Technical Report CERC-93-17
September 1993

US Army Corps of Engineers
Waterways Experiment Station

Los Angeles and Long Beach Harbors Model Enhancement Program, Improved Physical Model Harbor Resonance Methodology

by William C. Seabergh, Leonette J. Thomas
Coastal Engineering Research Center

Prepared for U.S. Army Engineer District, Los Angeles
Port of Los Angeles
Port of Long Beach

PRINTED ON RECYCLED PAPER

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3909 Halls Ferry Road
Vicksburg, MS 39180-6199

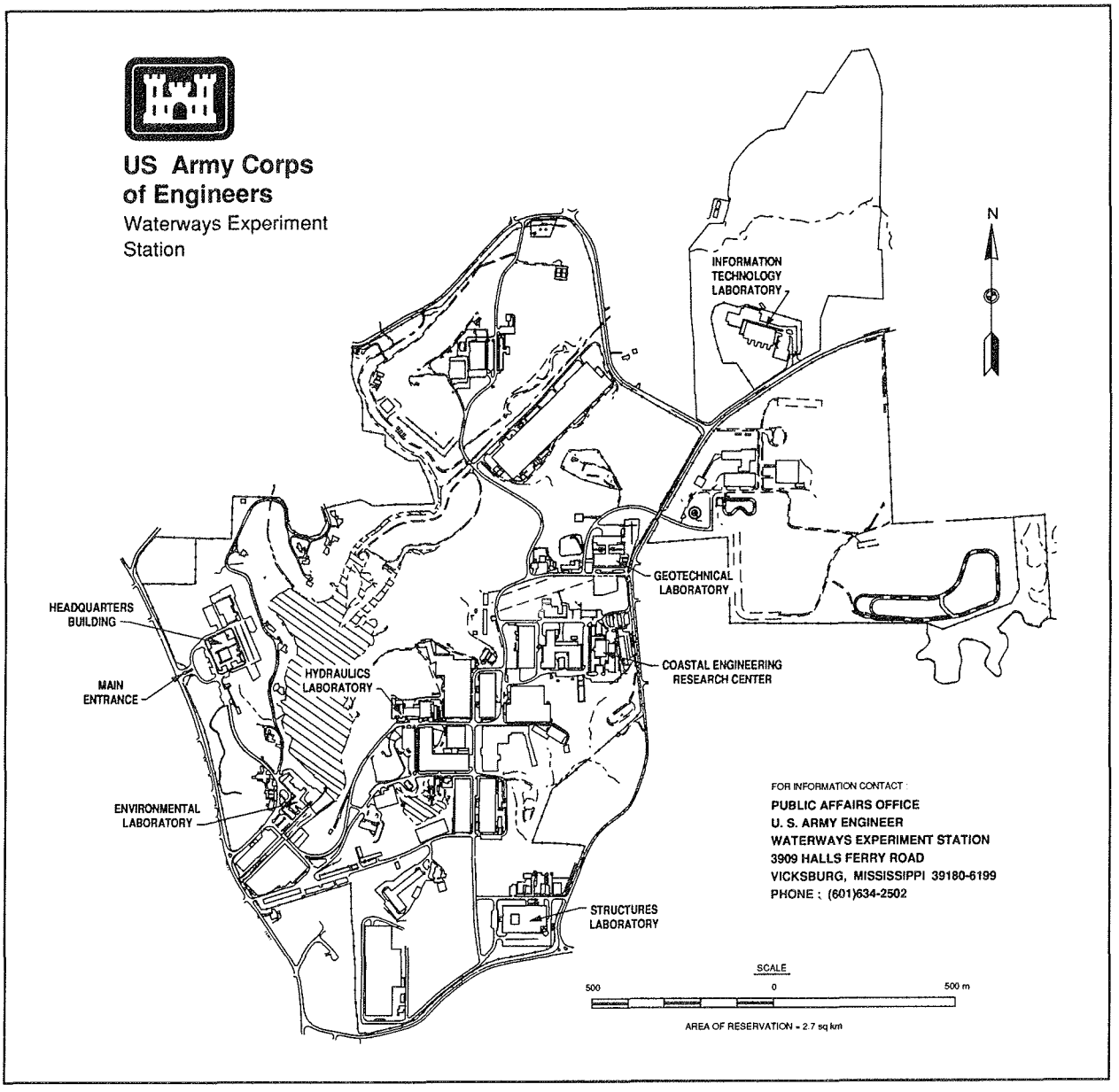
Final report

Approved for public release; distribution is unlimited

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

Port of Los Angeles
San Pedro, CA 90733-0151

Port of Long Beach
Long Beach, CA 90801-0570



Waterways Experiment Station Cataloging-in-Publication Data

Seabergh, William C.

Los Angeles and Long Beach Harbors Model Enhancement Program, improved physical model harbor resonance methodology / by William C. Seabergh, Leonette J. Thomas, Coastal Engineering Research Center ; prepared for U.S. Army Engineer District, Los Angeles, Port of Los Angeles, Port of Long Beach.

210 p. : ill. ; 28 cm. — (Technical report ; CERC-93-17)

Includes bibliographical references.

1. Harbors — California — Los Angeles — Hydrodynamics. 2. Hydraulic models. 3. Ocean waves — Simulation methods. 4. Water waves — Simulation methods. I. Thomas, Leonette J. II. United States. Army. Corps of Engineers. Los Angeles. III. WORLDPORT LA. IV. Port of Long Beach. V. Coastal Engineering Research Center (U.S.) VI. U.S. Army Engineer Waterways Experiment Station. VII. Title. VIII. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; CERC-93-17.

TA7 W34 no.CERC-93-17

PREFACE

This report was prepared by the Coastal Engineering Research Center (CERC) at the US Army Engineer Waterways Experiment Station (WES) and is a product of the Los Angeles and Long Beach Harbors Model Enhancement (HME) Program. The HME Program has been conducted jointly by the Ports of Los Angeles and Long Beach (LA/LB); the US Army Engineer District, Los Angeles (SPL); and WES. The purpose of the HME Program has been to provide state-of-the-art engineering tools to aid in port development. In response to the expansion of oceanborne world commerce, the Ports of LA/LB are conducting planning studies for harbor development in coordination with SPL. Ports are a natural resource, and enhanced port capacity is vital to the Nation's economic well-being. In a feasibility study being conducted by SPL, the Ports of LA/LB are proposing a well-defined and necessary expansion to accommodate predicted needs in the near future. The Corps of Engineers will be charged with responsibility for providing deeper channels and determining effects of this construction on the local environment. This includes changes in harbor resonance caused by expansion and channel deepening.

The investigation was conducted during the period June 1987 through March 1989 by personnel of the Wave Processes Branch (WPB), Wave Dynamics Division (WDD), CERC. WPB personnel involved in the study were Mr. William C. Seabergh, Ms. Leonette E. Thomas, and Mr. Larry A. Barnes, under the direct supervision of Mr. Douglas Outlaw, former Chief, WPB, and Mr. Dennis G. Markle, current Chief, WPB, and Mr. C. E. Chatham, Chief, WDD. Mr. Seabergh and Ms. Thomas prepared the report. Ms. Debbie Fulcher, WPB, assisted in preparation of the final report and Messrs. Lonnie Friar and Rick Floyd, Instrumentation Services Division, provided instrumentation support. Overall CERC management of the HME Program was furnished by Messrs. Outlaw and Seabergh and this study was conducted under the general supervision of Dr. James R. Houston, Director, CERC, and Mr. Charles C. Calhoun, Jr., Assistant Director, CERC.

During the course of the study, significant liaison was maintained between WES, SPL, and the Ports. Mr. Dan Muslin, followed by Mr. Angel P. Fuertes, and then Mr. Mike Piszker, were SPL points of contact. Mr. John Warwar, Mr. Dick Wittkop, and Ms. Lillian Kawasaki, Port of Los Angeles, and Mr. Michael Burke, followed by Mr. Angel Fuertes and Dr. Geraldine Knatz, Port

of Long Beach, were Ports of LA/LB points of contact and provided invaluable assistance.

Dr. Robert W. Whalin was Director of WES during model testing and the preparation and publication of this report. COL Bruce K. Howard, EN, was Commander.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

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

Multiply	By	To Obtain
acres	4046.8564	square metres
feet	0.3048	metres
square feet	0.09290304	square metres
square miles	2.589998	square kilometres
miles (US nautical)	1.852	kilometres

LOS ANGELES AND LONG BEACH HARBORS MODEL ENHANCEMENT PROGRAM

IMPROVED PHYSICAL MODEL HARBOR RESONANCE METHODOLOGY

Coastal Model Investigation

PART I: INTRODUCTION

Background and Purpose of Study

1. A physical scale model of Los Angeles and Long Beach Harbors was constructed at the US Army Engineer Waterways Experiment Station in 1973. This 1:400 horizontal, 1:100 vertical scale model (Figure 1) was designed to reproduce tides and waves. Since 1973, the model has been used to examine the effects of harbor expansion projects on tidal currents and harbor resonance. More recently it has been used exclusively for performing harbor resonance tests with simulation of long-period waves. These tests involve the construction of proposed projects in the model and subjecting them to a series of over 200 monochromatic wave tests, with wave periods ranging from 30 to 400 sec. Wave data are usually collected at 50 or more locations throughout the harbors at existing and proposed berths (see Seabergh (1985), for example).* As part of the Harbors Model Enhancement (HME) Program, Task A.6 was developed to provide spectral long-period wave testing capability. Using prototype long-period wave data collected offshore of the harbors under Task A.1 of the HME, it was possible to develop long-period wave spectra which could be input to the computer-controlled model wave generators. This approach permits many periods (or frequencies) to be reproduced simultaneously over a broad range for an individual test. These results can be used to pinpoint troublesome wave period ranges, which create harbor surge conditions that may lead to difficult loading/unloading conditions and possible ship damage. Tests may then be conducted with monochromatic waves at a finer resolution to provide input to a moored ship motion model, developed under Task A.5 of the HME Program.

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* Seabergh, W. C. 1985. "Los Angeles and Long Beach Harbors Model Study, Deep-Draft Dry Bulk Export Terminal, Alternative 6: Resonant Response and Tidal Circulation Studies," Miscellaneous Paper CERC-85-8, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

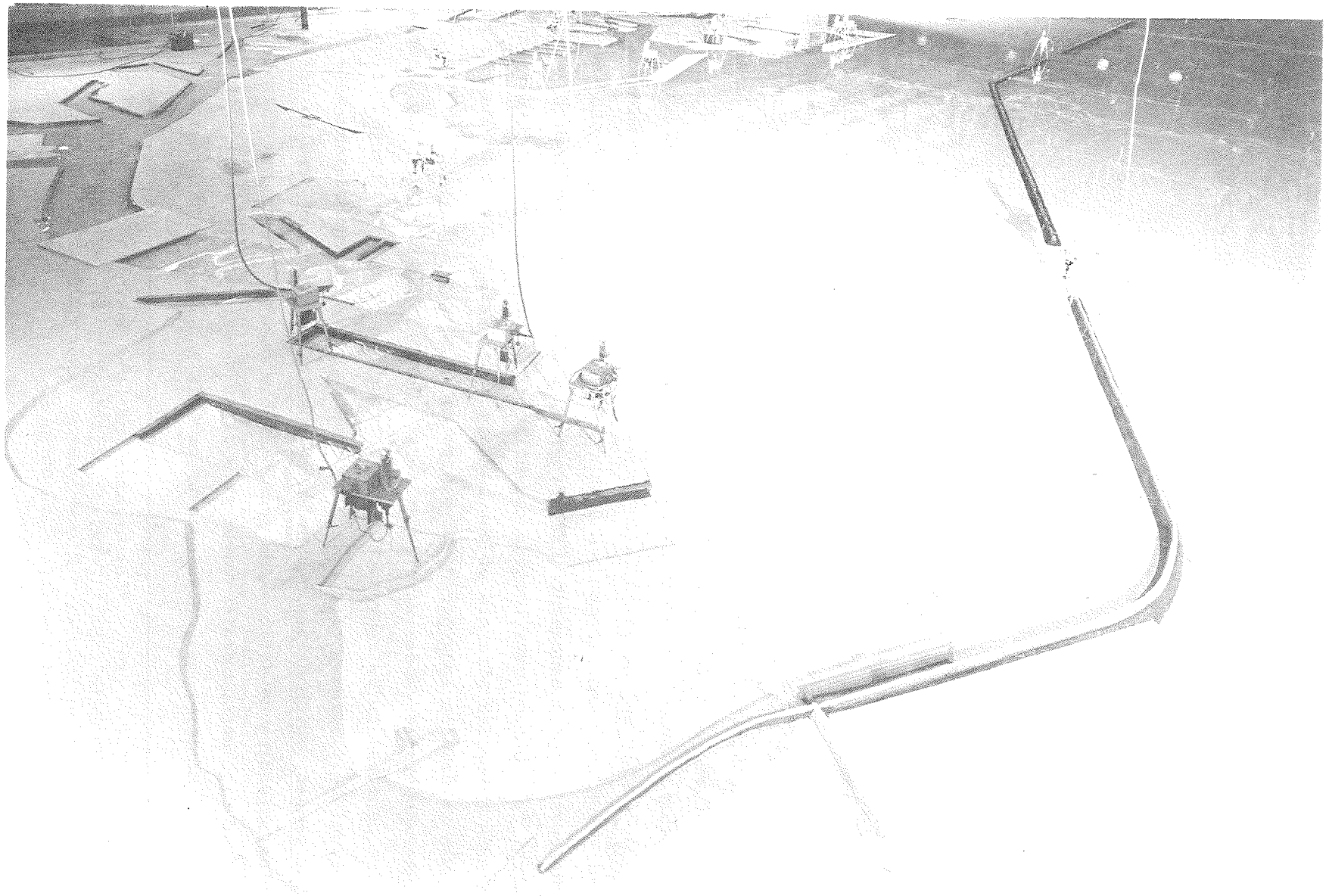

Figure 1. Scale model of Los Angeles - Long Beach Harbors

This testing procedure will reduce testing time and permit the examination of a number of harbor configuration alternatives in a much shorter time period than before.

Model Enhancement Program

2. The Ports of Los Angeles and Long Beach are conducting planning studies for harbor development in coordination with the US Army Corps of Engineers, Los Angeles District (SPL). The Ports, in order to meet the forecast demand for berthing space resulting from increased Pacific Rim trade, will need deeper and wider channels and up to 2,400 acres* of new landfill. Figure 2 shows the existing harbor configuration and Figure 3 shows an example of a proposed plan. SPL has determined that there is a Federal interest in construction and maintenance of new navigation channels to meet projected cargo growth. In order to provide up-to-date modeling technology to help design the proposed plans, the Los Angeles - Long Beach Harbors HME Program was developed. Major elements of the Program include three-dimensional numerical modeling of tidal circulation and water quality, a numerical moored ship motion model, and work to include modeling long-period spectral waves in the physical model, as described in this report. In conjunction with the modeling efforts, field data were collected that included tidal velocities and elevation, water quality data, winds, moored ship movements and mooring forces, and long-period wave data.

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 4.

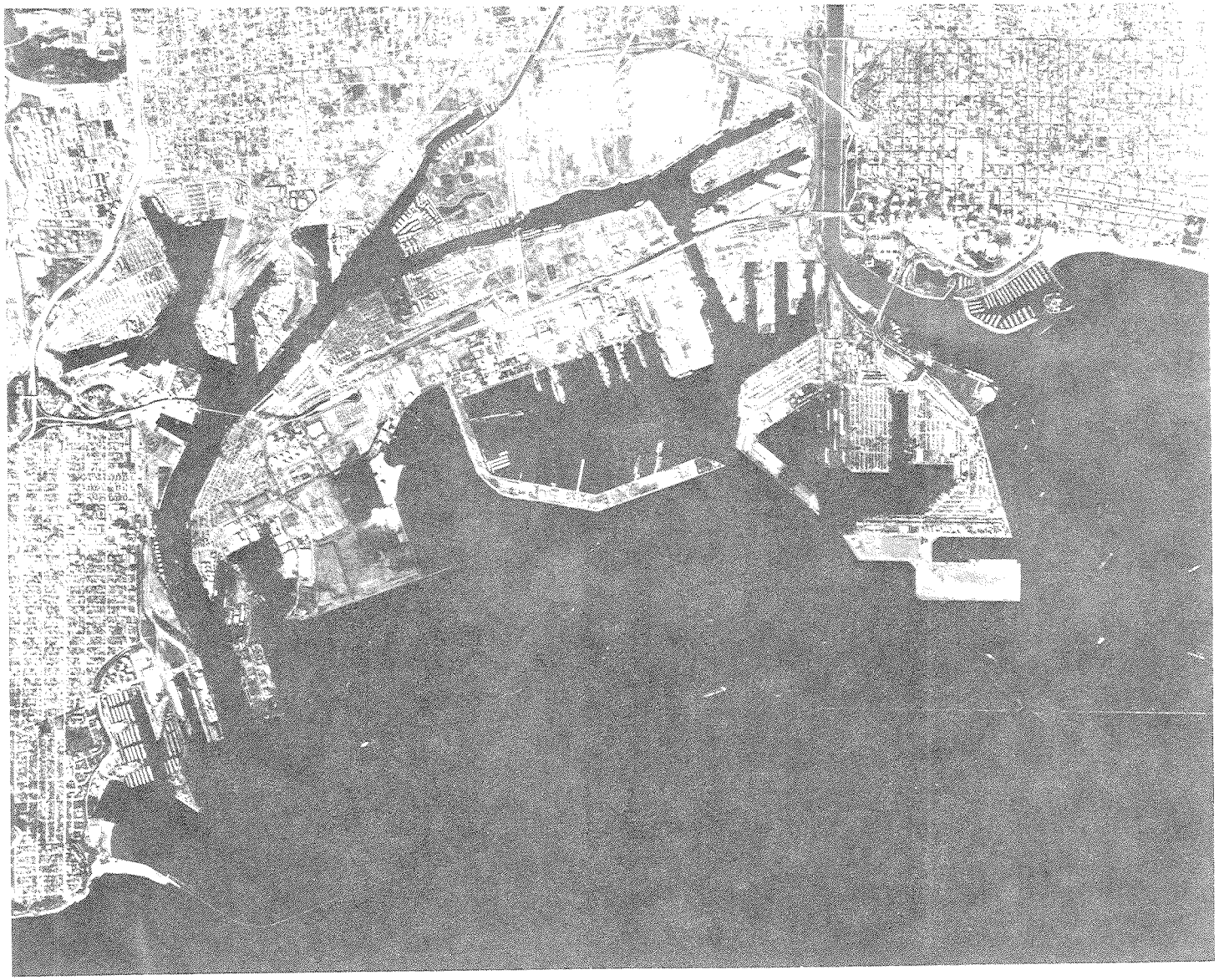

Figure 2. Los Angeles - Long Beach Harbors (1992)

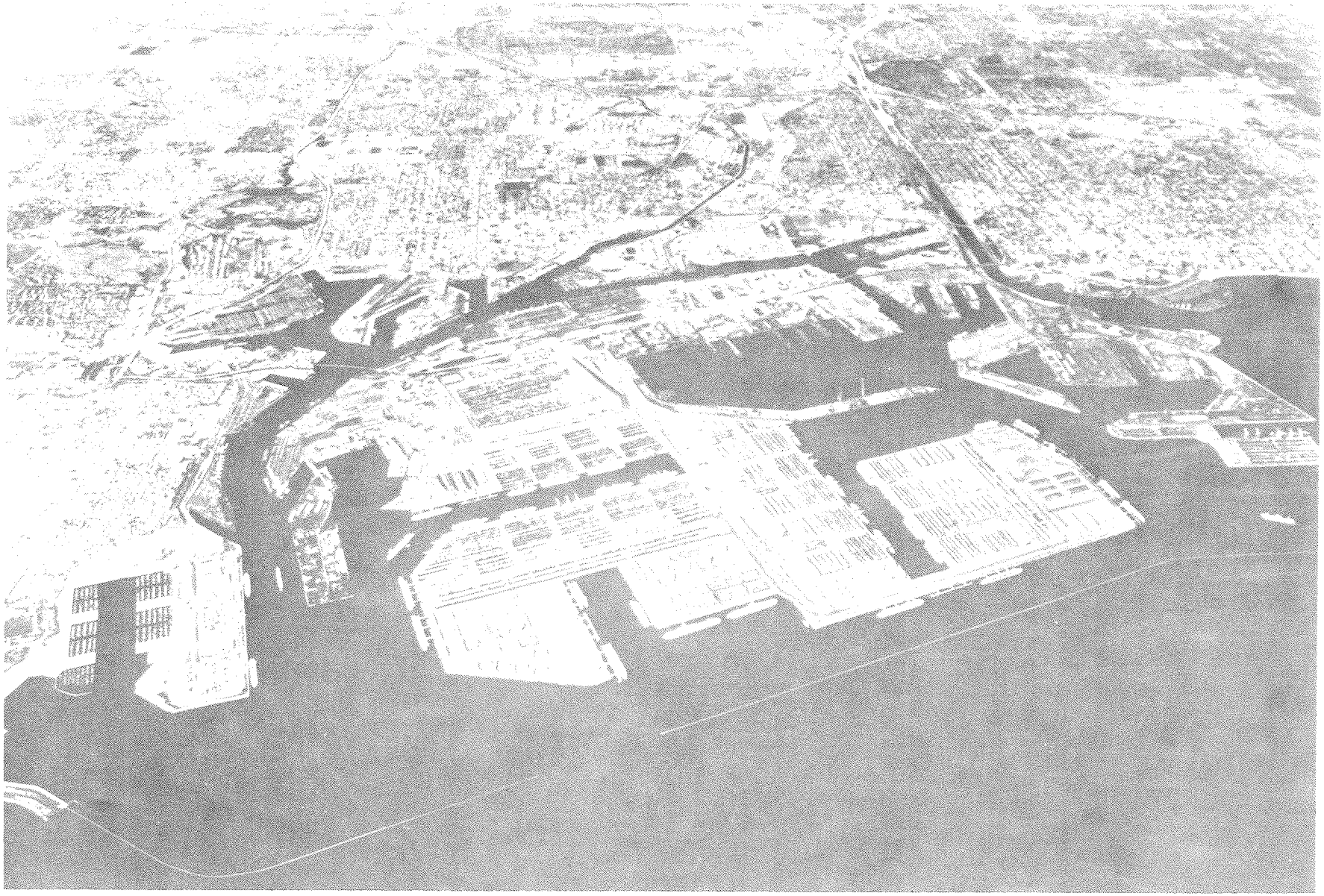

Figure 3. An example of proposed expansion

PART II: THE LOS ANGELES - LONG BEACH HARBORS PHYSICAL MODEL

Model Description

3. The Los Angeles and Long Beach Harbors model was molded in concrete grout at a vertical scale of 1:100 and a horizontal scale of 1:400 and reproduced San Pedro Bay and the Pacific Ocean seaward of the harbor out to the -300 ft mean lower low water (mllw) contour. The model shoreline extended from 2 miles northwest of Point Fermin to Huntington Beach. The total area reproduced in the model covered about 44,000 sq ft, representing 253 sq miles in the prototype. The model layout is shown in Figure 4, and Figure 5 shows the harbors' basins and the channels modeled.

4. The model was originally constructed to conditions as they existed in the early 1970's and has been periodically updated. For this work, care was taken to ensure that the latest bathymetry and harbor geometry were in place. The Long Beach Harbor Pier J Expansion and associated increased channel depths, which are currently being completed (1992), were also included in the definition of current conditions.

Model Design Conditions

5. During initial model design a number of specific investigations were made to aid in selection of model scales and to ensure accurate reproduction of long-period wave phenomena. Details are found in Outlaw et al. (1977).* A listing of items studied follows:

a. Wave refraction.

b. Energy transmission through the breakwaters.

c. Wave diffraction.

d. Reflection from the offshore bathymetry and harbor boundaries.

e. Model wave filters and absorbers.

f. Model wave height attenuation.

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* Outlaw, D. G., Durham, D. L., Chatham, C. E., and Whalin, R. W. 1977. "Los Angeles and Long Beach Harbors' Model Study; Report 4, Model Design," Technical Report H-75-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Figure 4. Model layout

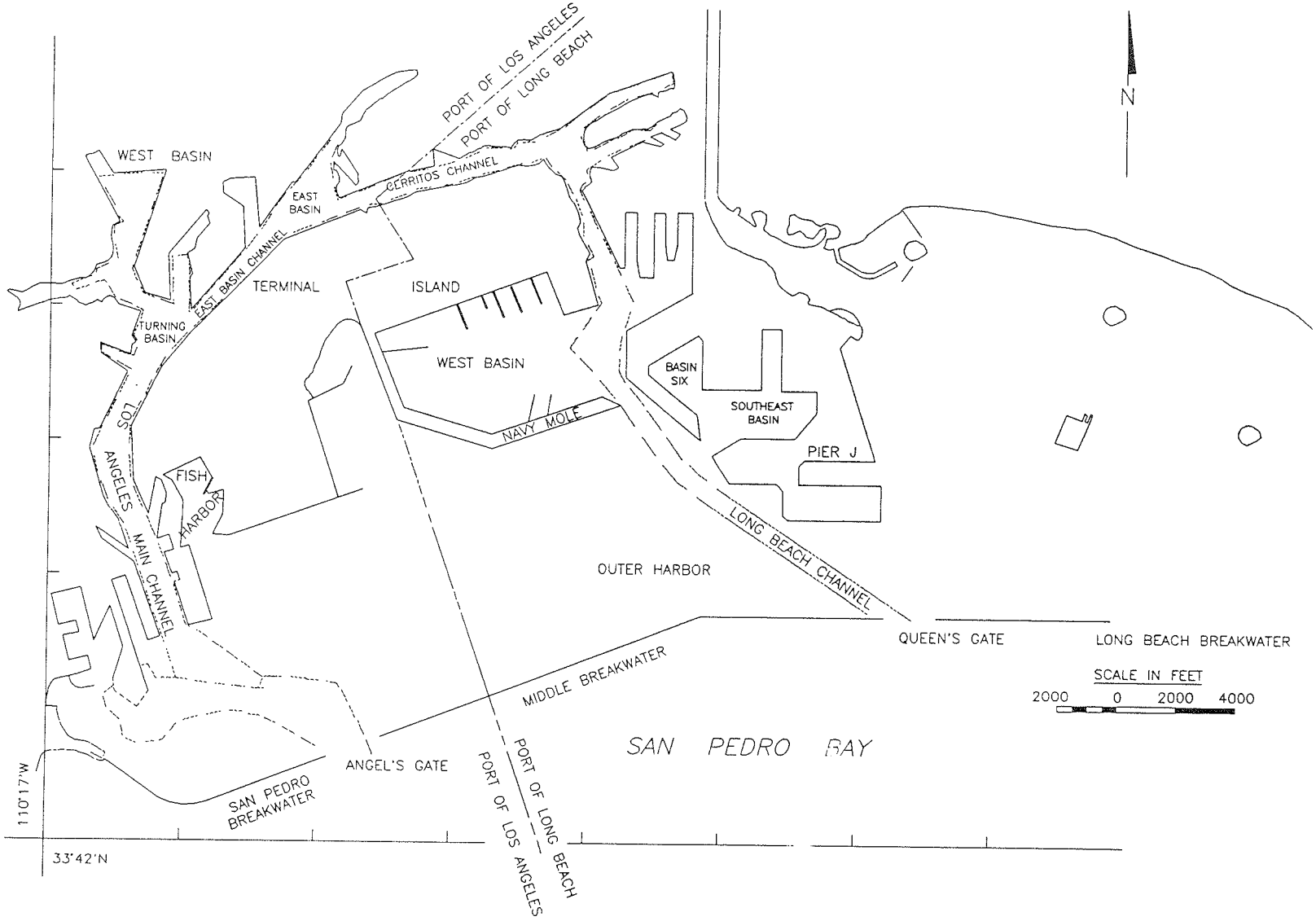


Figure 5. Location of city boundaries and various channels and basins

Items a and c are important wave phenomena that govern how wave energy is distributed along the coast and throughout the harbors. Both cannot be exactly scaled simultaneously in a distorted scale model; however, due to the nature of long-period waves, a solution can be found for exact scaling of diffraction and exact scaling of refraction down to the 85-sec wave period, below which adjustments to wave generator position can be made to correctly reproduce refraction. A brief discussion of this follows.

6. Diffraction is the phenomenon in which energy is transmitted laterally along a wave crest, as when waves propagate into the lee of a structure. It is a function of x/L or y/L (the ratio of horizontal distance to wavelength L). Refraction is the process by which wave direction and amplitude are changed due to the part of the wave in shallower water advancing more slowly than that in deeper water. Refractive effects depend on wave celerity and are a function of h/L (the ratio of water depth h to wavelength L). Consequently, if wavelength is scaled by the vertical scale in a distorted scale model, refraction is in exact similitude. If wavelength is scaled by the horizontal scale, diffraction is in exact similitude. Furthermore, in the Los Angeles - Long Beach Harbors model study it is desired to obtain similitude of mode shapes and resonant frequencies of oscillation. The governing Helmholtz equation for harbor oscillations is

$$\frac{\partial}{\partial x}\left(h\frac{\partial \eta}{\partial x}\right) + \frac{\partial}{\partial y}\left(h\frac{\partial \eta}{\partial y}\right) + \frac{\sigma^2}{g}\eta = 0 \qquad (1)$$

where

x,y,z = axes of a rectangular coordinate system fixed at the mean water surface

η = local surface elevation

σ = angular frequency

g = acceleration due to gravity

Since the same equation applies in model and prototype, it may be written as

$$\left(h_r\frac{\eta_r}{x_r^2}\right)\frac{\partial}{\partial x_p}\left(h_p\frac{\partial \eta_p}{\partial x_p}\right) + \left(h_r\frac{\eta_r}{y_r^2}\right)\frac{\partial}{\partial y_p}\left(h_p\frac{\partial \eta_p}{\partial y_p}\right) + \eta_r\sigma_r^2\left(\frac{\sigma_p^2}{g}\right)\eta_p = 0 \qquad (2)$$

where the subscript p represents the prototype and the subscript r represents

the scale ratio of model to prototype. From inspectional analysis, the coefficients of the above equation must be equal, or

$$\frac{h_r}{x_r^2} = \frac{h_r}{y_r^2} = \sigma_r^2 \tag{3}$$

after dividing by η . This indicates that a hydraulic model may be distorted for proper simulation of harbor resonant oscillation frequencies. The angular frequency may be written in terms of wavelength and water depth and this equation indicates that wavelength must be scaled by the horizontal scale.

7. From the previous paragraph it was determined that when wavelength is scaled by the horizontal scale, diffraction and harbor resonance conditions will be in similitude. However, refraction can have a scale effect due to model distortion, but if the wave is a shallow-water wave where wave celerity is governed by local depth, model distortion will have little effect on refraction. This is seen from the equation for wave celerity c, from small-amplitude wave theory

$$c = \left(\frac{gL}{2\pi}\tanh\frac{2\pi h}{L}\right)^{\frac{1}{2}} \tag{4}$$

As the wave period increases, tanh 2πh/L approaches 2πh/L, and the celerity becomes

$$C = (gh)^{\frac{1}{2}} \tag{5}$$

This indicates that for shallow-water waves, celerity (and thus refraction) is independent of wavelength, and the use of model distortion has no significant effect on wave refraction.

8. Based on Froudian similitude, the time scale for model wave period, using a horizontal scale for wave length as shown earlier, is written as (Outlaw et al., op. cit.)

$$T_r = \left[L_r \frac{\tanh\left(\frac{2\pi}{L_p}h_p\right)}{\tanh\left(\frac{2\pi}{L_m}h_m\right)}\right]^{\frac{1}{2}} \tag{6}$$

with the subscript m referring to the model. As tanh (2πh/L) approaches

$(2\pi h/L)$, the time scale ratio can be approximated by

$$T_r = \frac{L_r}{(h_r)^{\frac{1}{2}}} \tag{7}$$

which when applicable (e.g., the prototype wave period calculated from Equation 7 is within 1 percent or less of the period calculated from Equation 6 for T ≥ 85 sec), indicates a model-to-prototype time scale of 1:40 for wave period.

Model Appurtenances

Wave generator

9. The electrohydraulic wave generator was composed of 13 segments, each independentally controlled from a computer-generated command signal and equipped with a 15-ft paddle. The segments can be positioned to approximate a curved wavefront 78,000 ft long (prototype). Details of generator design are found in Outlaw et al., op. cit.

Data acquisition

10. Wave data acquisition, wave generator control signals and feedback, and wave gage calibration were performed using an Automated Data Acquisition and Control System (ADACS). A schematic is shown in Figure 6. At the heart of the system is a Digital Equipment Corporation (DEC) Microvax computer. Wave data are collected at various locations throughout the model. The ADACS can handle 30 gages for a test run. The sensor used is a water-surface-piercing parallel-rod resistance type wave gage where the conductance between the two rods is measured and is directly proportional to submergence. This system can detect changes in water elevation to 0.001 ft.

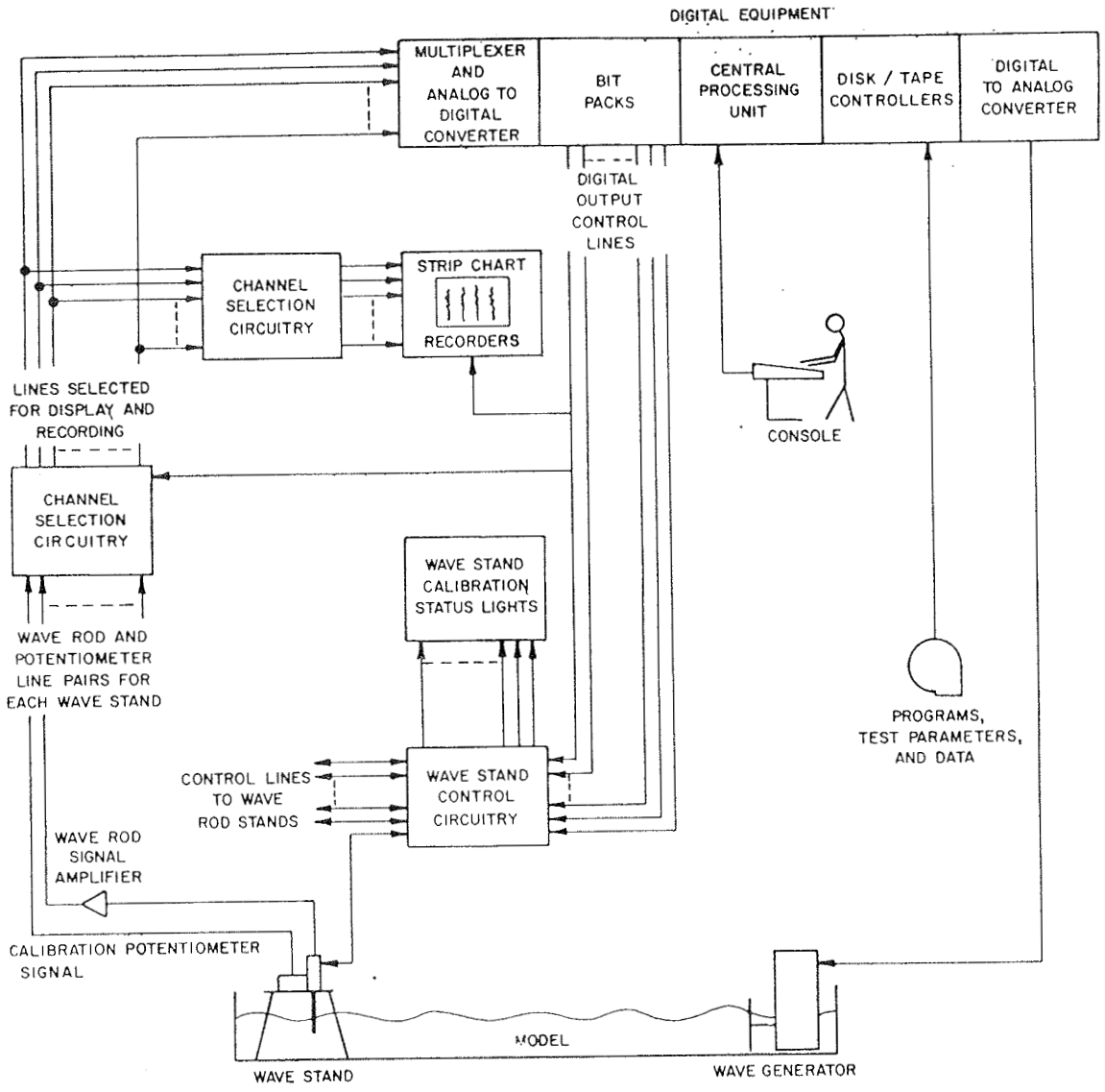


Figure 6. Automated Data Acquisition and Control System (ADACS)

PART III: MODEL TESTING APPROACH

Plan of Study

11. At the initiation of this study, about 2 years of long-period wave data had been collected at an offshore oil platform (Platform Edith) 8 miles south of the harbors (see Figure 7 for location of Edith and seven harbor gages operated over the same period). Using this information, long-period spectra were selected for programming the model wave generators, data were collected in the model at locations of prototype gages, and these data were compared to prototype spectra. Needed changes to wave generator energy distribution were made by adjustment of the controllers of the 13 independent generator segments and model-prototype comparisons were rechecked. When good model-prototype comparisons were achieved, model base data spectra were collected at stations throughout the harbor to be used for comparison with proposed harbor expansion tests.

Selection of Test Conditions

12. An analysis of Platform Edith long-period wave data was made to determine appropriate input to the model wave generators. Two storms were outstanding in the data record as far as their impact on the harbors. The largest event recorded was the Martin Luther King Day storm of 17 January 1988. The short period portion of the wave spectrum had a significant wave height of 7.5 m (24.6 ft) during the peak period of energy measured at Platform Edith. The long-period portion of the wave spectrum contained 270 cm^2 (0.29 ft^2) of energy and was distributed as seen in Figure 8. This event caused significant damage to the Southern California coastline. The second event selected occurred on 2 February 1986 and resulted in significant harbor agitation with numerous reports of moored ship difficulties (Figure 8). The third long wave spectrum selected was based on an average or mean long-period wave spectrum condition representative of a southerly approach (Figure 8). Since the mean spectrum was nearly flat, a uniform, constant-energy spectrum was created for use in the model.

13. In order to transform the spectral representation into an actual time series of waves in the model, the program TSGMN3P0 took the discretely

defined spectral energy (36 frequency components from 0.1 to 1.33 cps) and created a control signal which has 256 frequency bands (Δf=0.00479) for the wave generator. The control signal was input to the program SPLASH, which controlled the wave paddle to create the desired wave spectrum. In order to produce an analysis that accurately defined the energy in the broad range of wave periods contained in the long-period spectrum, each individual test was run for 512 sec. Runs of shorter test durations compared closely to the 512-sec test, indicating no problems with contamination of the wave records due to re-reflected waves off model boundaries or the wave generator. The boundaries have multiple layers of a fibrous matrix wave absorber and the irregular ocean contours and shoreline boundary do not appear to direct significant energy back to the wave generator. The 13 individual units that make up the wave generator were operated in phase, but wave amplitude was varied along the wave front to create an appropriate energy distribution approaching the harbors. Since the two storms being run approached from a westerly quadrant, energy distribution was adjusted for that approach. The uniform-spectrum energy distribution was adjusted for a southerly wave approach, more typical of moderate summer swell conditions. Ship motion observations in the prototype indicate that these two directional approaches (the west for winter storms, and the south for hurricane and Southern Hemisphere swell) create an annual bimodal distribution for significant moored ship motion events.

14. The model was updated to include the latest harbor configuration and after initial base data sets were collected, the Long Beach Harbor's Pier J expansion, with its associated channel deepening, was added in concurrence with its construction in the prototype and a new base data set was collected.

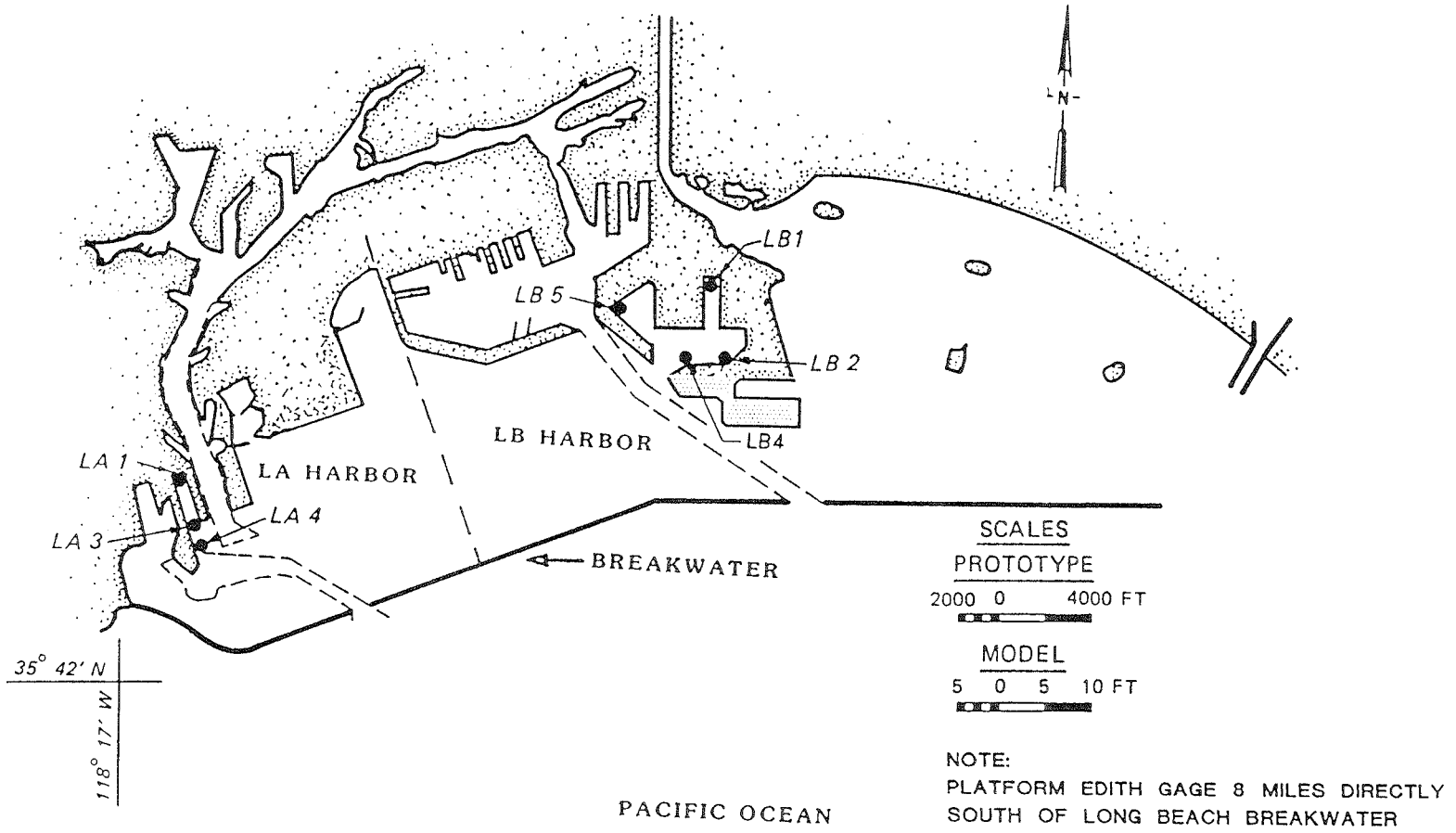


Figure 7. Location of waves gages LA1, LA3, LA4, LB11, LB2, LB4, LB5 and Edith

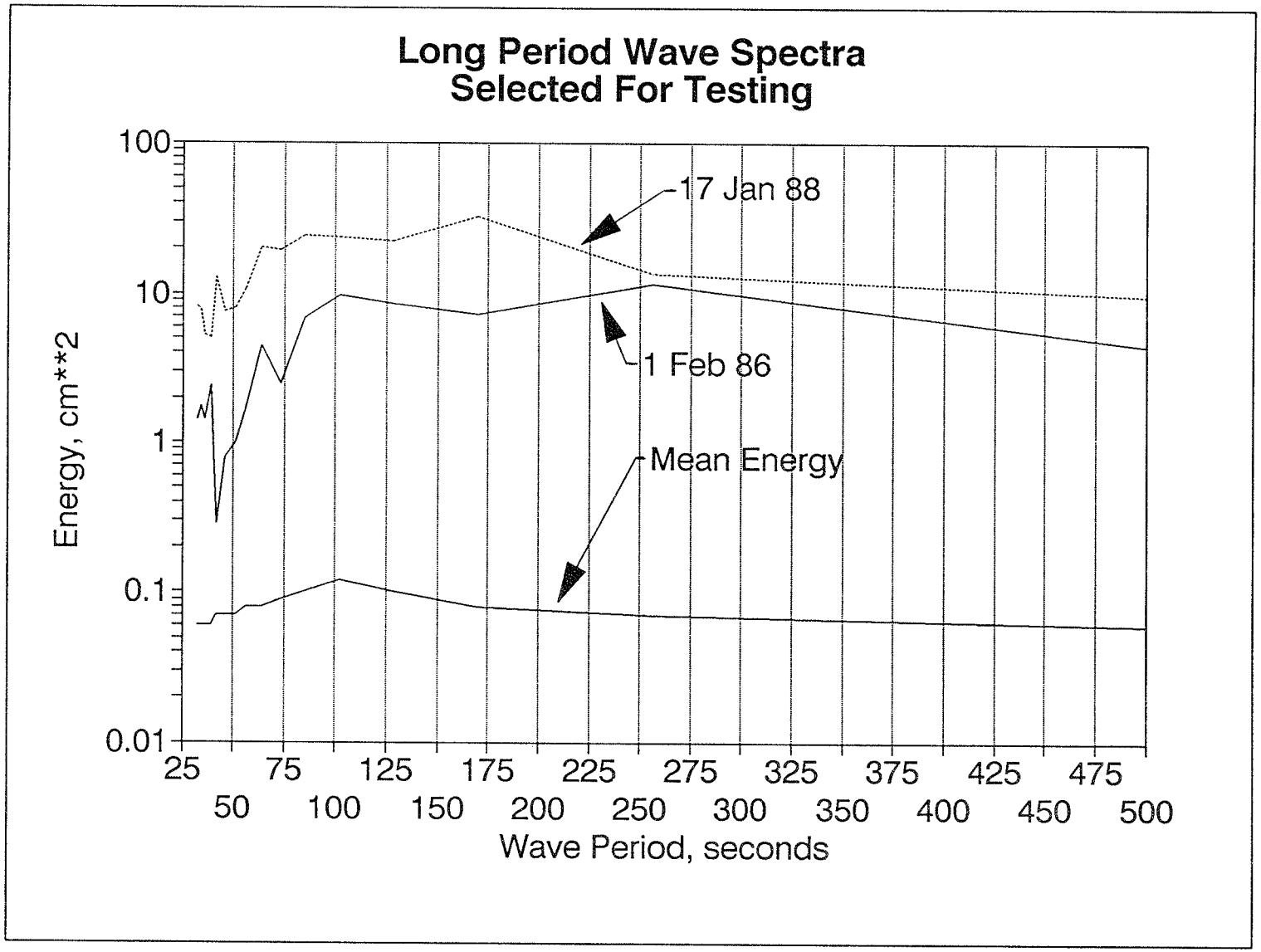


Figure 8. Long-period wave spectra selected for testing

PART IV: MODEL DATA COLLECTION

Initial Testing

15. Model wave height data were initially collected at the seven prototype gage locations seen in Figure 7. These wave heights are typically converted to a wave height amplification. Wave height amplification is traditionally defined as the ratio of the wave height at a particular location in a harbor to twice the incident wave height at the harbor mouth. This definition results from the fact that the standing wave height for a fully reflective straight coast with no harbor would be twice the incident wave height due to superposition of the incident and reflected waves. However, in the hydraulic model there is variation in wave height along the harbor boundary due to wave refraction. In the previous Los Angeles - Long Beach Harbor resonance studies, incident wave height in deep water is used and the amplification (R) is defined as

$$R=H_s/H_i \tag{8}$$

H_s = significant wave height at gage in harbor
H_i = deepwater incident wave height

In this study, data were available at the ocean wave gage on Platform Edith. In order to facilitate direct comparison with prototype data, wave height data at each harbor gage were divided by wave height measured at a gage located at the analogous location of Platform Edith in the model ocean. Since the waves being studied were composed of many frequencies (or a spectrum), the digital output from the gage was analyzed by Fast Fourier Analysis (FFT) to determine an energy level that could be converted to a wave height (by taking four times the square root of the energy) for each frequency band. Water elevation data were collected at a rate of 20 readings per second at each gage location. A total of 8,192 data points were collected at each gage during a test. The data were windowed with a cosine square taper and after FFT analysis, the raw spectral estimates (Δf=0.0024414) were smoothed by averaging eight bands, so that Δf for model data was 0.01953.

16. Some adjustment of the range of the overall wave generator stroke was made in some cases in order to keep waves in the linear range. This was done since the long waves being studied are of low aspect; that is, their

height-to-length ratio is very low, even for the largest ones studied. Also, it is important to note that wave height is normalized in the final analysis to an amplification, so that a ratio is taken.

17. For the seven prototype gage locations initially tested, not all gages were operational for a given storm. During the February 1986 storm, gage LA-4 was down and during the severe January 1988 storm, gages LA-1 and LA-3 were not operational. Figures 9 and 10 show a comparison between model and prototype wave height amplification (determined by the square root of the ratio of energy for a certain frequency band at a given harbor gage to that at the ocean gage at Platform Edith) for the February 86 storm at gages LB-2 and LA-1. The comparison is not direct since the prototype data were analyzed with a wider frequency interval, while the model data have finer frequency (or wave period) resolution. For example, the prototype data point at wave period 256 sec on the gage LA-1 plot is averaged over a bandwidth covering 204 to 341 sec. At lower wave periods, the comparison is more easily made as the wave period increments become smaller. Figures 9 and 10 and Plates 1-4 indicate that the model harbor spectral response closely reproduced the prototype for the February storm.

