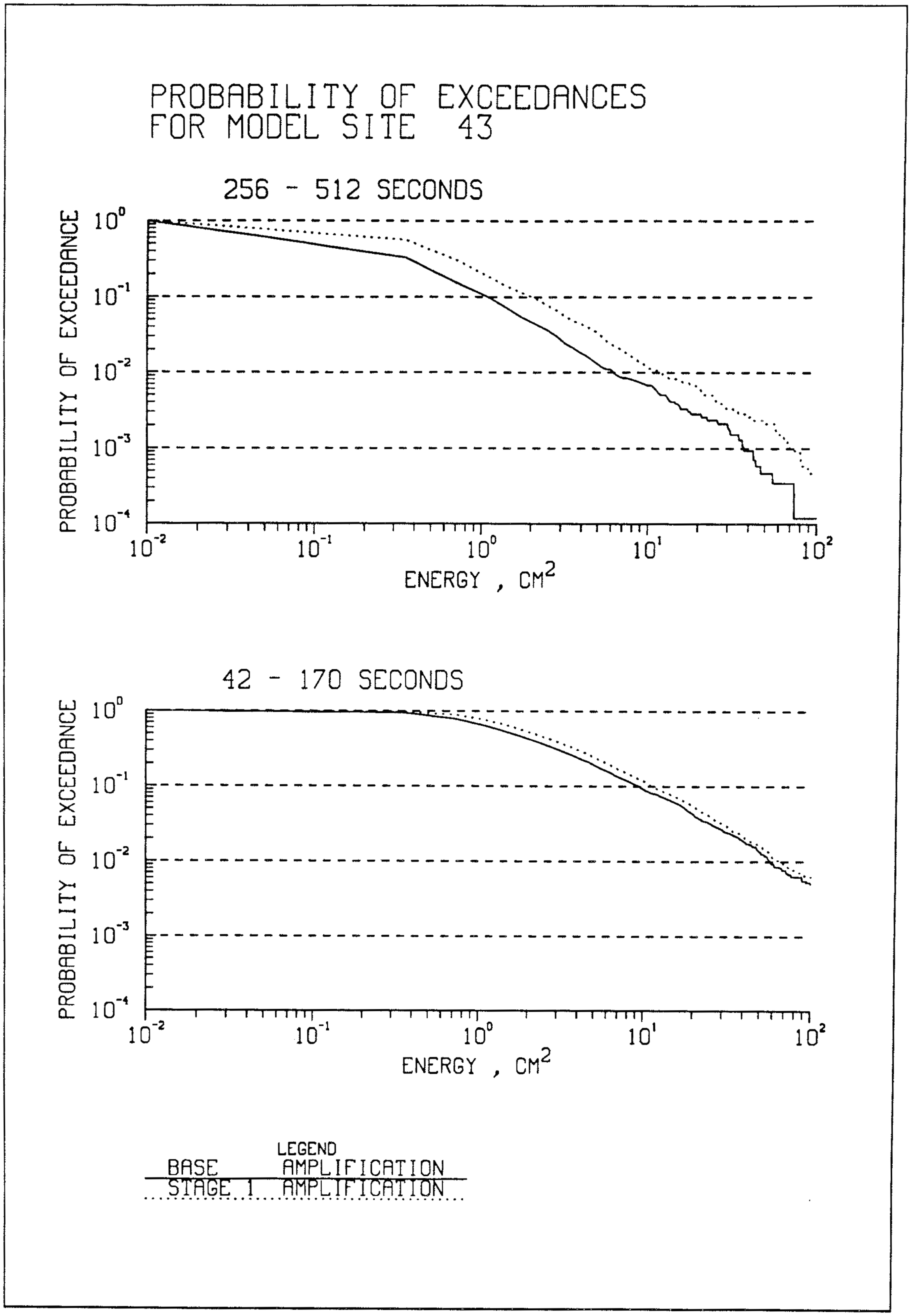
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 39
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 40
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY, CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY, CM2
LEGEND
BASE AMPLIFICATION
STAGE I AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 41
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION


PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 42
256 - 512 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION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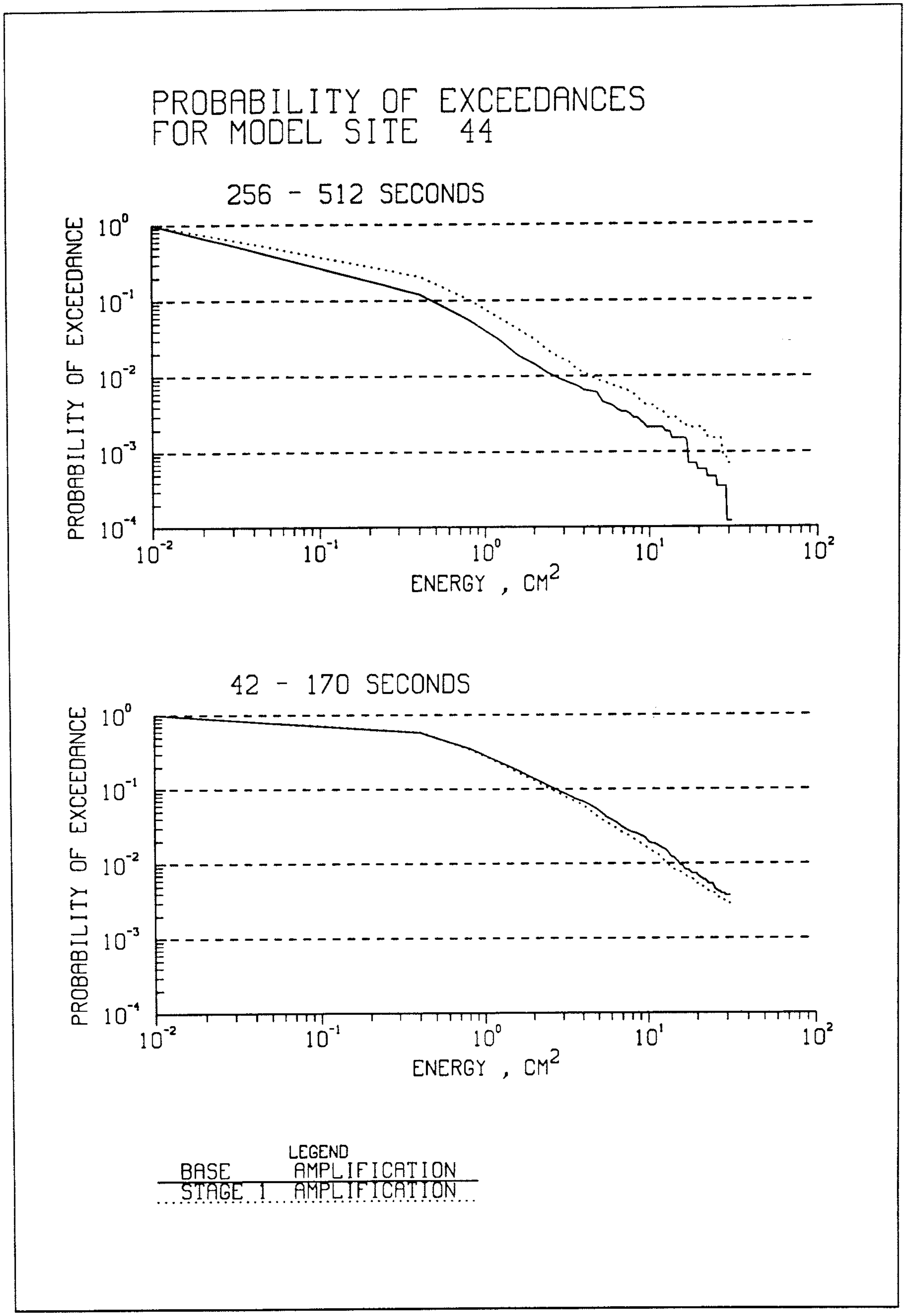
STAGE 1 AMPLIFICATION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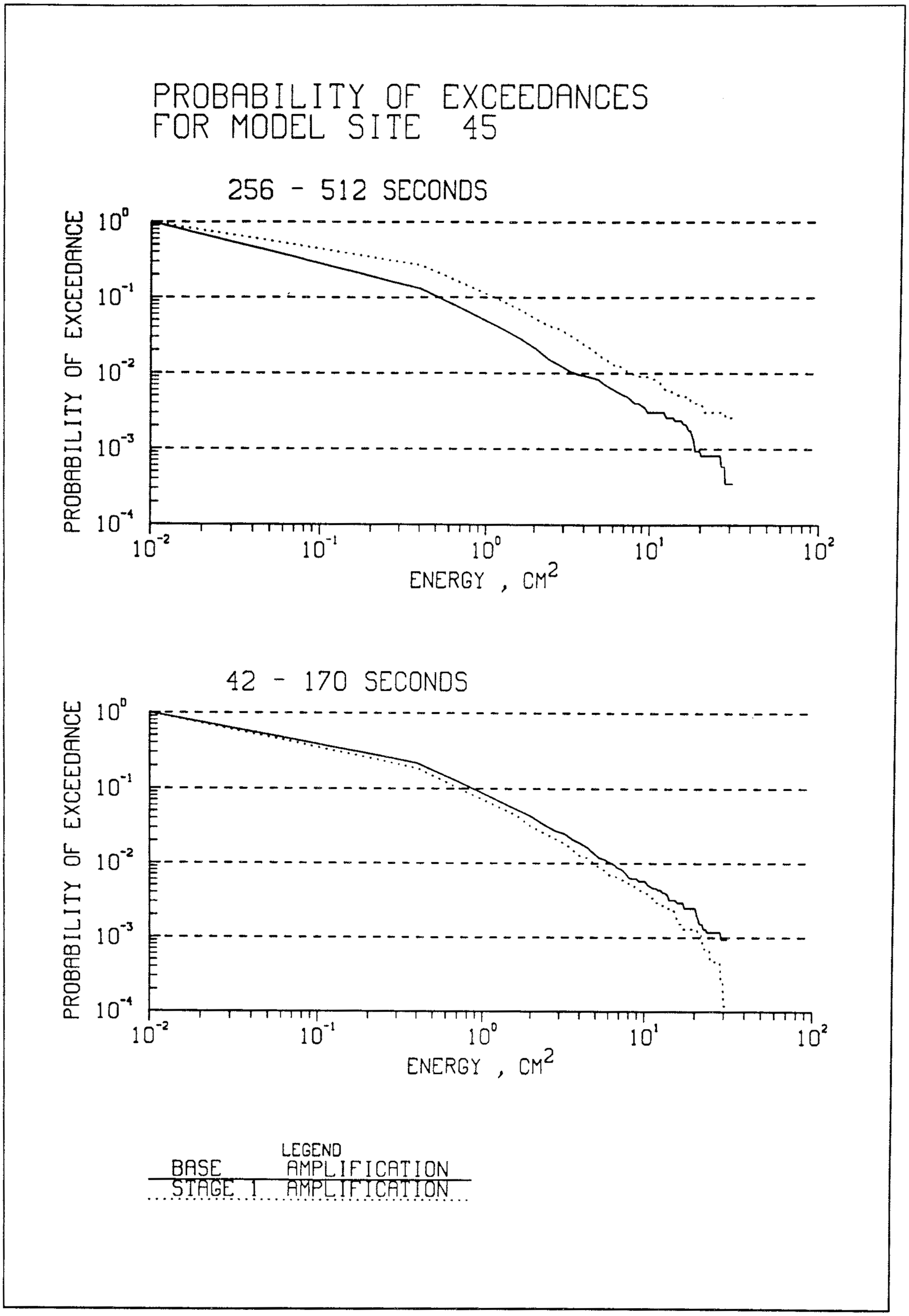