18. Comparisons of prototype and model wave height amplification for the January 1988 storm are shown for gages LA-4 and LB-2 in Figures 11 and 12. Plates 5-7 contain the other gages compared. Generally, the comparison is reasonable but the model is a little more responsive than the prototype for this extreme event. It should also be noted that the prototype offshore gage at Platform Edith was not synchronized with the harbor gages at that time, but sampled data about 30 min earlier during this time period. The variation of energy in different frequency bands during a storm event could be significant. Possibly the ocean gage captured the maximum wave condition, which may have subsided somewhat when the harbor gages were sampled. Also, in examining many prototype data sets, it is apparent that as ocean energy increases, harbor wave height amplification decreases relative to Platform Edith. This may be caused by highly nonlinear wave motions effecting a different basin response than at lower energy conditions. There were reports of waves overtopping the Outer Harbor breakwater during this storm, which would produce a complex wave field in the harbor itself. Also, the northwest to southeast storm track may have afforded the harbor more protection relative to the wave gage at Platform Edith than could be obtained in the physical model because of boundary

contraints, creating lower prototype wave amplifications when a wave height amplification ratio between the harbor gage and the Platform Edith gage is taken. Whatever the reason, the model results are reasonable and perhaps slightly conservative for the January 1988 storm.

19. The uniform wave spectrum was designed to typify a somewhat average long wave condition with a southerly approach to the harbors. The model results are compared with values of wave height amplification for a median energy level. For example, Figure 13 shows data for the 73-sec period band of energy at gages Edith and LB-2. With 8,760 hr in a year, energy values at 4,380 hr would represent a median energy condition, and the square root of the energy ratio between gages LB-2 and Edith would determine the median wave height amplification. Energy conditions at, say, 20 hr would represent an extreme wave event. Figure 13 shows that when taking the ratio of the energy at LB-2 to that of Edith, this ratio curve indicates a decrease with higher energy conditions. As mentioned earlier, this possibly indicates the harbors are sheltered relative to Platform Edith for higher energy conditions, which are usually from the west. Figures 14 and 15 show gages LB-5 and LA-3, respectively. Plates 8-12 include the remainder of the gages. Generally, the model spectra correlate well with the prototype median.

Final Tests

20. After testing of the three long-period wave spectra for the prototype wave gage locations, data were collected at other locations throughout the harbors. Figure 16 shows positions of all gages where data were collected. These data will be considered as "base" data, with which data for proposed harbor changes will be compared in order to understand the effect of a given plan on the harbors. Appendix A contains this information.

Application

21. The wave spectra developed here can be used in the initial stage of testing a proposed harbor configuration. An examination of the output response at locations where increases in wave amplitude occur can then be examined in further detail and resolution can be achieved by running monochromatic waves (which have base data whose period spacing is much finer than that of the spectra).

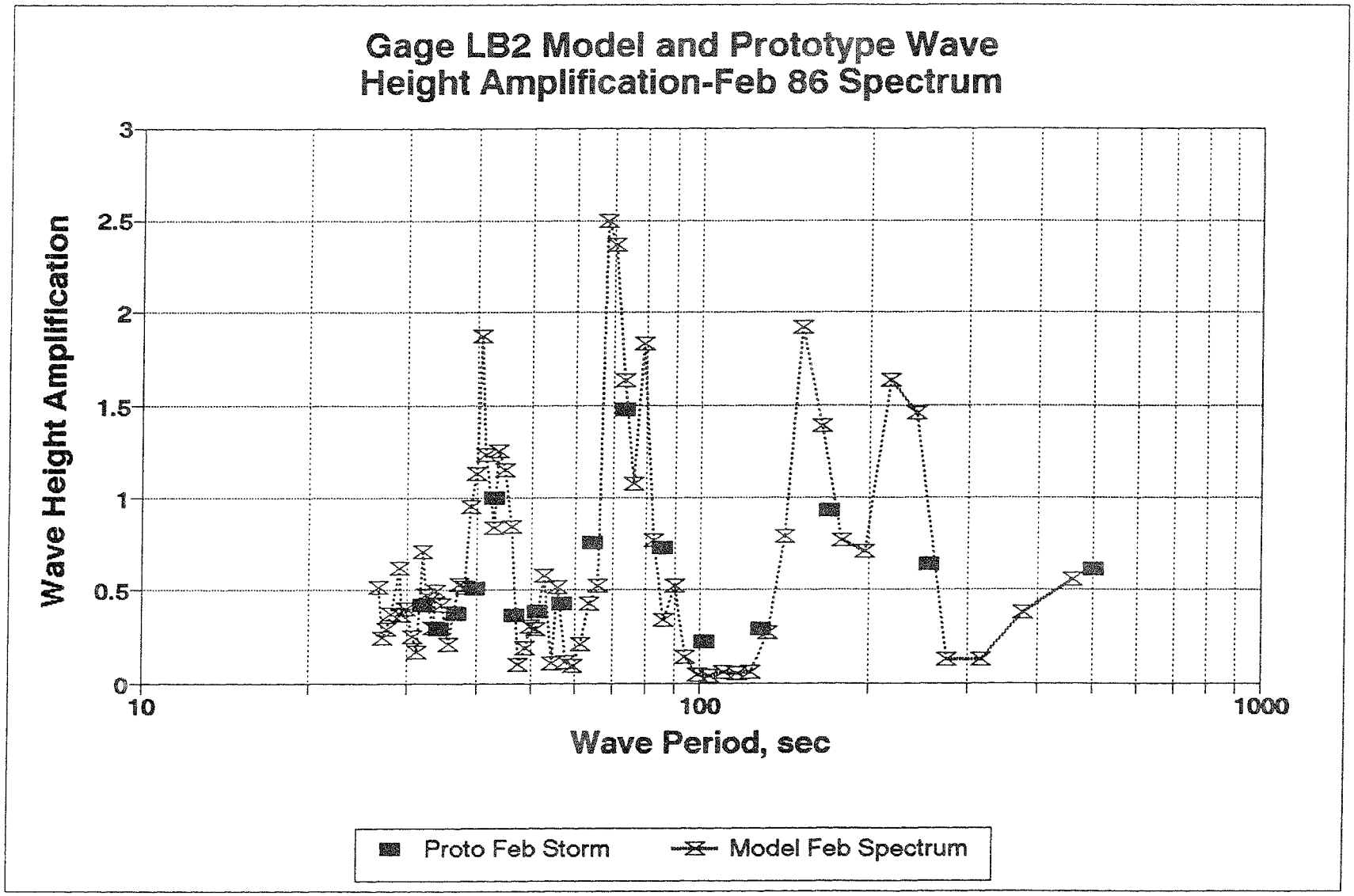


Figure 9. Prototype-to-model comparison of wave amplification at gage LB2 for February 1986 spectrum

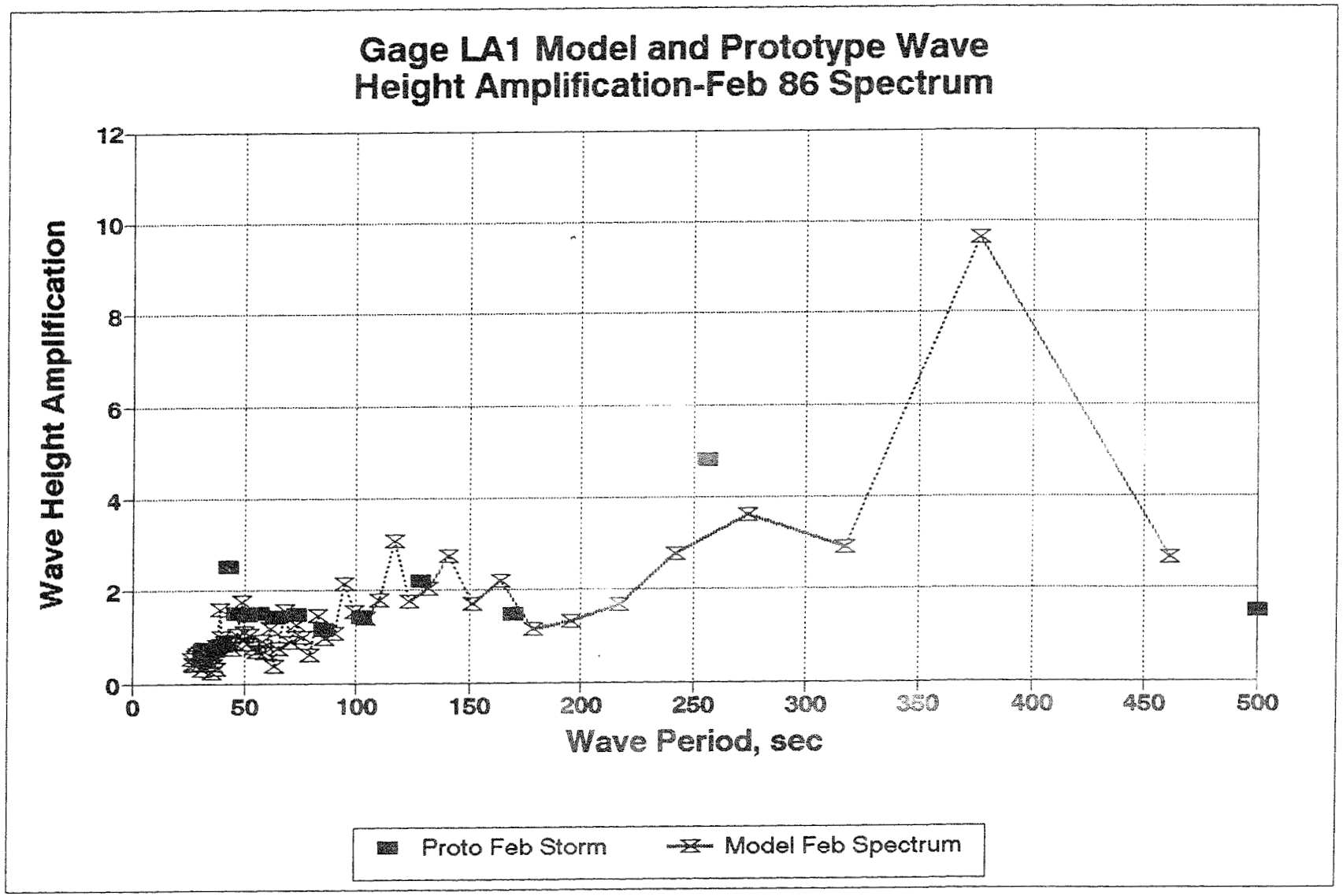


Figure 10. Prototype-to-model comparson of wave amplification at gage LA1 for February 1986 spectrum

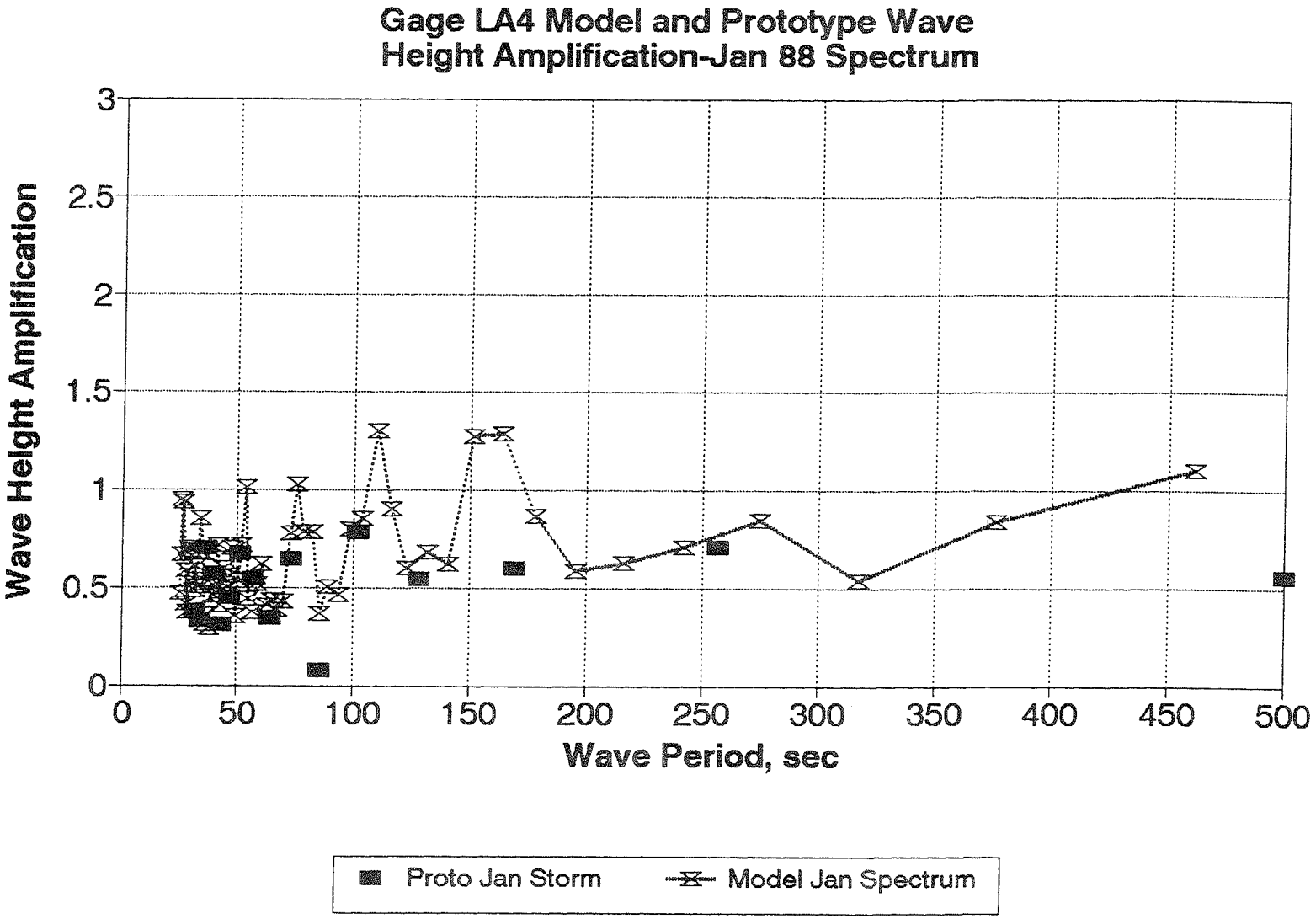


Figure 11. Prototype-to-model comparison of wave amplification at gage LA4 for January 1988 spectrum

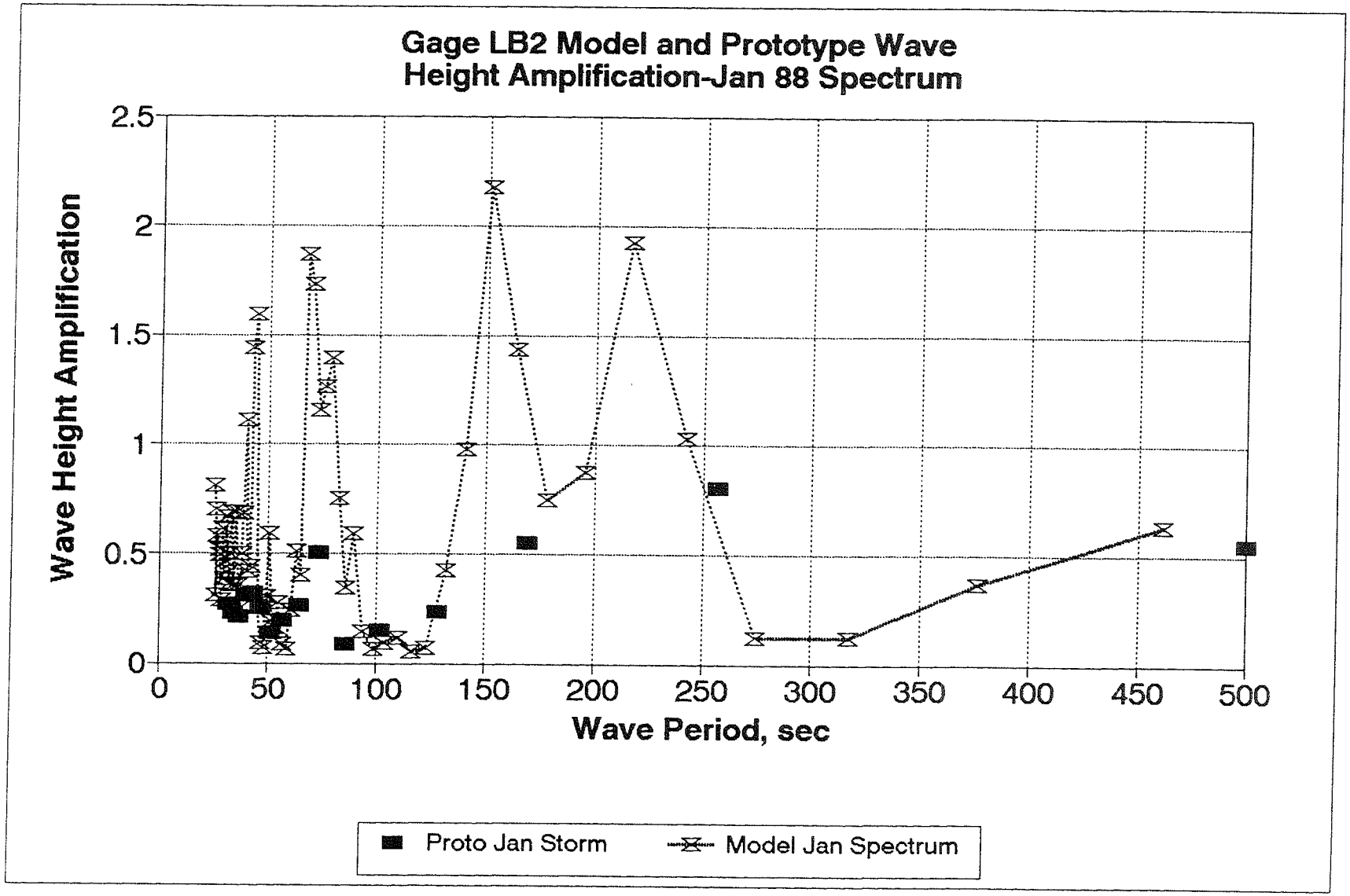


Figure 12. Prototype-to-model comparison of wave amplification at gage LB2 for January 1988 spectrum

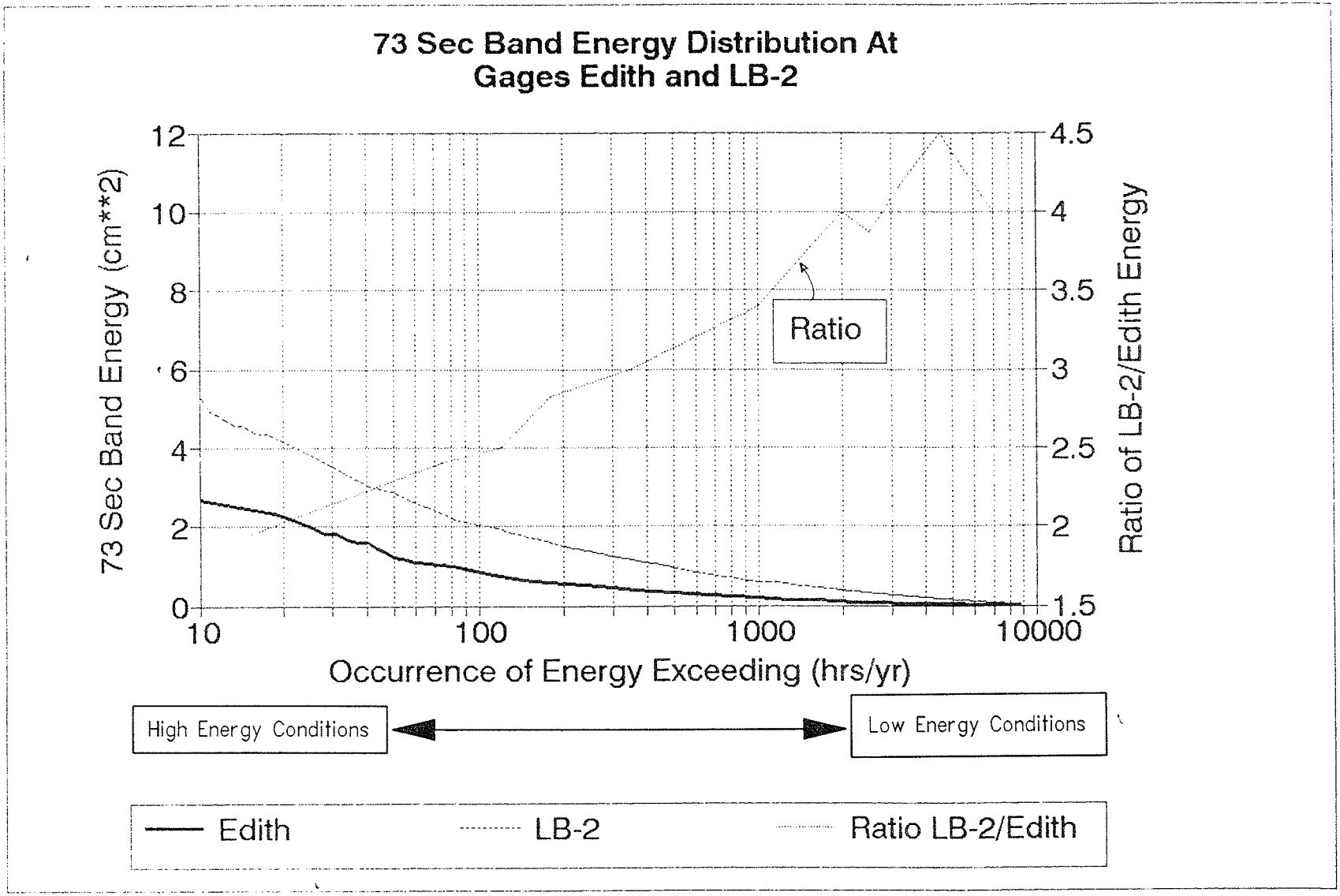


Figure 13. Variation of ratio of energy at gage LB2 to gage Edith from high- to low-energy conditions

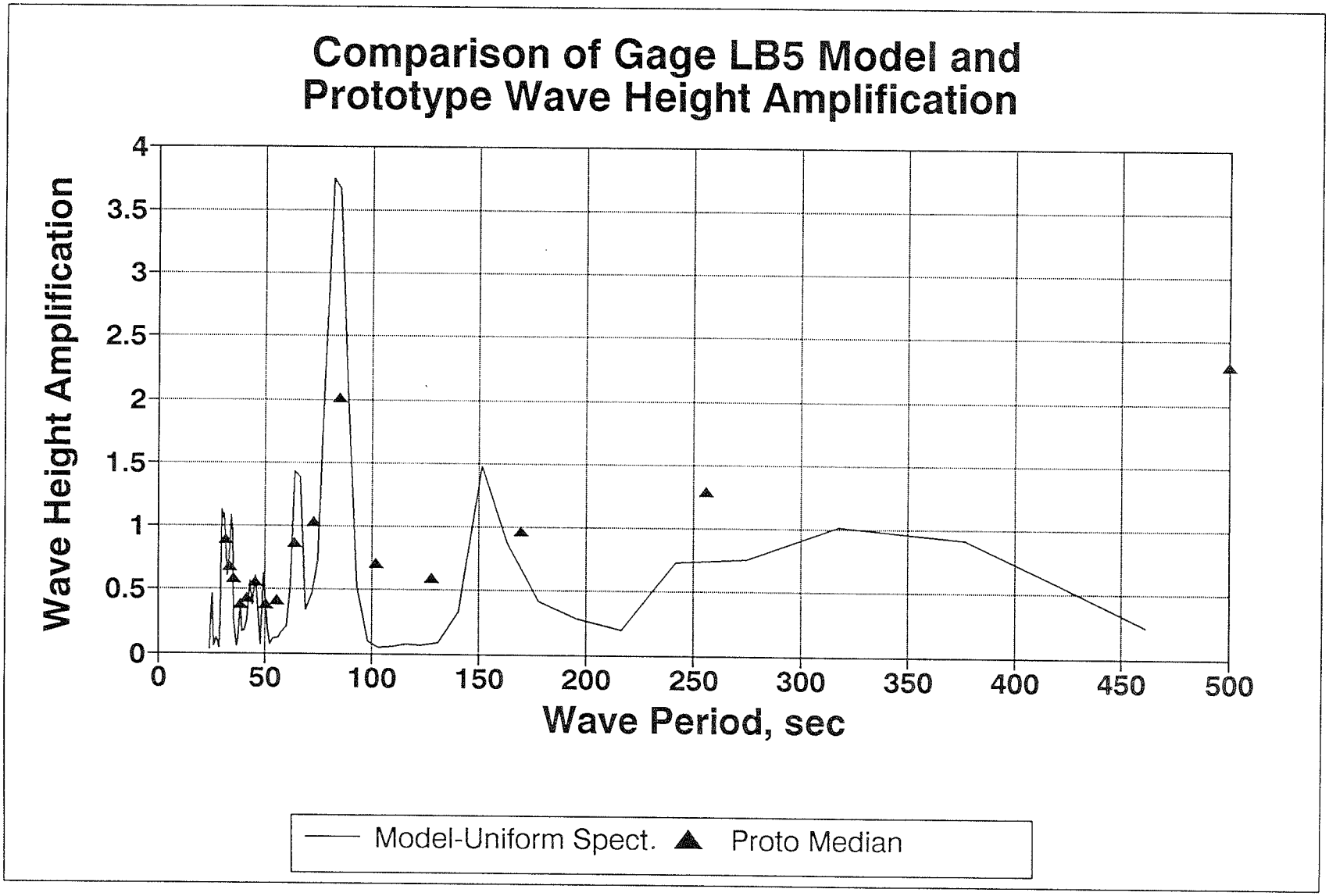


Figure 14. Comparison of model uniform spectrum and prototype median wave height amplifications at gage LB5

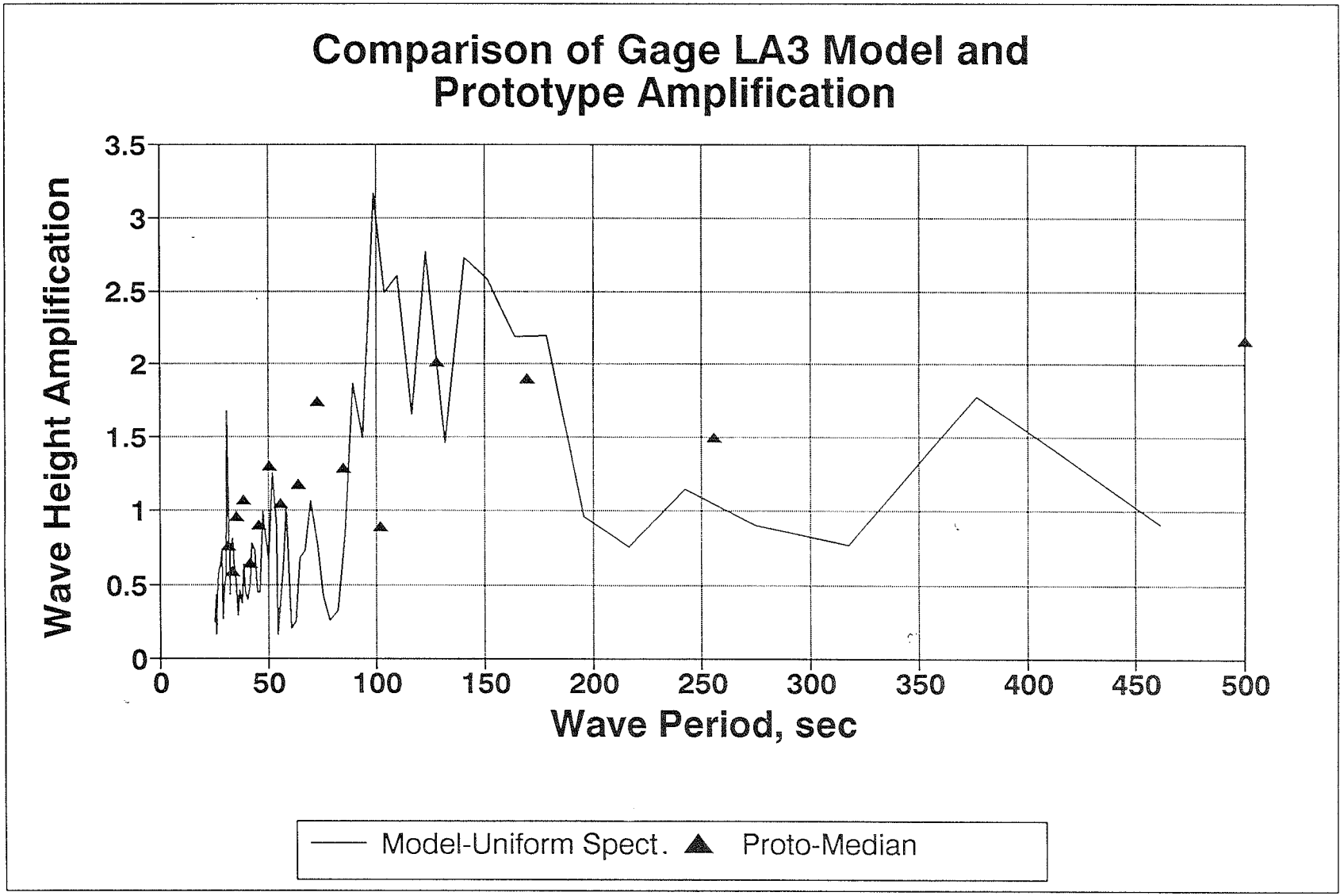


Figure 15. Comparison of model uniform spectrum and prototype median wave height amplifications at gage LA3

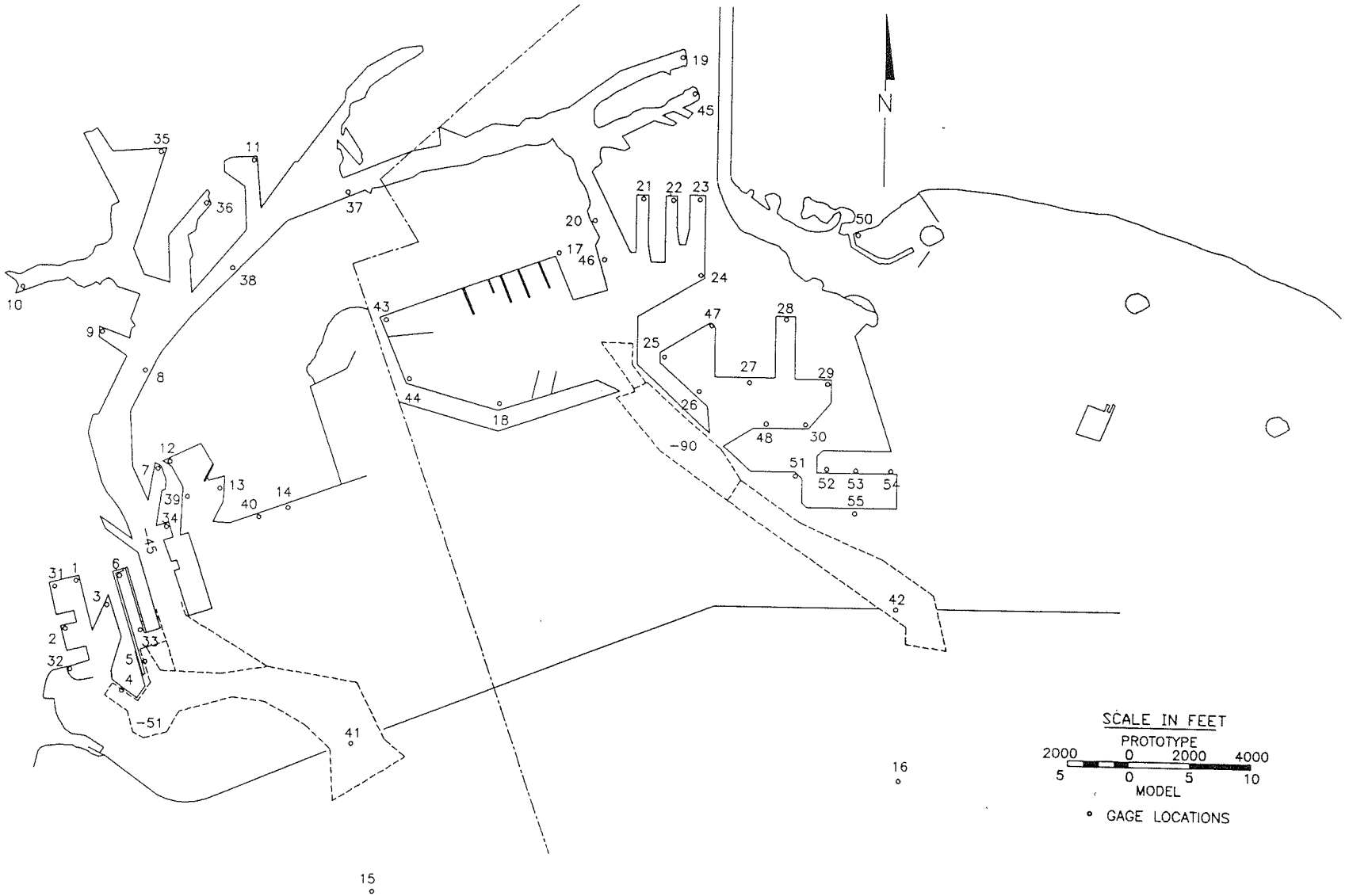


Figure 16. Model gage locations for base test

PART V: SUMMARY AND CONCLUSIONS

22. The Los Angeles - Long Beach physical model has proven to be a very useful tool in examining the effects of proposed plans on long-period waves and their possible resonance at various slips and basins throughout the harbors' complex. Individual monochromatic wave tests (at a single wave period or frequency) were conducted, with up to 200 individual wave tests run for a given plan in order to cover the desired wave periods from 30 to 400 sec. The development of spectral wave testing permits preliminary testing of a plan with only one to three test runs, dependent on the number of wave gages used (up to 30 locations may be sampled during a single test, though typically if all base gage sites and new berth sites are monitored, more than 60 gage locations will be examined). These tests may then be supplemented by individual monochromatic tests at wave periods that indicate troublesome wave resonance conditions.

23. In summary, three long-period wave spectra were selected for use in the Los Angeles - Long Beach Harbors distorted scale physical model. They included two storm conditions, February 1, 1986 and the Martin Luther King Day Storm on January 17, 1988. An average condition wave spectrum was developed based on long-term wave information. These spectra were used to program the wave generators, and wave data were collected at seven harbor gages in the model where prototype data had been collected. A comparison of model and prototype data indicated good correlation. The model was constructed to the most recent harbors' configuration (as of 1990), including Long Beach Harbor's Pier J expansion. Additional long-period wave data were collected at berth locations throughout the harbors for the three wave spectra conditions in order to have base data to compare with data collected for proposed future plans of harbor development.

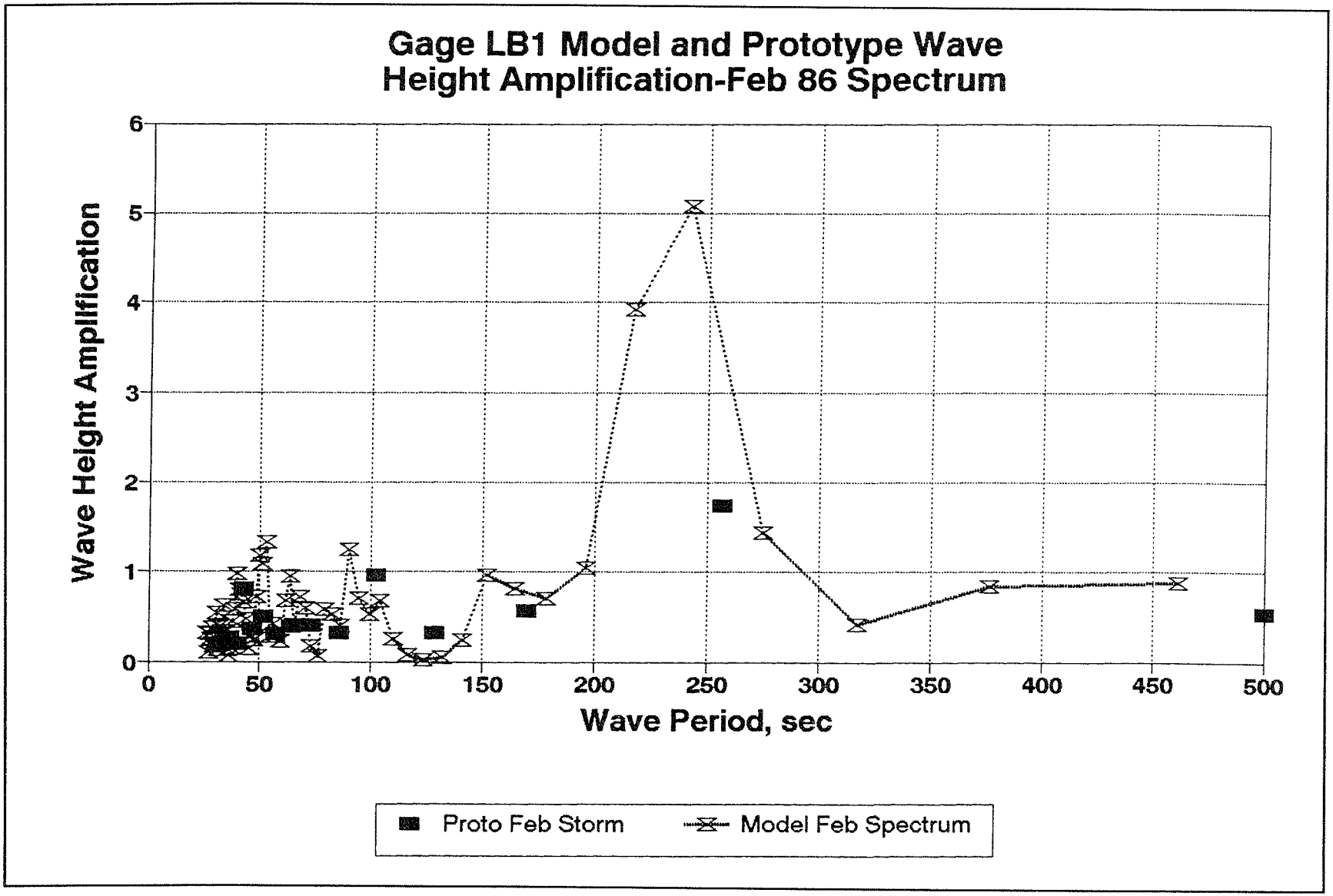

Gage LB1 Model and Prototype Wave Height Amplification-Feb 86 Spectrum
Wave Height Amplification
0
1
2
3
4
5
6
0
50
100
150
200
250
300
350
400
450
500
Wave Period, sec
Proto Feb Storm
Model Feb Spectrum

Plate 1

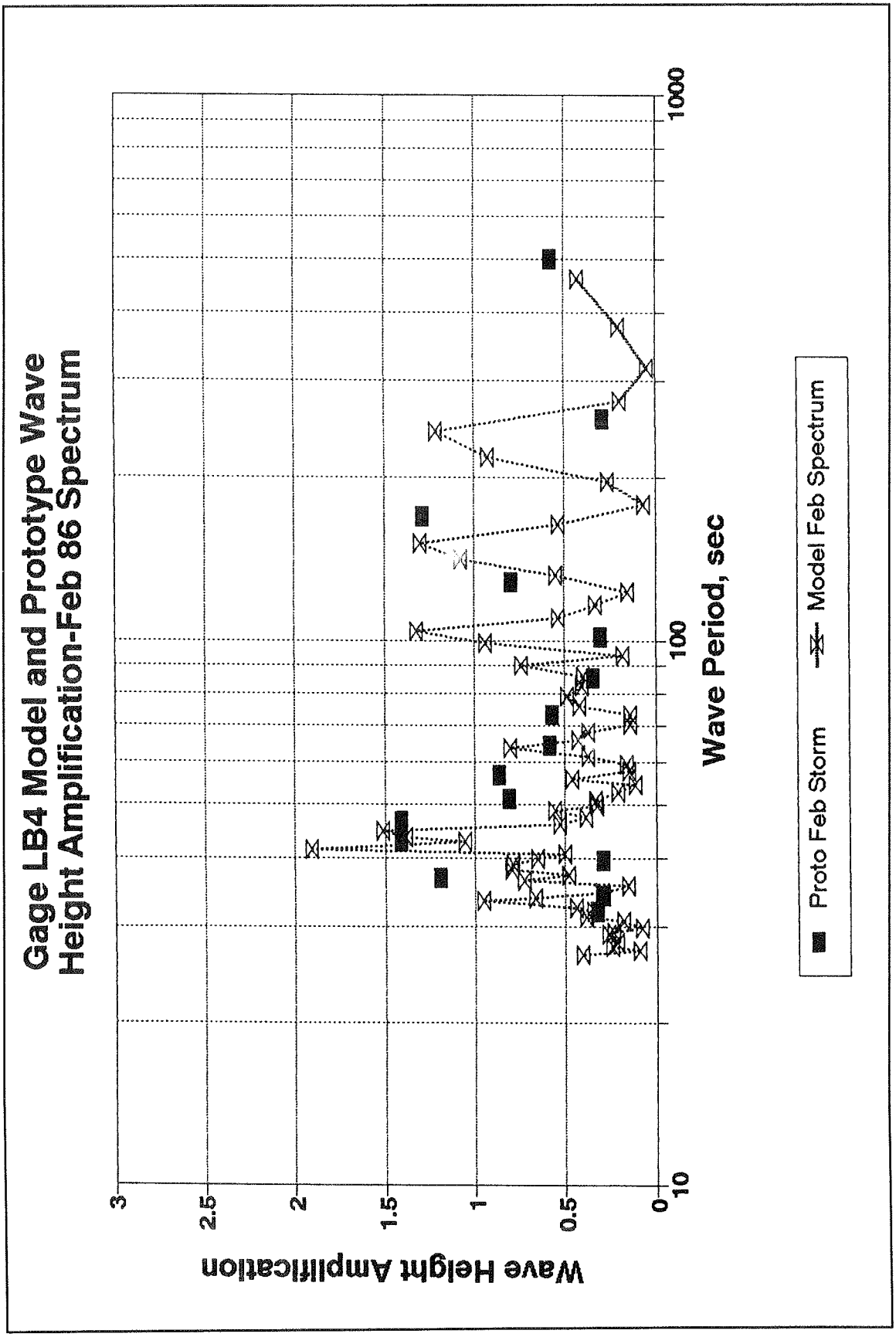

Gage LB4 Model and Prototype Wave
Height Amplification-Feb 86 Spectrum
Wave Height Amplification
3
2.5
2
1.5
1
0.5
0
10
100
1000
Wave Period, sec
Proto Feb Storm
Model Feb Spectrum

Plate 2

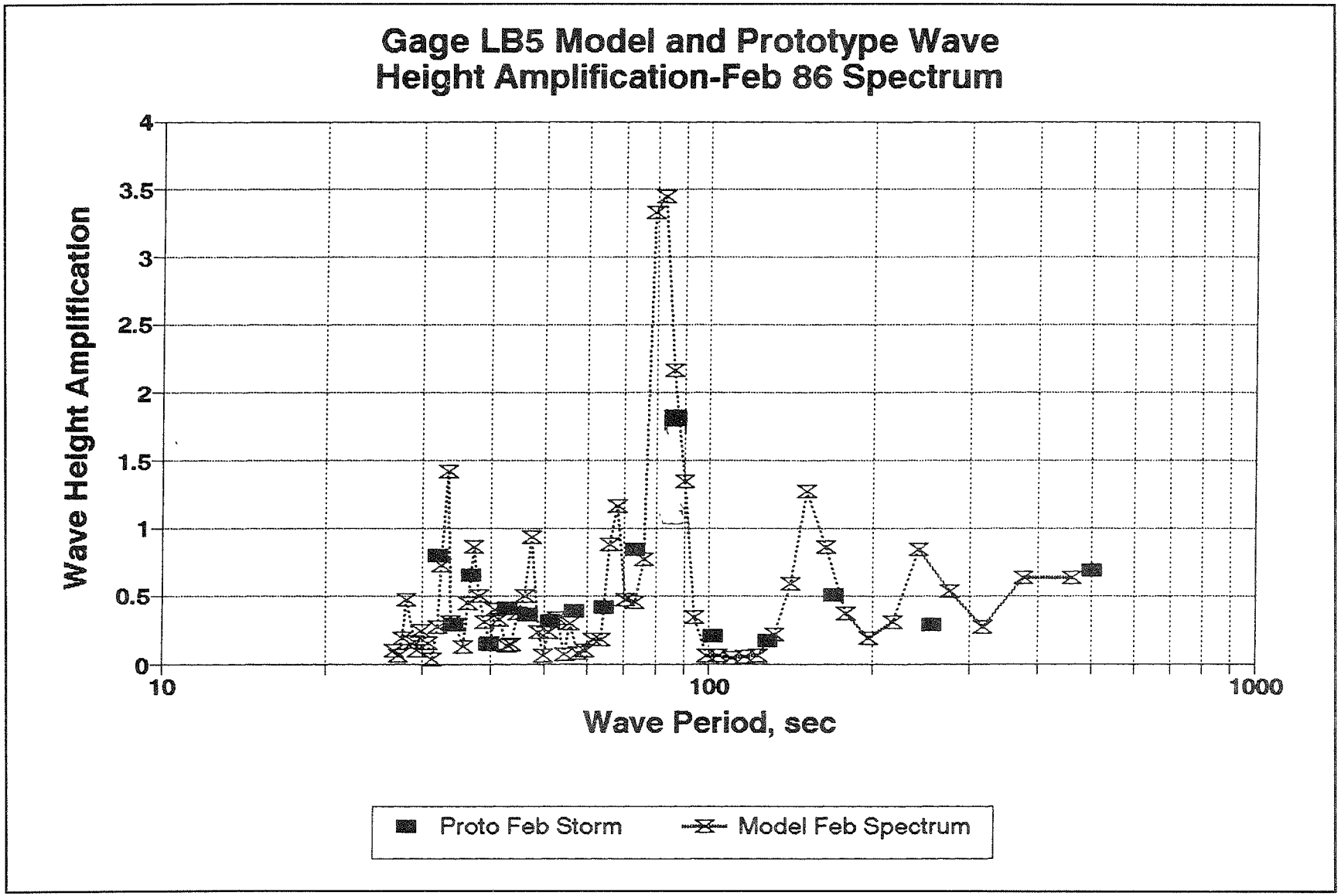

Gage LB5 Model and Prototype Wave Height Amplification-Feb 86 Spectrum
Wave Height Amplification
4
3.5
3
2.5
2
1.5
1
0.5
0
10
100
1000
Wave Period, sec
Proto Feb Storm
Model Feb Spectrum

Plate 3

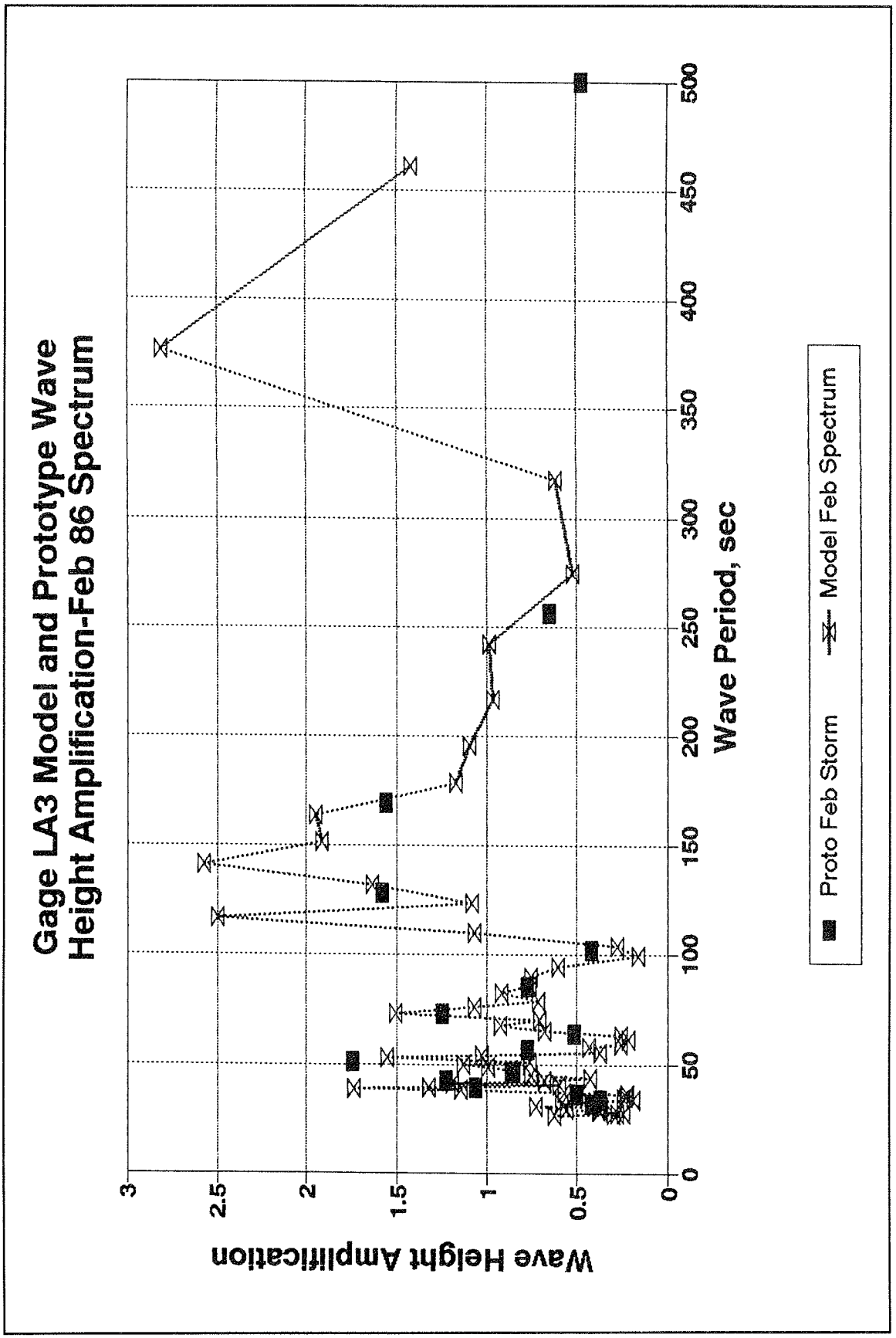

Gage LA3 Model and Prototype Wave
Height Amplification-Feb 86 Spectrum
Wave Helght Amplification
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
350
400
450
500
Wave Period, sec
Proto Feb Storm
Model Feb Spectrum

Plate 4

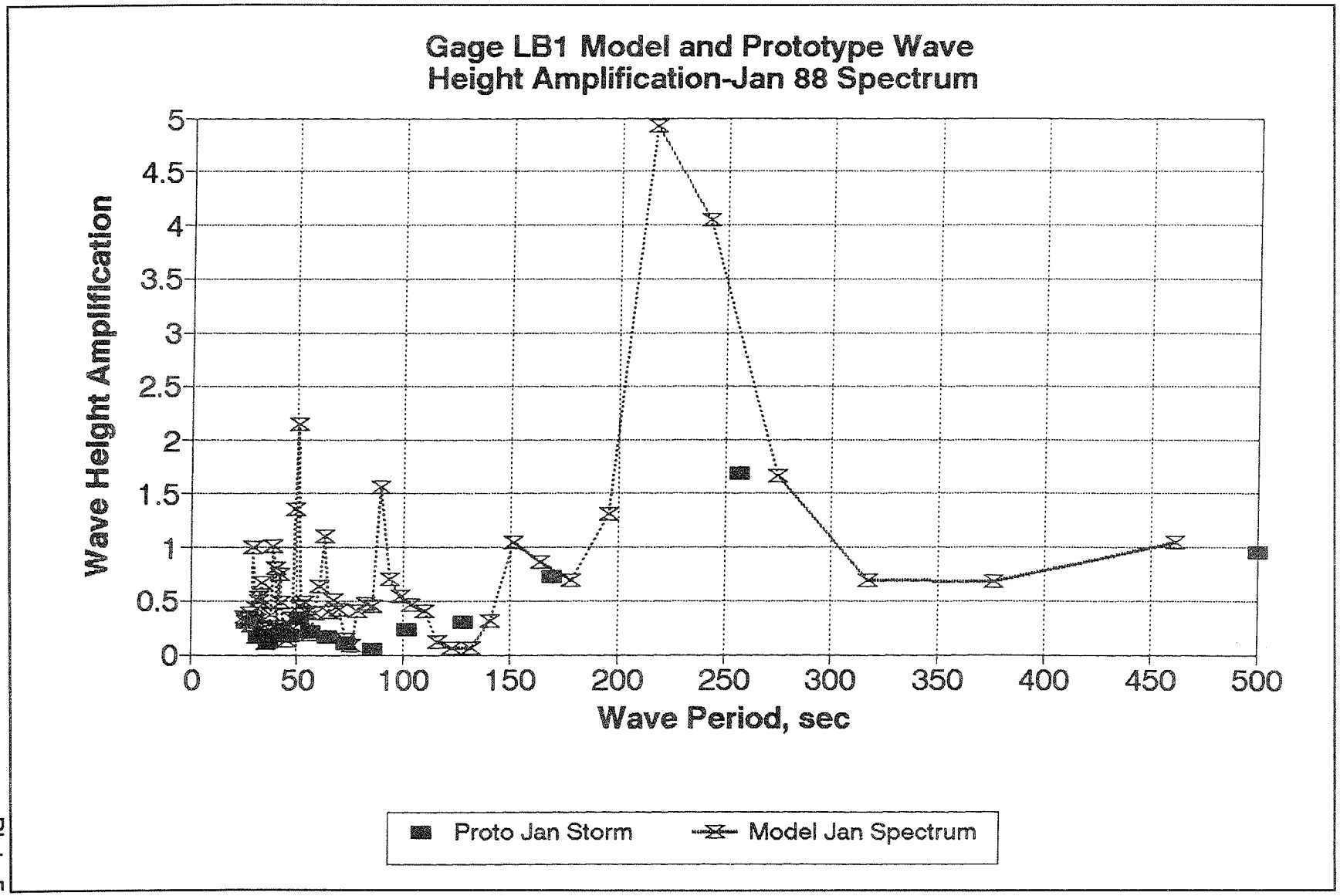
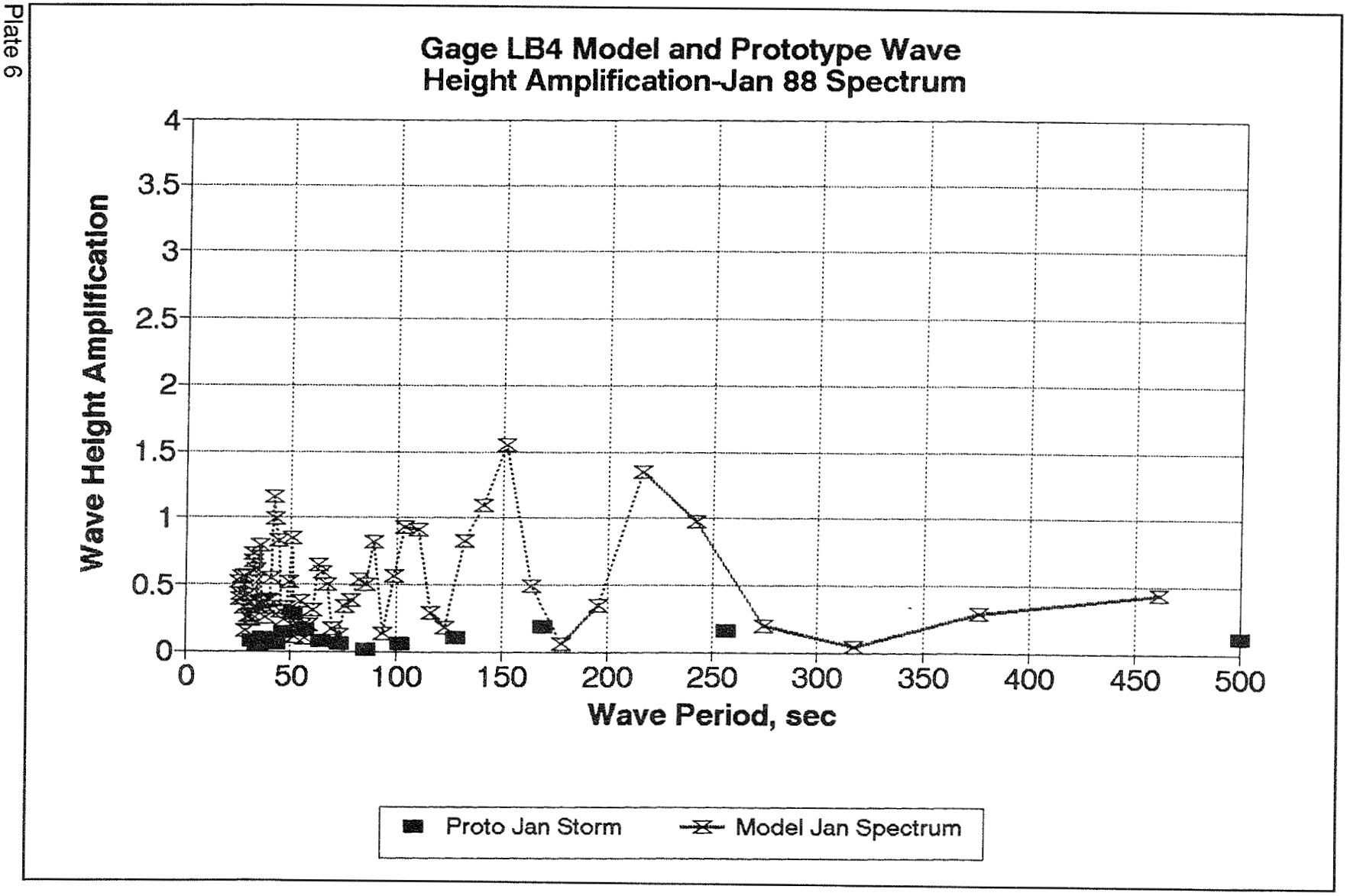

Gage LB1 Model and Prototype Wave Height Amplification-Jan 88 Spectrum
Wave Height Amplification
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
350
400
450
500
Wave Period, sec
Proto Jan Storm
Model Jan Spectrum

Plate 5

Plate 6


Gage LB4 Model and Prototype Wave Height Amplification-Jan 88 Spectrum
Wave Height Amplification
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
350
400
450
500
Wave Period, sec
Proto Jan Storm
Model Jan Spectrum

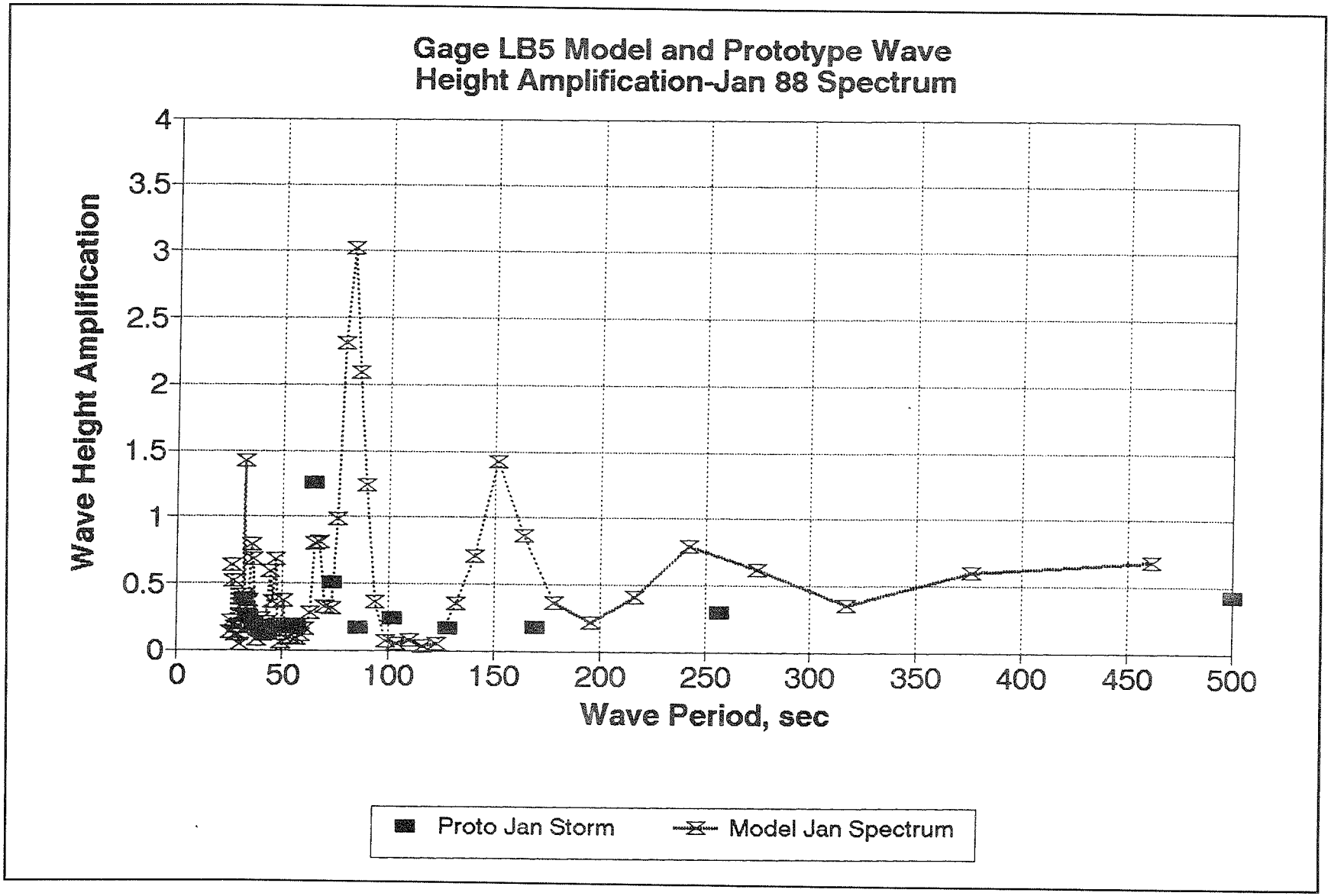
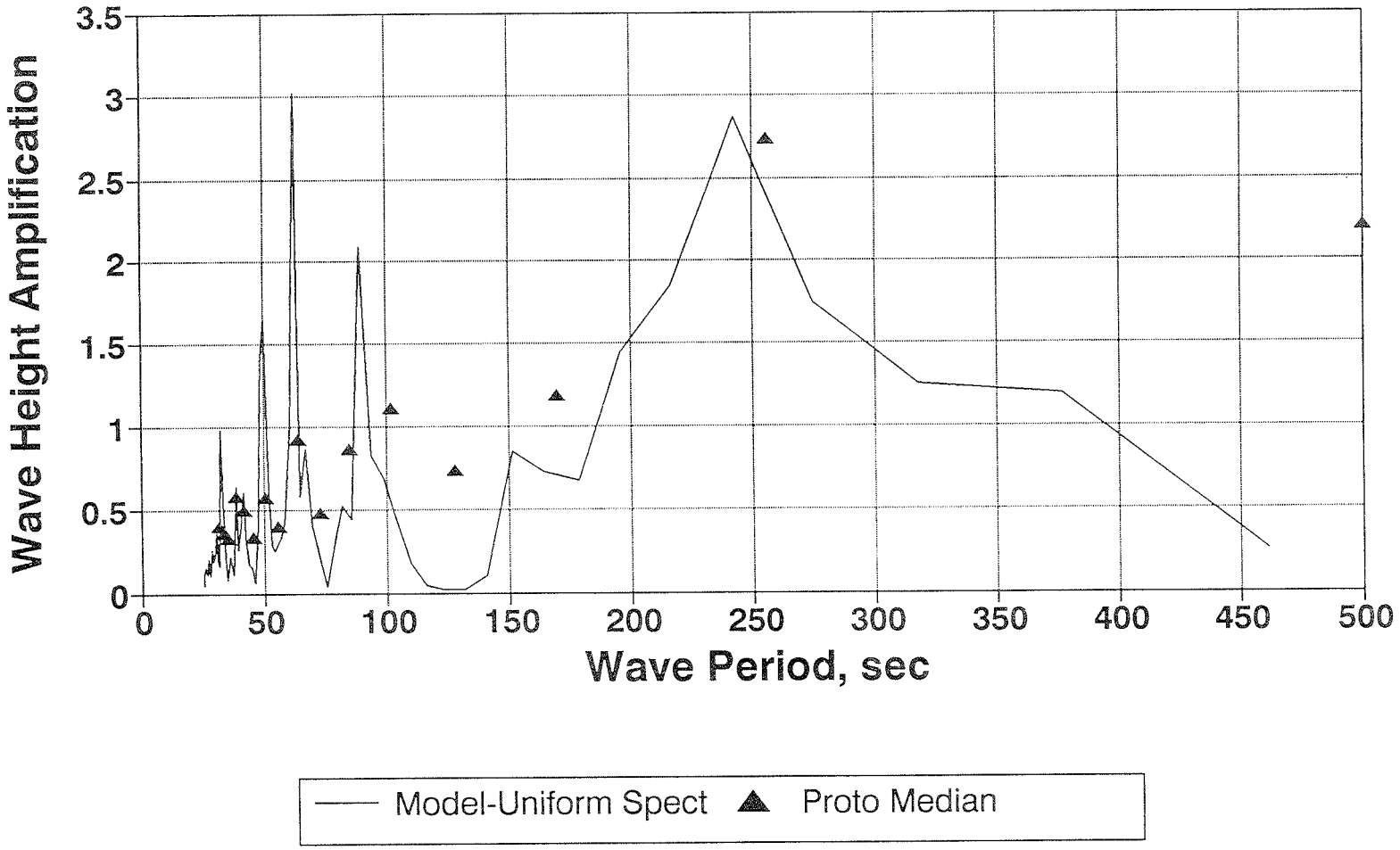

Gage LB5 Model and Prototype Wave Height Amplification-Jan 88 Spectrum
Wave Height Amplification
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
350
400
450
500
Wave Period, sec
Proto Jan Storm
Model Jan Spectrum

Plate 7

Plate 8

Comparison of Gage LB1 Model and Prototype Wave Height Amplification



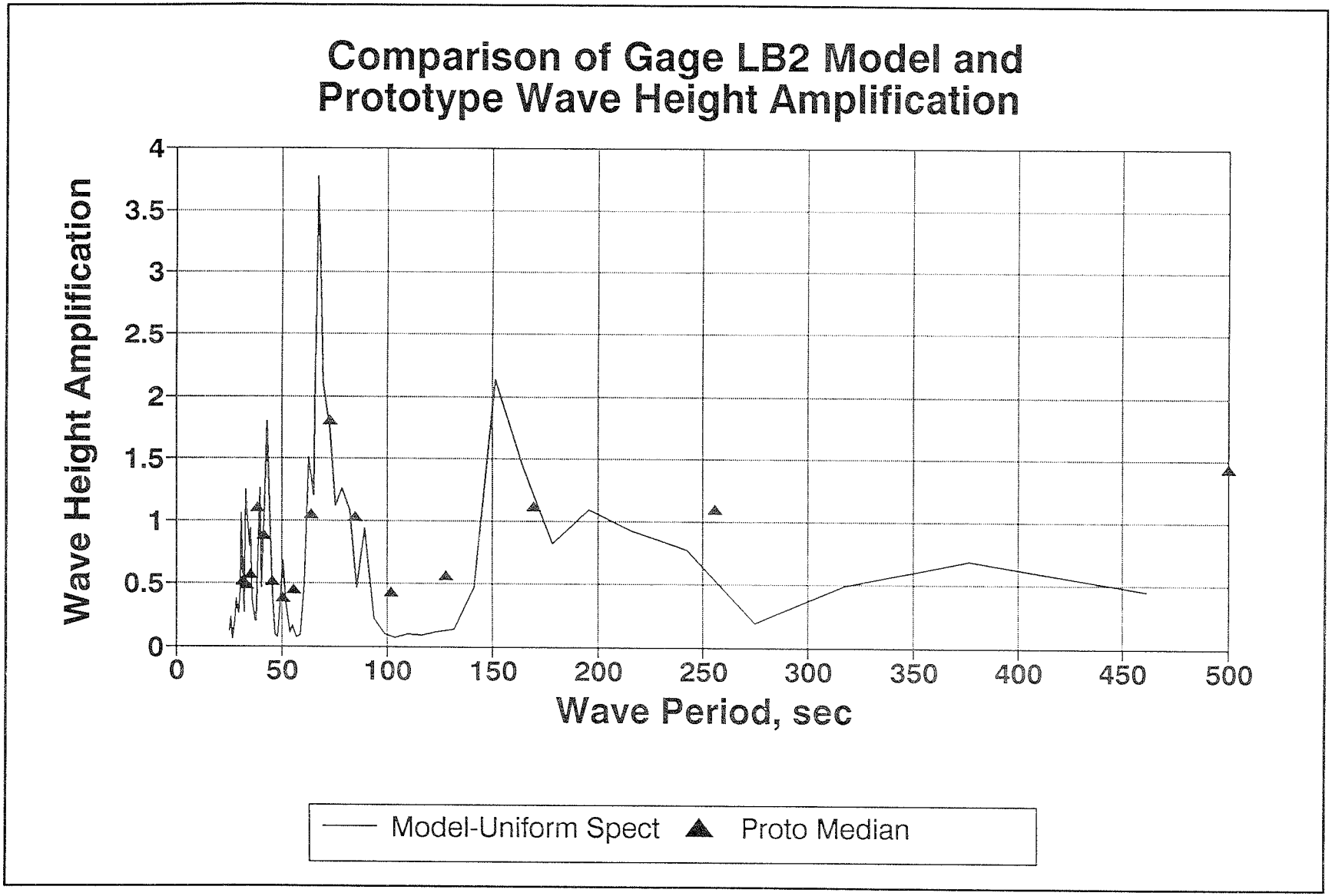
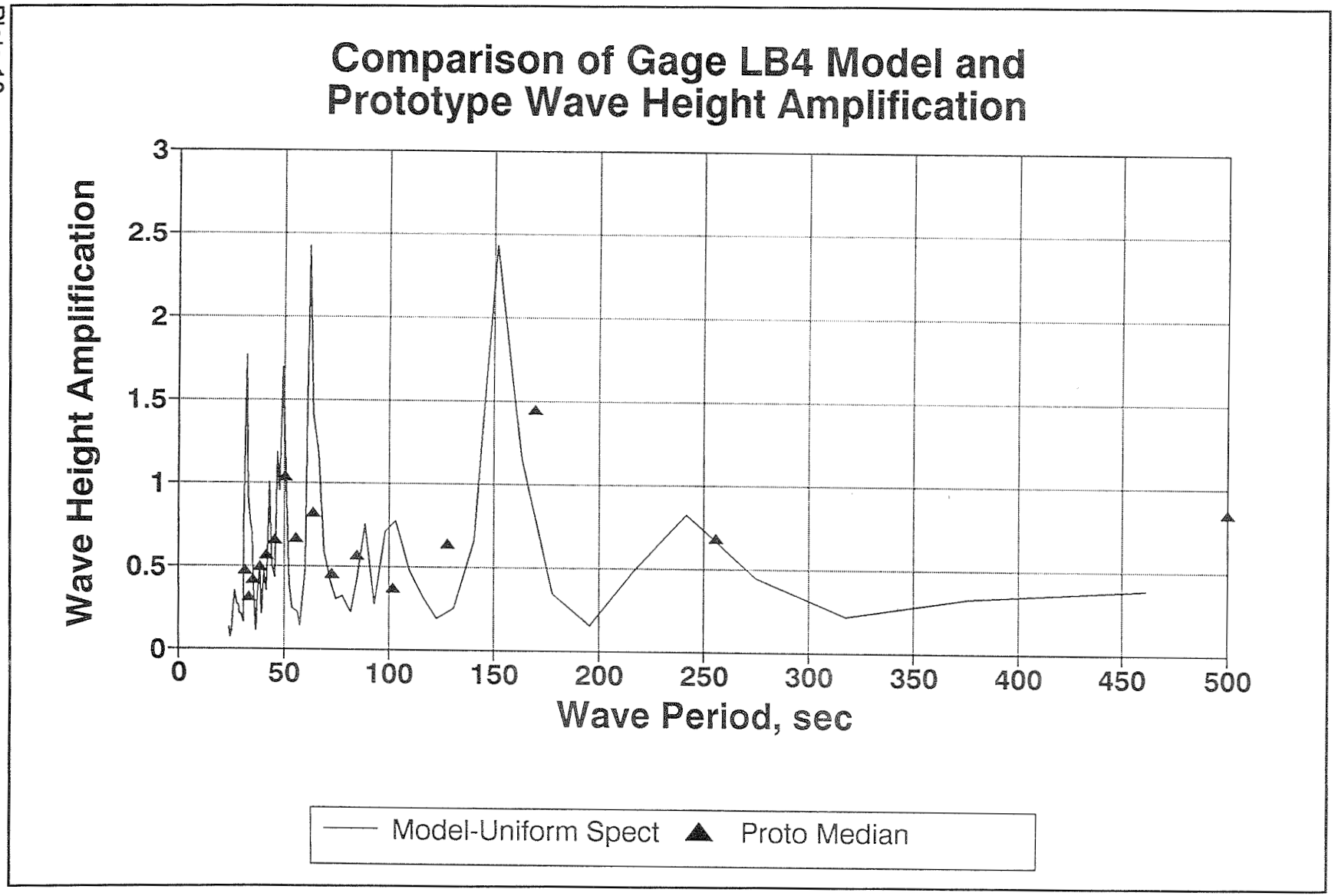

Comparison of Gage LB2 Model and Prototype Wave Height Amplification
Wave Height Amplification
0
0.5
1
1.5
2
2.5
3
3.5
4
0
50
100
150
200
250
300
350
400
450
500
Wave Period, sec
Model-Uniform Spect
Proto Median

Plate 9

Plate 10


Comparison of Gage LB4 Model and
Prototype Wave Height Amplification
Wave Height Amplification
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
350
400
450
500
Wave Period, sec
Model-Uniform Spect
Proto Median

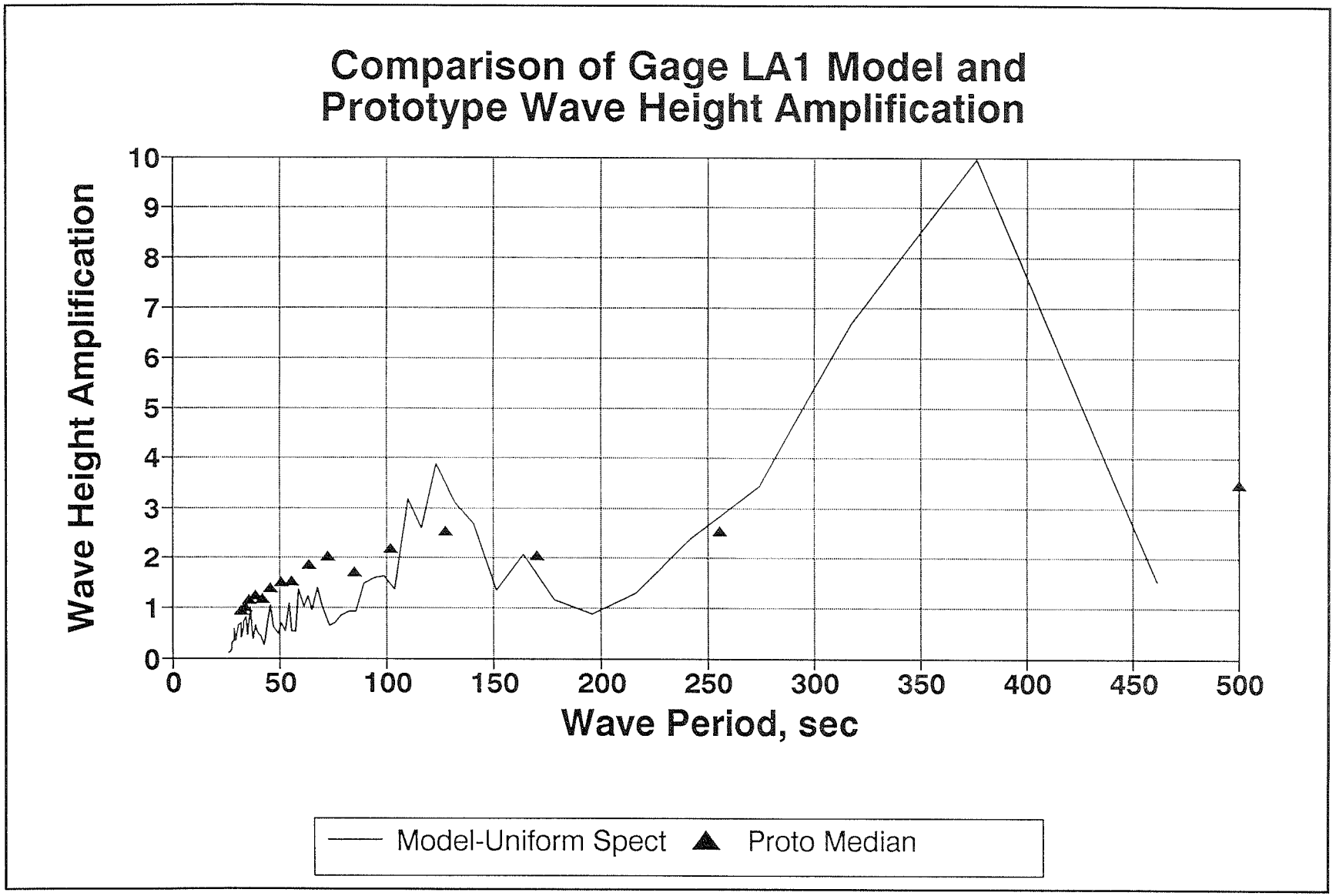
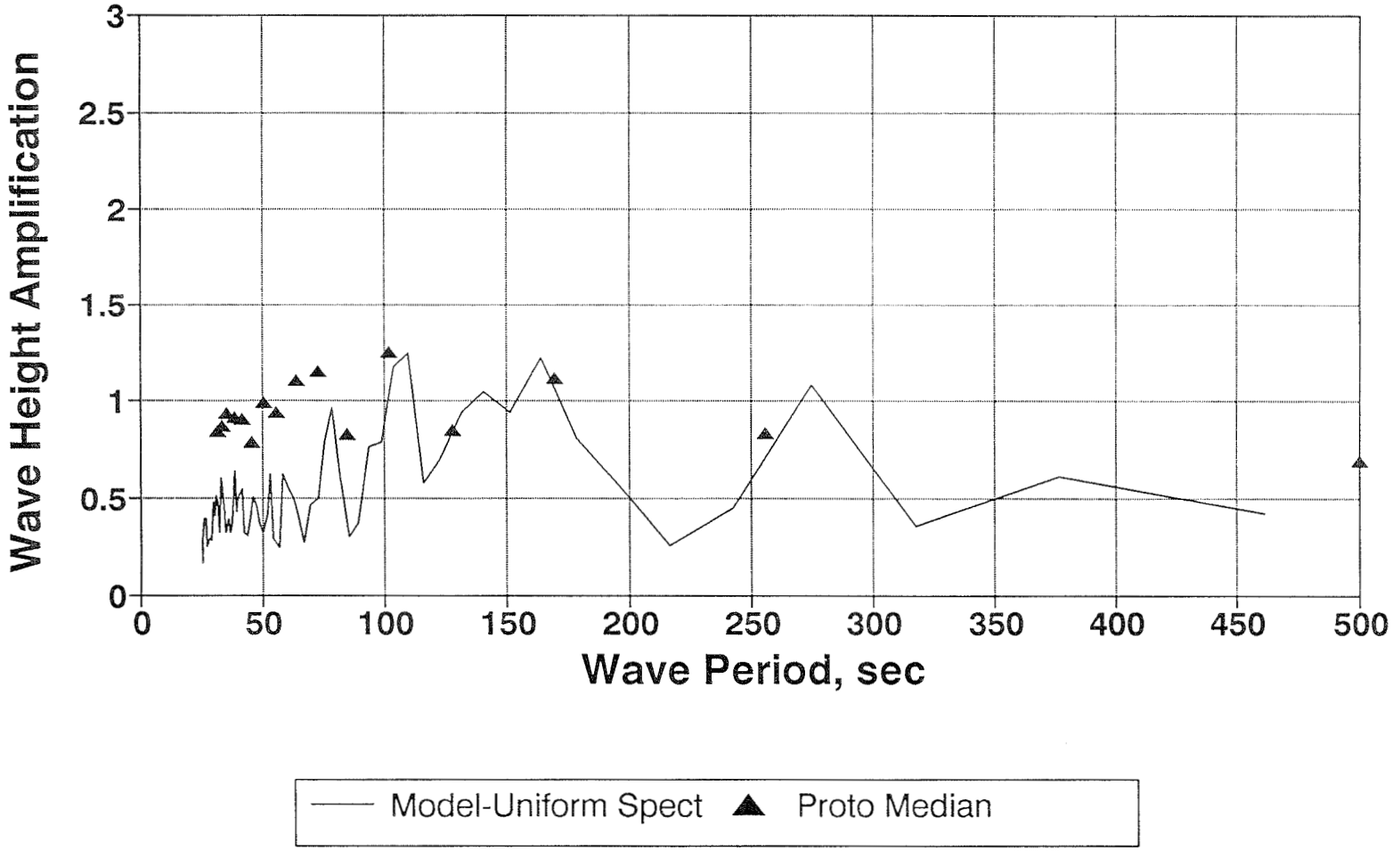

Comparison of Gage LA1 Model and Prototype Wave Height Amplification
Wave Height Amplification
0
1
2
3
4
5
6
7
8
9
10
0
50
100
150
200
250
300
350
400
450
500
Wave Period, sec
Model-Uniform Spect
Proto Median

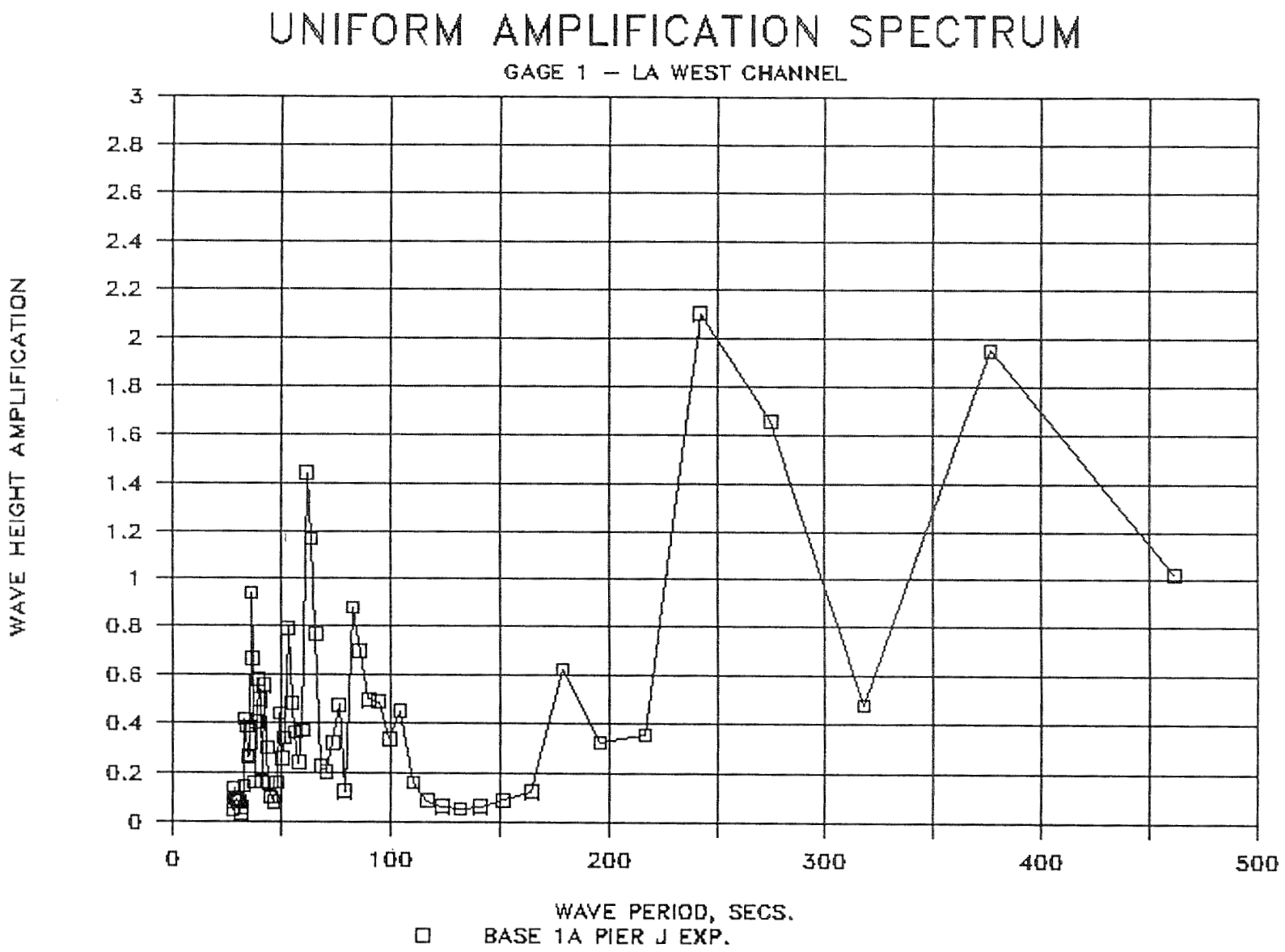
Plate 11

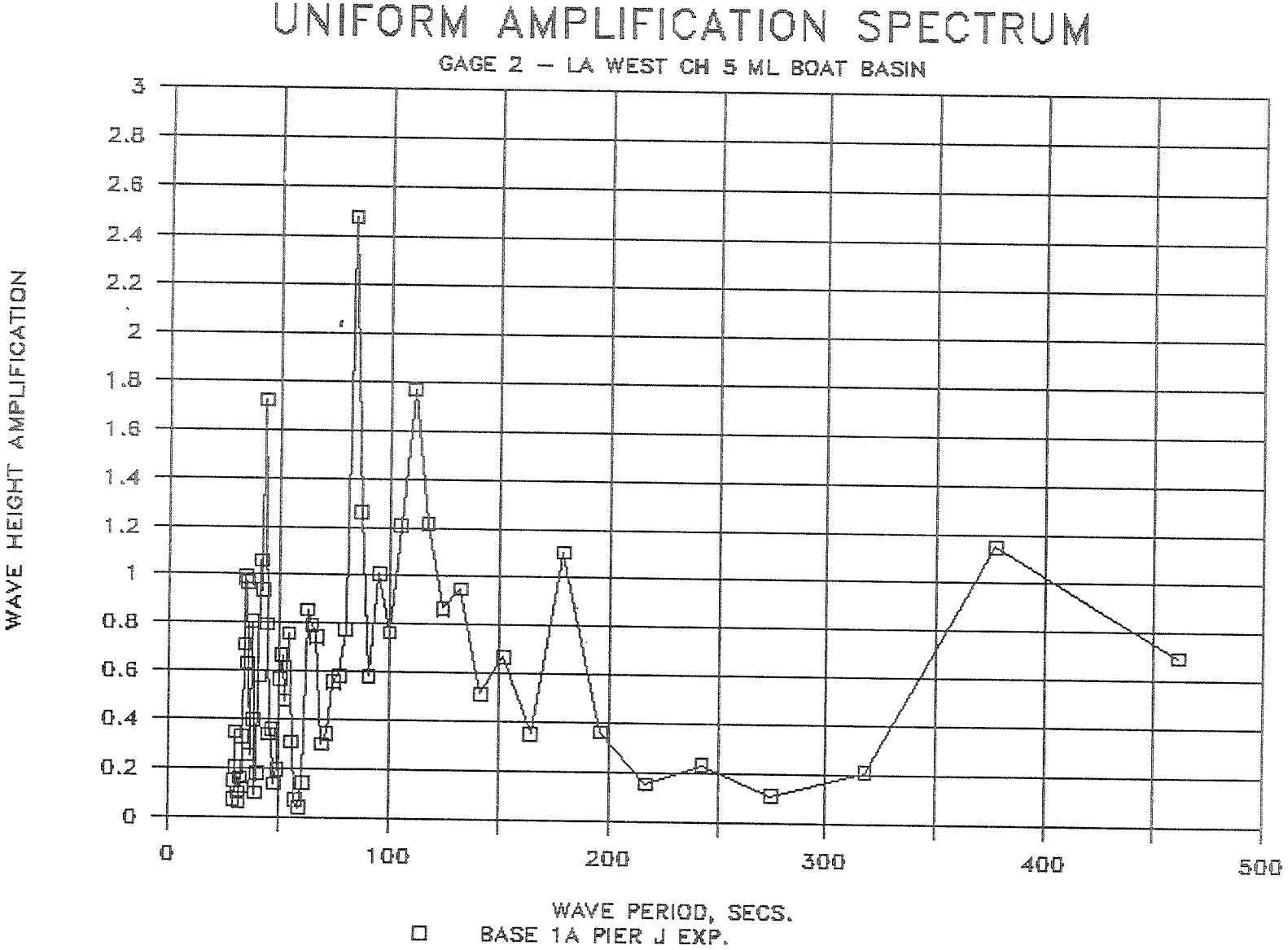
Plate 12

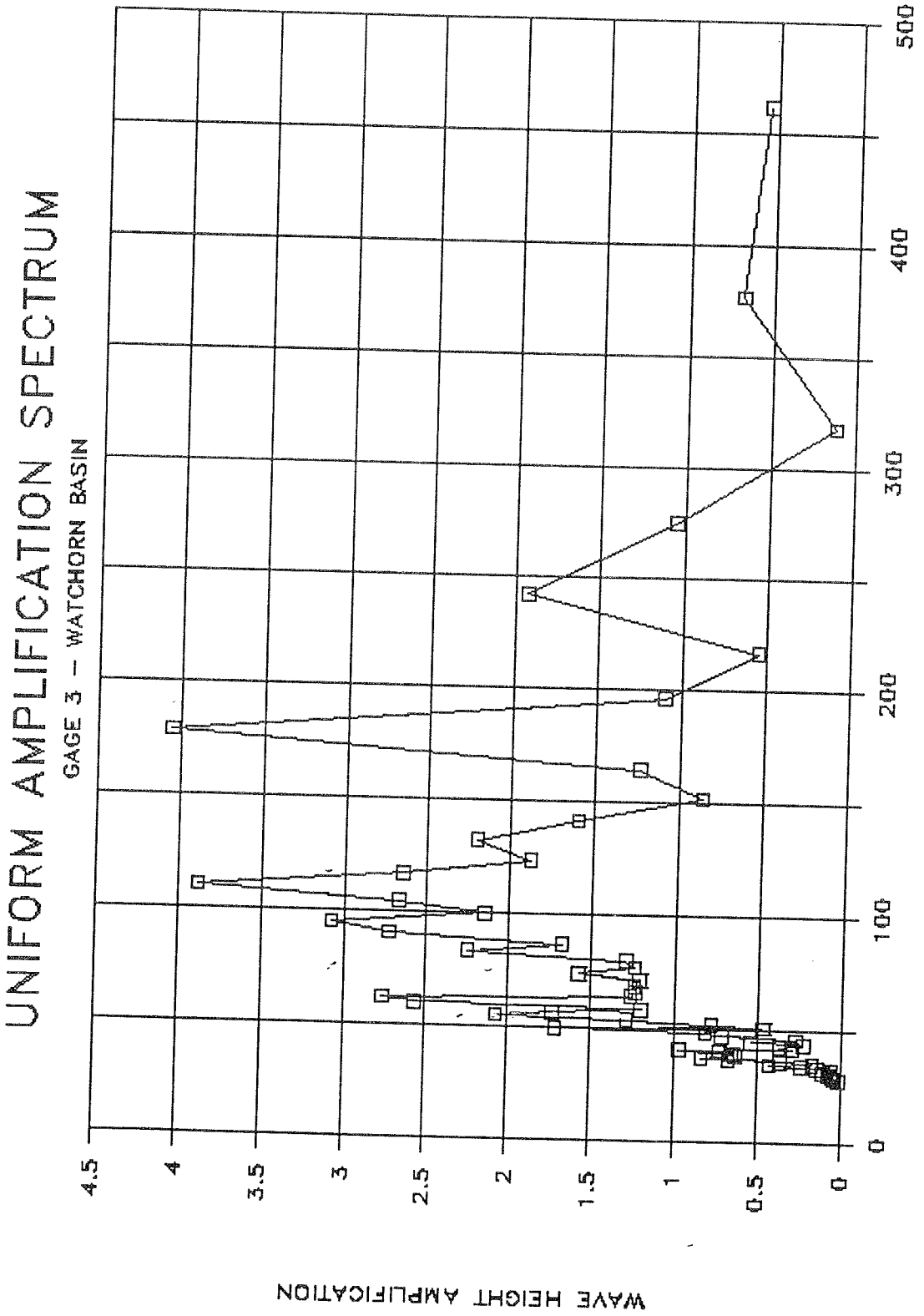
Comparison of Gage LA4 Model and Prototype Wave Height Amplification

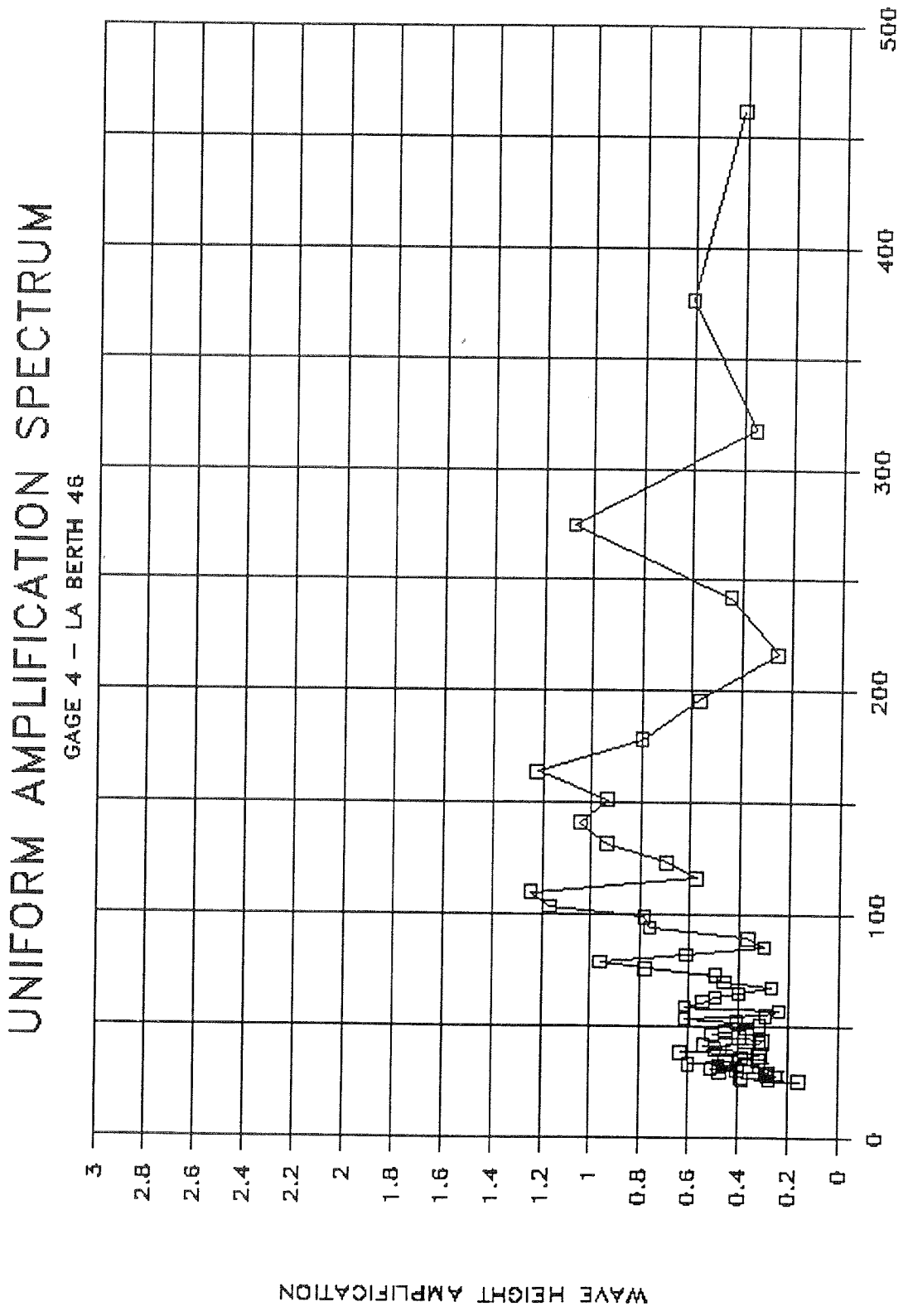


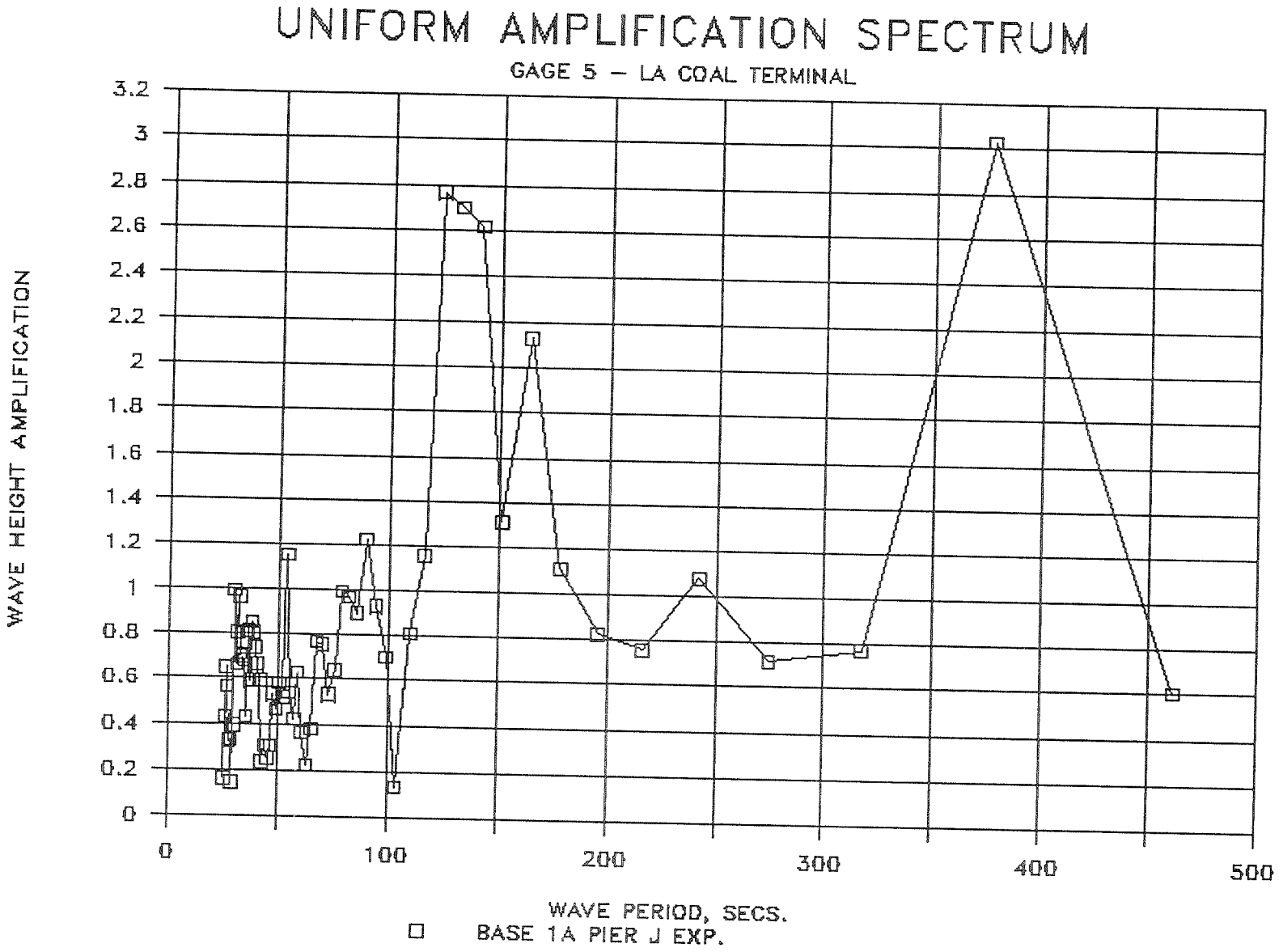
APPENDIX A: BASE CONDITION WAVE SPECTRAL AMPLIFICATION DATA

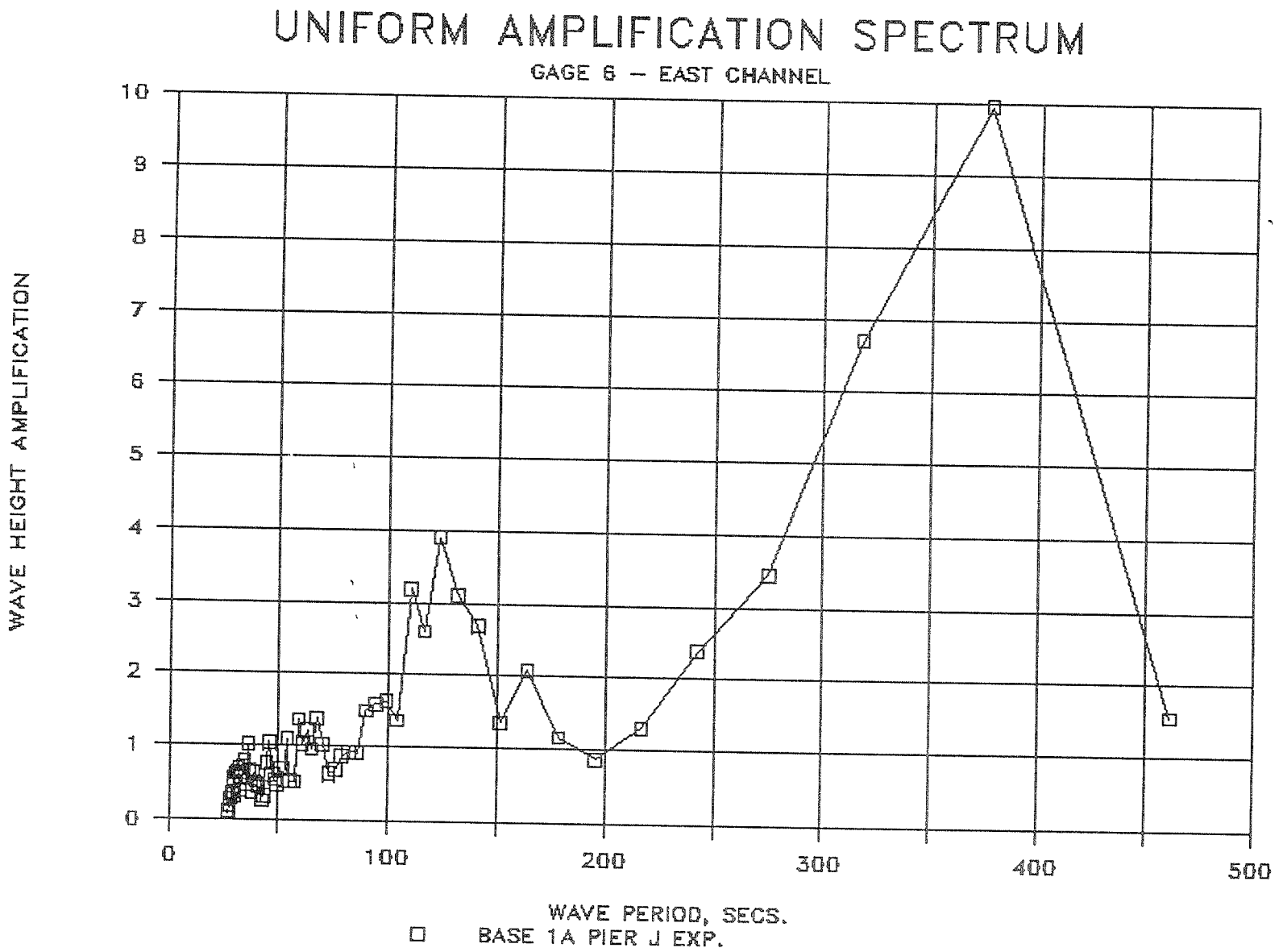

UNIFORM AMPLIFICATION SPECTRUM
GAGE 1 – LA WEST CHANNEL
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.