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION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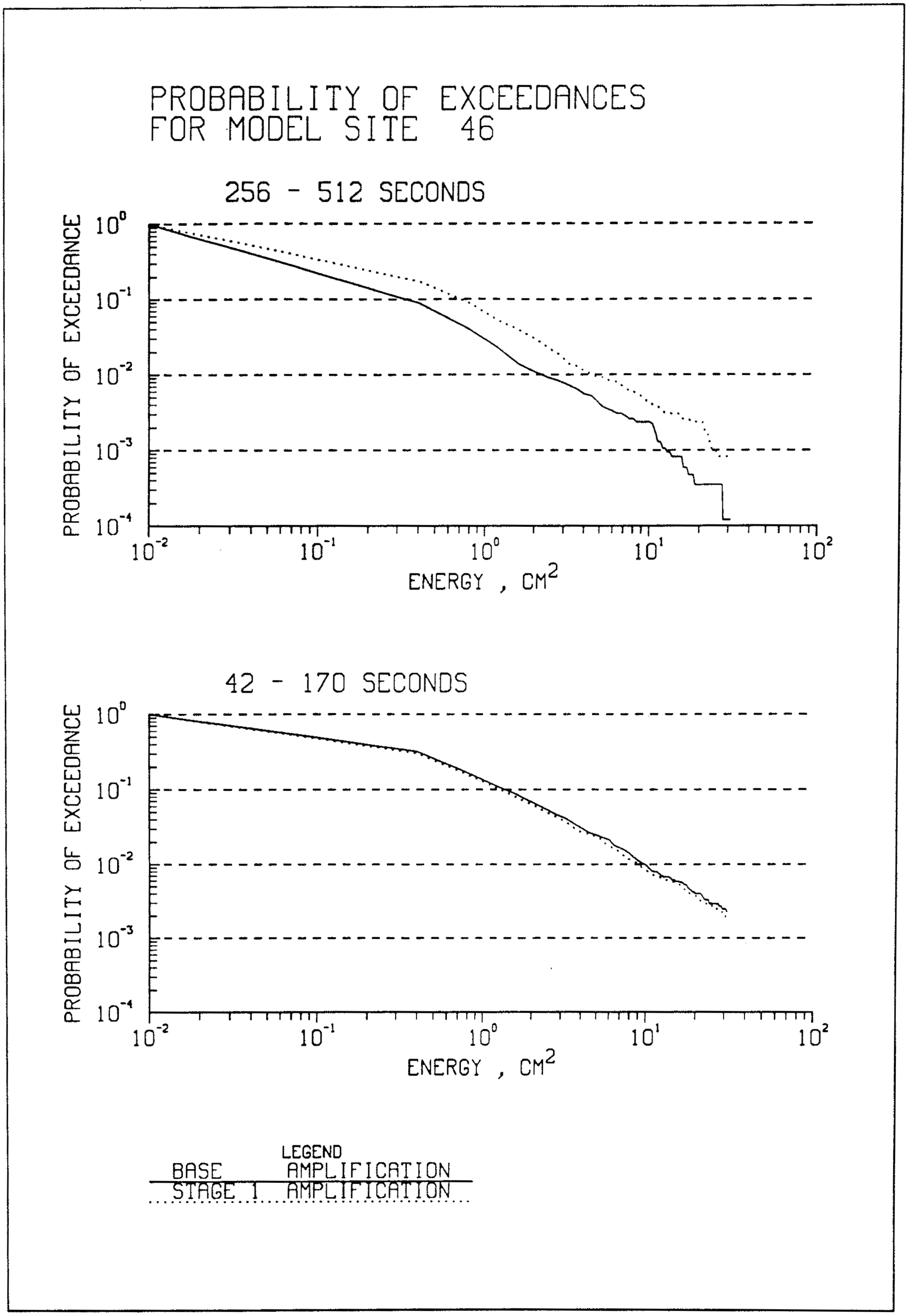
STAGE 1 AMPLIFICATION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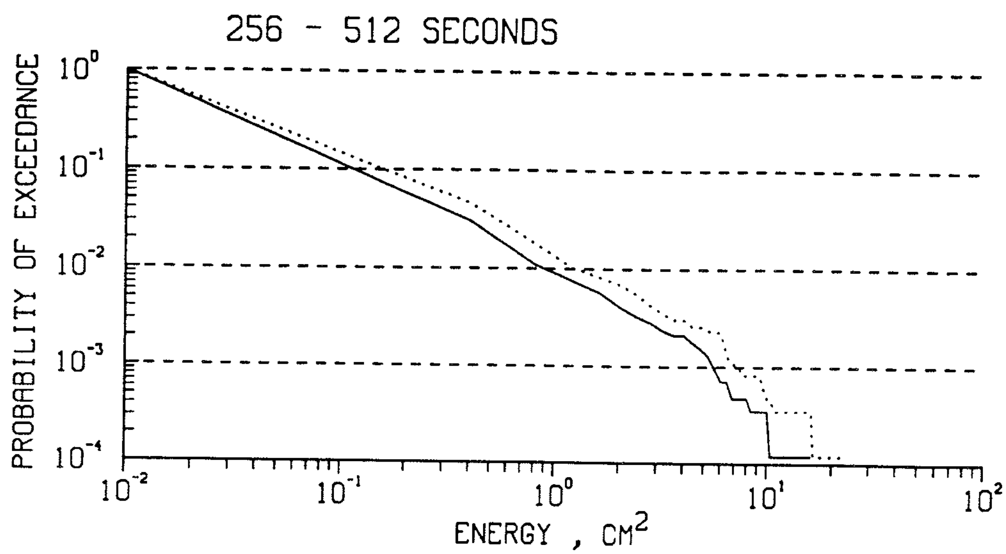
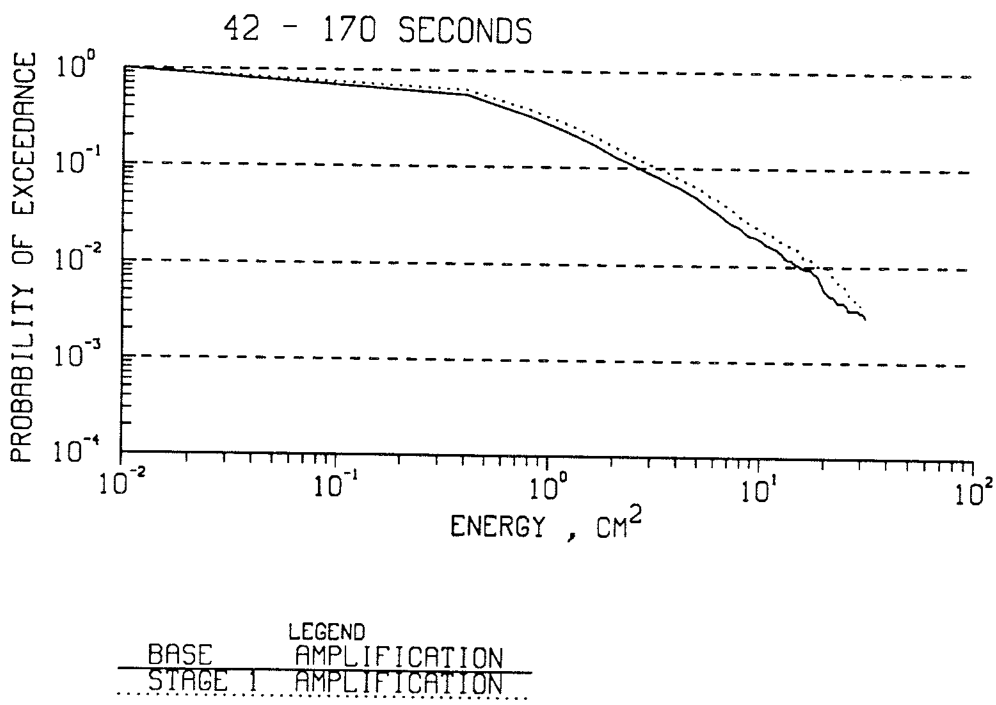
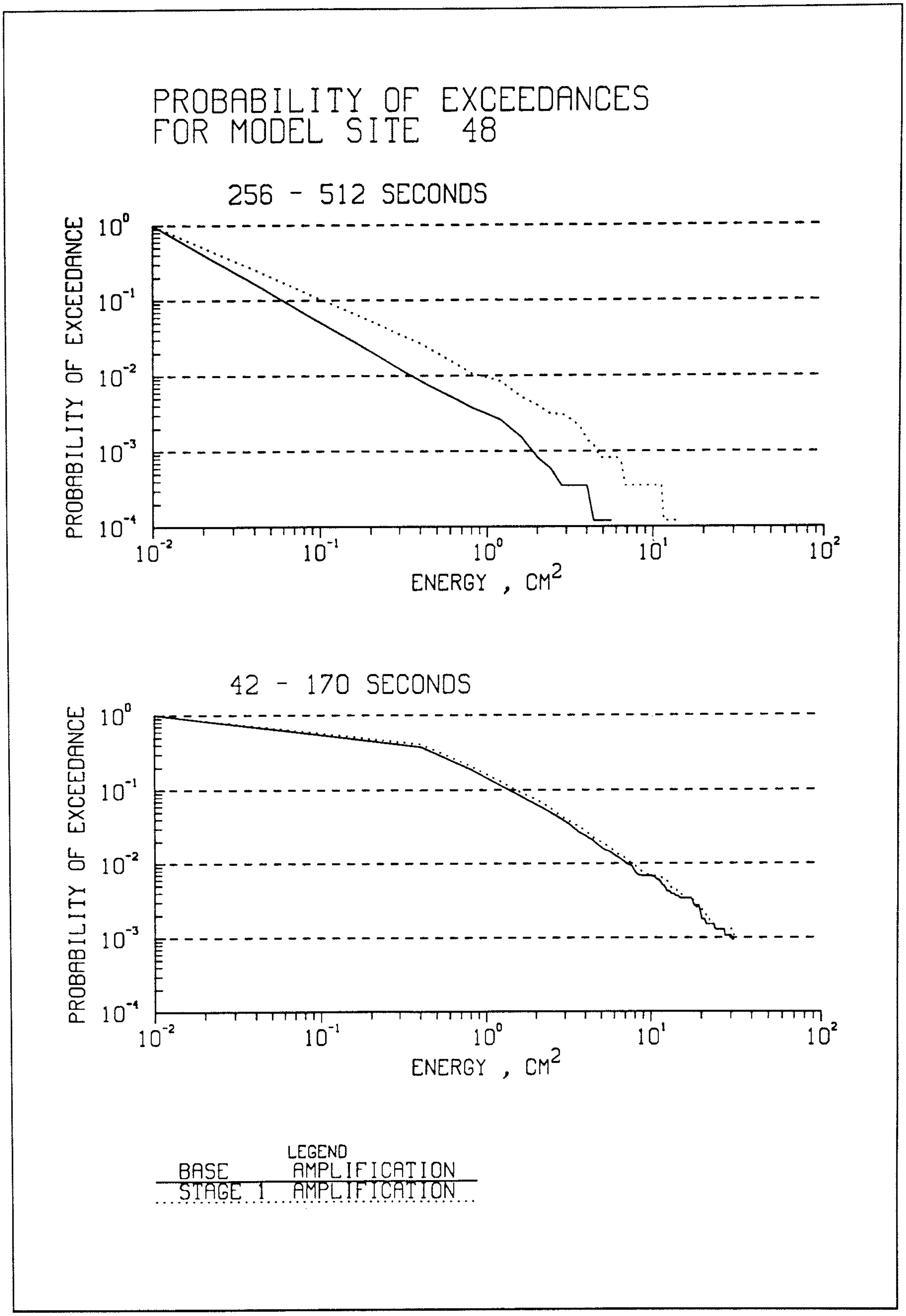
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION

PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 47



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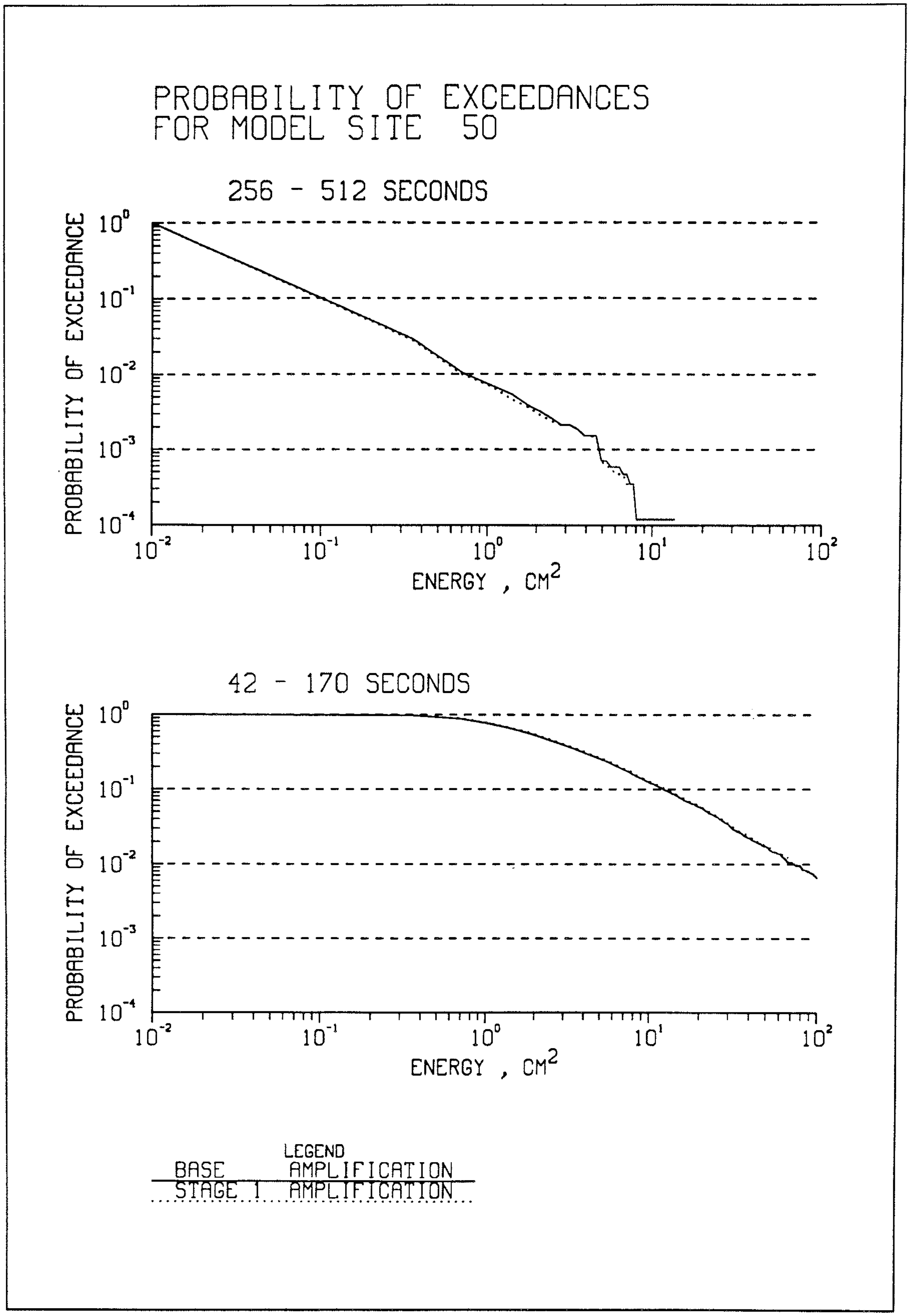
10^-1
10^0
10^1
10^2
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION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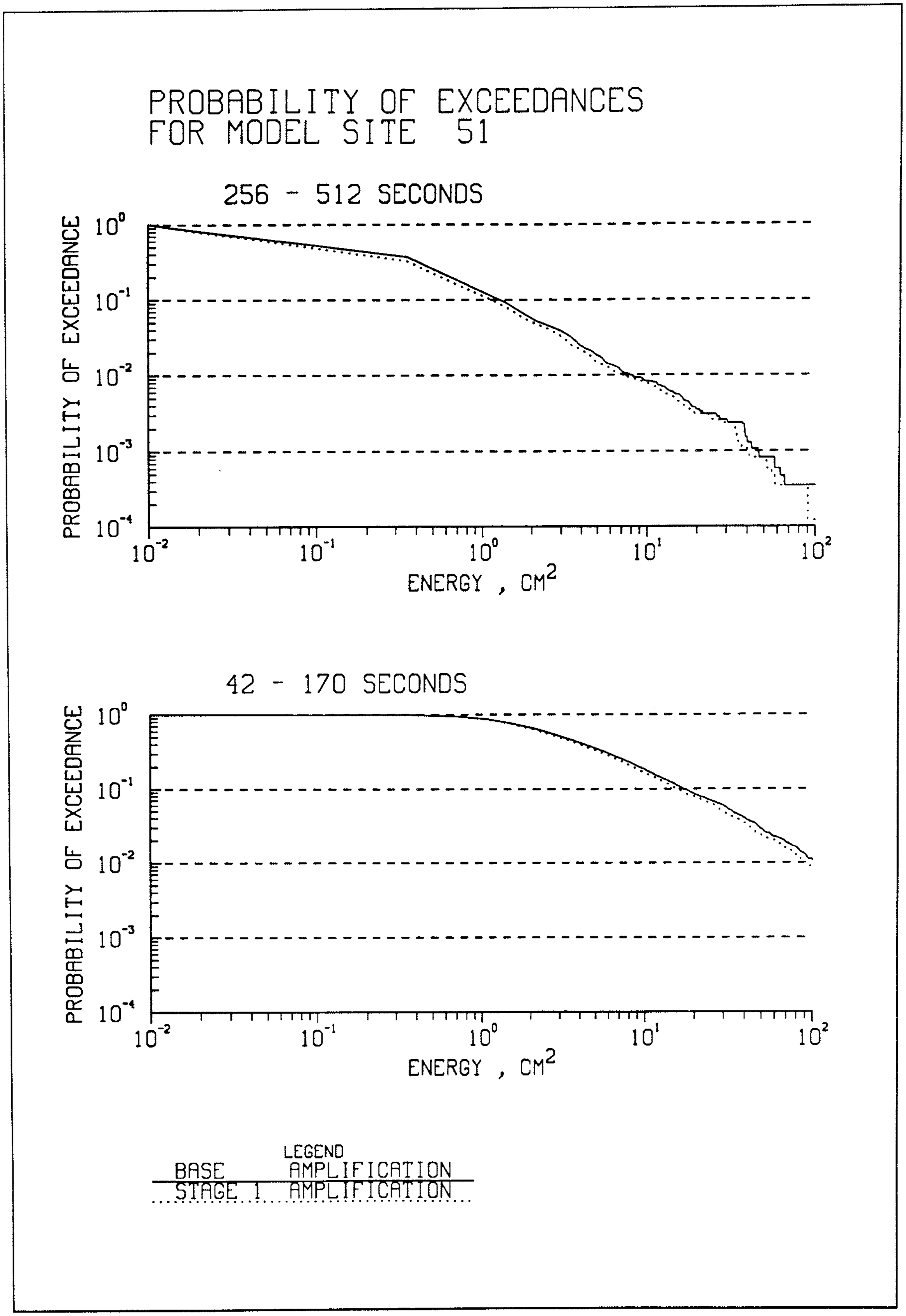
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION



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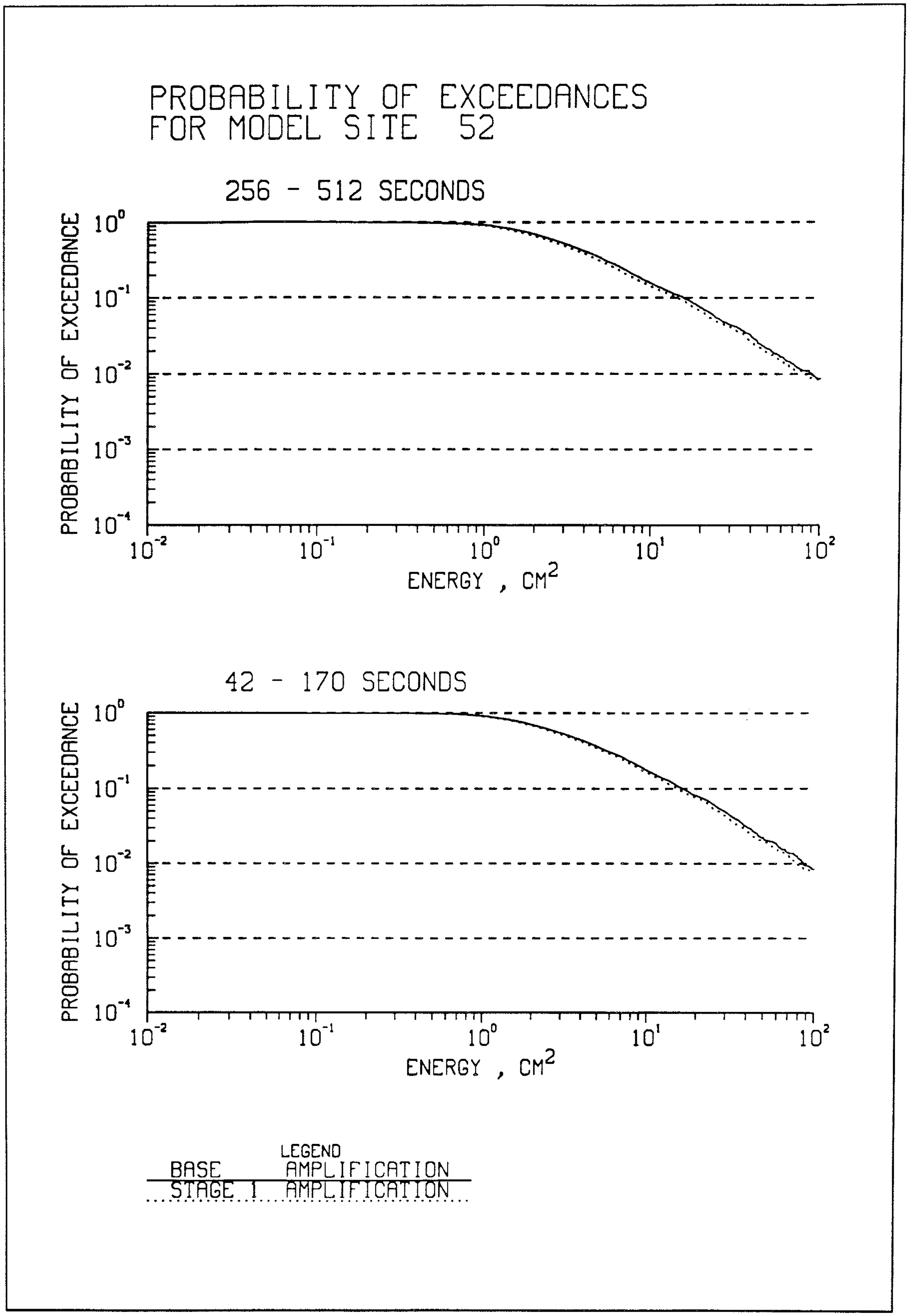
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION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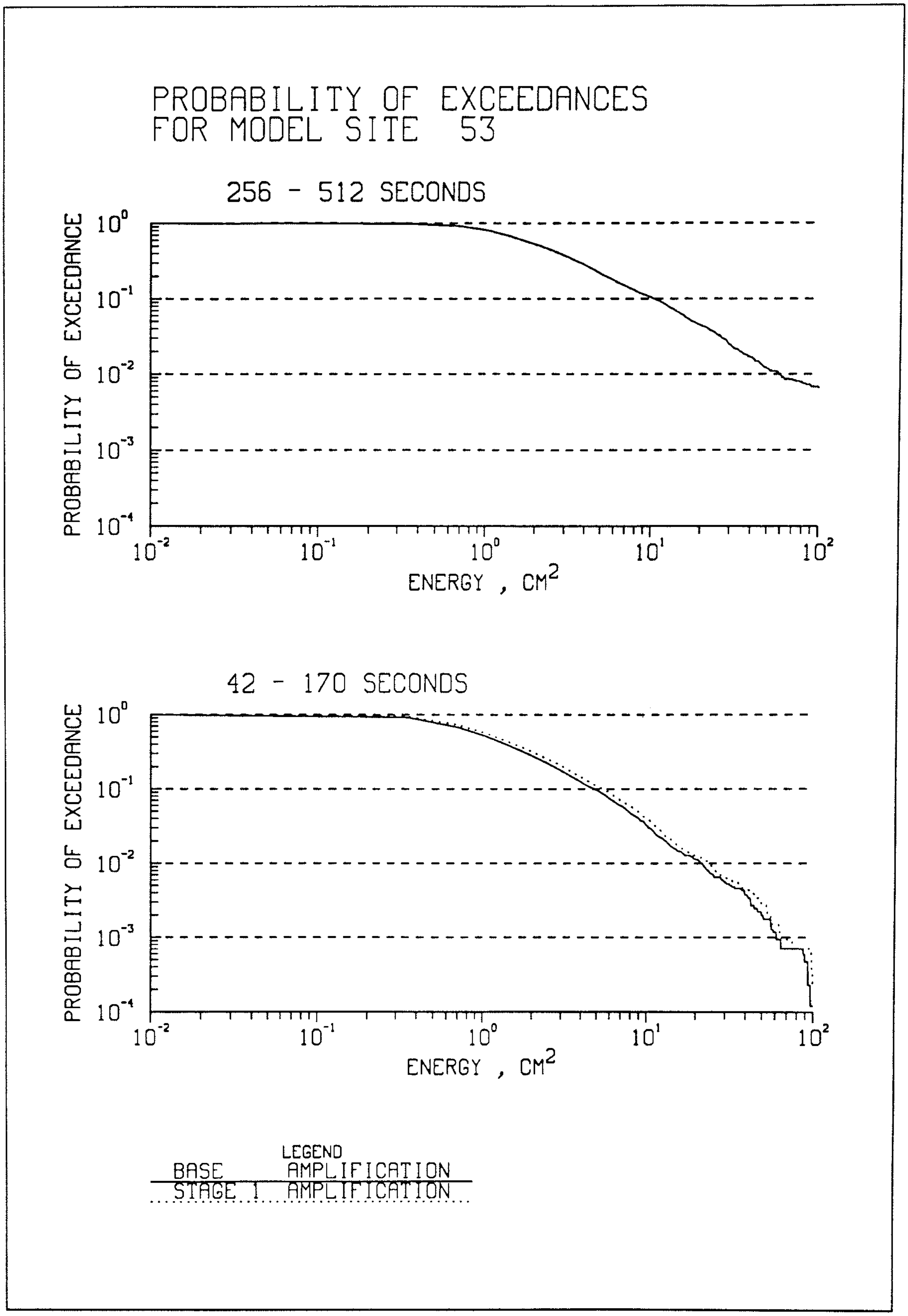
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION



PROBABILITY OF EXCEEDANCES
FOR MODEL SITE 53
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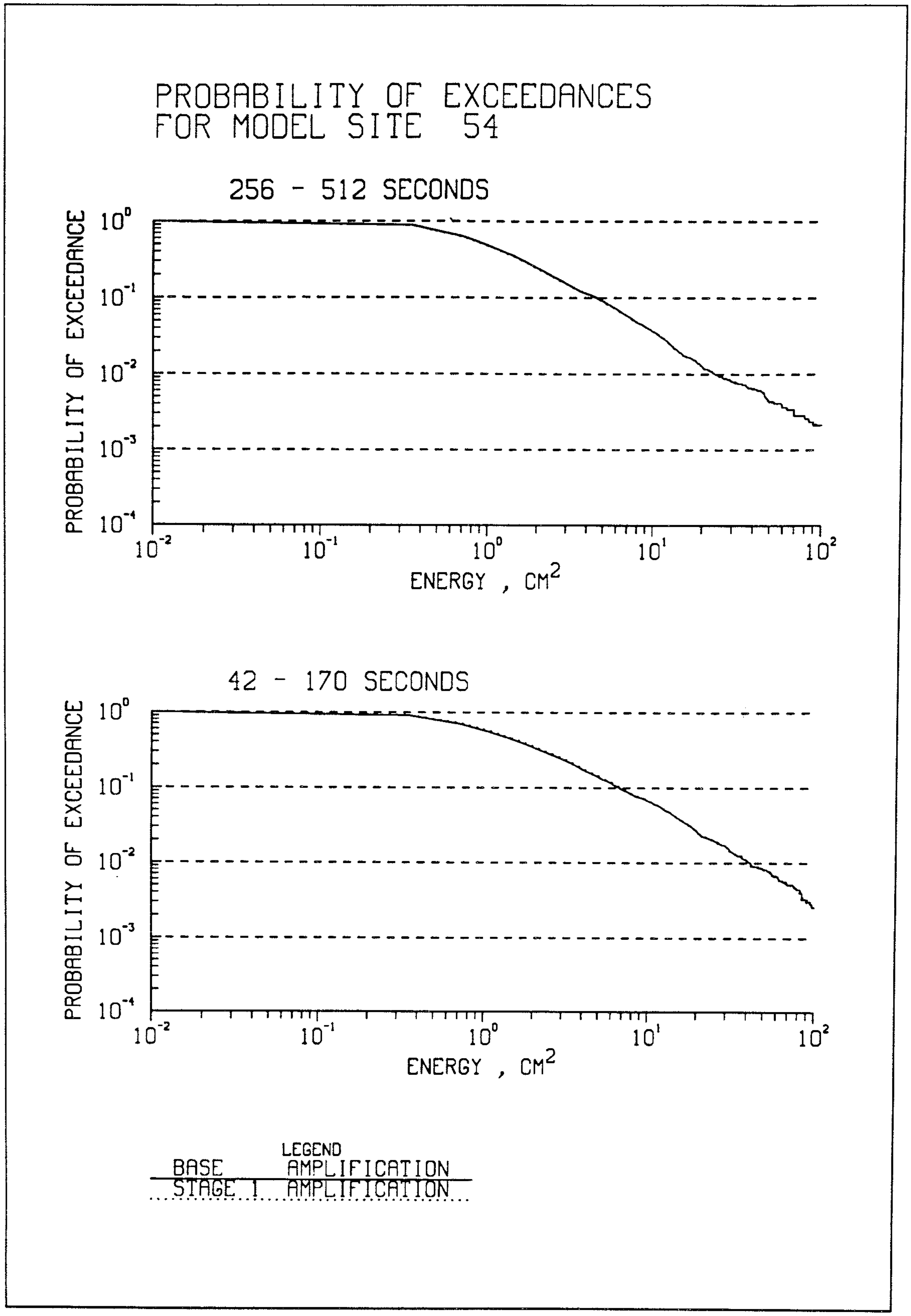
10^-2
10^-3
10^-4
10^-2
10^-1
10^0
10^1
10^2
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE 1 AMPLIFICATION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FOR MODEL SITE 54
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PROBABILITY OF EXCEEDANCE
ENERGY , CM2
42 - 170 SECONDS
PROBABILITY OF EXCEEDANCE
ENERGY , CM2
LEGEND
BASE AMPLIFICATION
STAGE I AMPLIFICATION