UNIFORM AMPLIFICATION SPECTRUM
GAGE 2 – LA WEST CH 5 ML BOAT BASIN
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.


UNIFORM AMPLIFICATION SPECTRUM
GAGE 3 – WATCHORN BASIN
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

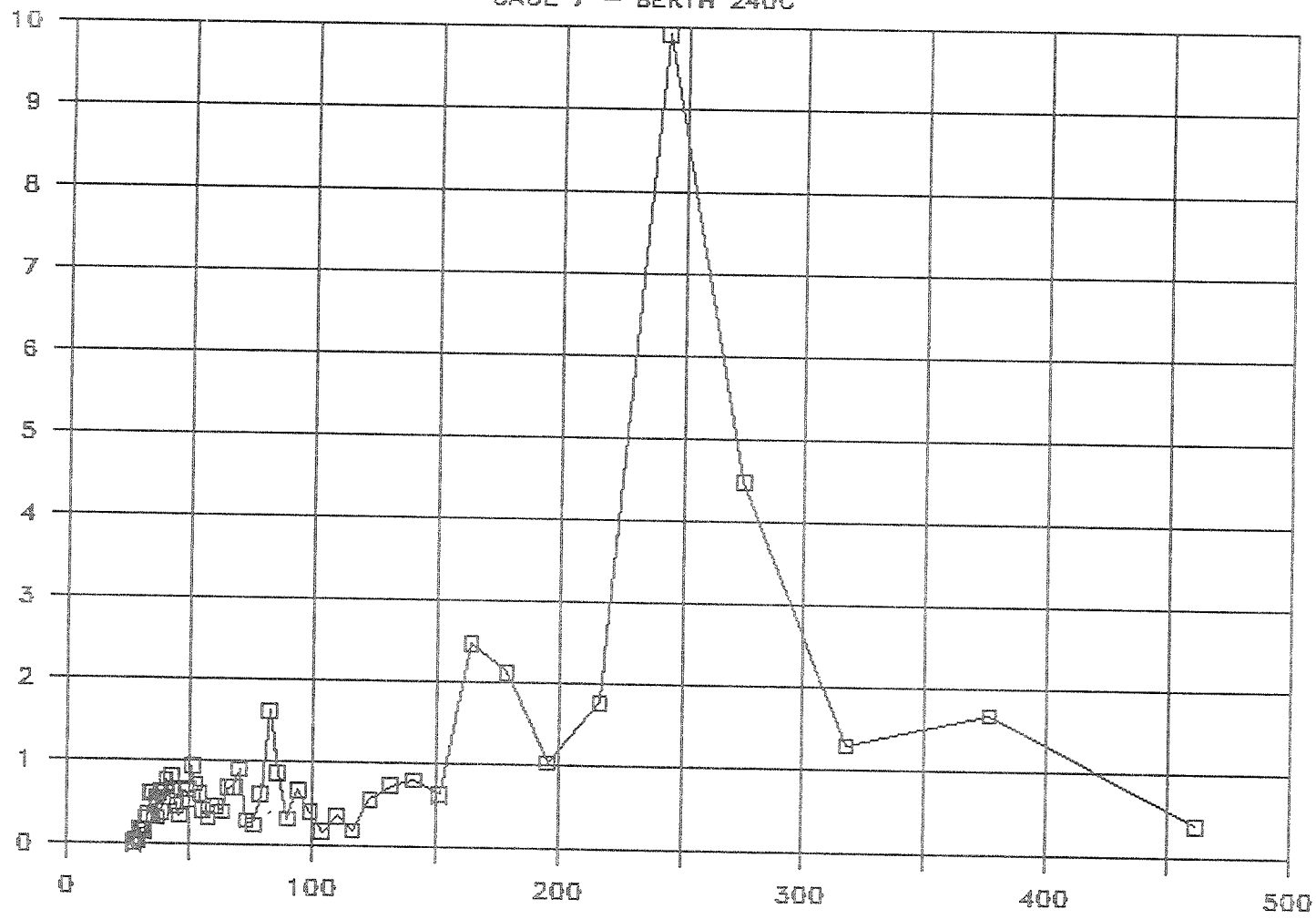

UNIFORM AMPLIFICATION SPECTRUM
GAGE 4 – LA BERTH 46
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
0
100
200
300
400
500


UNIFORM AMPLIFICATION SPECTRUM
GAGE 5 – LA COAL TERMINAL
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.


UNIFORM AMPLIFICATION SPECTRUM
GAGE 6 – EAST CHANNEL
WAVE HEIGHT AMPLIFICATION
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

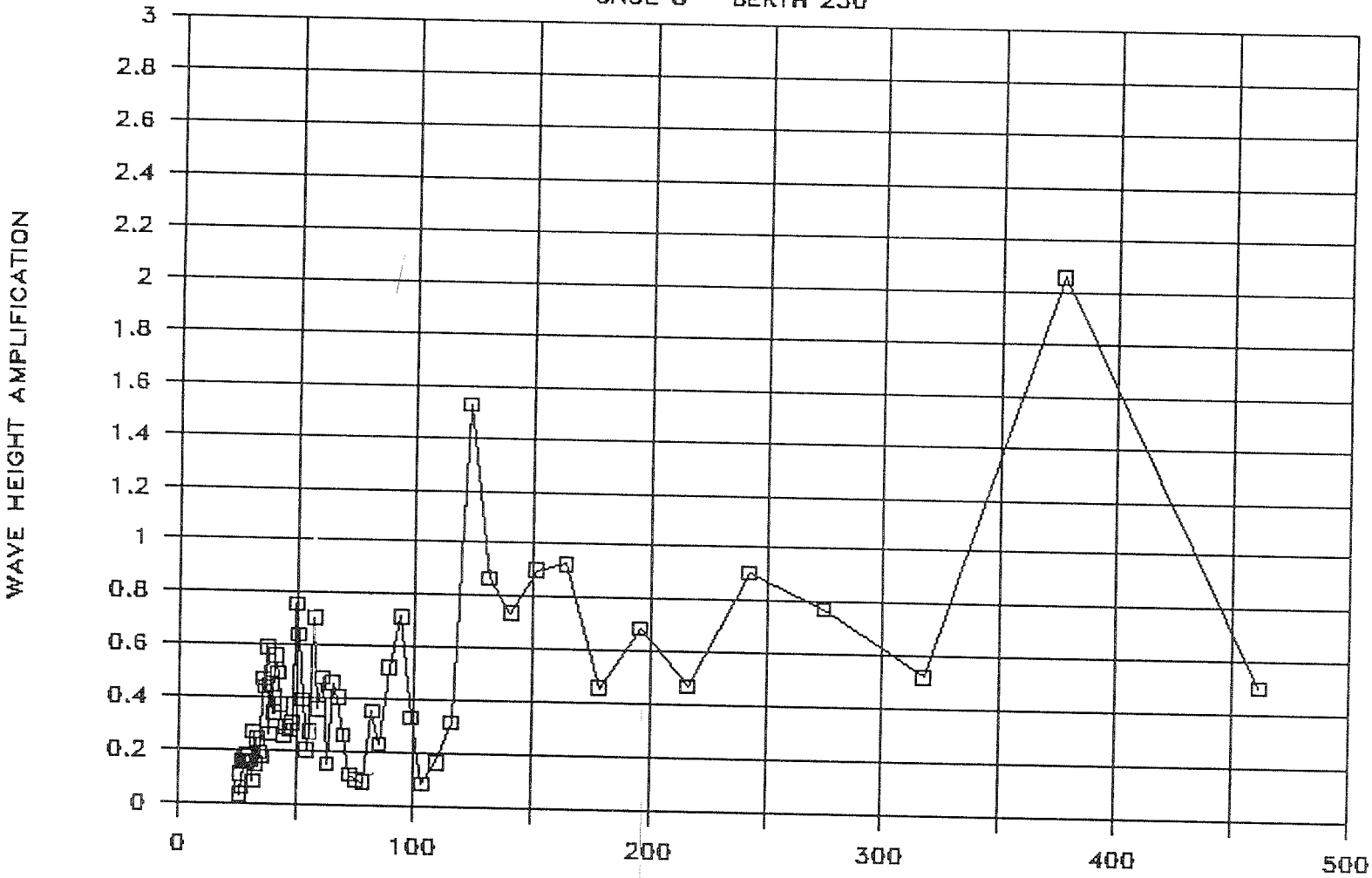
UNIFORM AMPLIFICATION SPECTRUM

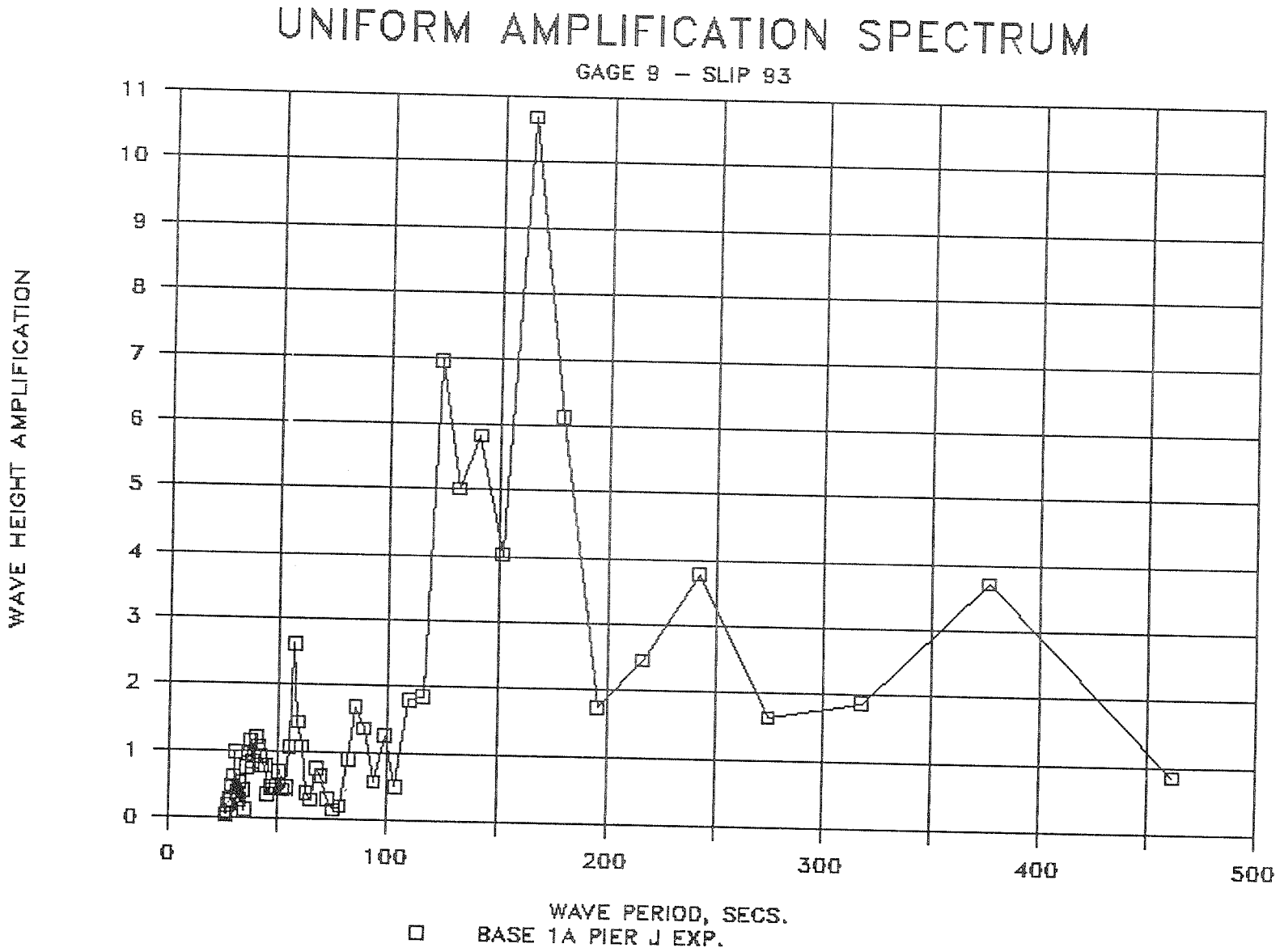
GAGE 7 – BERTH 240C

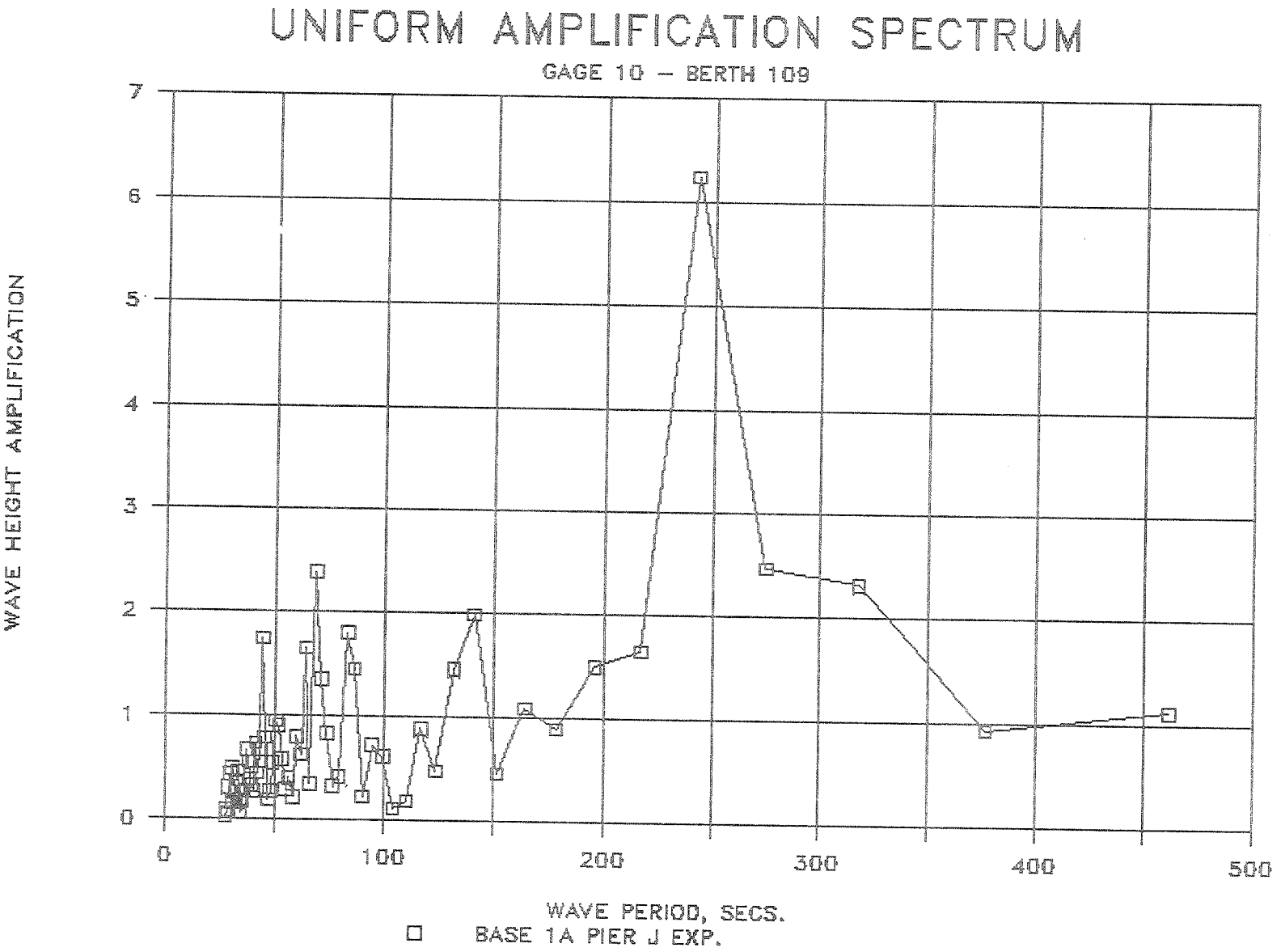


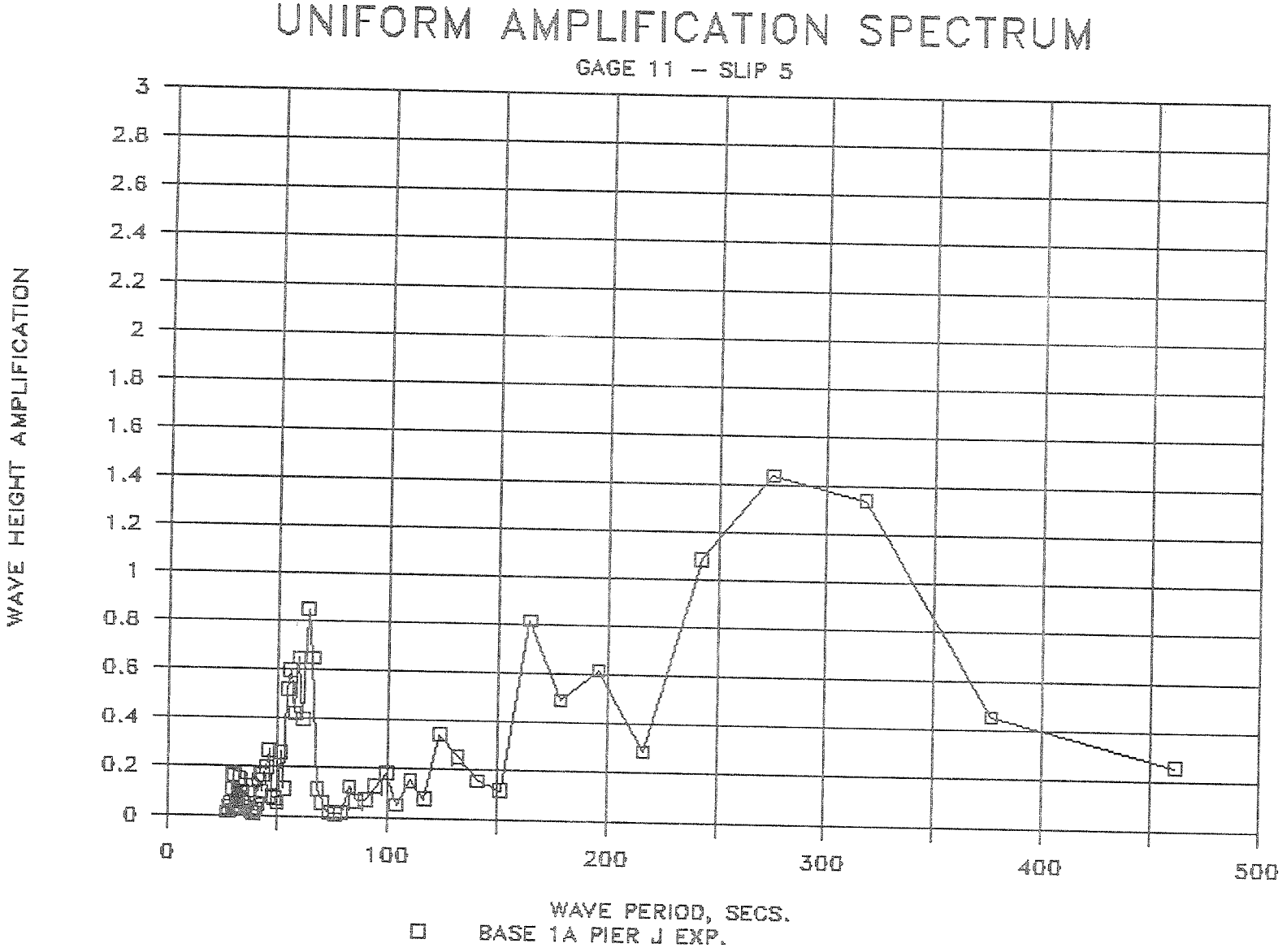
UNIFORM AMPLIFICATION SPECTRUM

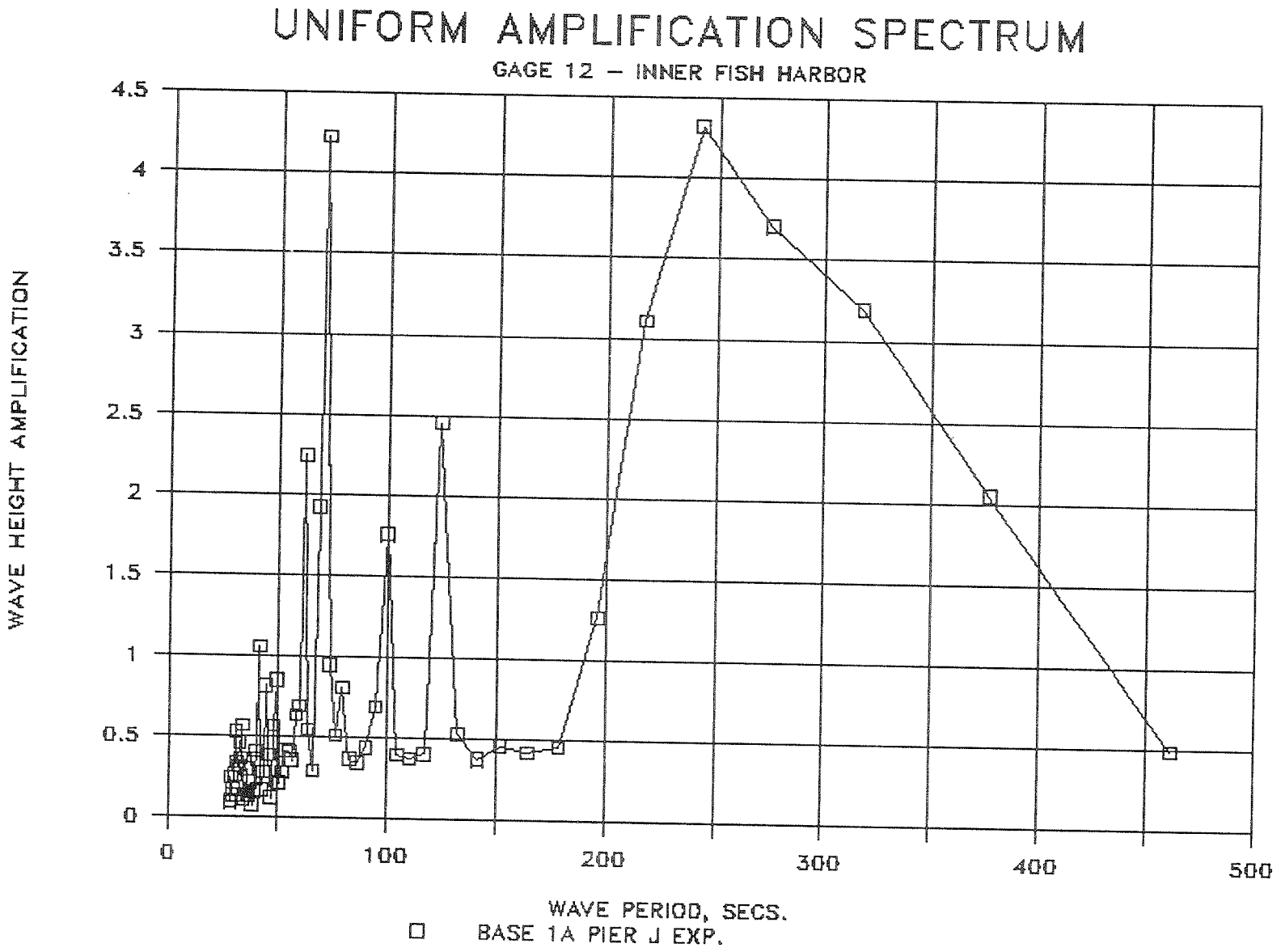
GAGE 8 – BERTH 230

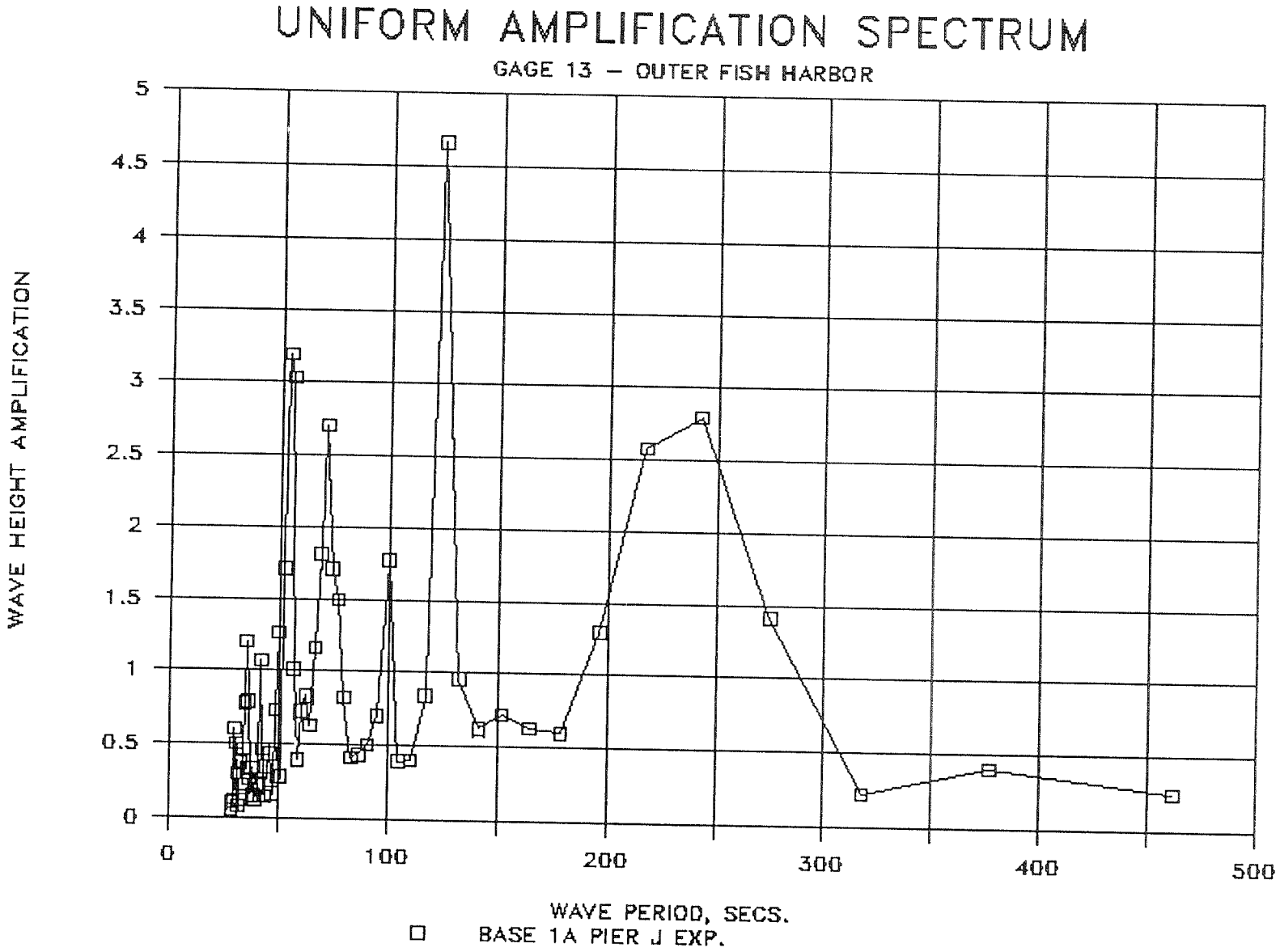


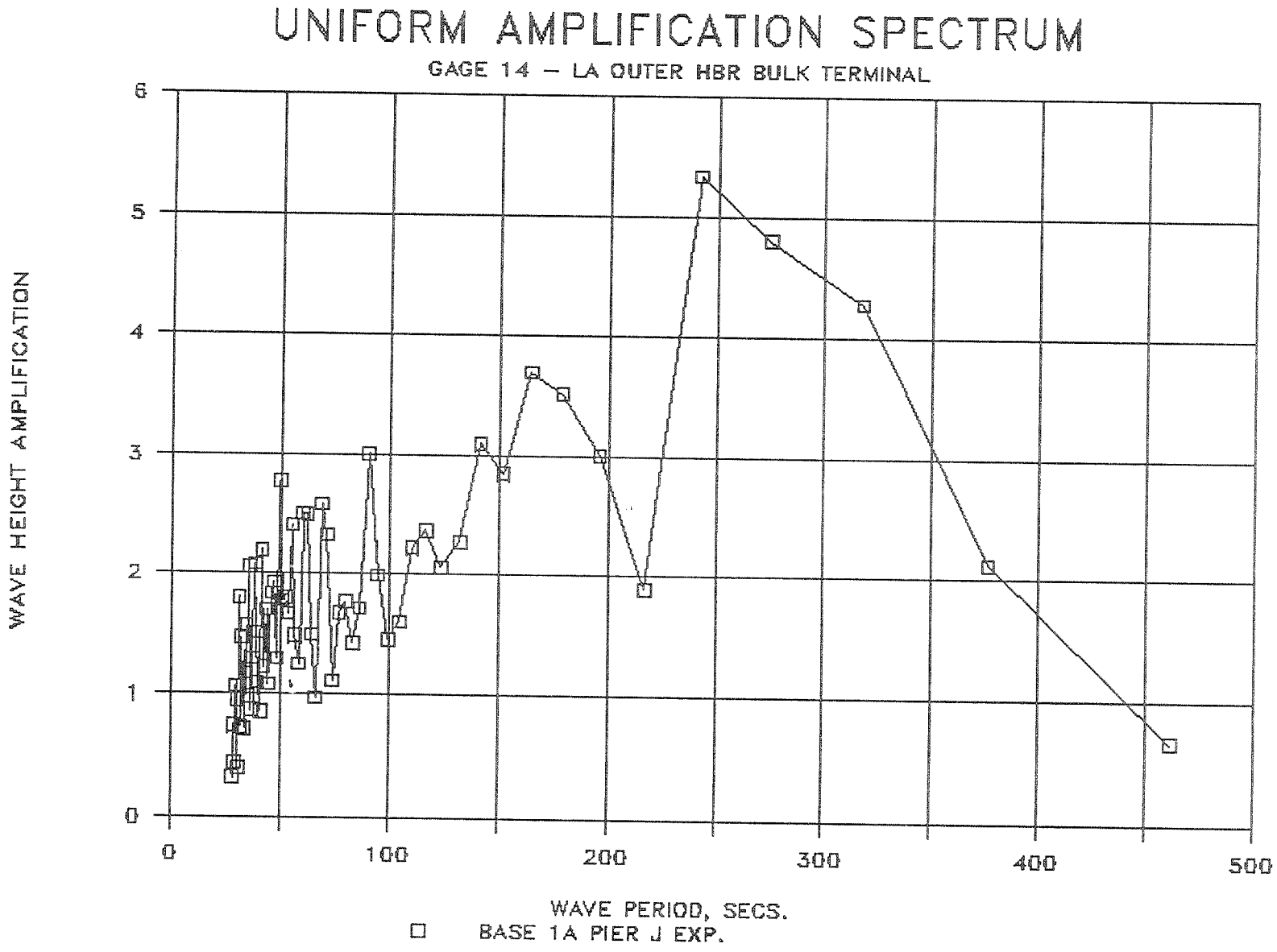

UNIFORM AMPLIFICATION SPECTRUM
GAGE 9 – SLIP 93
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
10
11
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

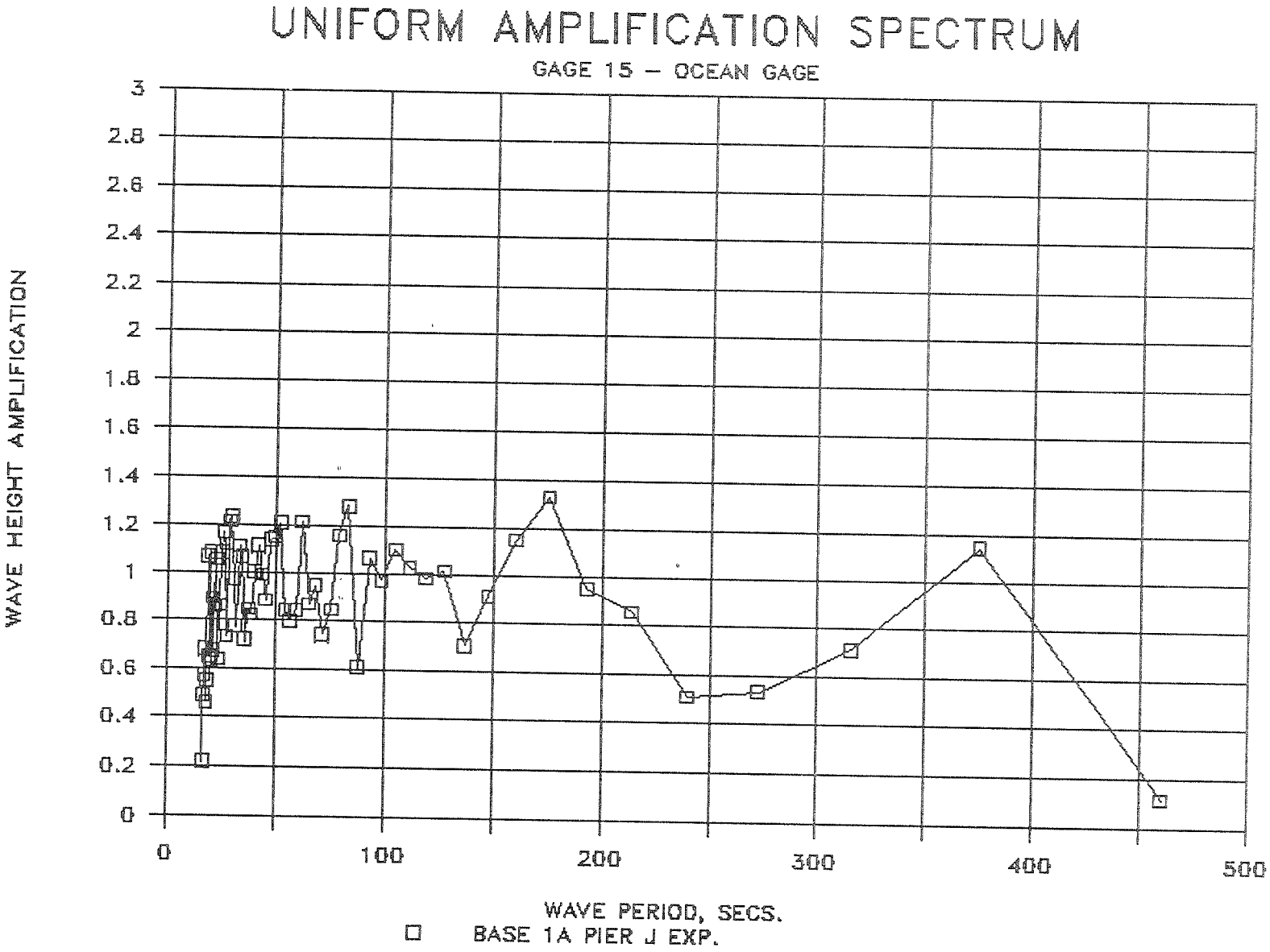

UNIFORM AMPLIFICATION SPECTRUM
GAGE 10 – BERTH 109
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

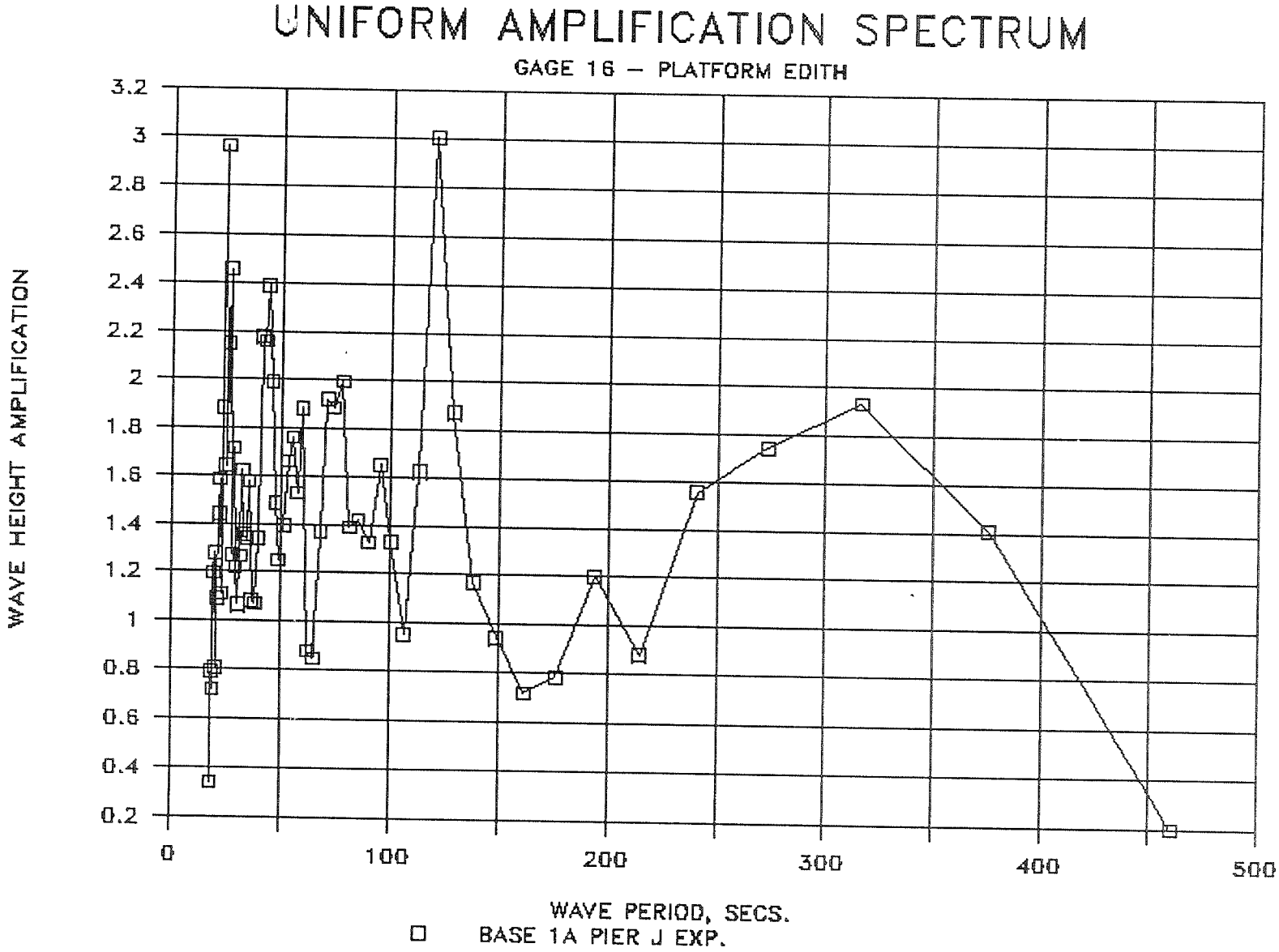

UNIFORM AMPLIFICATION SPECTRUM
GAGE 11 – SLIP 5
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

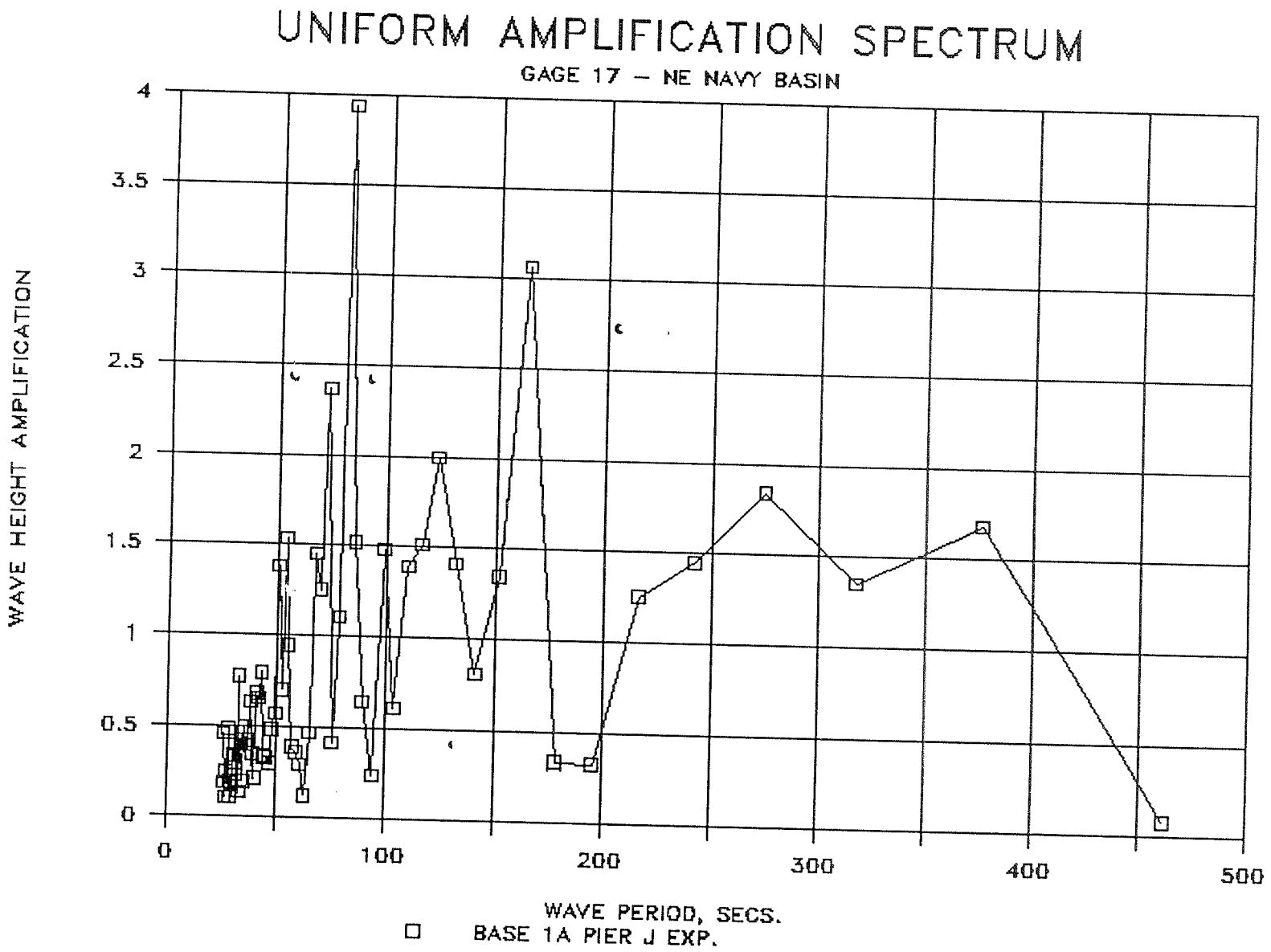

UNIFORM AMPLIFICATION SPECTRUM
GAGE 12 – INNER FISH HARBOR
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

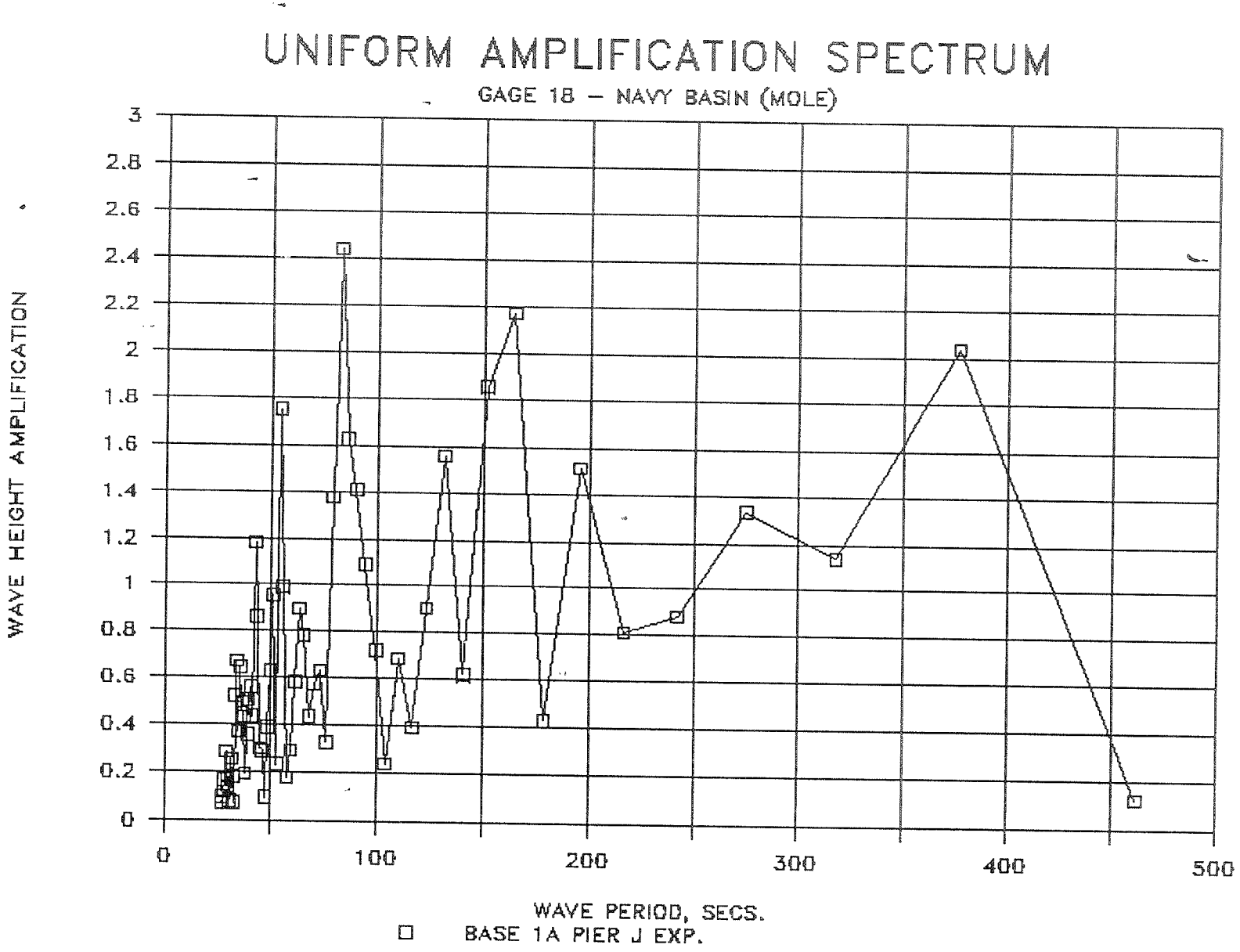

UNIFORM AMPLIFICATION SPECTRUM
GAGE 13 – OUTER FISH HARBOR
WAVE HEIGHT AMPLIFICATION
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

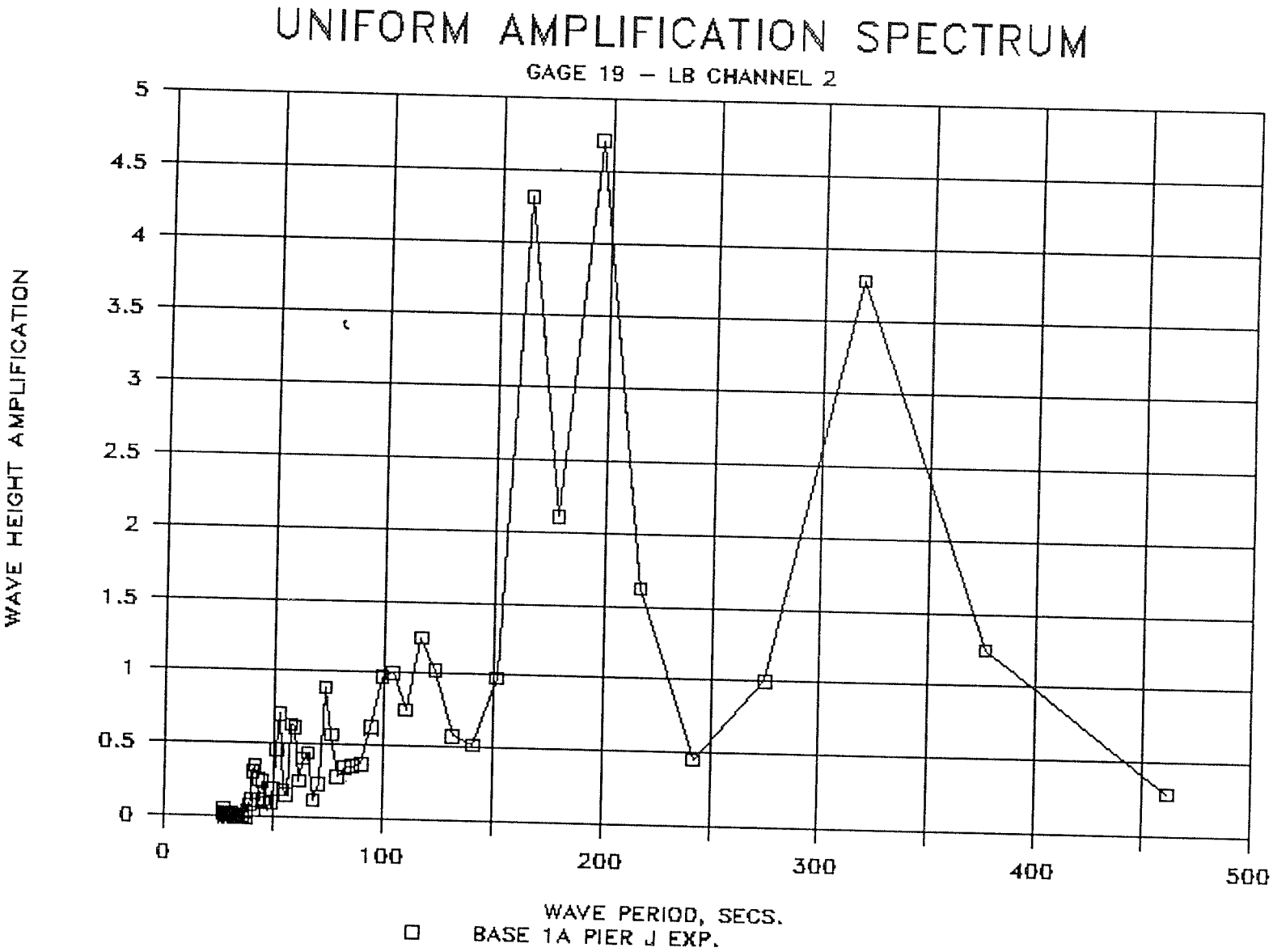

UNIFORM AMPLIFICATION SPECTRUM
GAGE 14 — LA OUTER HBR BULK TERMINAL
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

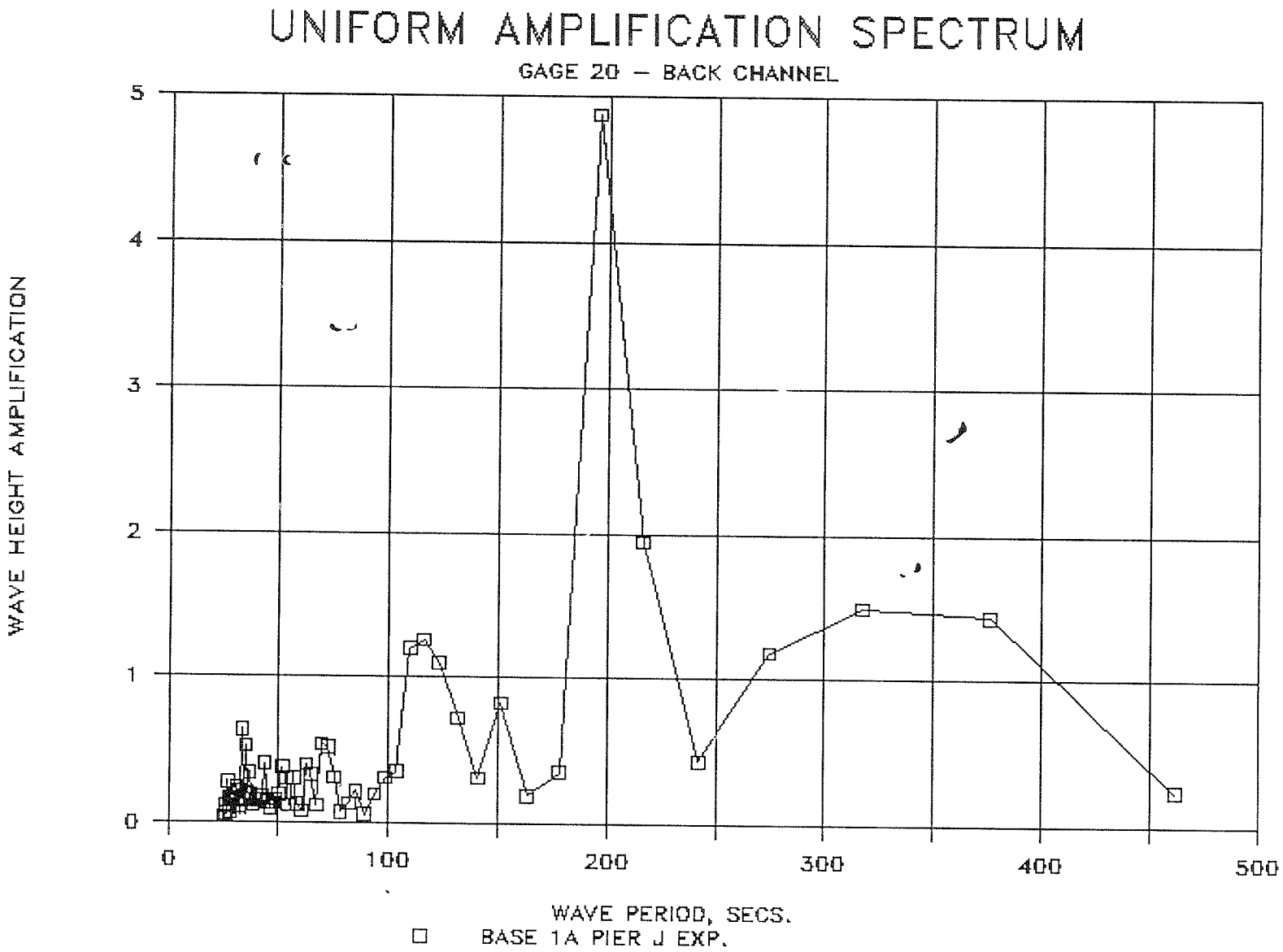

UNIFORM AMPLIFICATION SPECTRUM
GAGE 15 – OCEAN GAGE
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

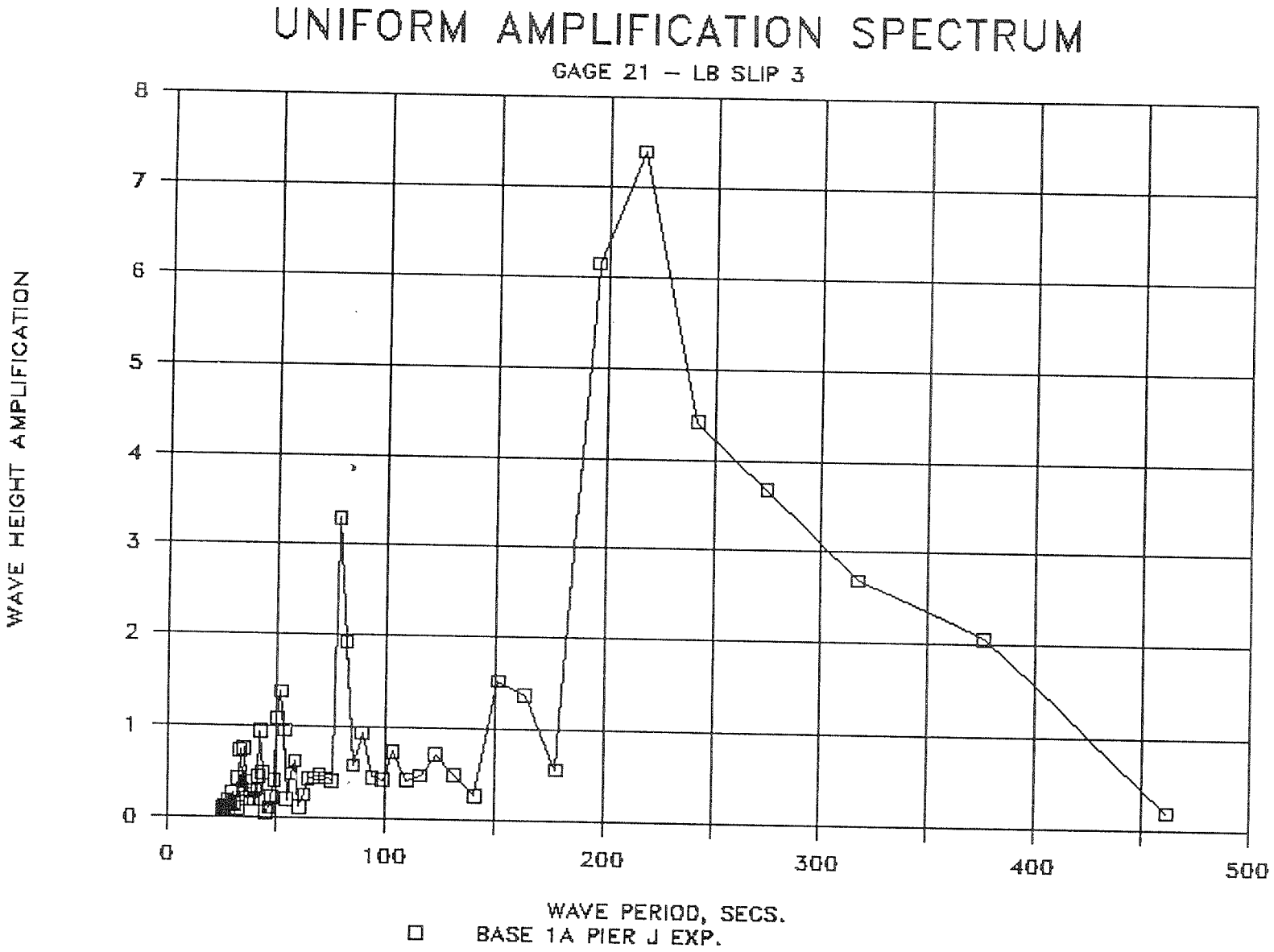

UNIFORM AMPLIFICATION SPECTRUM
GAGE 16 – PLATFORM EDITH
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

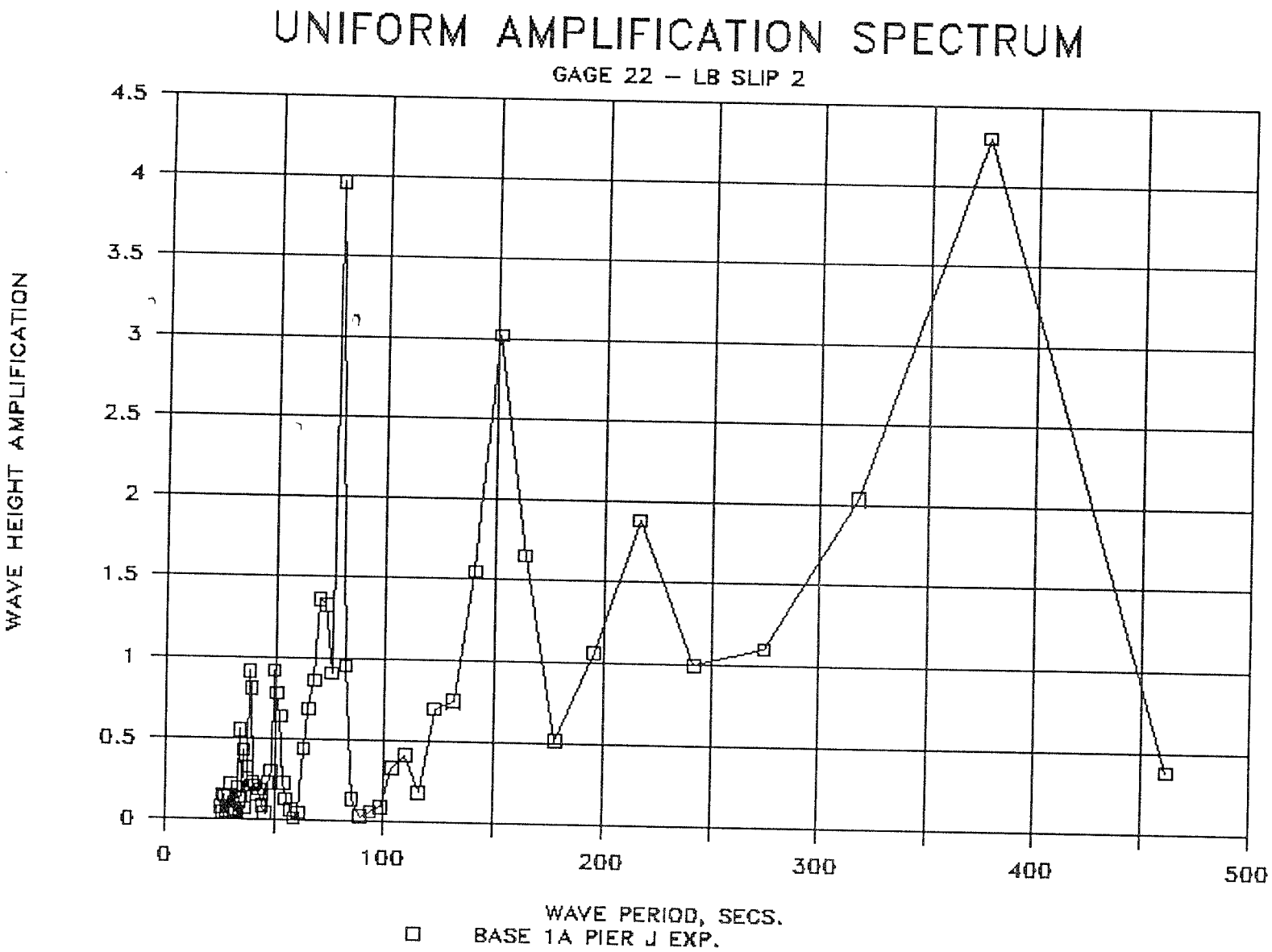

UNIFORM AMPLIFICATION SPECTRUM
GAGE 17 – NE NAVY BASIN
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

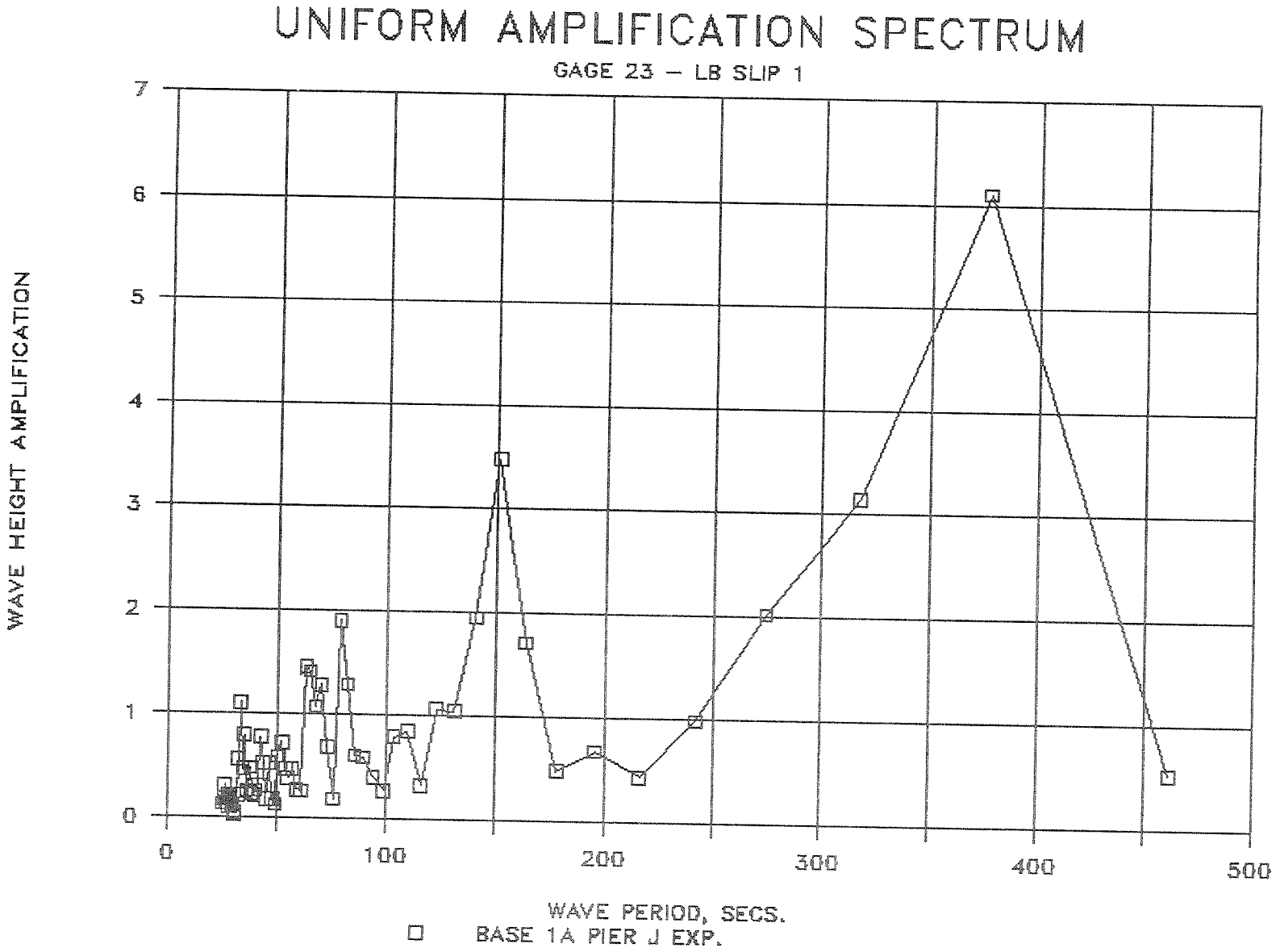

UNIFORM AMPLIFICATION SPECTRUM
GAGE 18 – NAVY BASIN (MOLE)
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

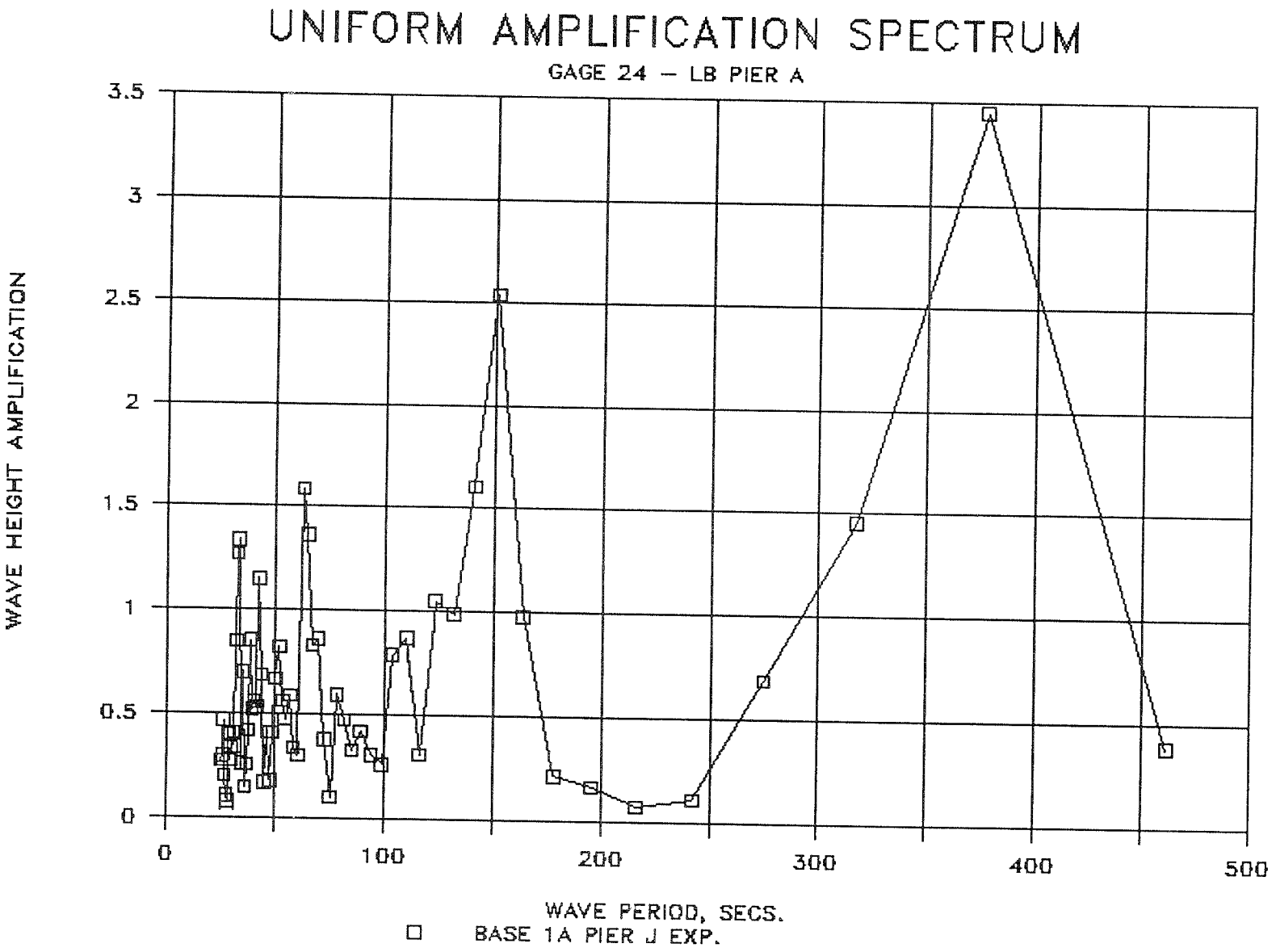

UNIFORM AMPLIFICATION SPECTRUM
GAGE 19 – LB CHANNEL 2
WAVE HEIGHT AMPLIFICATION
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

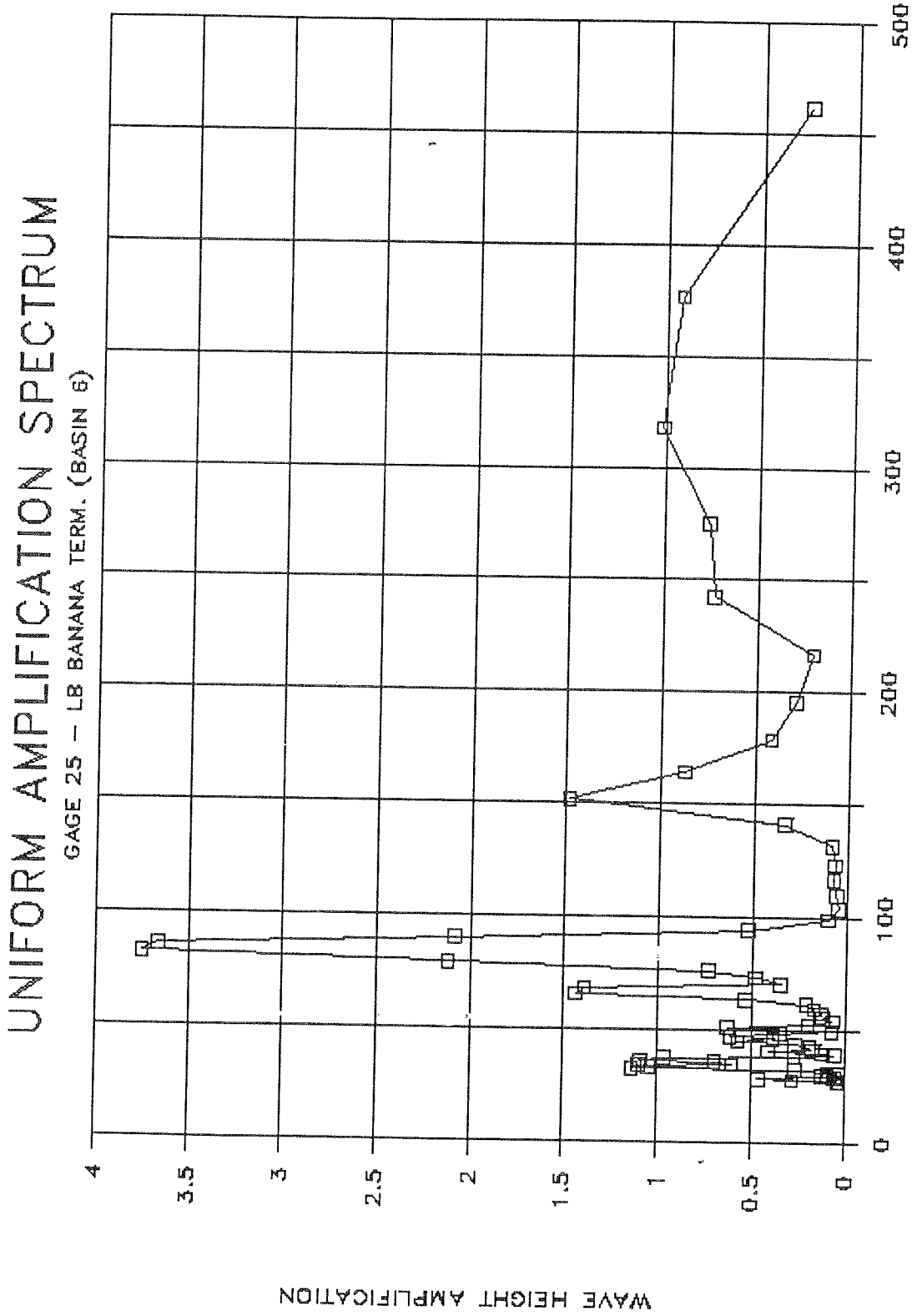

UNIFORM AMPLIFICATION SPECTRUM
GAGE 20 — BACK CHANNEL
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

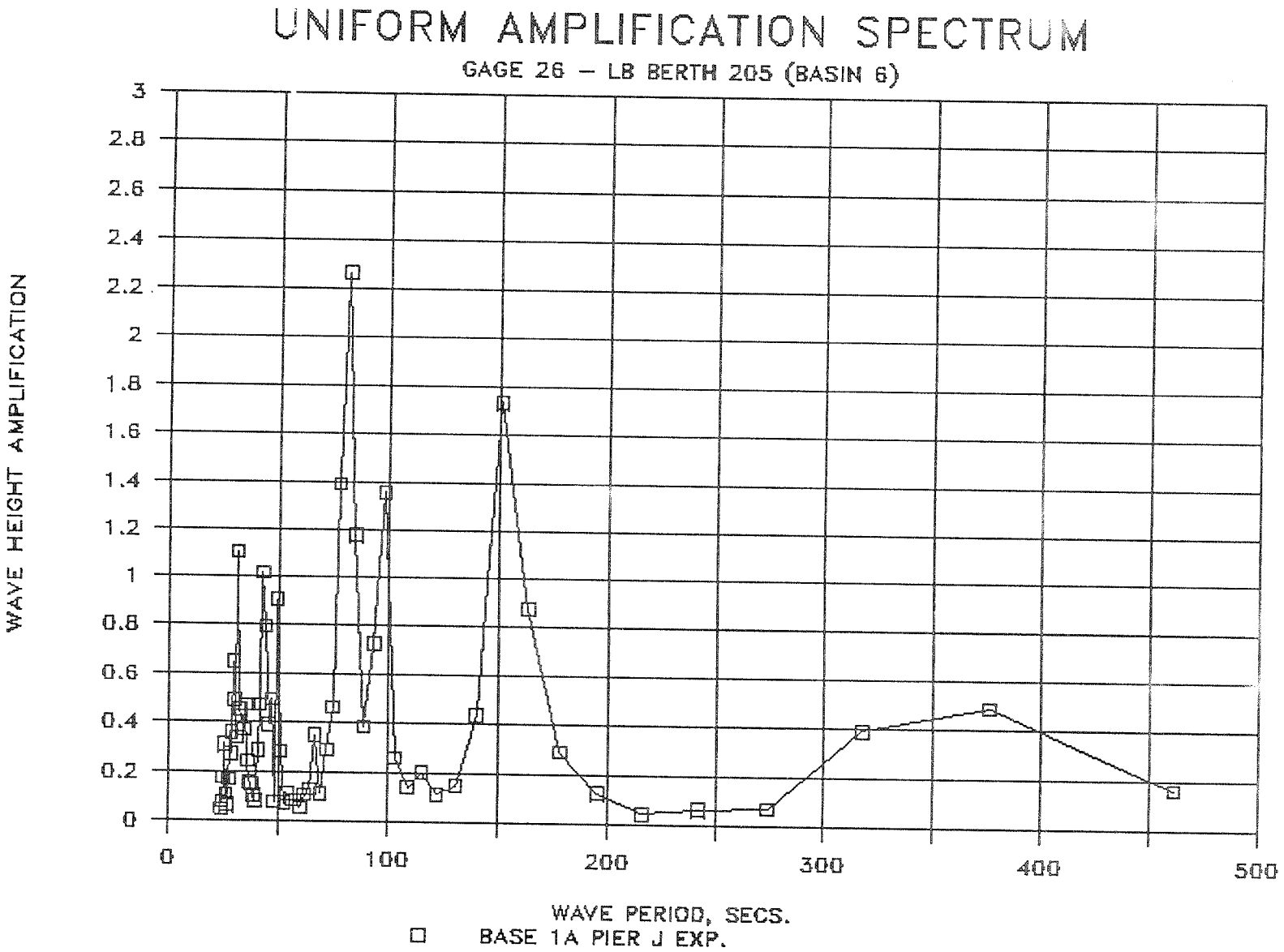

UNIFORM AMPLIFICATION SPECTRUM
GAGE 21 – LB SLIP 3
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

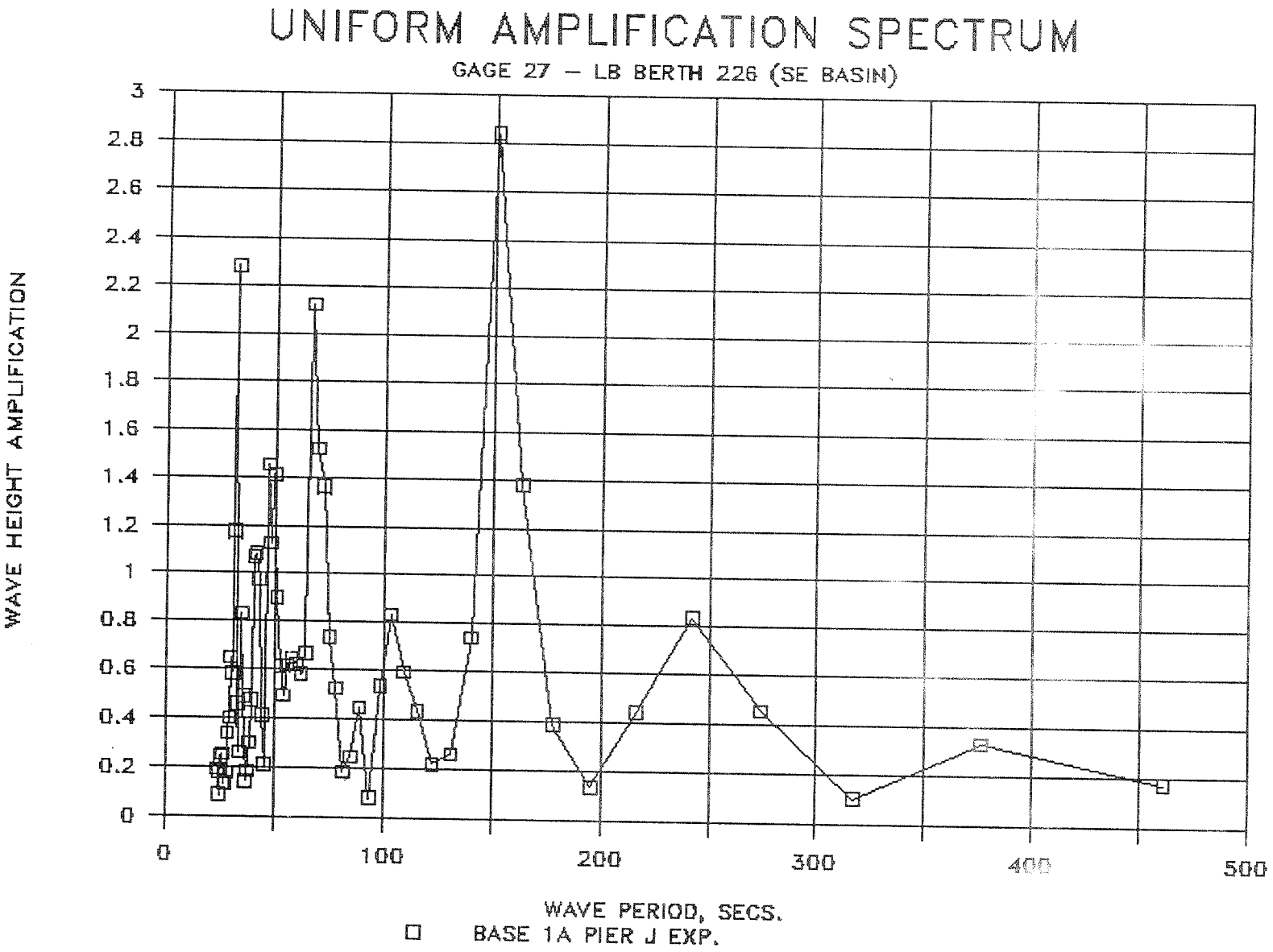

UNIFORM AMPLIFICATION SPECTRUM
GAGE 22 – LB SLIP 2
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

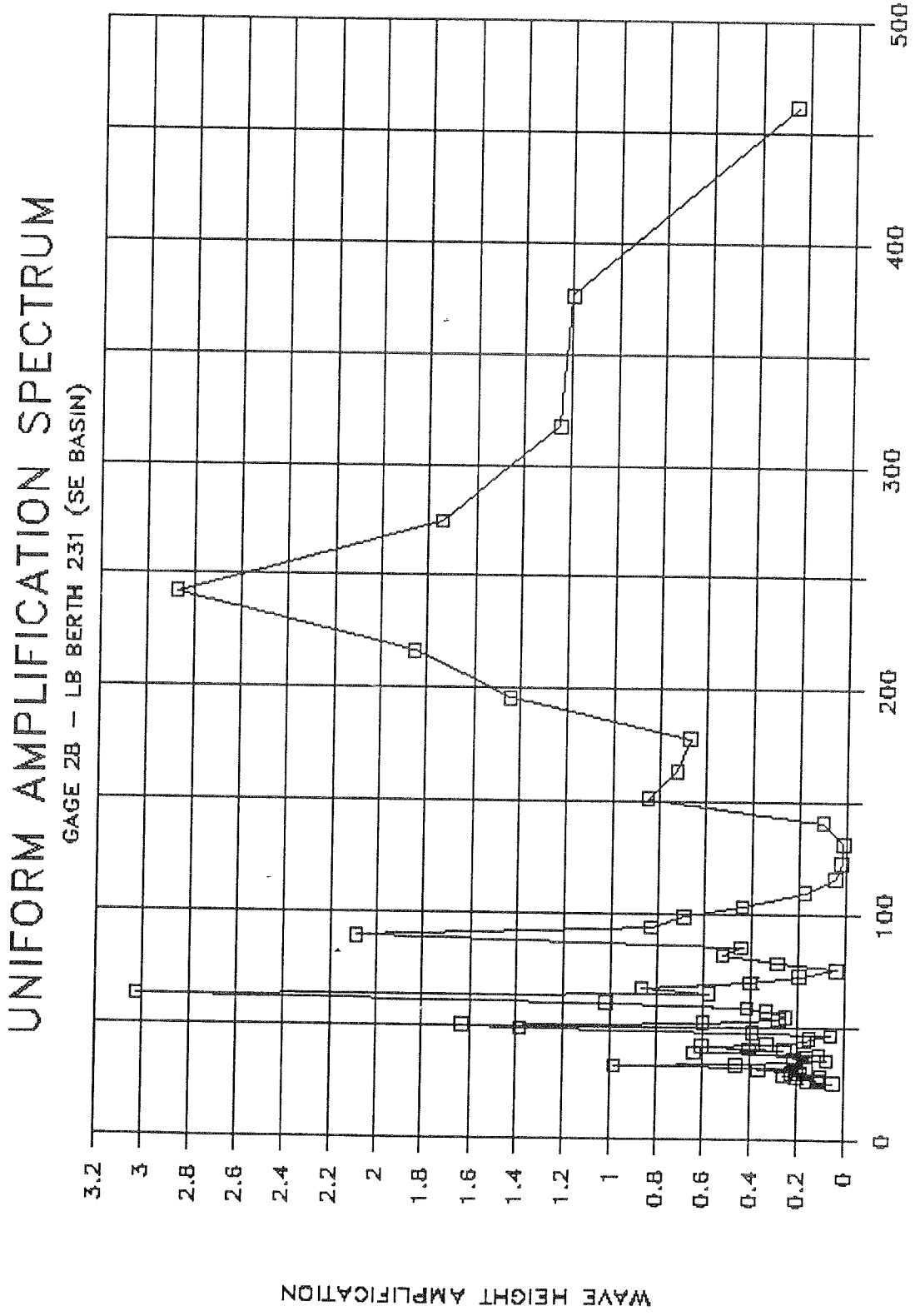

UNIFORM AMPLIFICATION SPECTRUM
GAGE 23 – LB SLIP 1
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

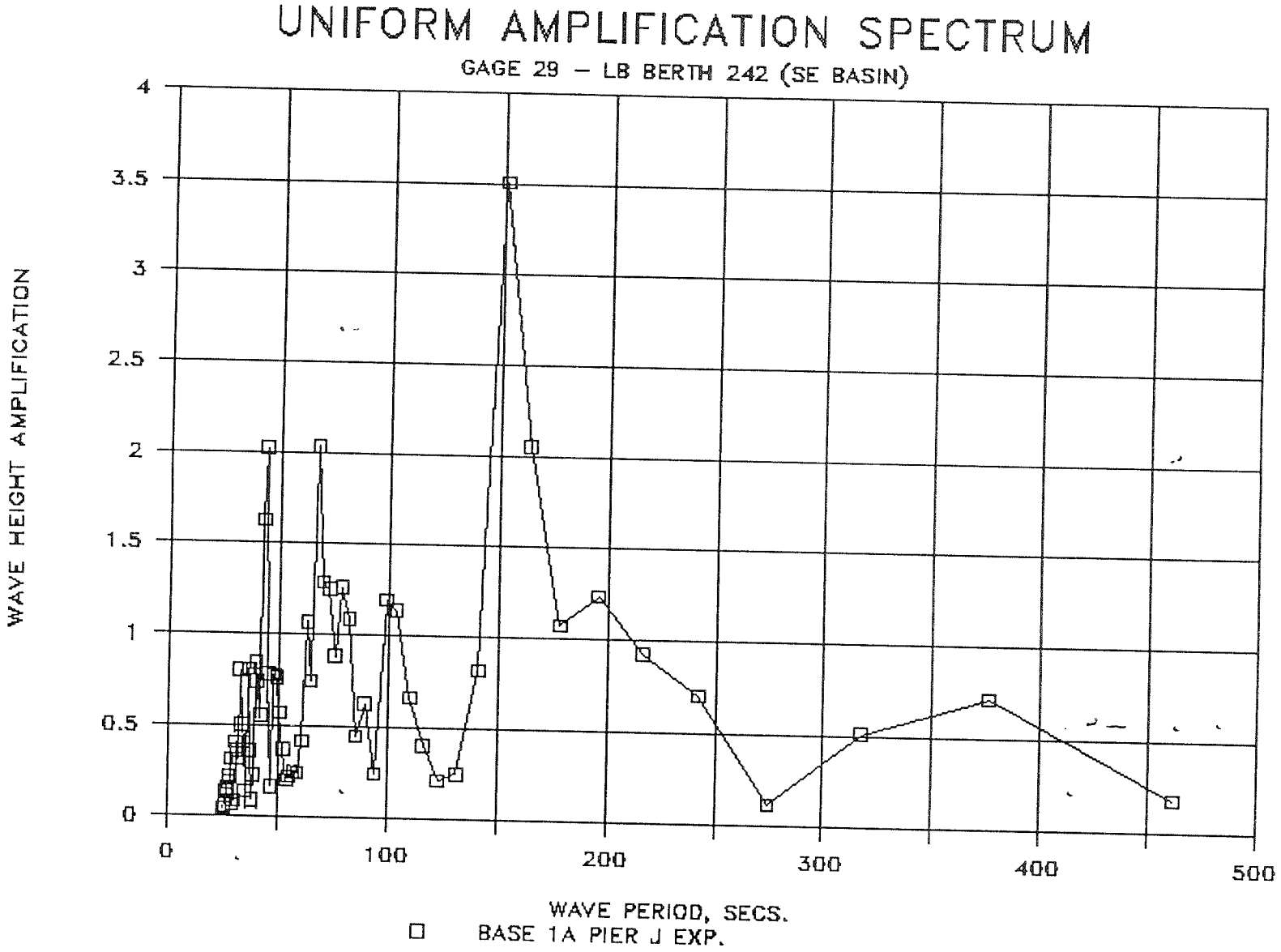

UNIFORM AMPLIFICATION SPECTRUM
GAGE 24 – LB PIER A
WAVE HEIGHT AMPLIFICATION
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

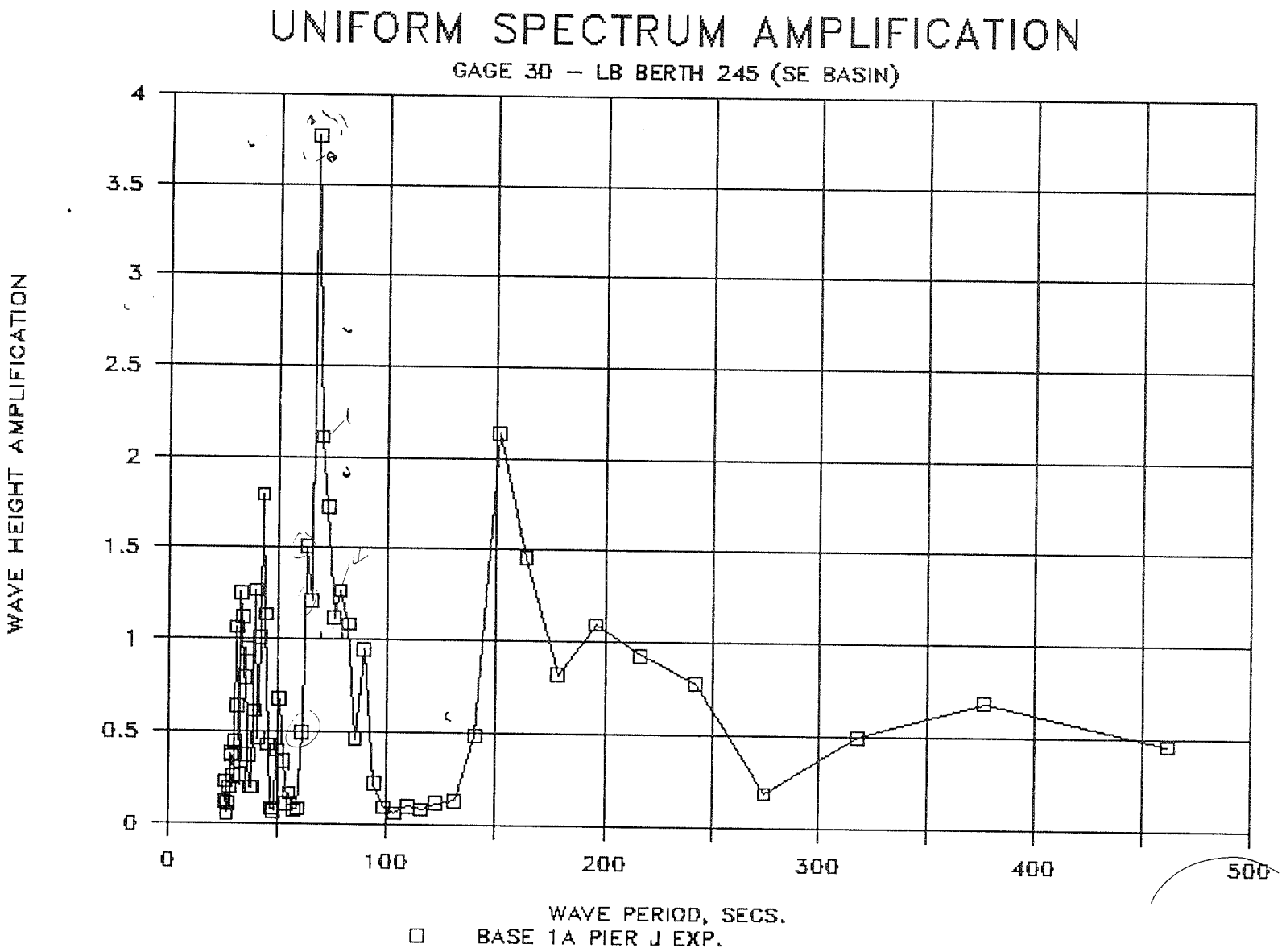

UNIFORM AMPLIFICATION SPECTRUM
GAGE 25 – LB BANANA TERM. (BASIN 6)
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.
0
0.5
1
1.5
2
2.5
3
3.5
4
0
100
200
300
400
500