Appendix C
Table of 1-Percent PE Values

Table C1
1-Percent PE Values

Model Site	Period Range	Condition	Energy (sq cm)	Wave Height (cm)
001	170	Stage 1	0.593	3.08
001	170	Base	2.529	6.36
001	512	Stage 1	1.645	5.13
001	512	Base	2.941	6.86
002	170	Stage 1	4.365	8.36
002	170	Base	9.897	12.58
002	512	Stage 1	0.348	2.36
002	512	Base	0.664	3.26
003	170	Stage 1	23.640	19.45
003	170	Base	42.190	25.98
003	512	Stage 1	3.548	7.53
003	512	Base	1.368	4.68
004	170	Stage 1	2.360	6.14
004	170	Base	5.298	9.21
004	512	Stage 1	0.503	2.84
004	512	Base	0.578	3.04
005	170	Stage 1	12.697	14.25
005	170	Base	14.365	15.16
005	512	Stage 1	0.661	3.25
005	512	Base	3.130	7.08
006	170	Stage 1	34.665	23.55
006	170	Base	35.532	23.84
006	512	Stage 1	16.107	16.05
006	512	Base	49.190	28.05
007	170	Stage 1	9.115	12.08
007	170	Base	7.473	10.93
007	512	Stage 1	23.864	19.54
007	512	Base	28.873	21.49
008	170	Stage 1	7.529	10.98
008	170	Base	3.214	7.17
008	512	Stage 1	2.883	6.79
008	512	Base	1.685	5.19
009	170	Stage 1	24.690	19.88
009	170	Base	101.340	40.27
009	512	Stage 1	1.173	4.33
009	512	Base	9.805	12.53
010	170	Stage 1	1.785	5.34
010	170	Base	10.247	12.80
010	512	Stage 1	0.993	3.99
010	512	Base	12.664	14.23
011	170	Stage 1	0.915	3.83
011	170	Base	1.180	4.34
011	512	Stage 1	0.646	3.22
011	512	Base	1.284	4.53

(Sheet 1 of 6)

Table C1 (Continued)

Model Site	Period Range	Condition	Energy (sq cm)	Wave Height (cm)
012	170	Stage 1	4.834	8.79
012	170	Base	13.537	14.72
012	512	Stage 1	1.549	4.98
012	512	Base	11.647	13.65
013	170	Stage 1	2.635	6.49
013	170	Base	21.528	18.56
013	512	Stage 1	0.349	2.36
013	512	Base	3.694	7.69
014	170	Stage 1	3.834	7.83
014	170	Base	48.657	27.90
014	512	Stage 1	0.417	2.58
014	512	Base	17.947	16.95
015	170	Stage 1	10.623	13.04
015	170	Base	10.435	12.92
015	512	Stage 1	0.896	3.79
015	512	Base	0.806	3.59
016	170	Stage 1	24.340	19.73
016	170	Base	39.732	25.21
016	512	Stage 1	2.734	6.61
016	512	Base	3.233	7.19
017	170	Stage 1	9.015	12.01
017	170	Base	19.265	17.56
017	512	Stage 1	3.084	7.02
017	512	Base	2.686	6.56
018	170	Stage 1	4.932	8.88
018	170	Base	11.379	13.49
018	512	Stage 1	0.359	2.40
018	512	Base	2.064	5.75
019	170	Stage 1	8.892	11.93
019	170	Base	17.418	16.69
019	512	Stage 1	8.147	11.42
019	512	Base	4.504	8.49
020	170	Stage 1	12.805	14.31
020	170	Base	10.393	12.90
020	512	Stage 1	5.490	9.37
020	512	Base	2.230	5.97
021	170	Stage 1	18.698	17.30
021	170	Base	21.729	18.65
021	512	Stage 1	39.740	25.22
021	512	Base	21.540	18.56
022	170	Stage 1	6.652	10.32
022	170	Base	13.073	14.46
022	512	Stage 1	12.957	14.40
022	512	Base	6.946	10.54
023	170	Stage 1	6.918	10.52
023	170	Base	12.023	13.87
023	512	Stage 1	17.276	16.63
023	512	Base	13.140	14.50

(Sheet 2 of 6)

Table C1 (Continued)