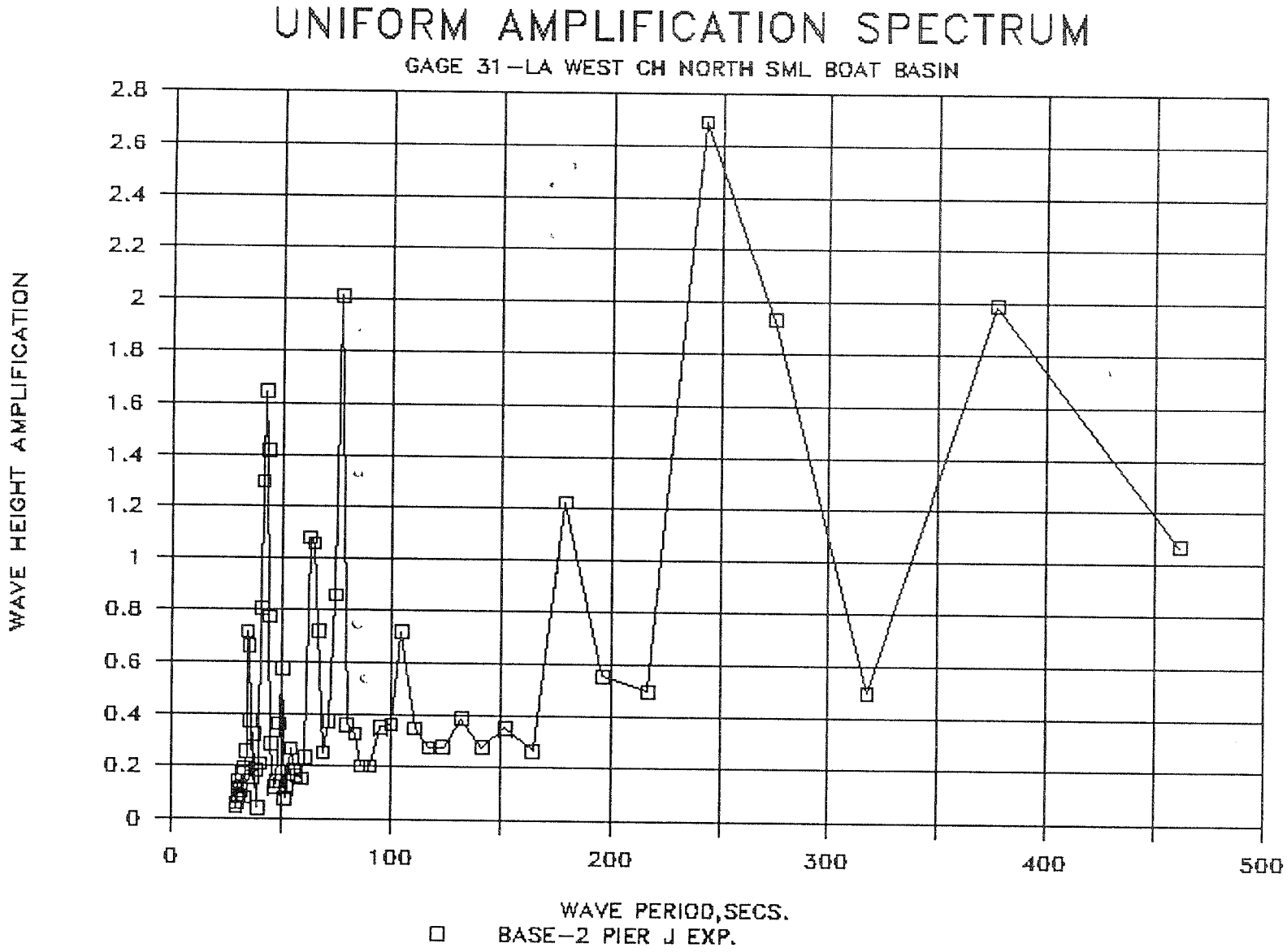

UNIFORM AMPLIFICATION SPECTRUM
GAGE 26 – LB BERTH 205 (BASIN 6)
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

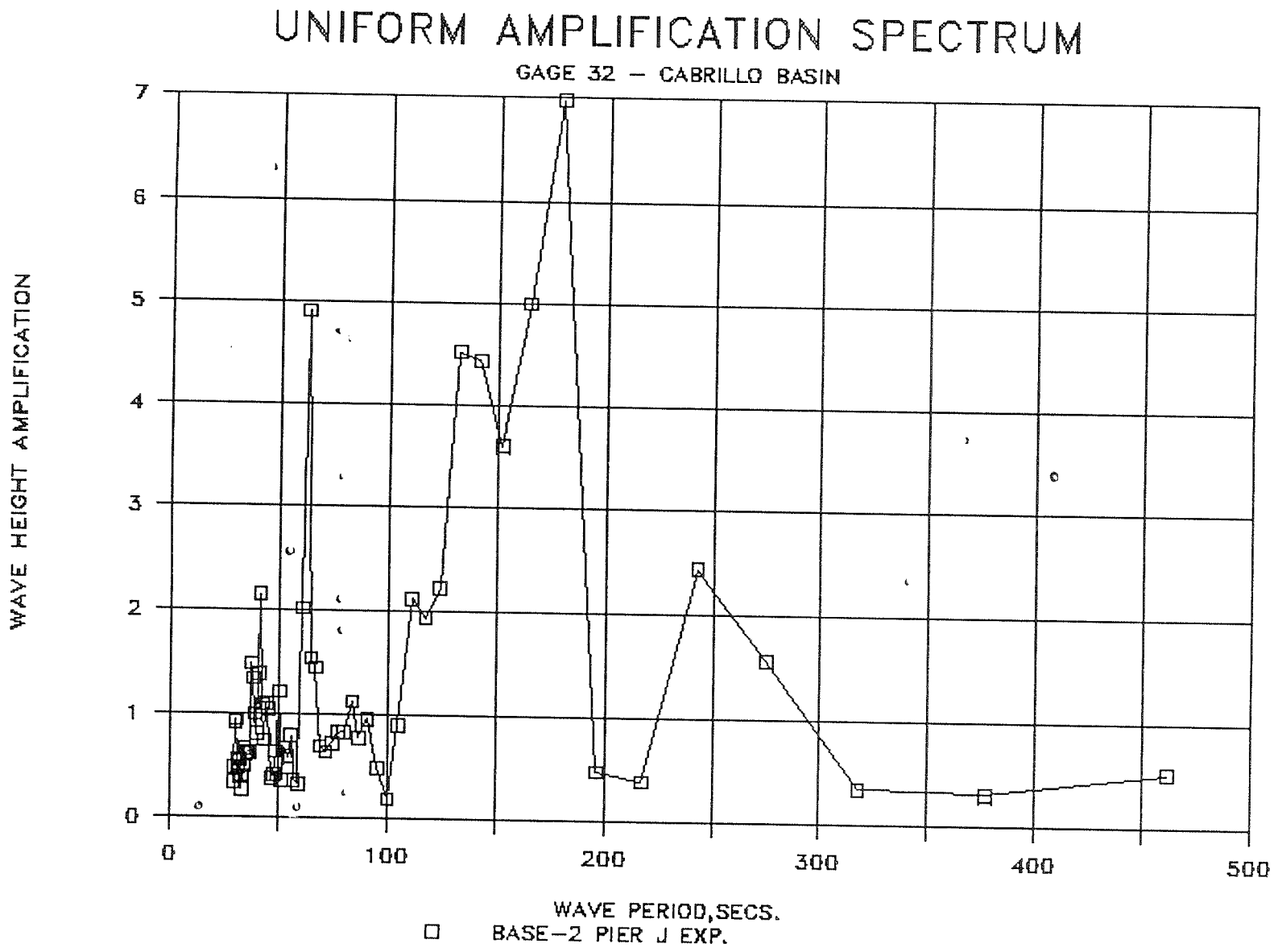

UNIFORM AMPLIFICATION SPECTRUM
GAGE 27 – LB BERTH 226 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

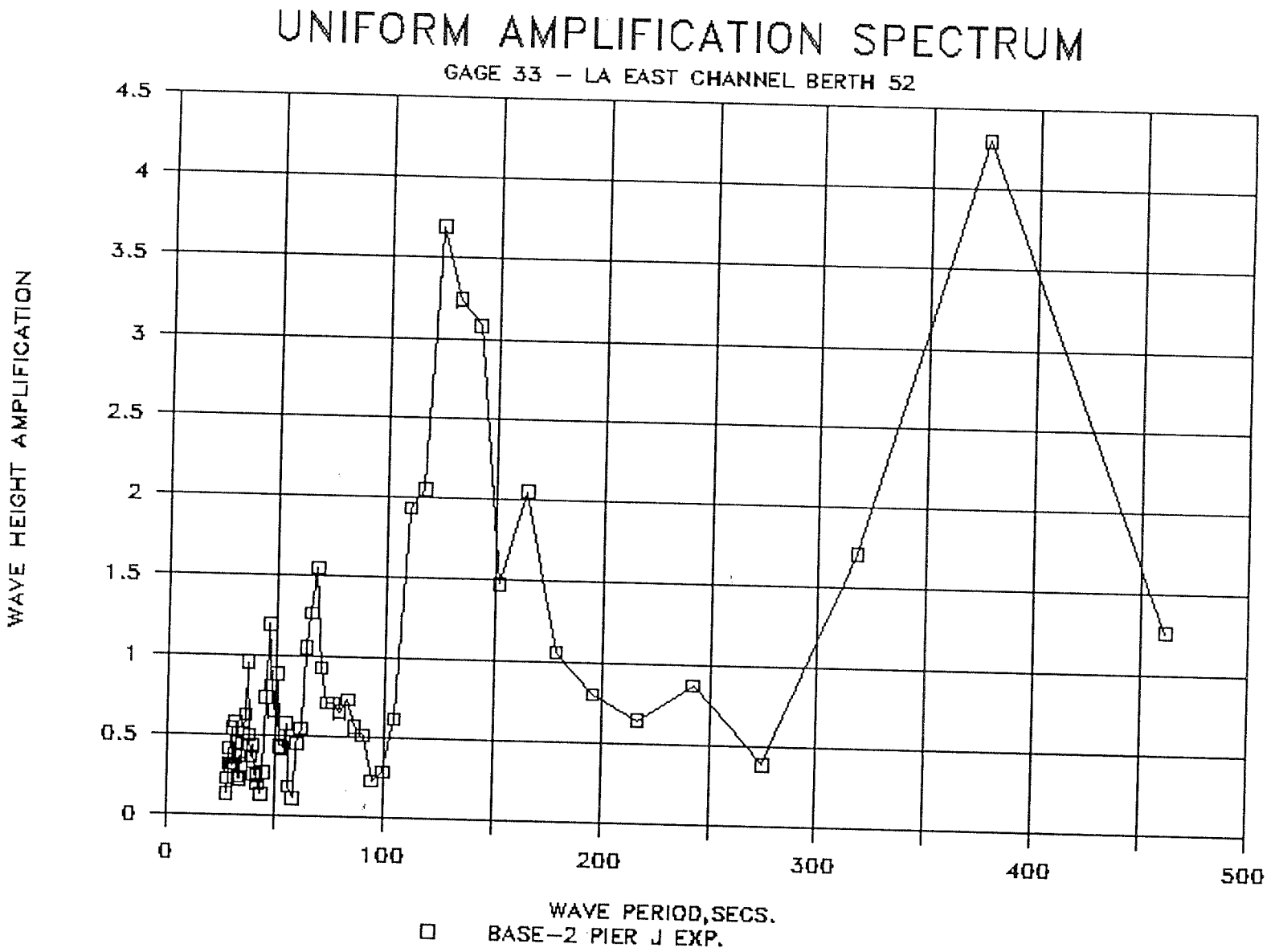

UNIFORM AMPLIFICATION SPECTRUM
GAGE 2B – LB BERTH 231 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

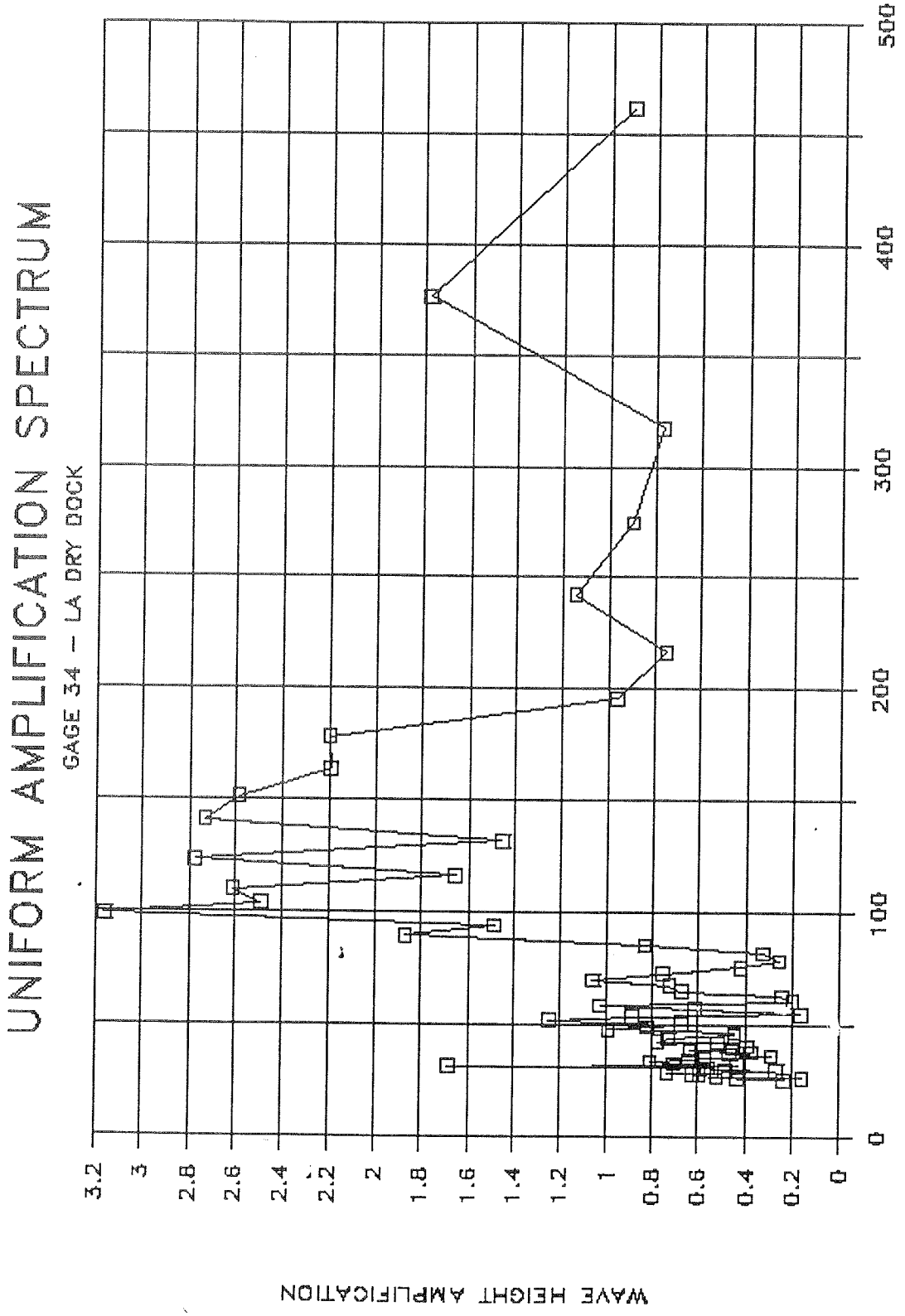

UNIFORM AMPLIFICATION SPECTRUM
GAGE 29 – LB BERTH 242 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

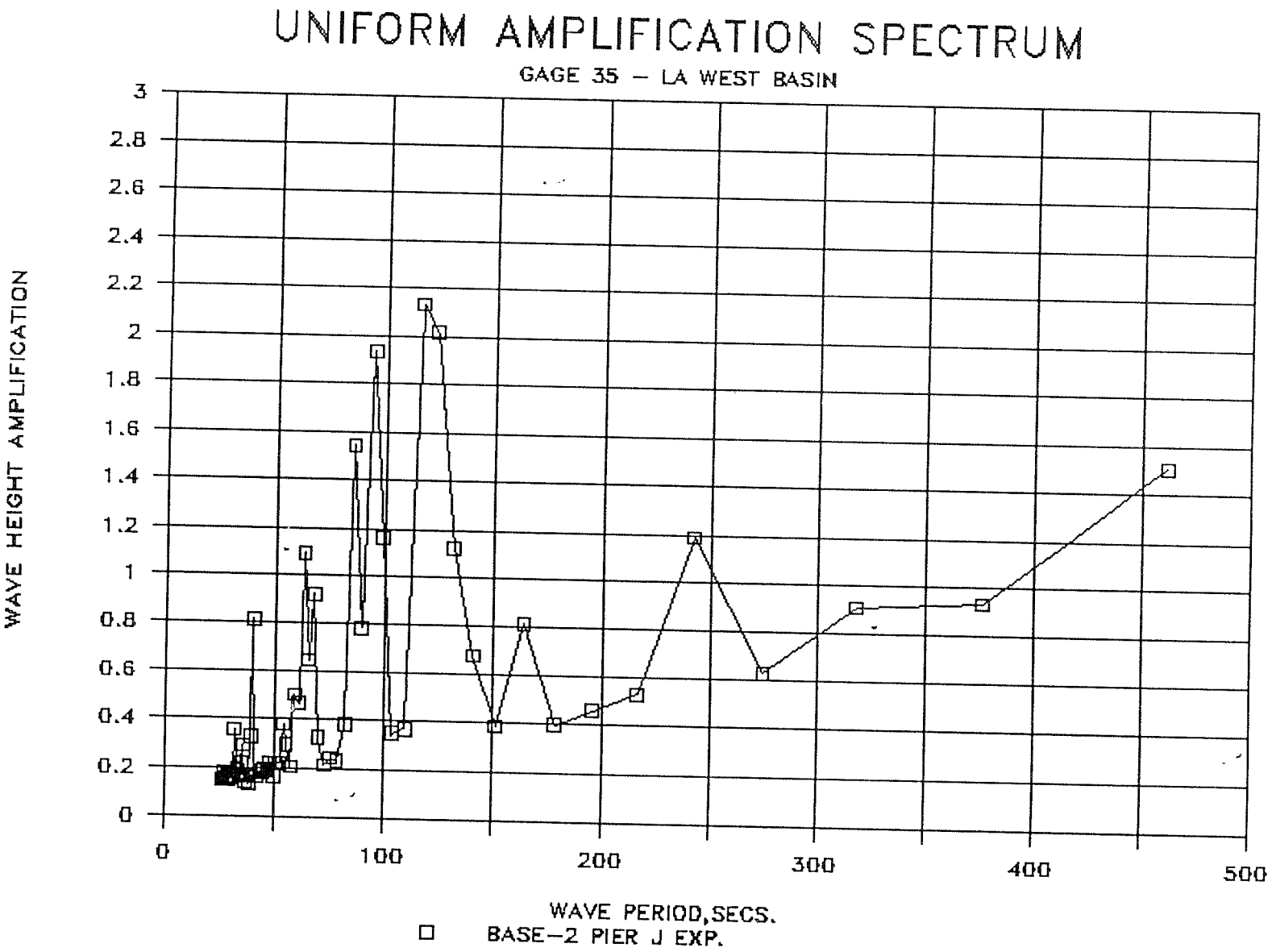

UNIFORM SPECTRUM AMPLIFICATION
GAGE 30 – LB BERTH 245 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

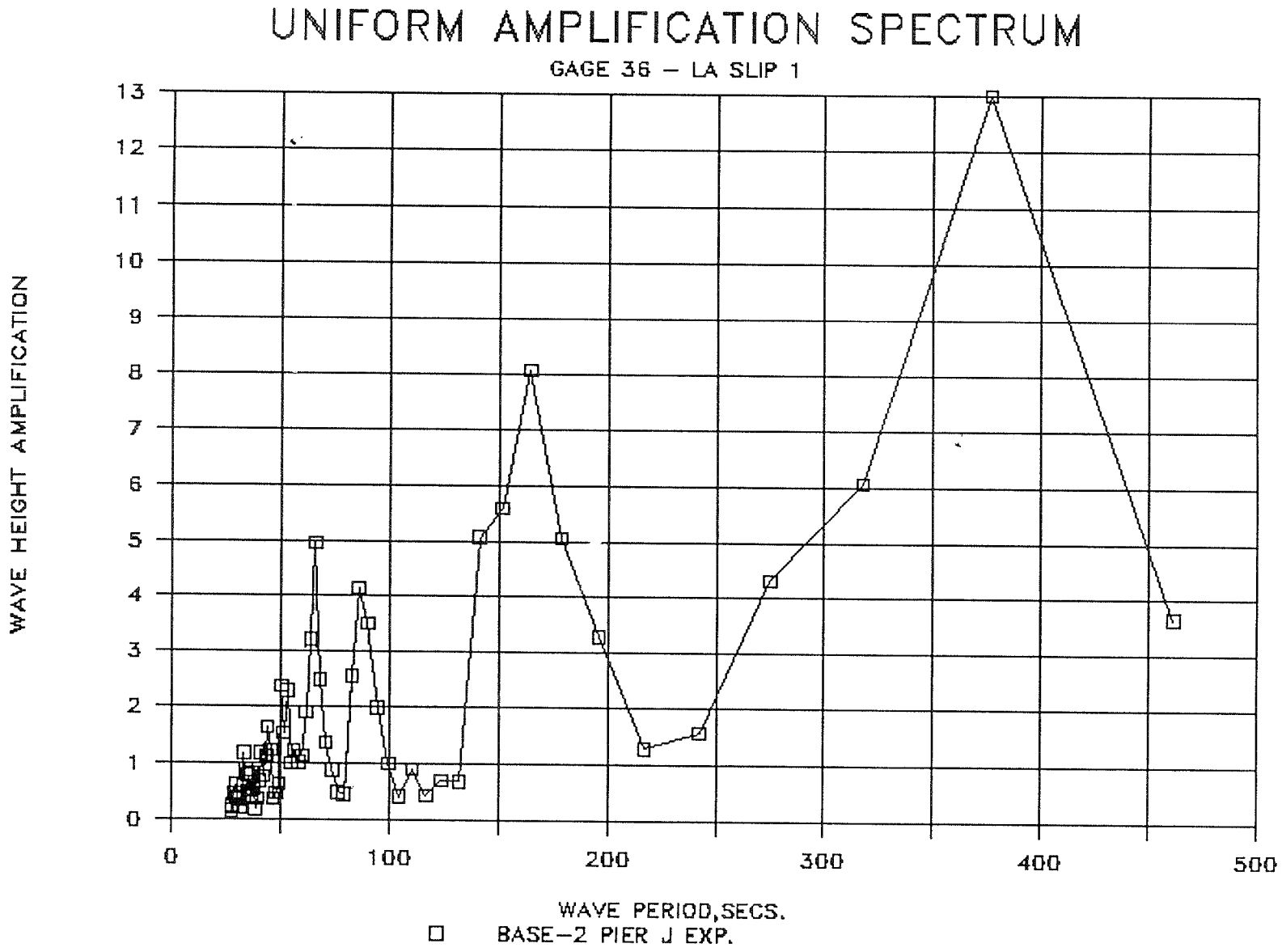

UNIFORM AMPLIFICATION SPECTRUM
GAGE 31—LA WEST CH NORTH SML BOAT BASIN
WAVE HEIGHT AMPLIFICATION
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE—2 PIER J EXP.

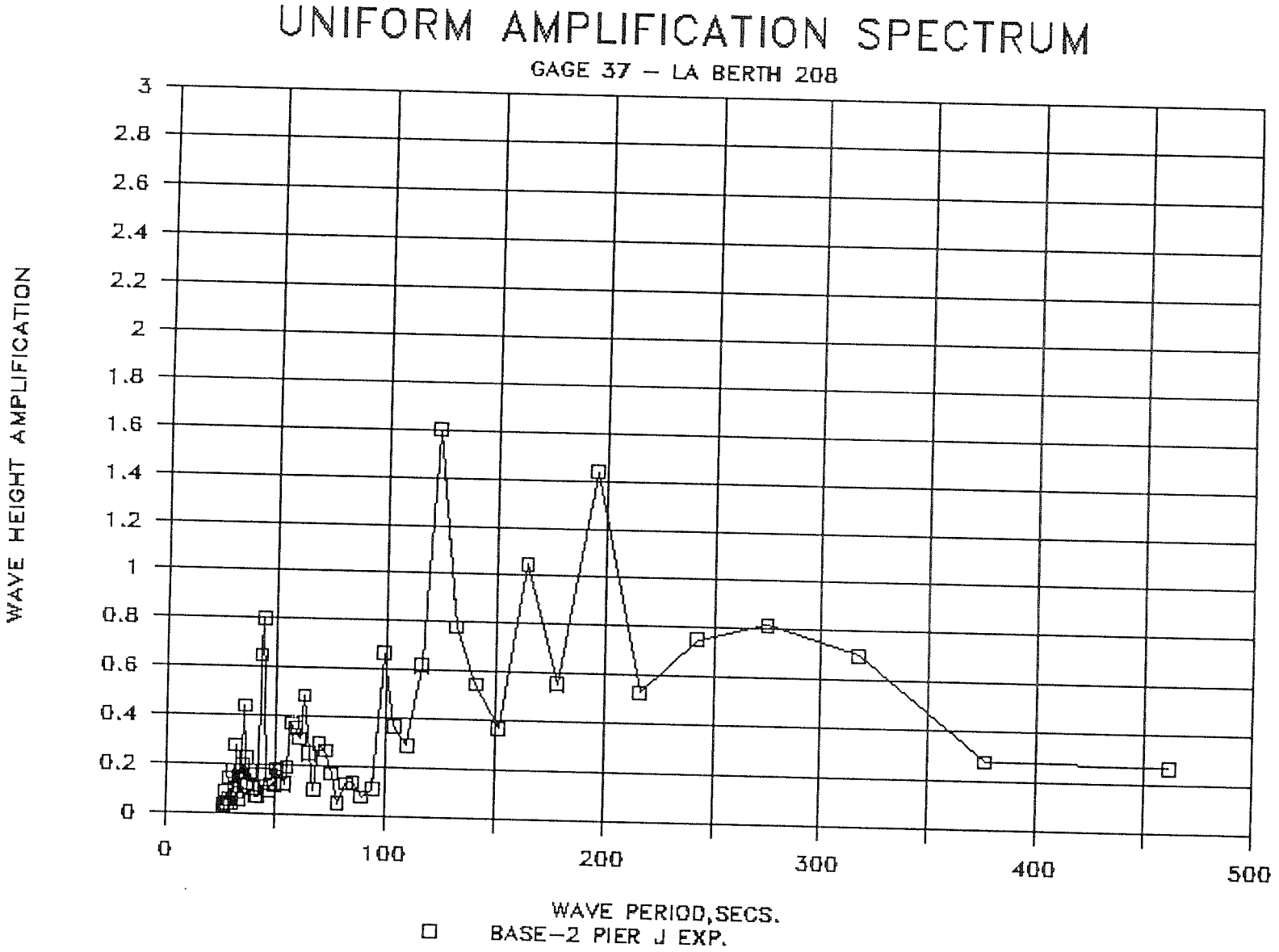

UNIFORM AMPLIFICATION SPECTRUM
GAGE 32 – CABRILLO BASIN
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.


UNIFORM AMPLIFICATION SPECTRUM
GAGE 33 – LA EAST CHANNEL BERTH 52
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.


UNIFORM AMPLIFICATION SPECTRUM
GAGE 34 – LA DRY DOCK
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
0
100
200
300
400
500

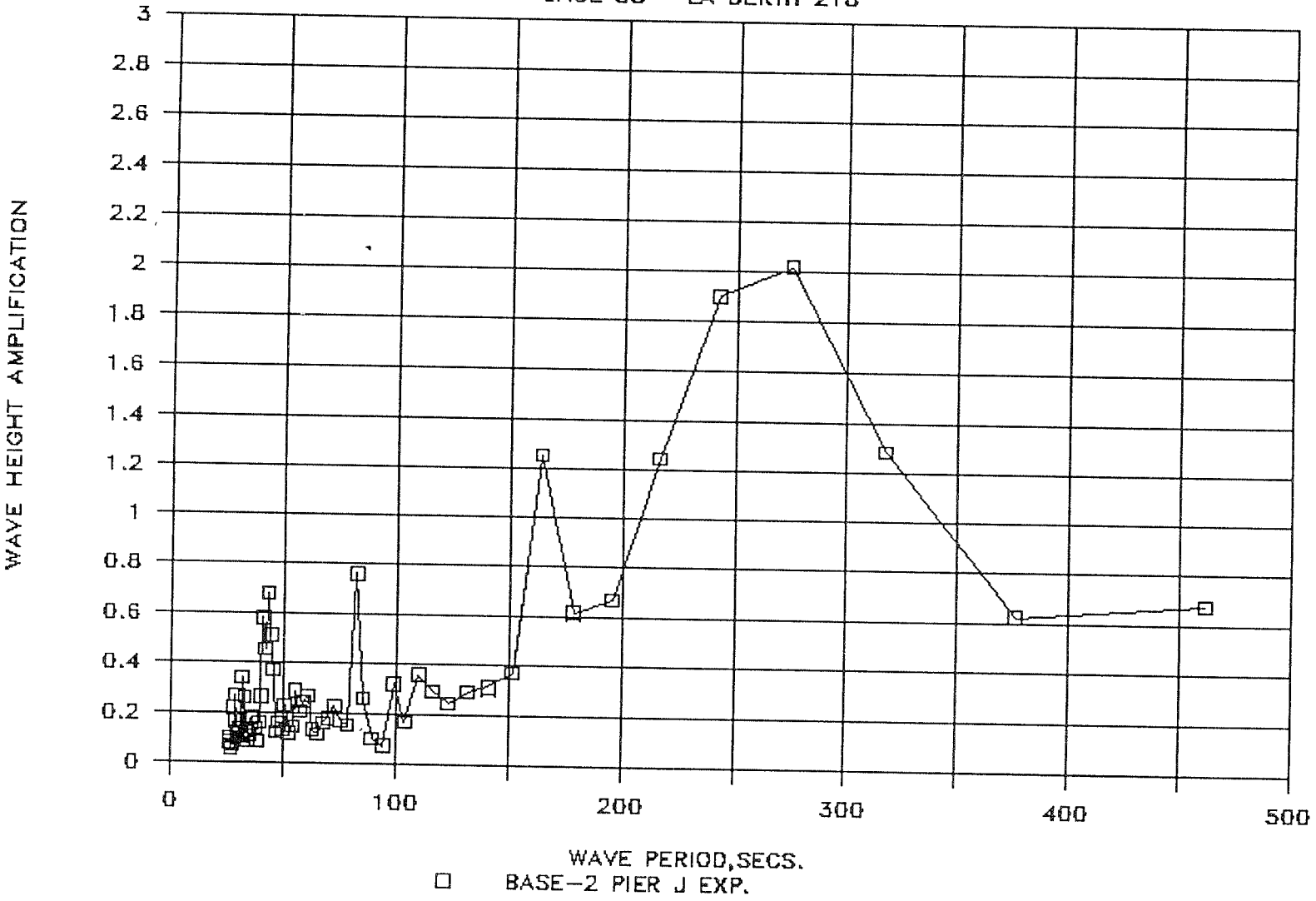

UNIFORM AMPLIFICATION SPECTRUM
GAGE 35 – LA WEST BASIN
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

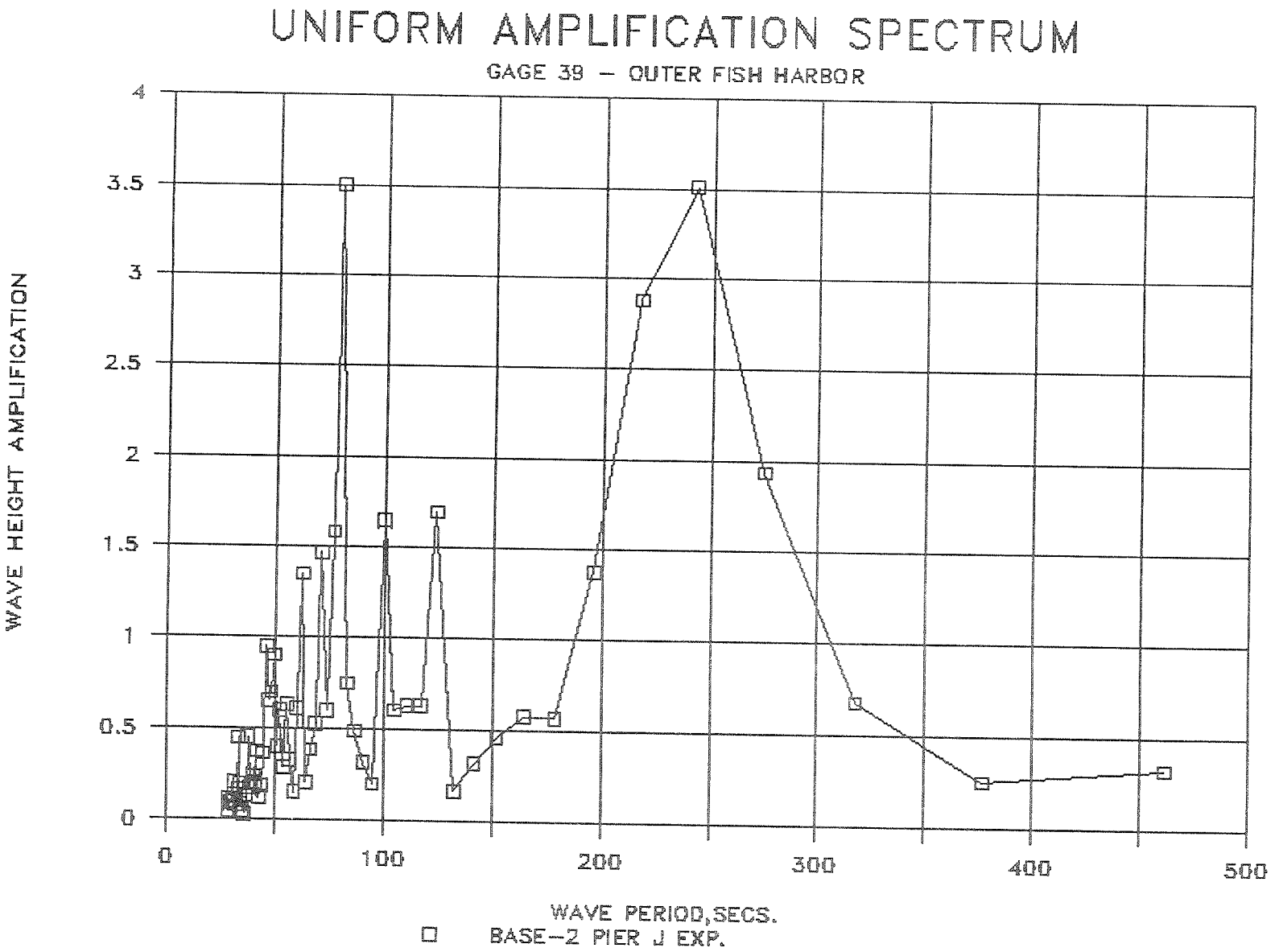

UNIFORM AMPLIFICATION SPECTRUM
GAGE 36 – LA SLIP 1
WAVE HEIGHT AMPLIFICATION
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

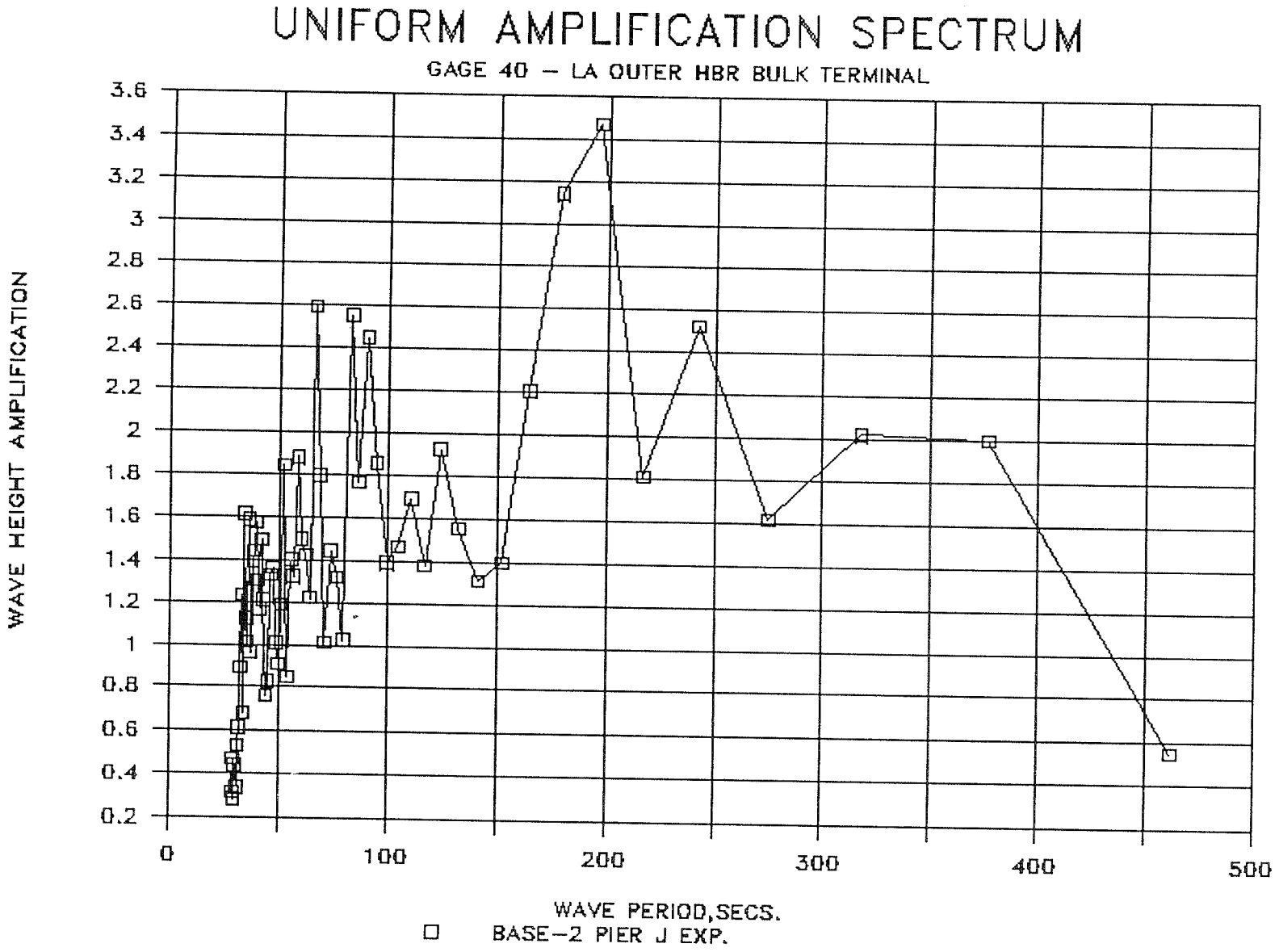

UNIFORM AMPLIFICATION SPECTRUM
GAGE 37 – LA BERTH 208
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

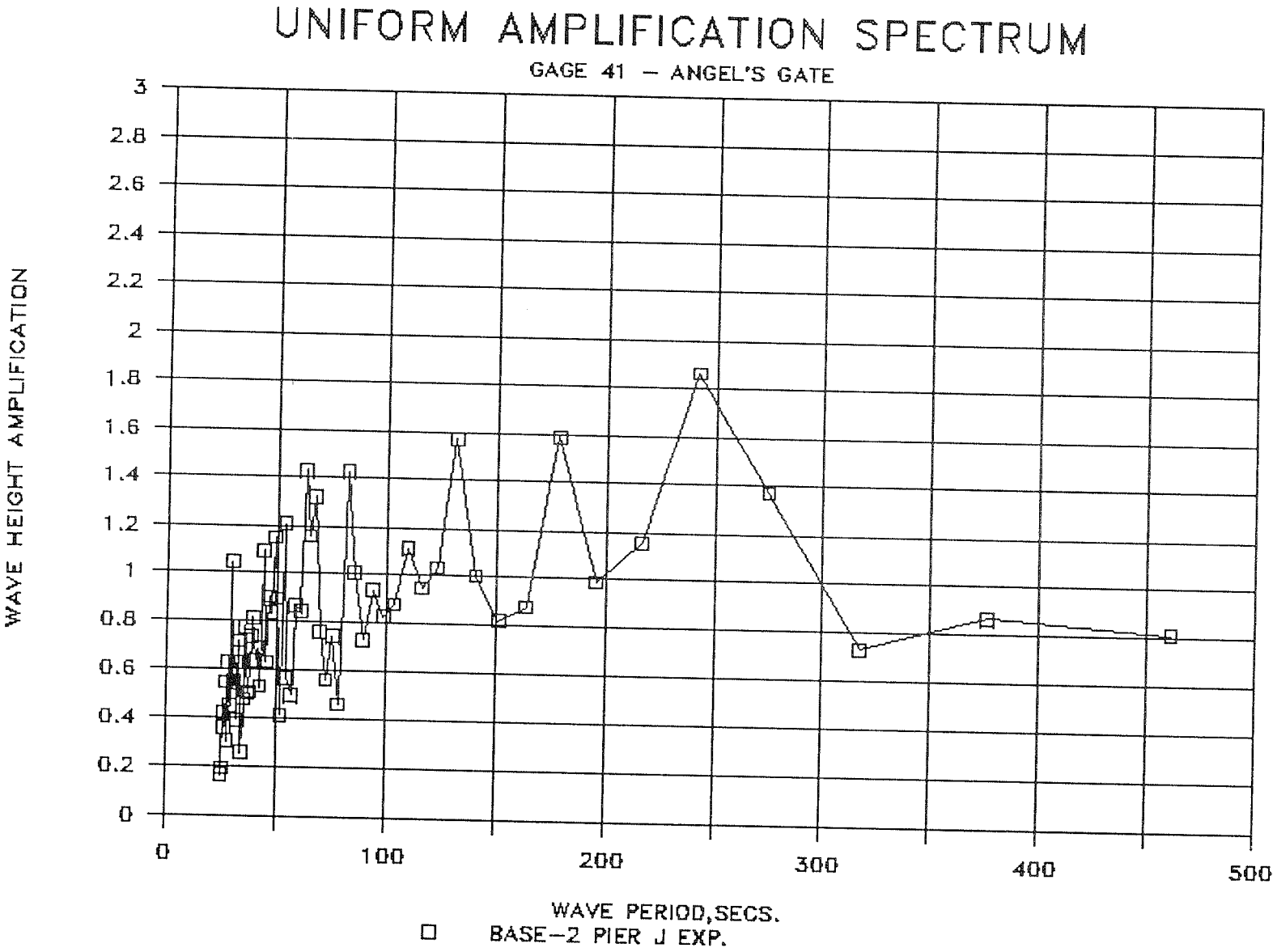
UNIFORM AMPLIFICATION SPECTRUM

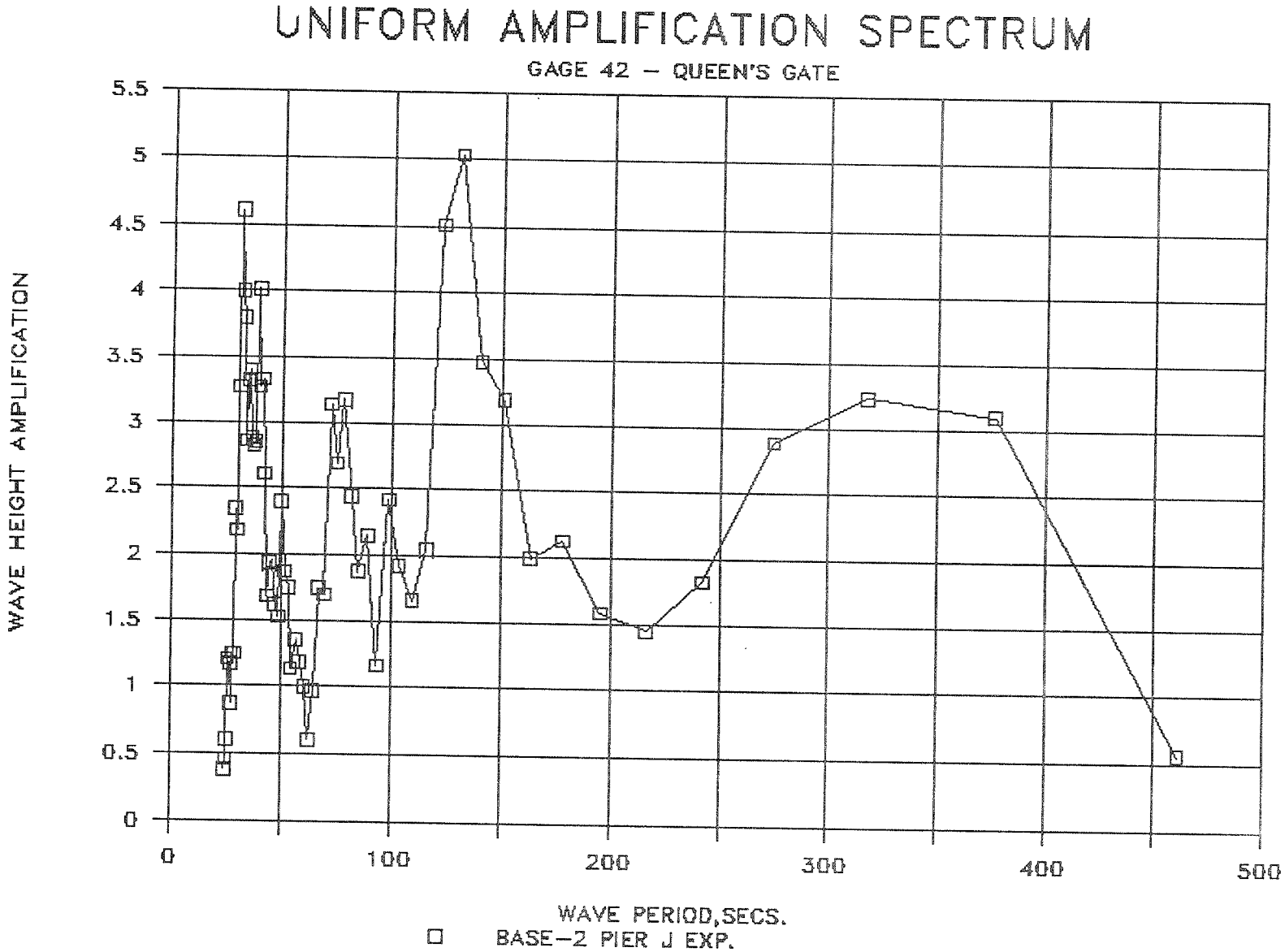
GAGE 38 – LA BERTH 218

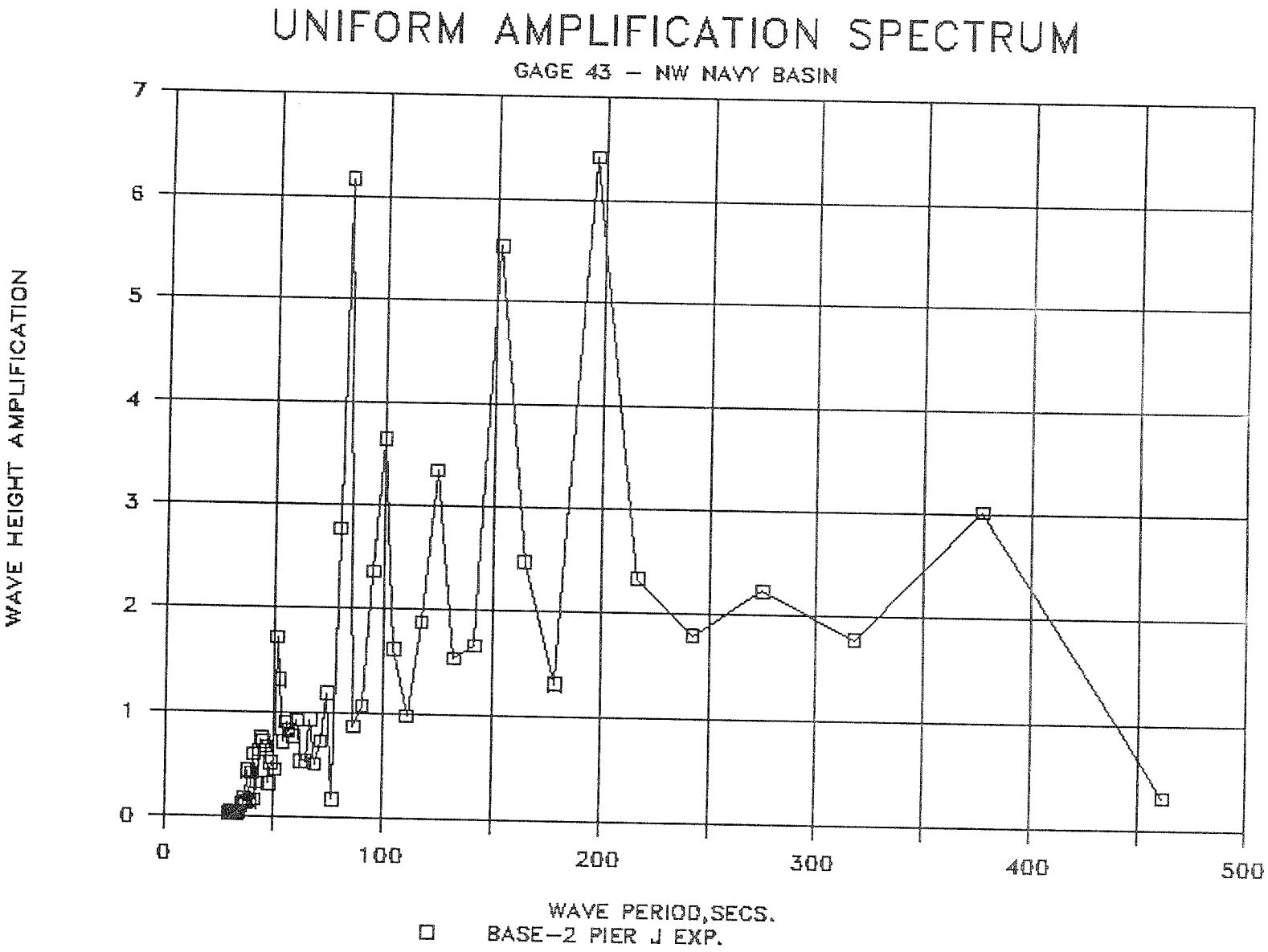


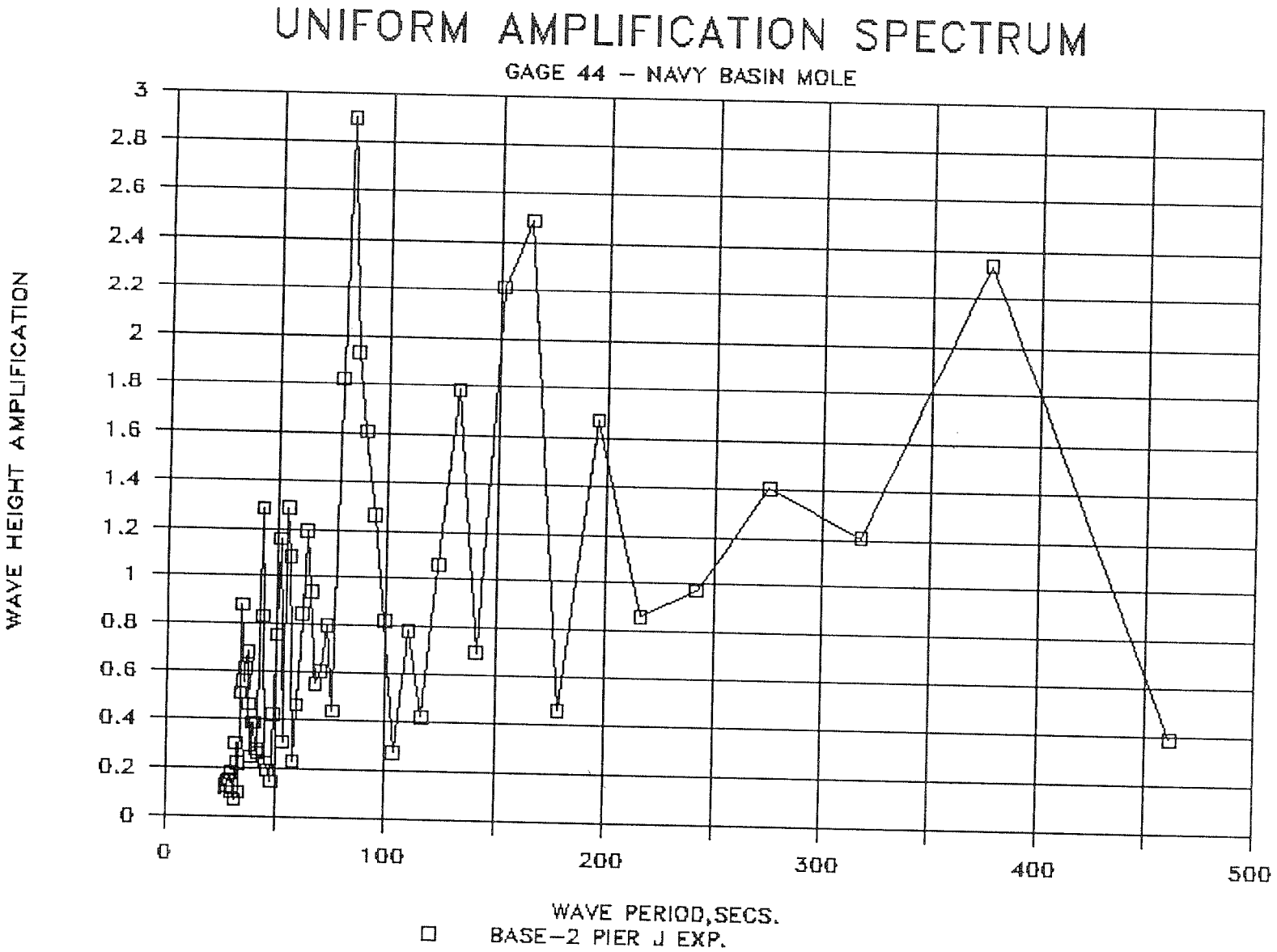

UNIFORM AMPLIFICATION SPECTRUM
GAGE 39 – OUTER FISH HARBOR
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–2 PIER J EXP.