Model Site	Period Range	Condition	Energy (sq cm)	Wave Height (cm)
024	170	Stage 1	4.277	8.27
024	170	Base	7.268	10.78
024	512	Stage 1	4.456	8.44
024	512	Base	3.754	7.75
025	170	Stage 1	15.346	15.67
025	170	Base	15.590	15.79
025	512	Stage 1	0.768	3.51
025	512	Base	0.753	3.47
026	170	Stage 1	5.604	9.47
026	170	Base	6.058	9.84
026	512	Stage 1	0.347	2.36
026	512	Base	0.347	2.36
027	170	Stage 1	4.673	8.65
027	170	Base	8.892	11.93
027	512	Stage 1	0.604	3.11
027	512	Base	0.350	2.37
028	170	Stage 1	9.905	12.59
028	170	Base	7.179	10.72
028	512	Stage 1	12.314	14.04
028	512	Base	4.044	8.04
029	170	Stage 1	15.873	15.94
029	170	Base	12.604	14.20
029	512	Stage 1	1.029	4.06
029	512	Base	0.598	3.09
030	170	Stage 1	8.004	11.32
030	170	Base	12.518	14.15
030	512	Stage 1	0.835	3.65
030	512	Base	0.641	3.20
031	170	Stage 1	2.773	6.66
031	170	Base	4.953	8.90
031	512	Stage 1	10.984	13.26
031	512	Base	3.800	7.80
032	170	Stage 1	>122.150	>44.21
032	170	Base	59.165	30.77
032	512	Stage 1	32.740	22.89
032	512	Base	2.025	5.69
033	170	Stage 1	29.217	21.62
033	170	Base	21.357	18.49
033	512	Stage 1	2.084	5.77
033	512	Base	6.177	9.94
034	170	Stage 1	13.155	14.51
034	170	Base	26.508	20.59
034	512	Stage 1	0.348	2.36
034	512	Base	1.780	5.34

(Sheet 3 of 6)

Table C1 (Continued)

Model Site	Period Range	Condition	Energy (sq cm)	Wave Height (cm)
035	170	Stage 1	5.956	9.76
035	170	Base	8.474	11.64
035	512	Stage 1	0.348	2.36
035	512	Base	1.505	4.91
036	170	Stage 1	20.674	18.19
036	170	Base	81.915	36.20
036	512	Stage 1	3.573	7.56
036	512	Base	60.734	31.17
037	170	Stage 1	3.984	7.98
037	170	Base	3.277	7.24
037	512	Stage 1	1.681	5.19
037	512	Base	0.591	3.07
038	170	Stage 1	1.329	4.61
038	170	Base	1.581	5.03
038	512	Stage 1	2.249	6.00
038	512	Base	2.615	6.47
039	170	Stage 1	3.182	7.14
039	170	Base	11.090	13.32
039	512	Stage 1	0.348	2.36
039	512	Base	5.708	9.56
040	170	Stage 1	7.074	10.64
040	170	Base	30.409	22.06
040	512	Stage 1	0.822	3.63
040	512	Base	4.732	8.70
041	170	Stage 1	11.740	13.71
041	170	Base	9.667	12.44
041	512	Stage 1	1.291	4.54
041	512	Base	1.973	5.62
042	170	Stage 1	69.747	33.41
042	170	Base	64.240	32.06
042	512	Stage 1	5.802	9.63
042	512	Base	7.937	11.27
043	170	Stage 1	66.947	32.73
043	170	Base	57.318	30.28
043	512	Stage 1	11.557	13.60
043	512	Base	6.186	9.95
044	170	Stage 1	13.073	14.46
044	170	Base	15.579	15.79
044	512	Stage 1	4.390	8.38
044	512	Base	2.640	6.50
045	170	Stage 1	4.798	8.76
045	170	Base	6.218	9.97
045	512	Stage 1	7.654	11.07
045	512	Base	3.504	7.49
046	170	Stage 1	9.183	12.12
046	170	Base	9.905	12.59
046	512	Stage 1	4.440	8.43
046	512	Base	2.183	5.91

(Sheet 4 of 6)

Table C1 (Continued)

Model Site	Period Range	Condition	Energy (sq cm)	Wave Height (cm)
047	170	Stage 1	19.440	17.64
047	170	Base	15.147	15.57
047	512	Stage 1	1.314	4.58
047	512	Base	0.931	3.86
048	170	Stage 1	7.618	11.04
048	170	Base	7.214	10.74
048	512	Stage 1	0.934	3.87
048	512	Base	0.350	2.37
050	170	Stage 1	75.143	34.67
050	170	Base	73.179	34.22
050	512	Stage 1	0.696	3.34
050	512	Base	0.738	3.44
051	170	Stage 1	91.365	38.23
051	170	Base	104.315	40.85
051	512	Stage 1	7.008	10.59
051	512	Base	7.882	11.23
052	170	Stage 1	78.582	35.46
052	170	Base	86.114	36.05
052	512	Stage 1	81.215	36.05
052	512	Base	89.265	37.79
053	170	Stage 1	24.157	19.66
053	170	Base	21.705	18.64
053	512	Stage 1	59.515	30.86
053	512	Base	59.165	30.77
054	170	Stage 1	40.965	25.60
054	170	Base	42.005	25.92
054	512	Stage 1	24.165	19.66
054	512	Base	24.157	19.66
055	170	Stage 1	>122.150	>44.21
055	170	Base	>122.150	>44.21
055	512	Stage 1	8.332	11.55
055	512	Base	10.415	12.91
056	170	Stage 1	13.055	14.45
056	512	Stage 1	1.002	4.00
057	170	Stage 1	>27.650	>21.03
057	512	Stage 1	11.297	13.44
058	170	Stage 1	12.904	14.37
058	512	Stage 1	9.735	12.48
060	170	Stage 1	13.655	14.78
060	512	Stage 1	1.880	5.48
061	170	Stage 1	5.534	9.41
061	512	Stage 1	0.691	3.33
063	170	Stage 1	5.973	9.78
063	512	Stage 1	0.998	4.00

(Sheet 5 of 6)

Table C1 (Concluded)

Model Site	Period Range	Condition	Energy (sq cm)	Wave Height (cm)
064	170	Stage 1	3.005	6.93
064	512	Stage 1	0.984	3.97
065	170	Stage 1	3.969	7.97
065	512	Stage 1	0.632	3.18
066	170	Stage 1	3.503	7.49
066	512	Stage 1	0.351	2.37
067	170	Stage 1	5.605	9.47
067	512	Stage 1	0.348	2.36
068	170	Stage 1	4.846	8.81
068	512	Stage 1	0.349	2.36
069	170	Stage 1	>27.650	>21.03
069	512	Stage 1	9.718	12.47
070	170	Stage 1	4.554	8.54
070	512	Stage 1	0.683	3.30
62A	170	Stage 1	1.099	4.19
62A	512	Stage 1	0.347	2.36
71A	170	Stage 1	3.705	7.70
71A	512	Stage 1	0.553	2.97

(Sheet 6 of 6)

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13. ABSTRACT *(Maximum 200 words)*

This report supplies the data needed to predict the magnitude and distribution of wave energy in the harbors after construction of the Los Angeles Harbor Pier 400 expansion. Prototype wave data have been collected at offshore Platform Edith as well as selected inshore sites within Los Angeles/Long Beach (LA/LB) Harbors since 1984. Harbor resonance studies were conducted in the LA/LB physical model to predict the distribution of wave energy due to the Pier 400 expansion. Using the amplification factors derived from physical model test results and offshore wave spectra, wave energy probability of exceedance tables and plots were constructed for each physical model wave gage location. These wave data are used to document the magnitude of waves occurring in the harbors due to the incident wave climate. The harbor response to incident wave energy affects ship motion and, therefore, the economic use of port facilities.

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