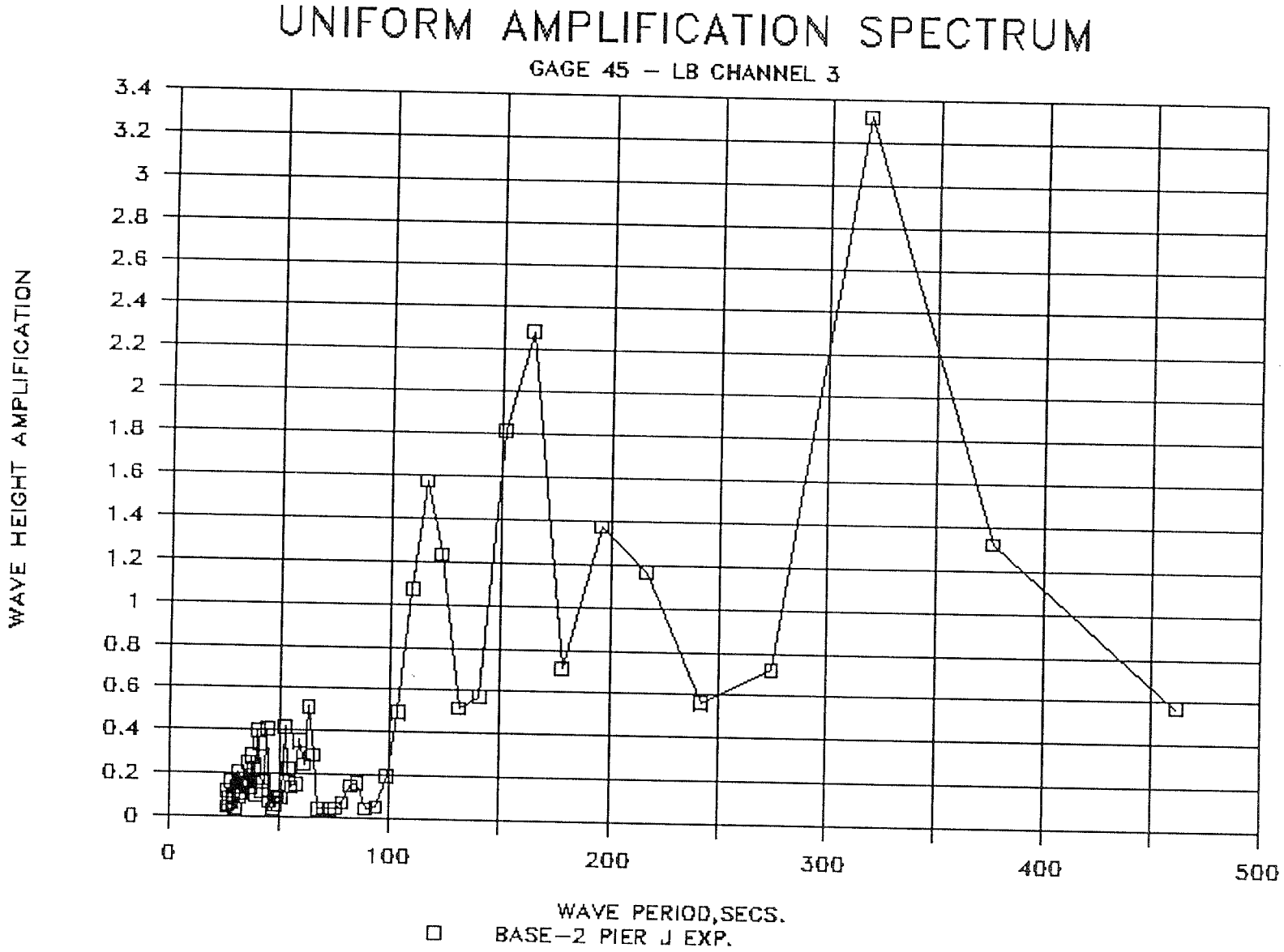

UNIFORM AMPLIFICATION SPECTRUM
GAGE 40 – LA OUTER HBR BULK TERMINAL
WAVE HEIGHT AMPLIFICATION
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

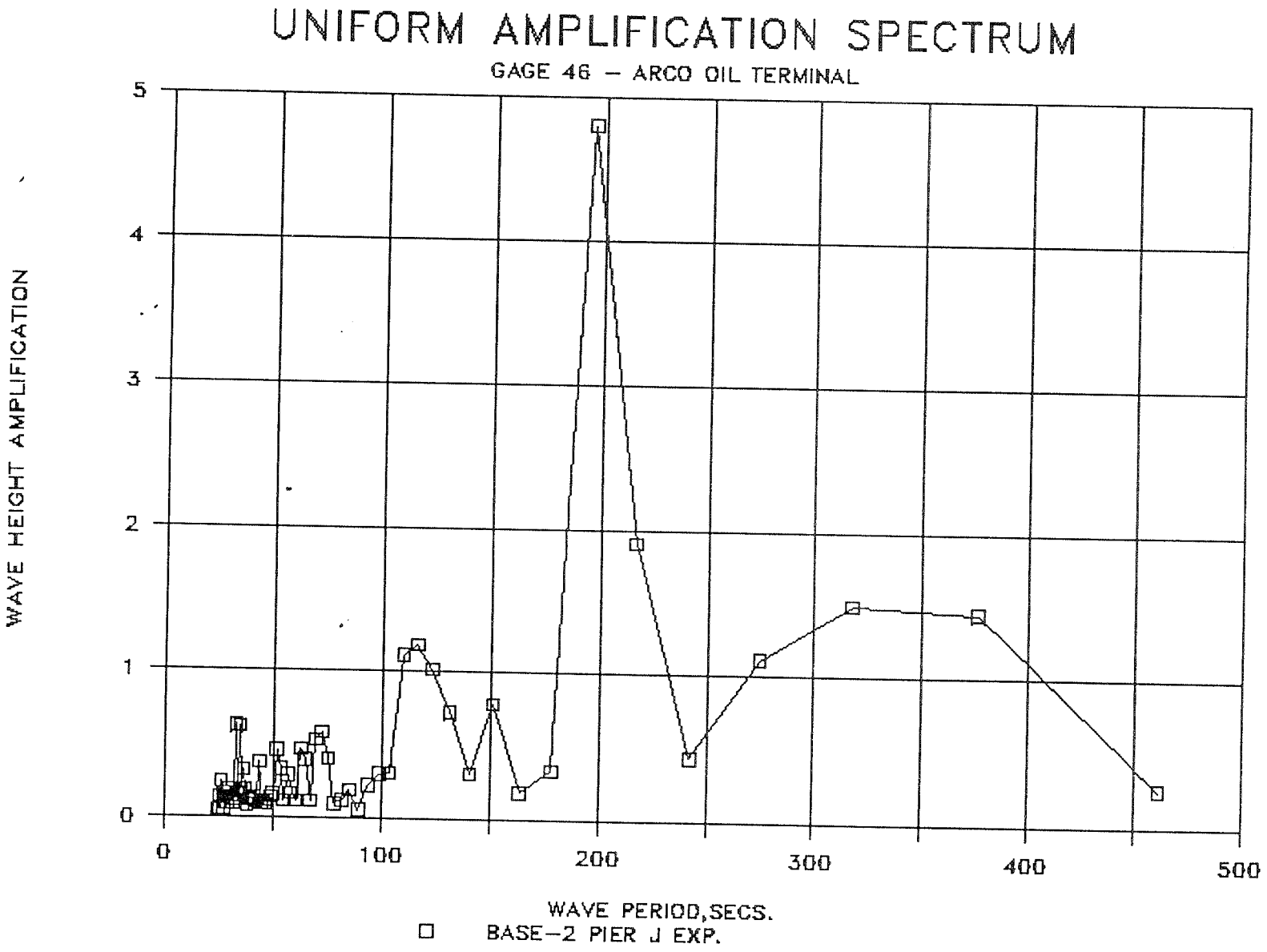

UNIFORM AMPLIFICATION SPECTRUM
GAGE 41 – ANGEL'S GATE
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

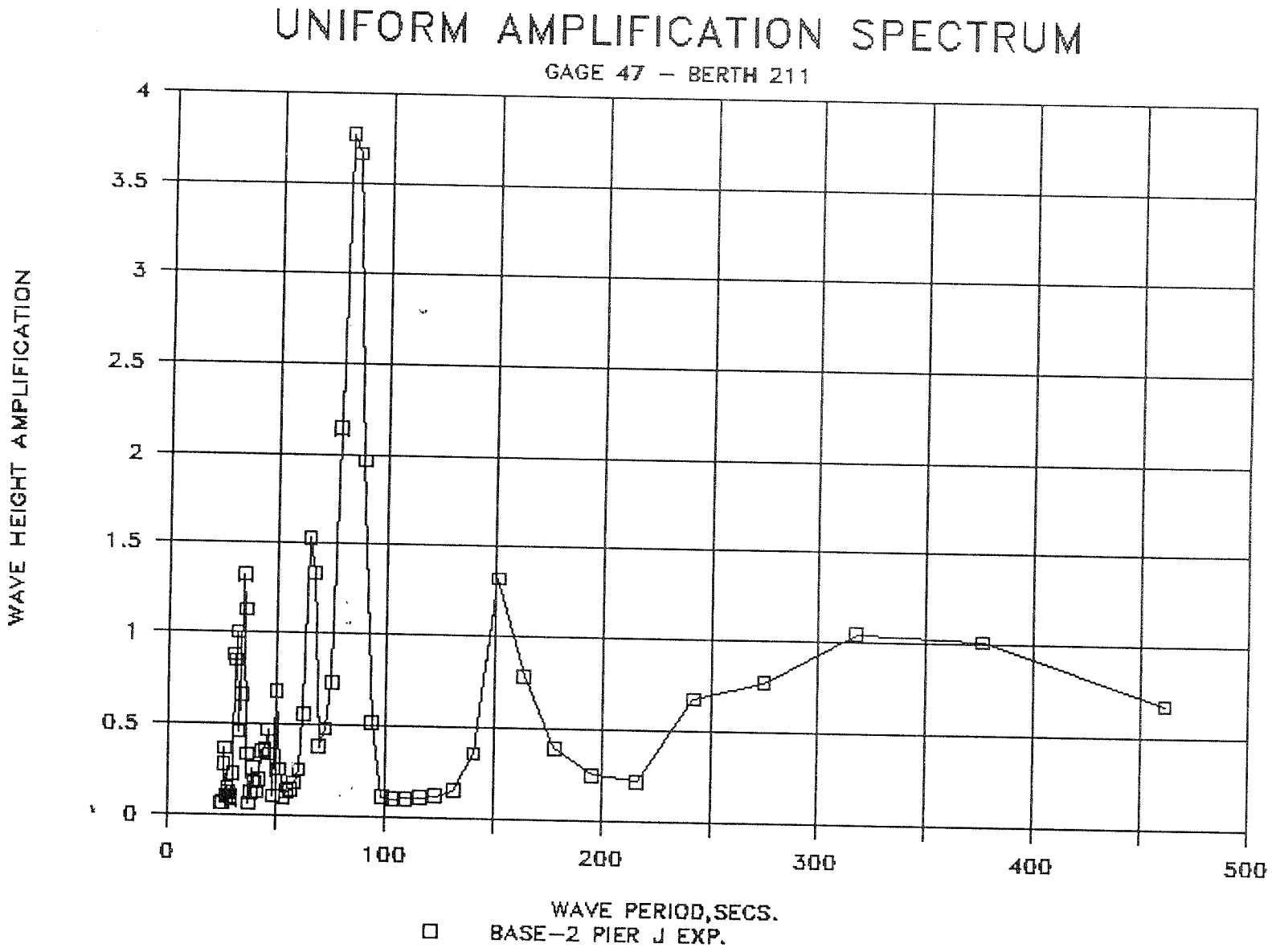

UNIFORM AMPLIFICATION SPECTRUM
GAGE 42 – QUEEN'S GATE
WAVE HEIGHT AMPLIFICATION
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

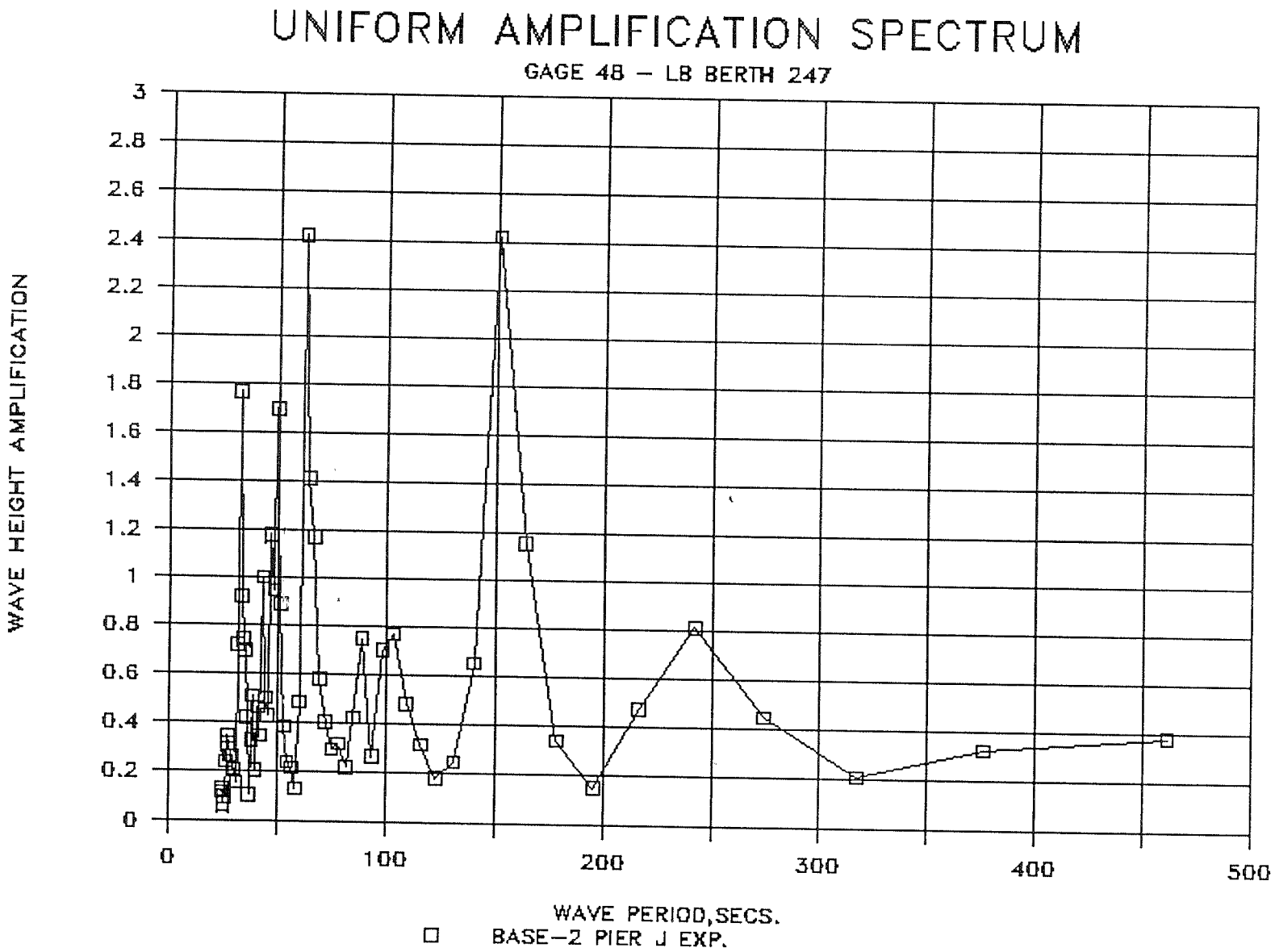

UNIFORM AMPLIFICATION SPECTRUM
GAGE 43 – NW NAVY BASIN
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

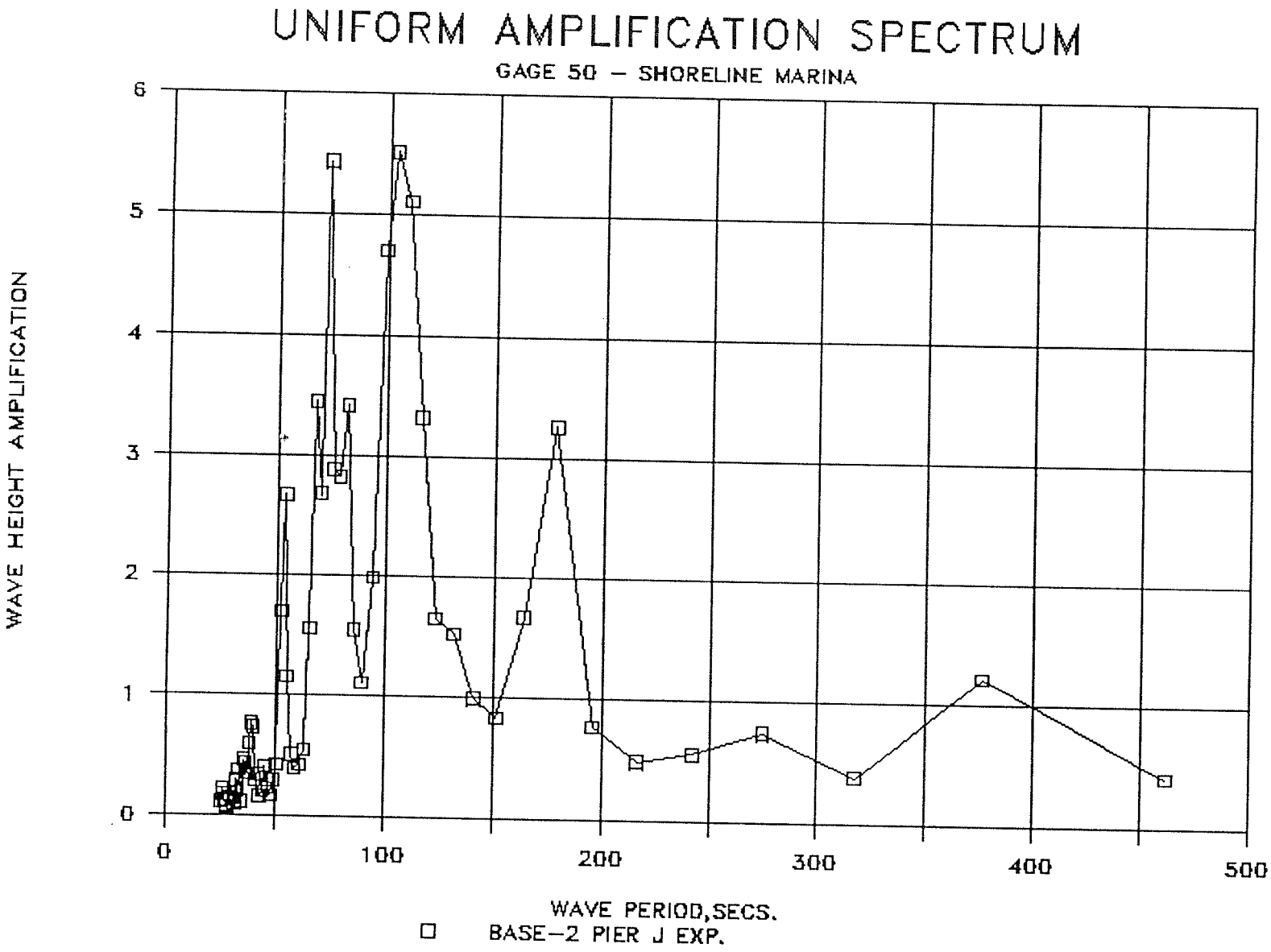

UNIFORM AMPLIFICATION SPECTRUM
GAGE 44 – NAVY BASIN MOLE
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

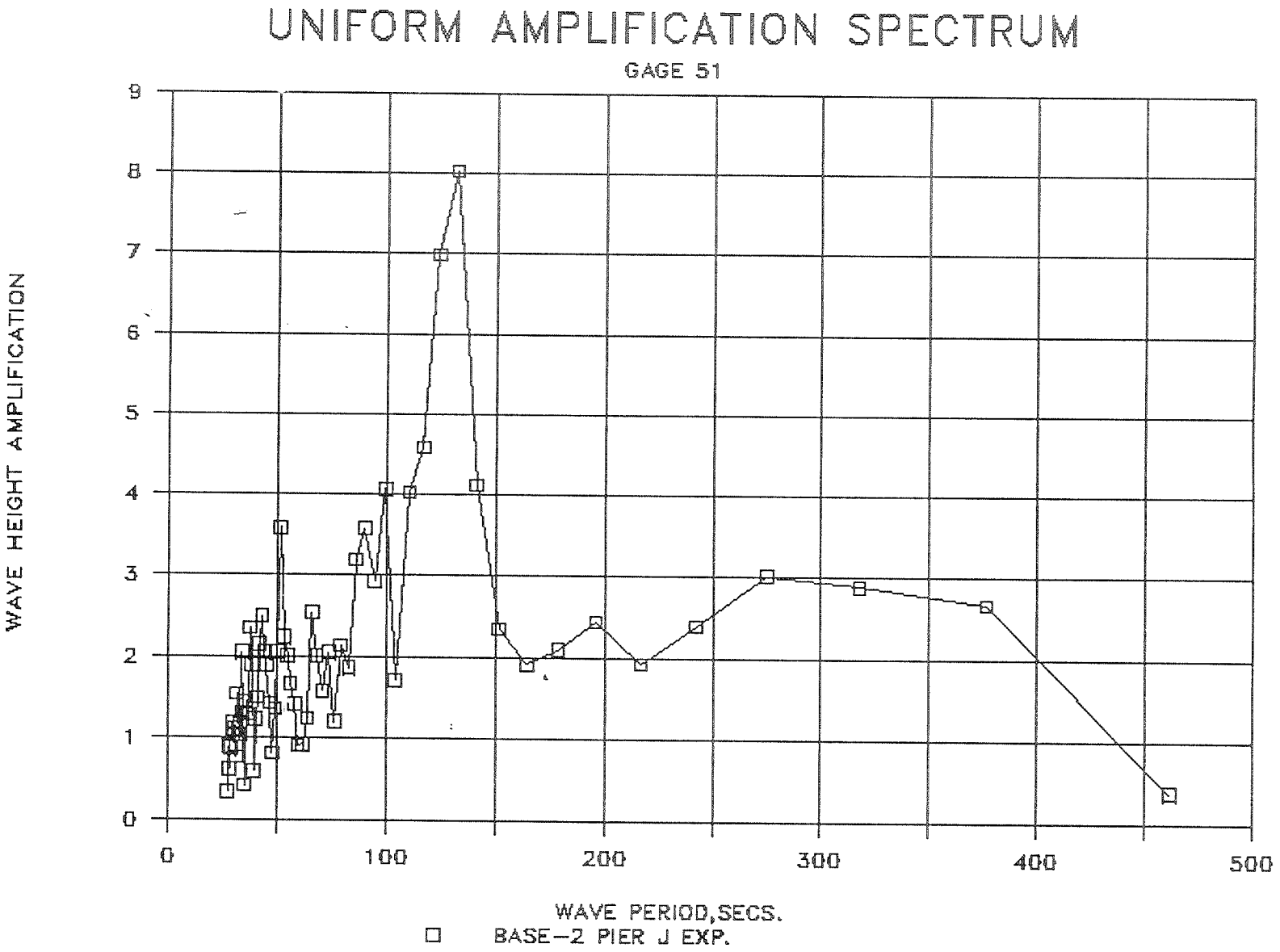

UNIFORM AMPLIFICATION SPECTRUM
GAGE 45 – LB CHANNEL 3
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

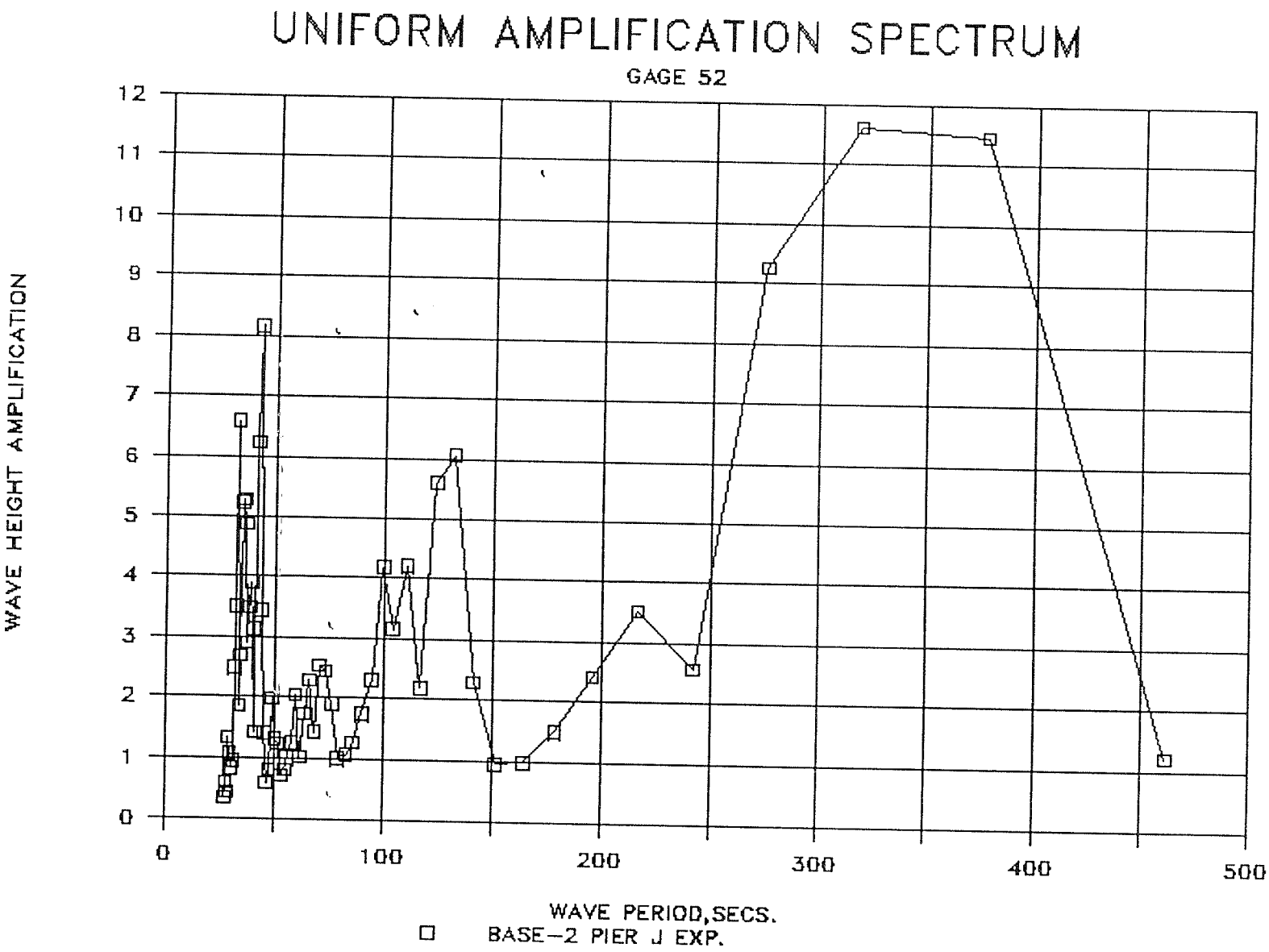

UNIFORM AMPLIFICATION SPECTRUM
GAGE 46 – ARCO OIL TERMINAL
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

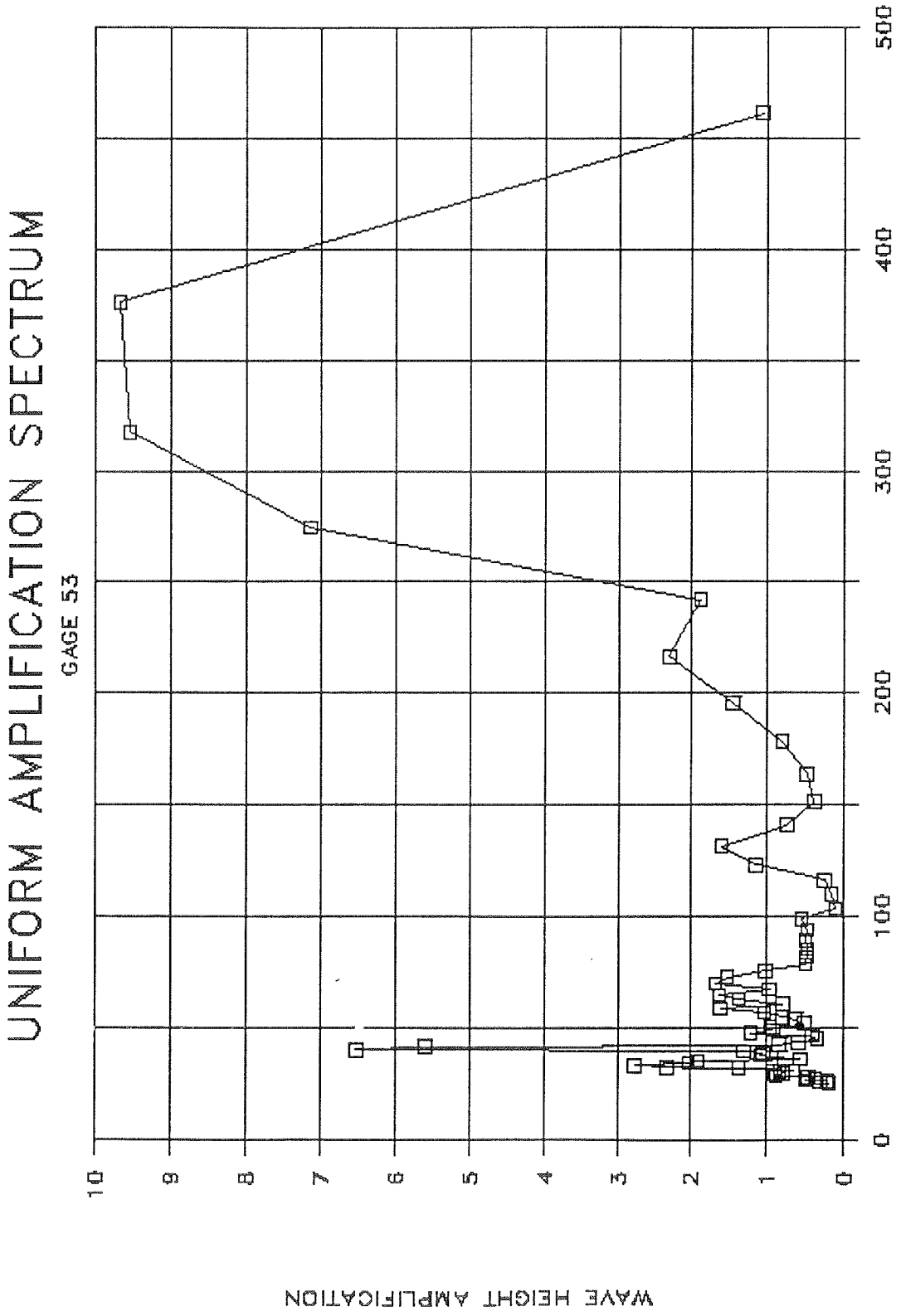

UNIFORM AMPLIFICATION SPECTRUM
GAGE 47 – BERTH 211
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

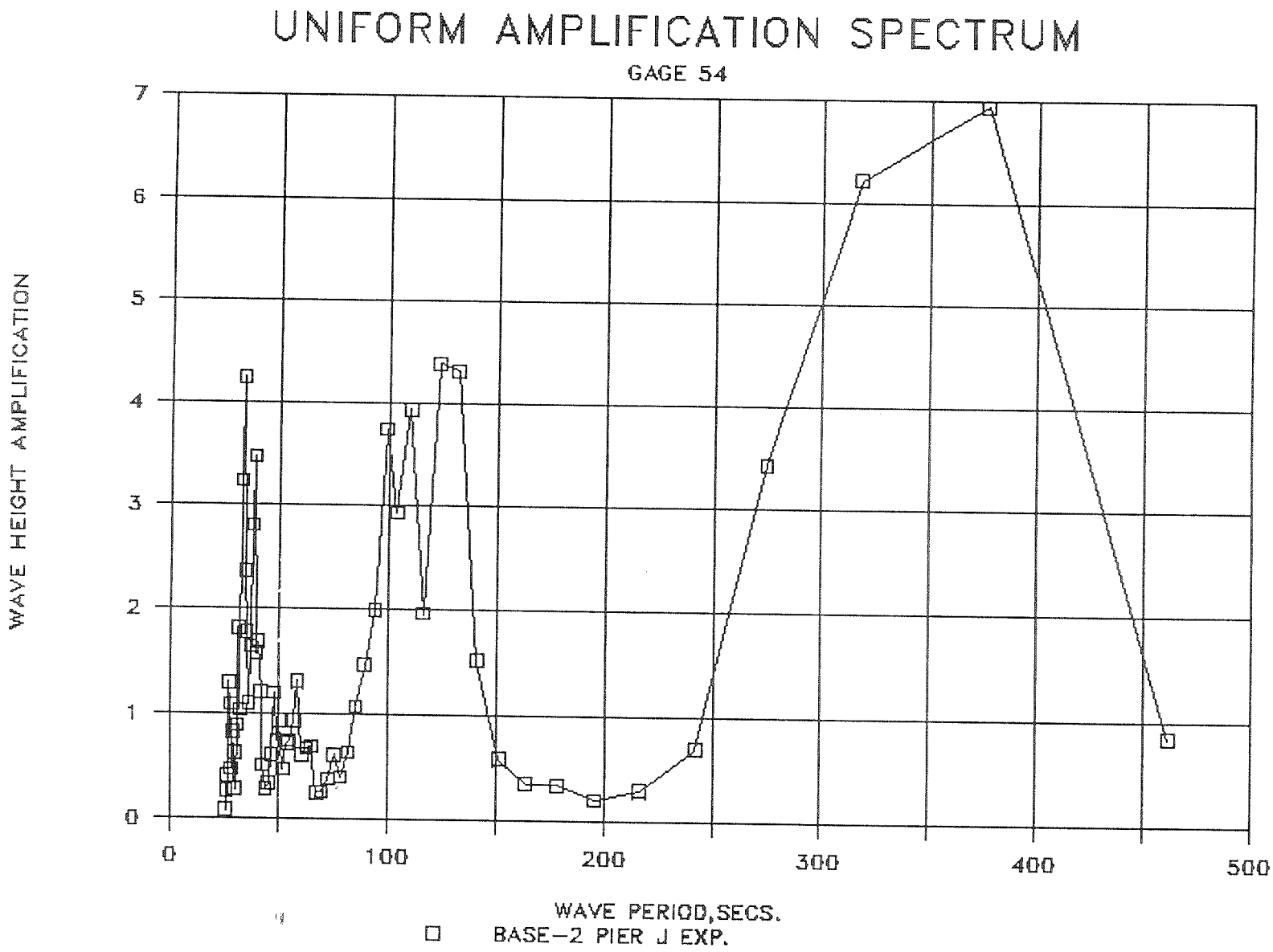

UNIFORM AMPLIFICATION SPECTRUM
GAGE 48 – LB BERTH 247
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

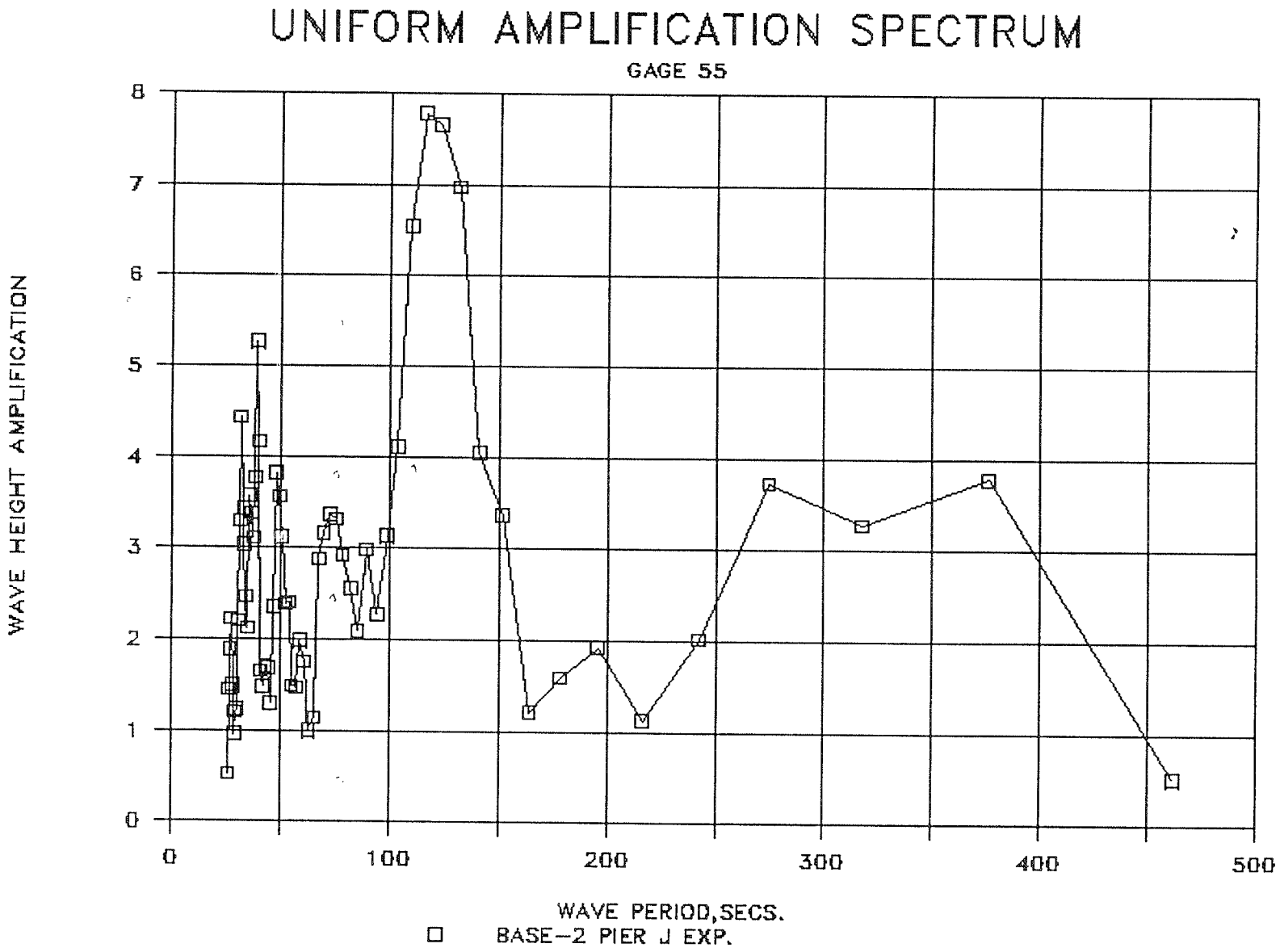

UNIFORM AMPLIFICATION SPECTRUM
GAGE 50 – SHORELINE MARINA
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

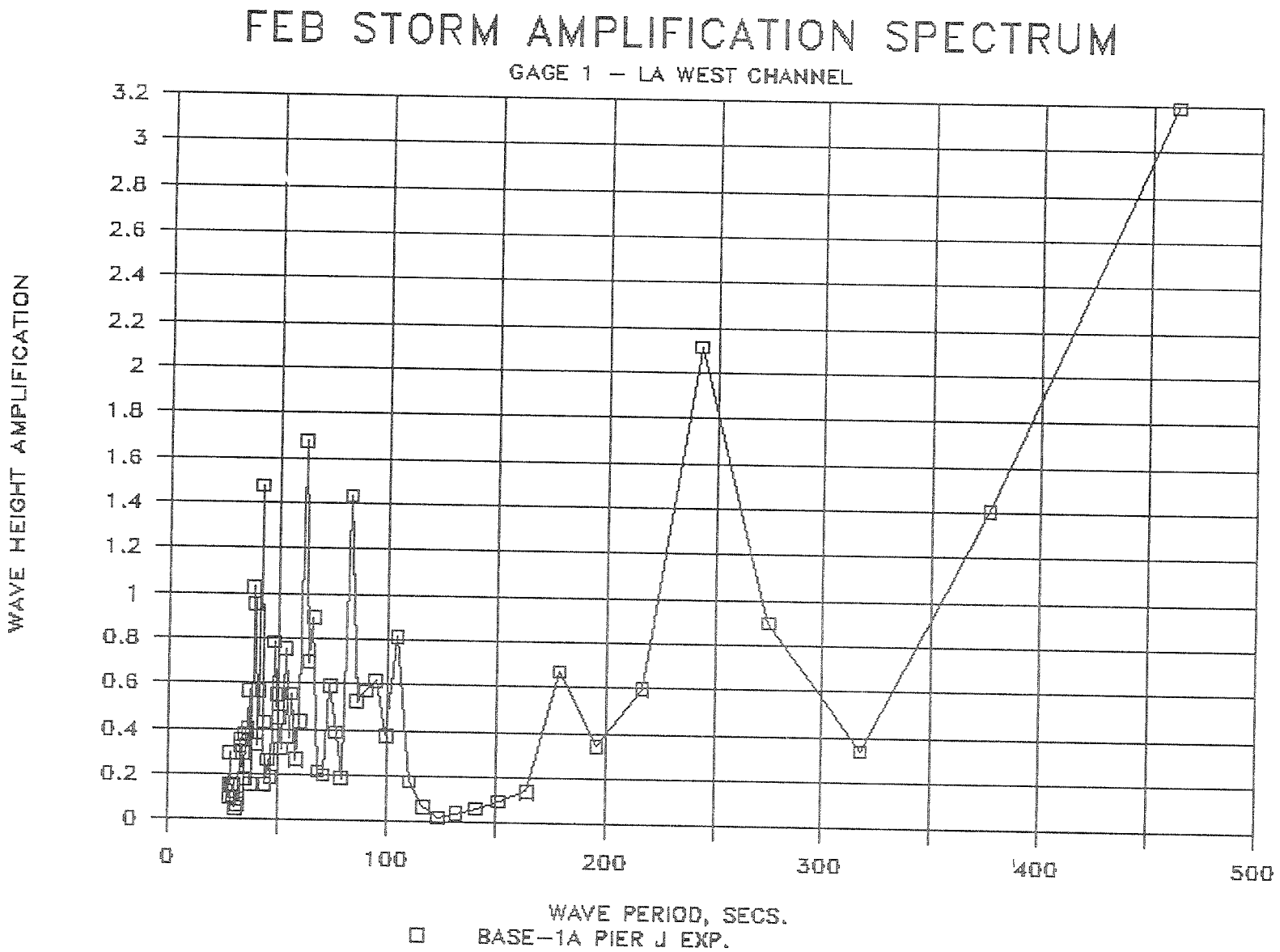

UNIFORM AMPLIFICATION SPECTRUM
GAGE 51
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.

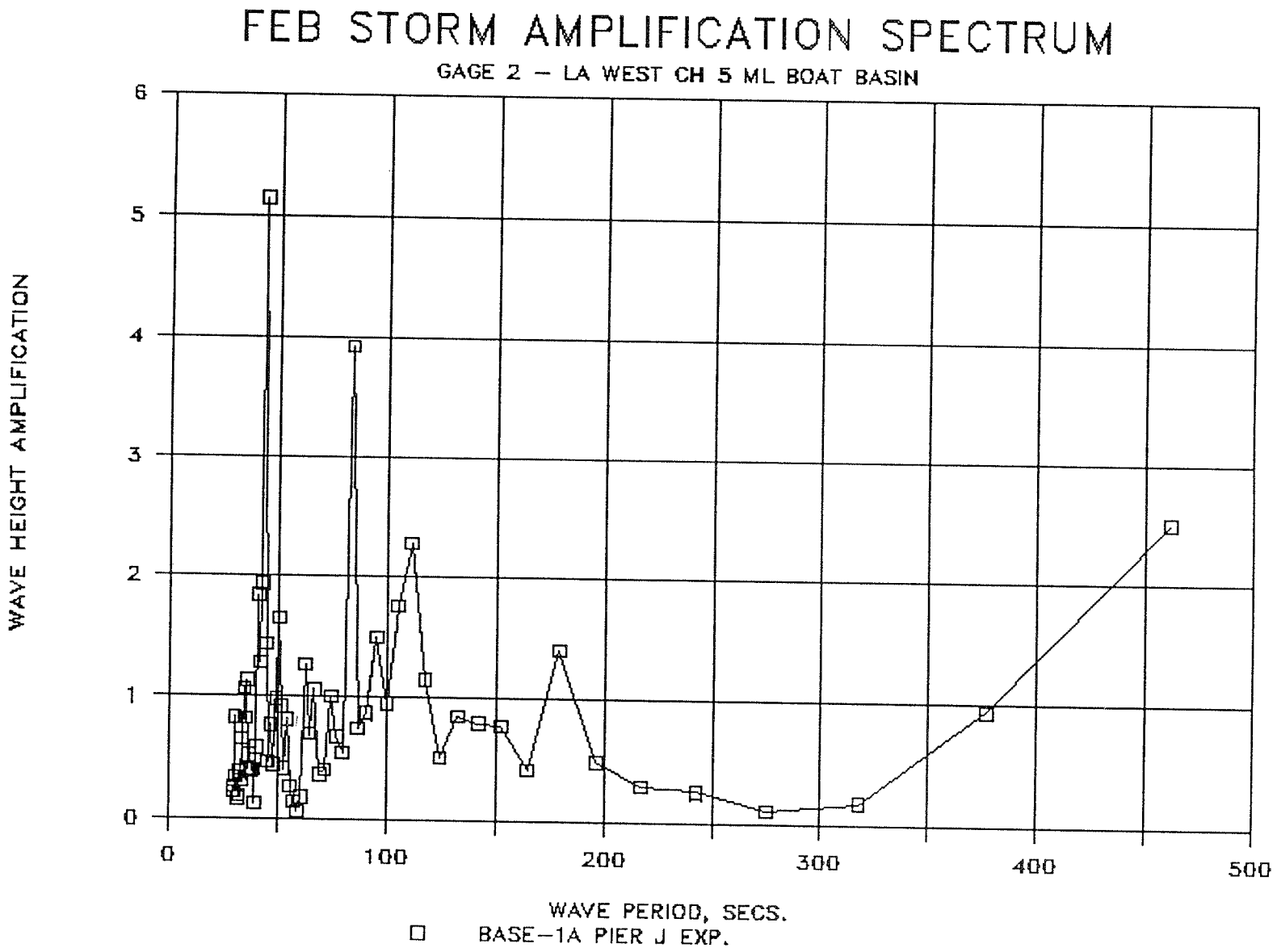

UNIFORM AMPLIFICATION SPECTRUM
GAGE 52
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
10
11
12
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.

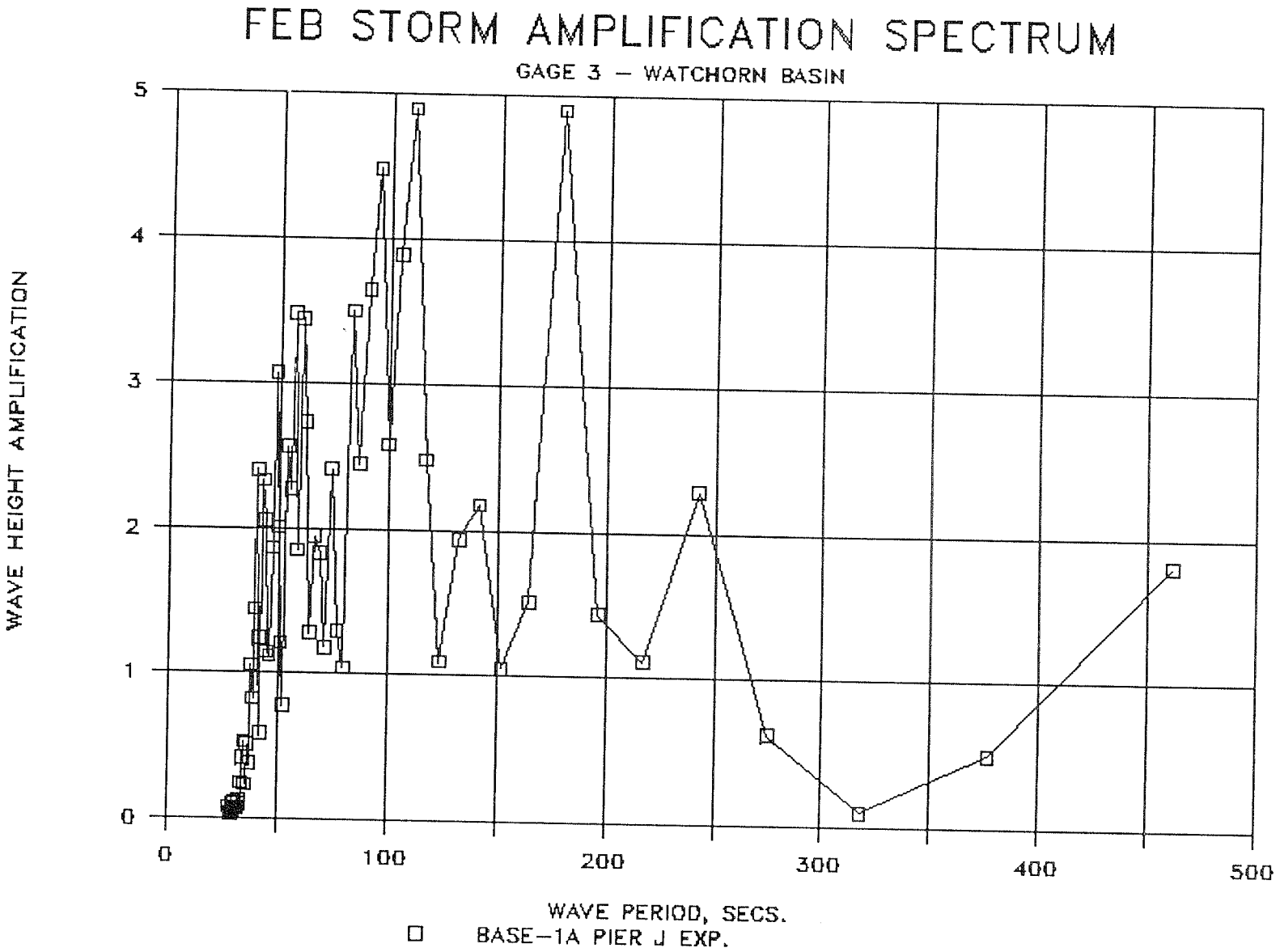

UNIFORM AMPLIFICATION SPECTRUM
GAGE 53
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.
0
1
2
3
4
5
6
7
8
9
10
0
100
200
300
400
500

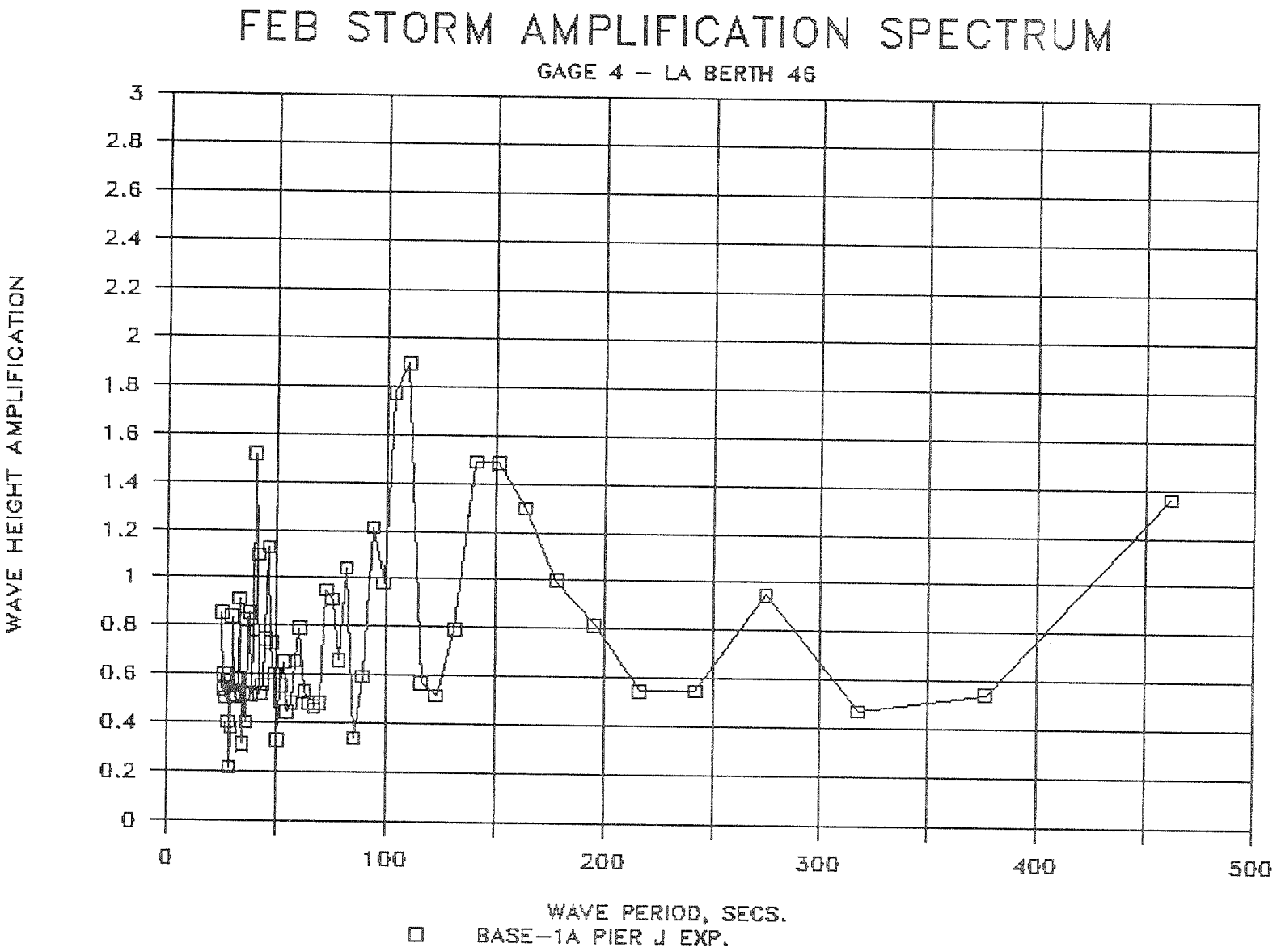

UNIFORM AMPLIFICATION SPECTRUM
GAGE 54
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.

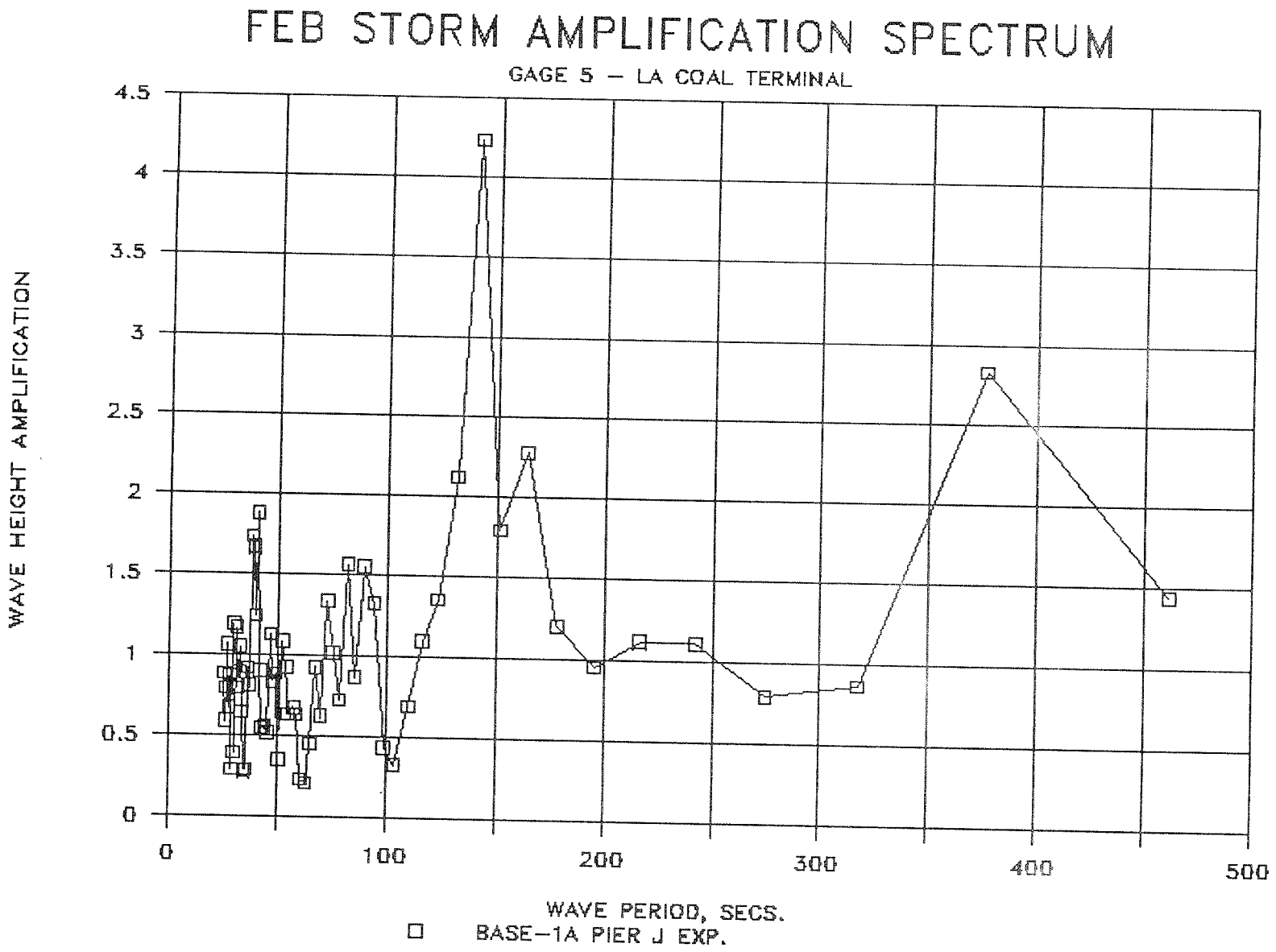

UNIFORM AMPLIFICATION SPECTRUM
GAGE 55
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.

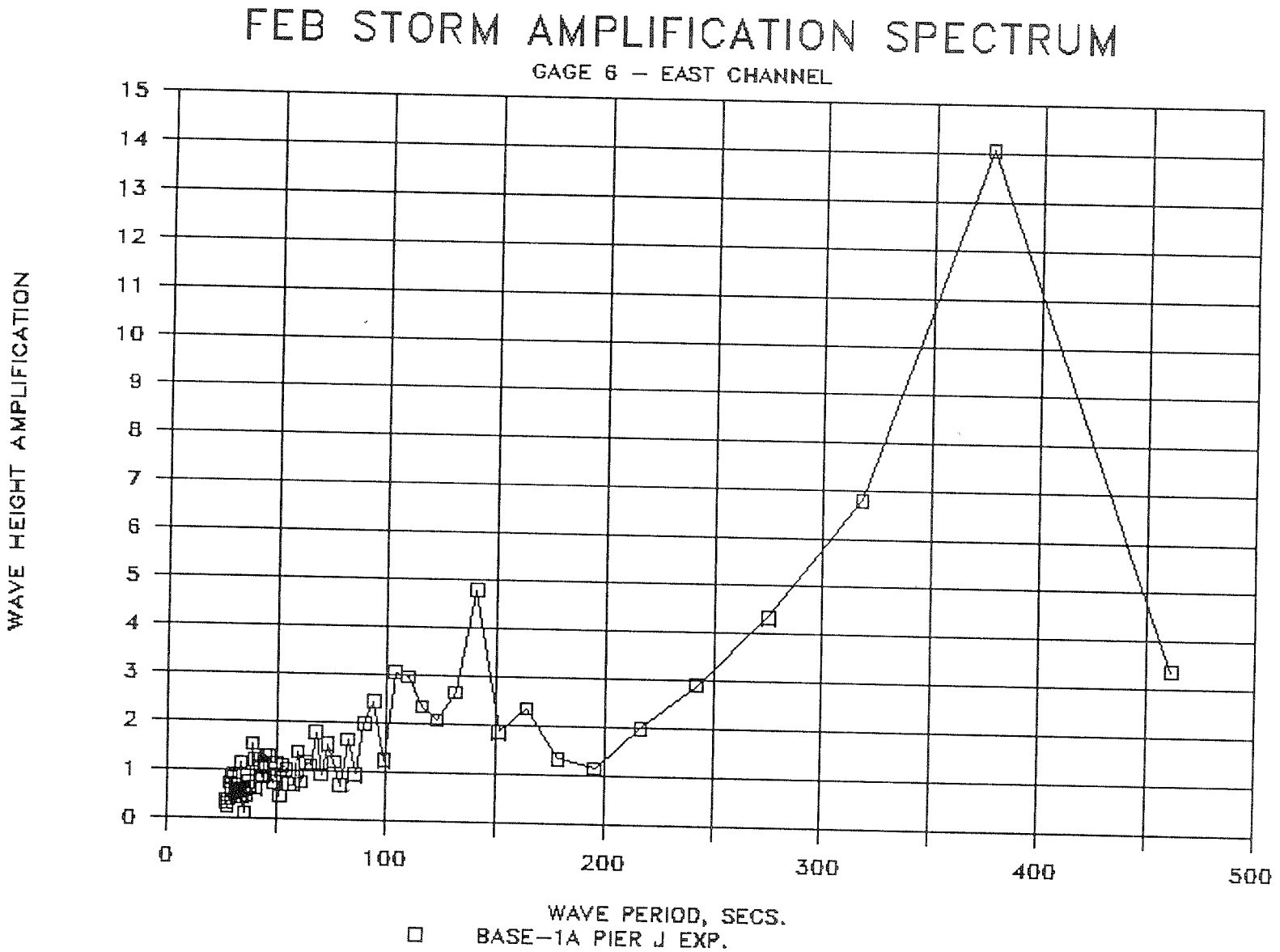

FEB STORM AMPLIFICATION SPECTRUM
GAGE 1 – LA WEST CHANNEL
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

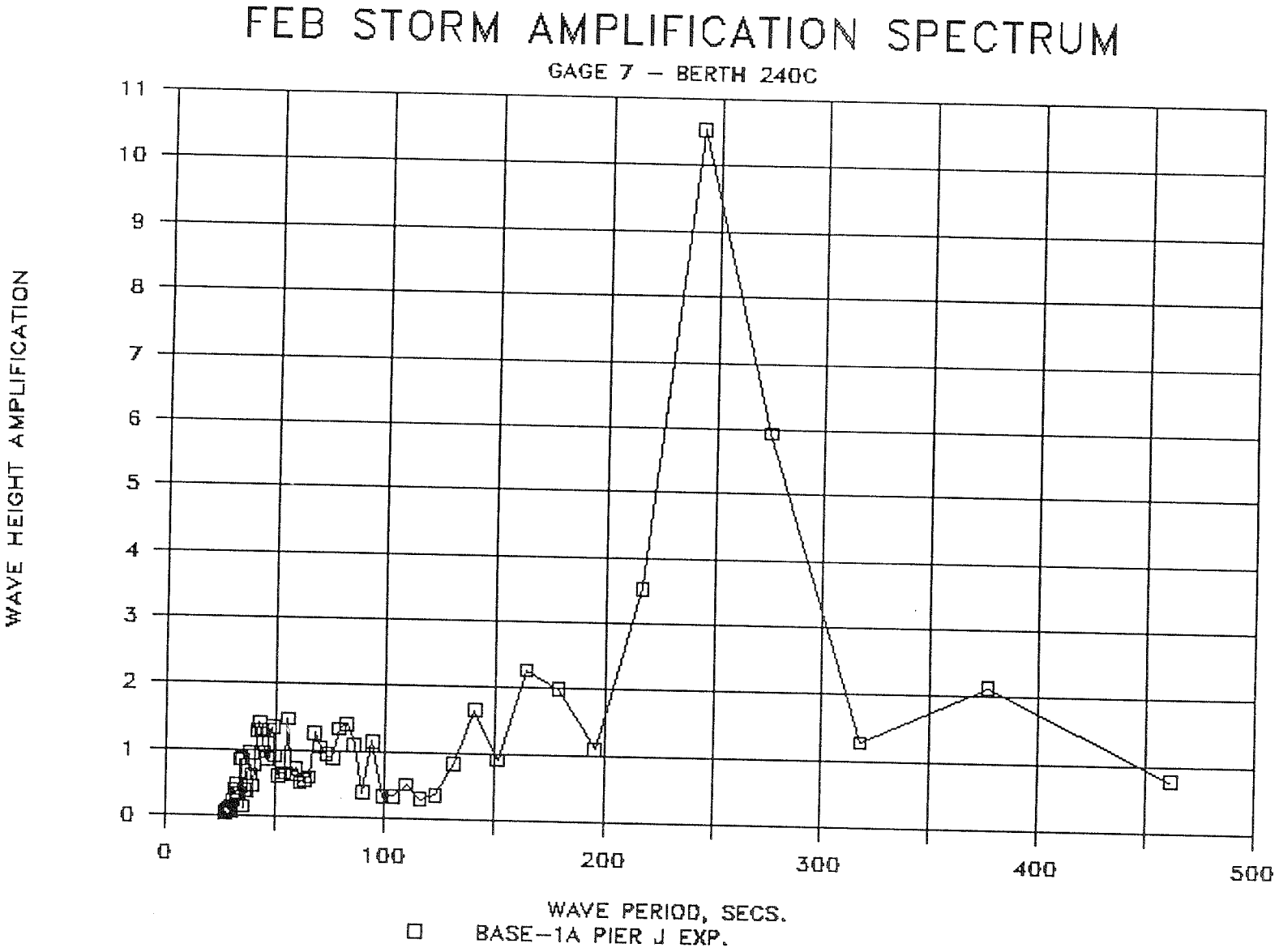

FEB STORM AMPLIFICATION SPECTRUM
GAGE 2 – LA WEST CH 5 ML BOAT BASIN
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

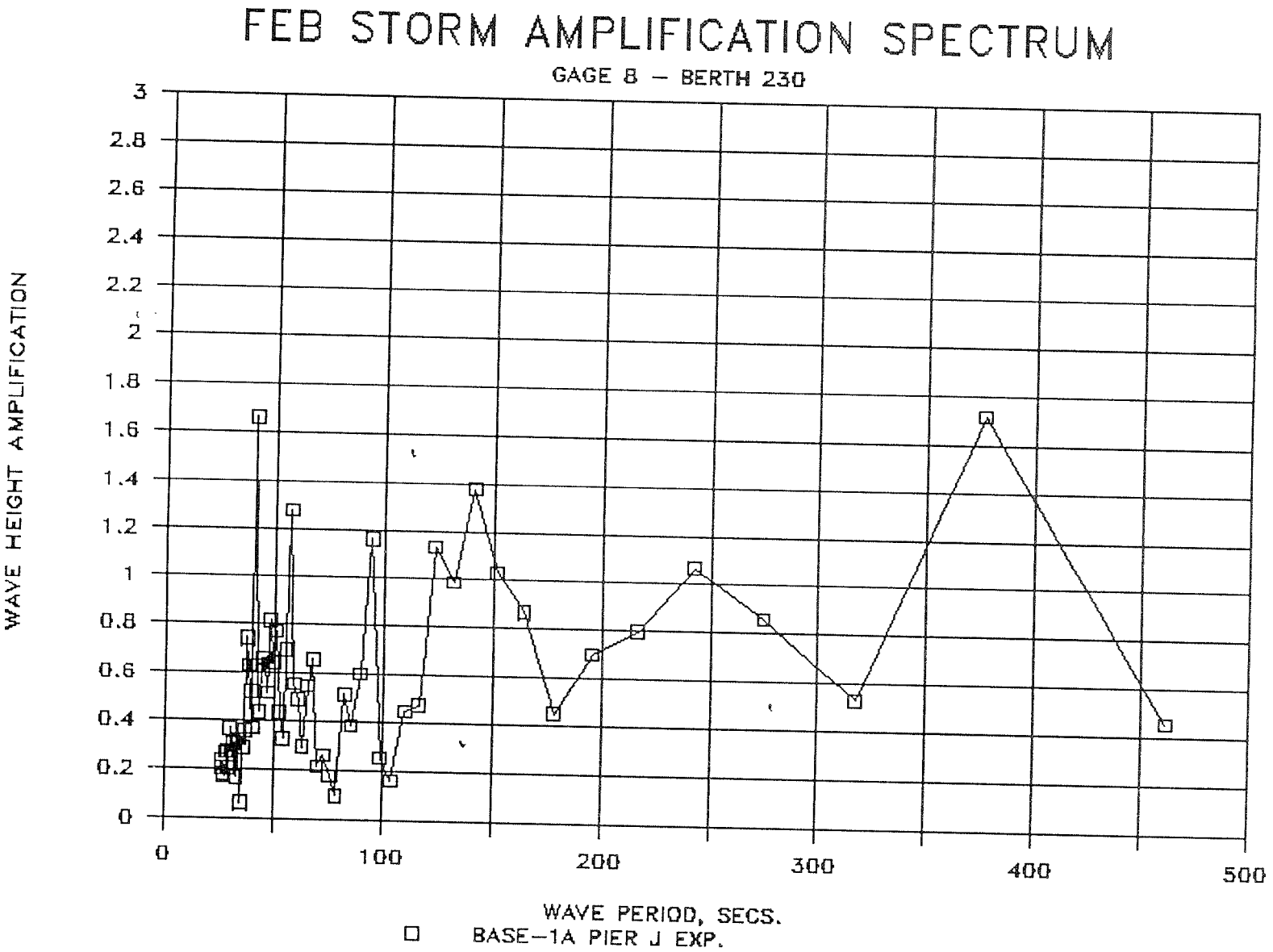

FEB STORM AMPLIFICATION SPECTRUM
GAGE 3 – WATCHORN BASIN
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

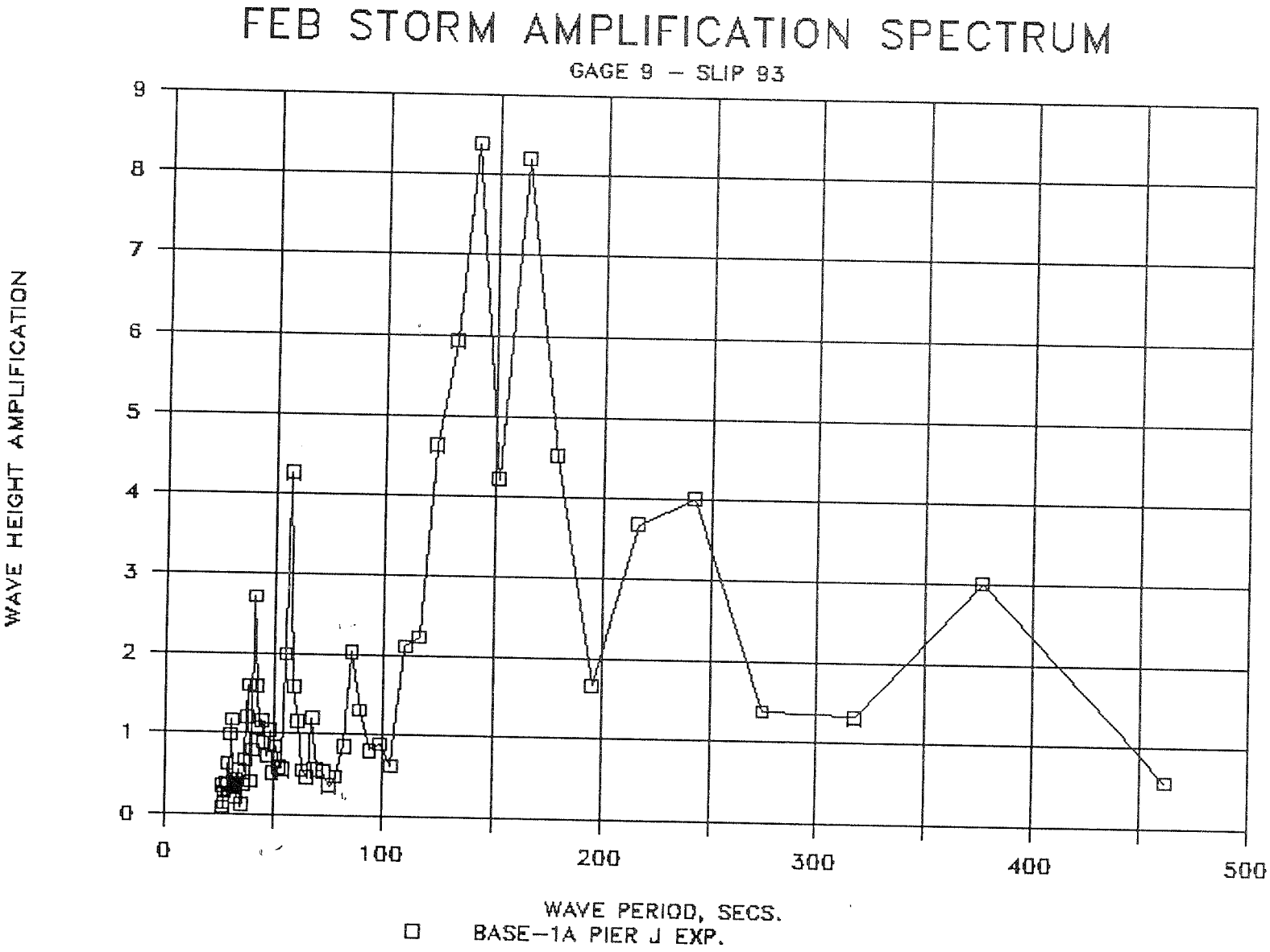

FEB STORM AMPLIFICATION SPECTRUM
GAGE 4 – LA BERTH 46
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

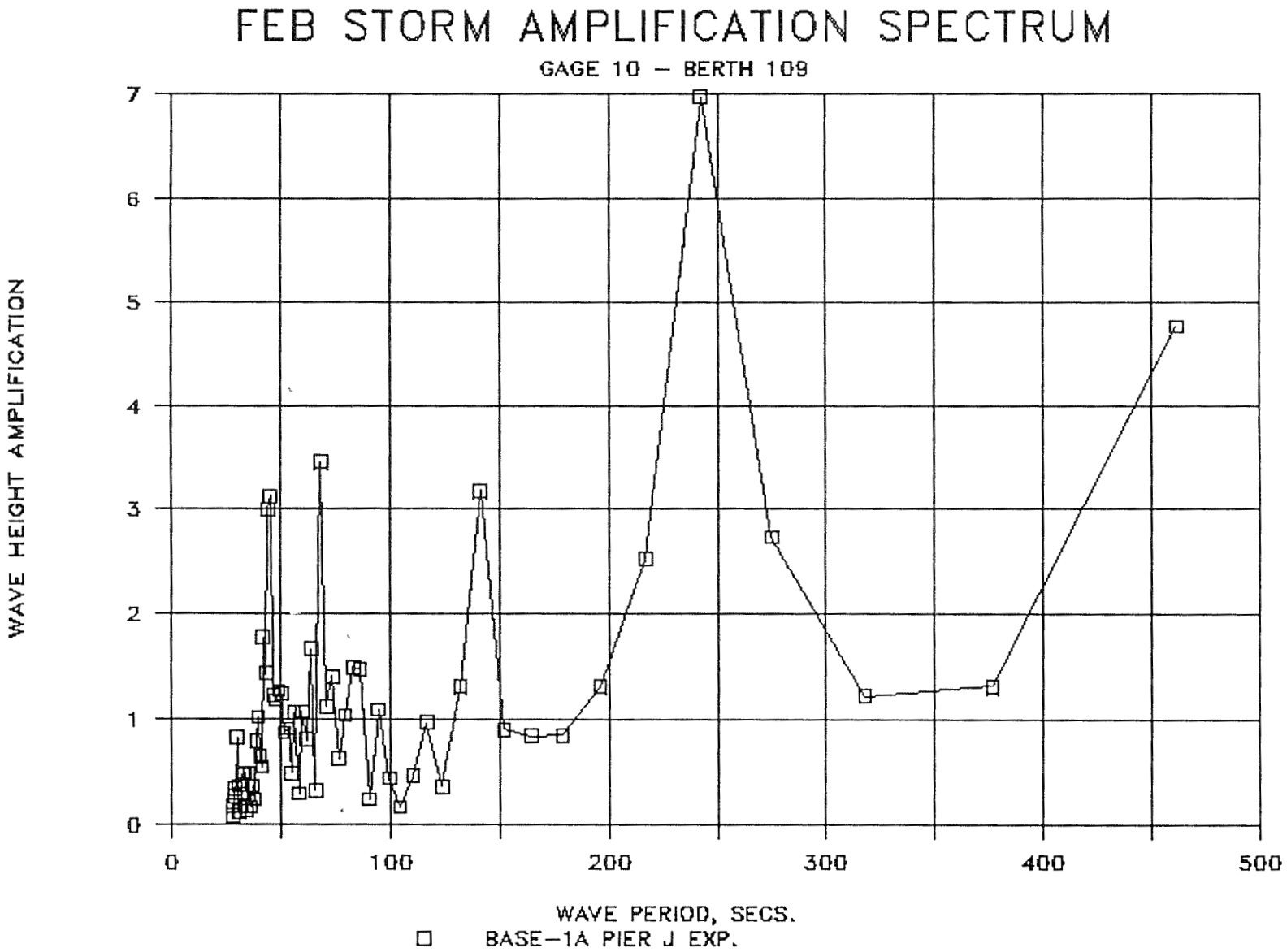

FEB STORM AMPLIFICATION SPECTRUM
GAGE 5 — LA COAL TERMINAL
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE-1A PIER J EXP.

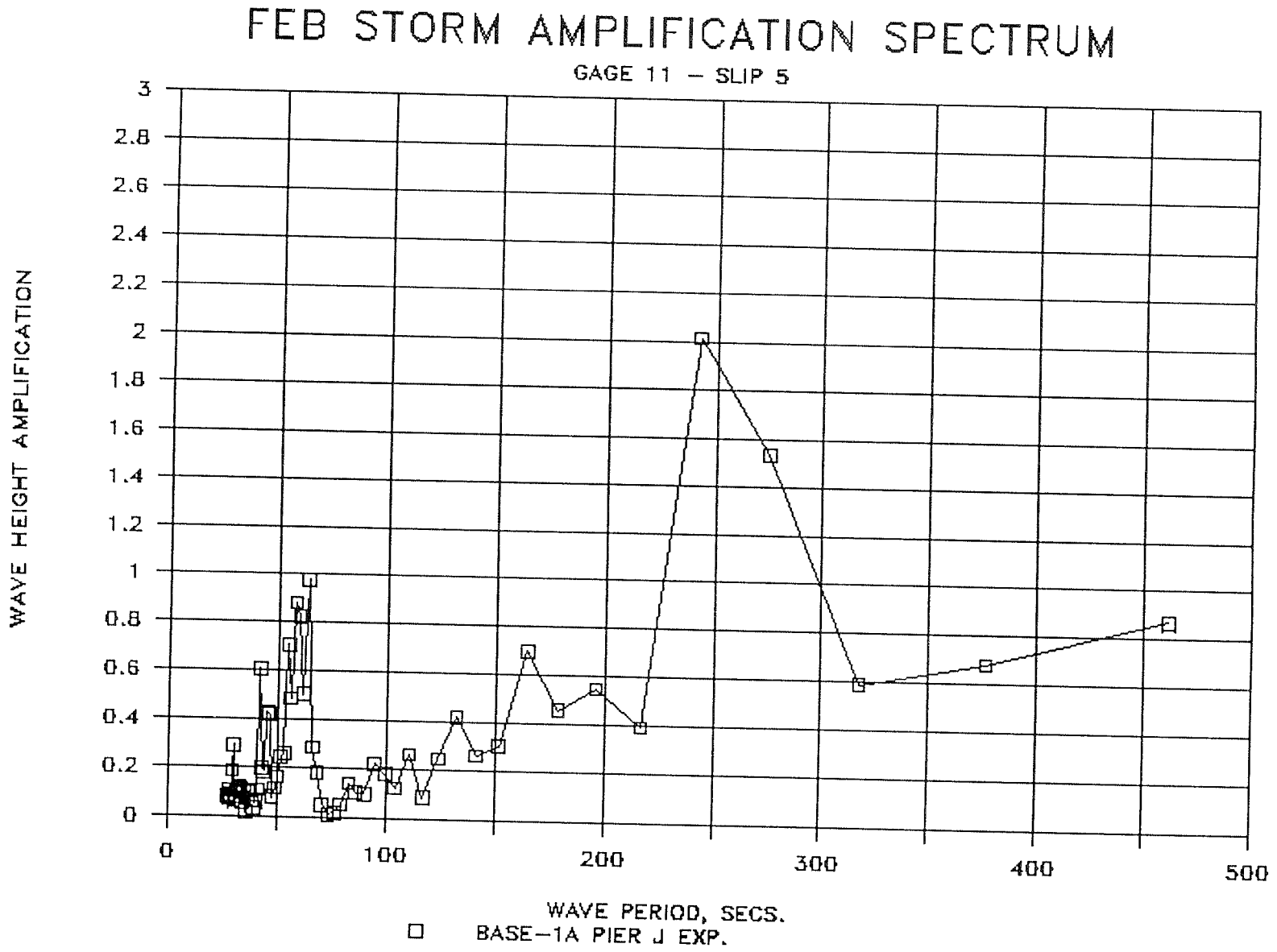

FEB STORM AMPLIFICATION SPECTRUM
GAGE 6 – EAST CHANNEL
WAVE HEIGHT AMPLIFICATION
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

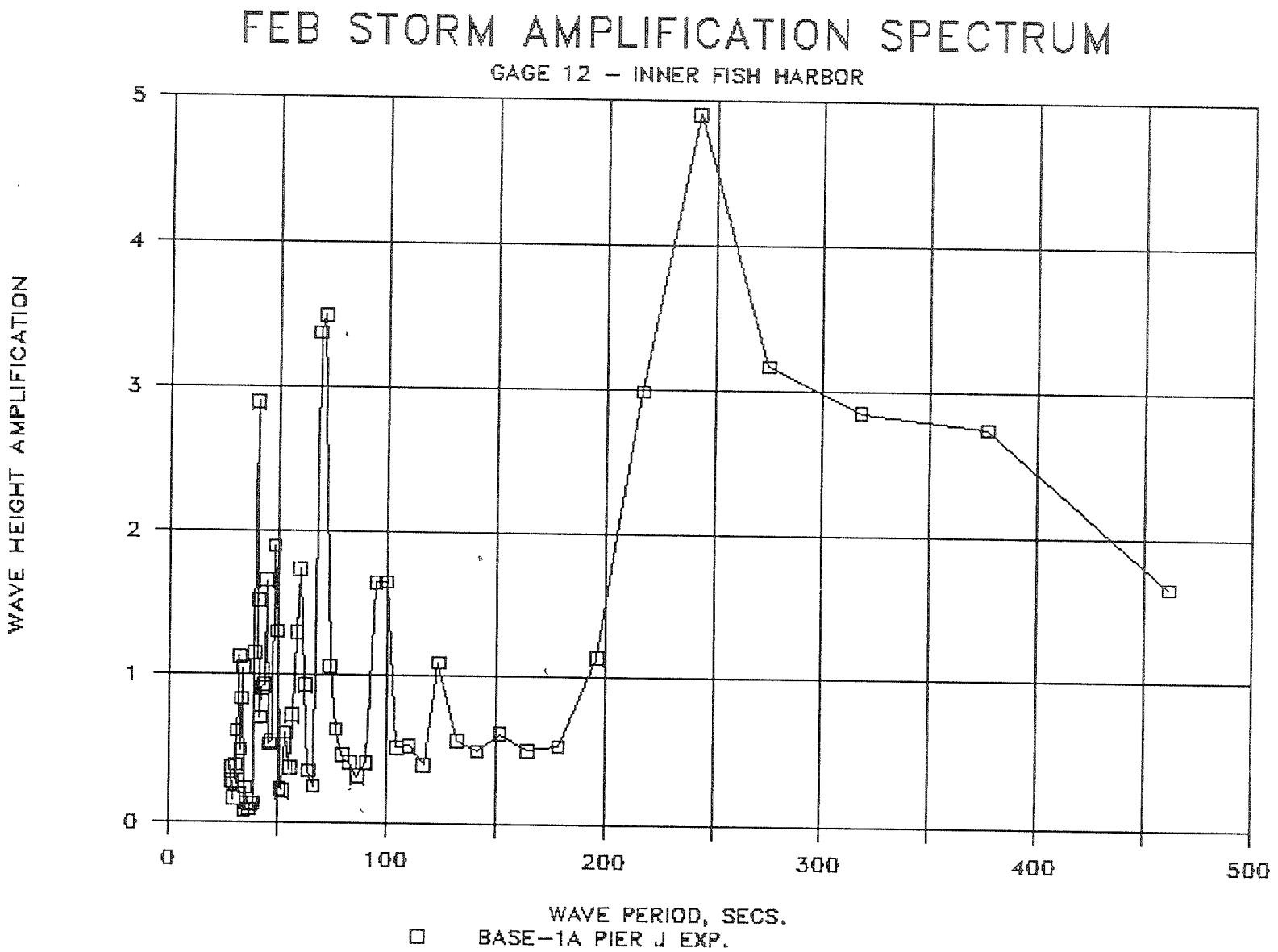

FEB STORM AMPLIFICATION SPECTRUM
GAGE 7 – BERTH 240C
WAVE HEIGHT AMPLIFICATION
11
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

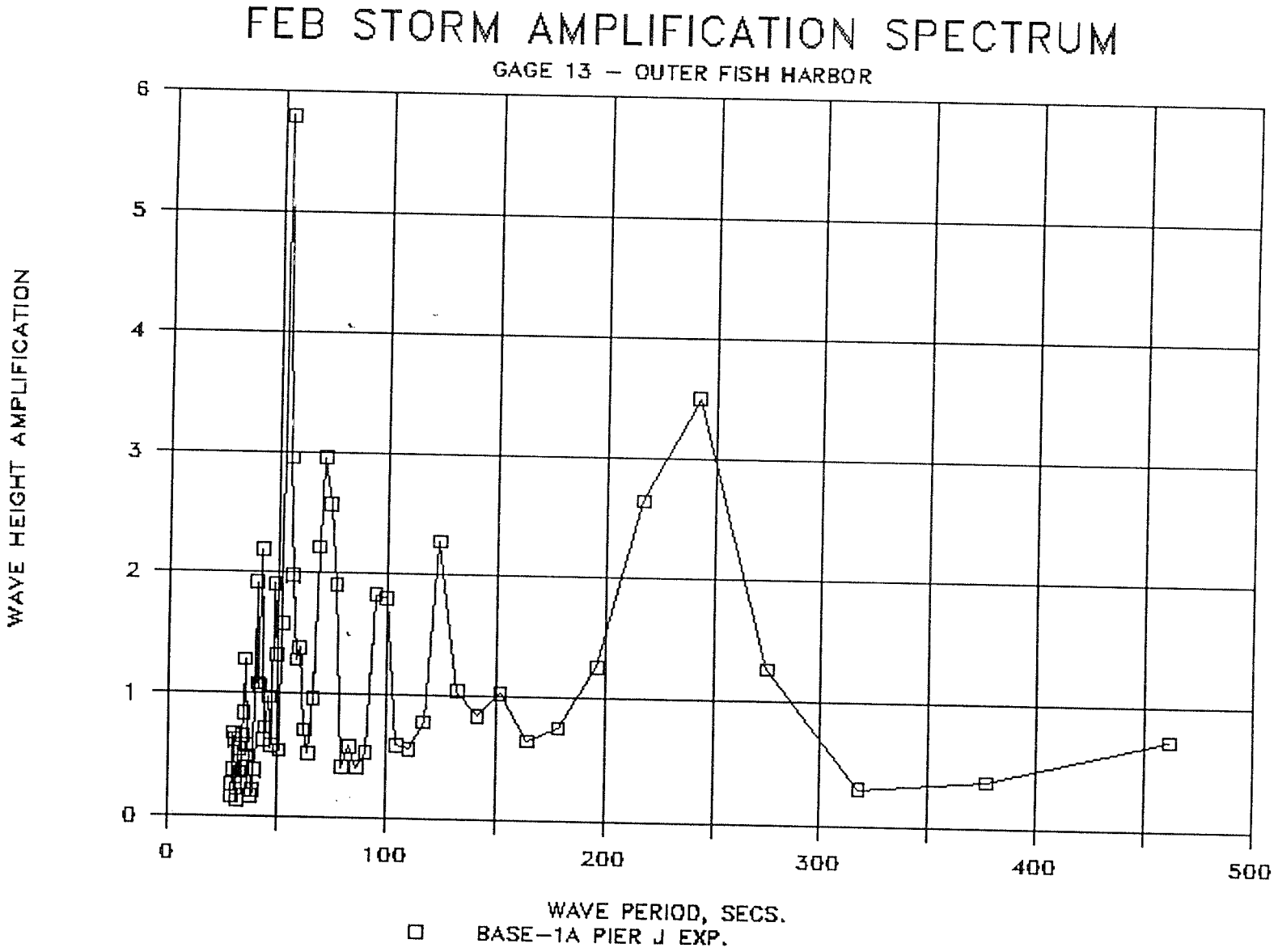

FEB STORM AMPLIFICATION SPECTRUM
GAGE 8 – BERTH 230
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

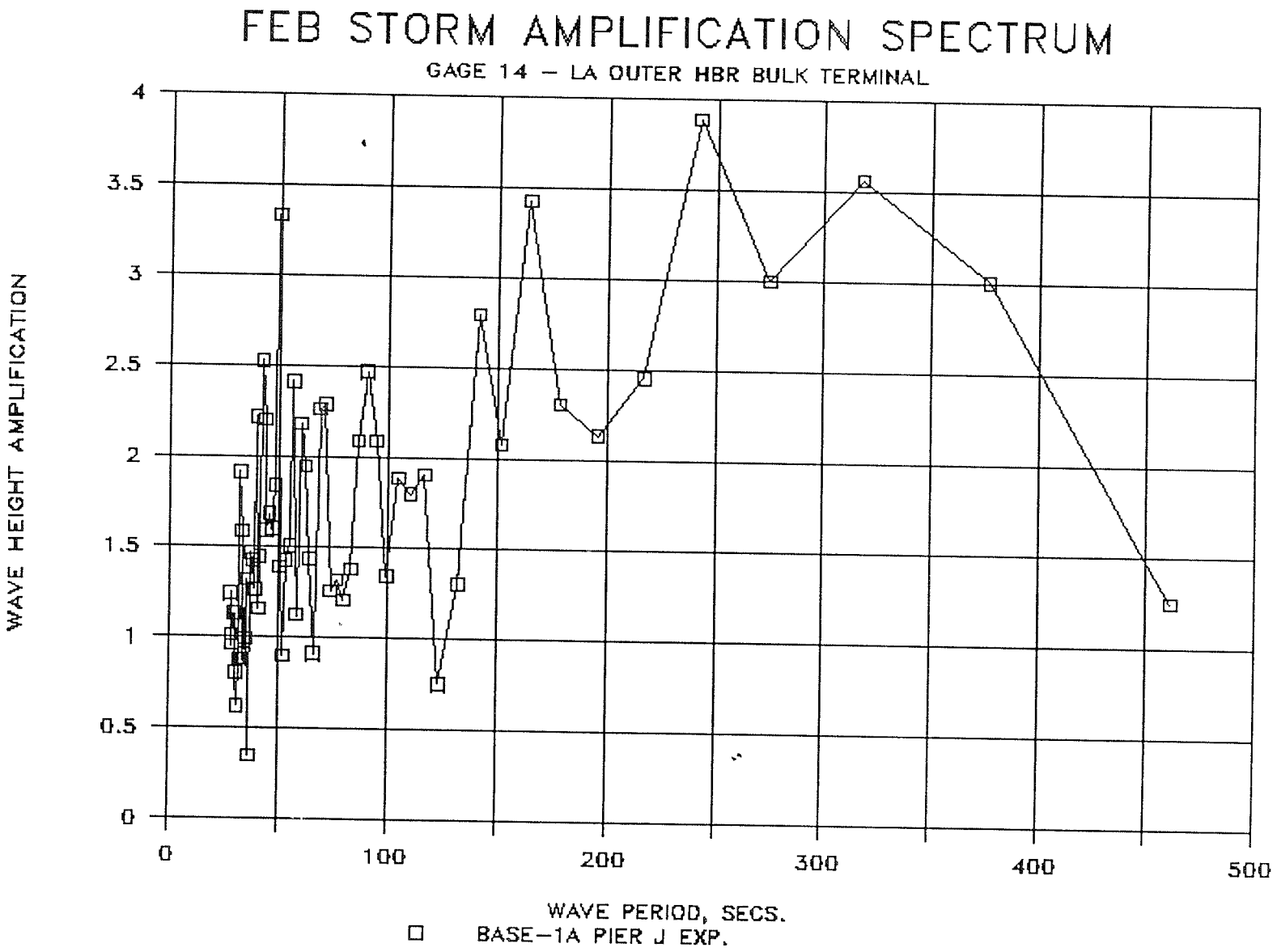

FEB STORM AMPLIFICATION SPECTRUM
GAGE 9 – SLIP 93
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

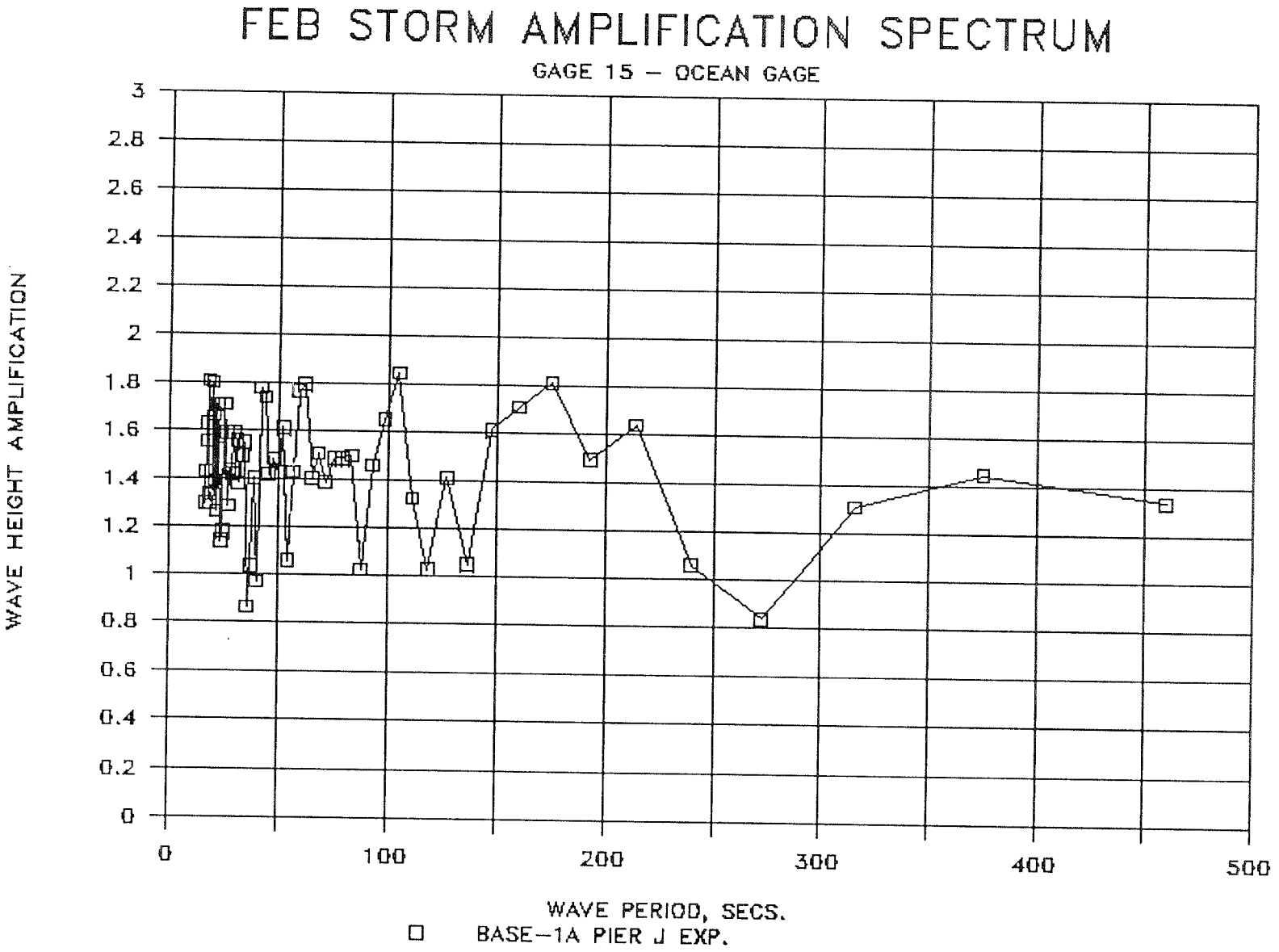

FEB STORM AMPLIFICATION SPECTRUM
GAGE 10 – BERTH 109
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

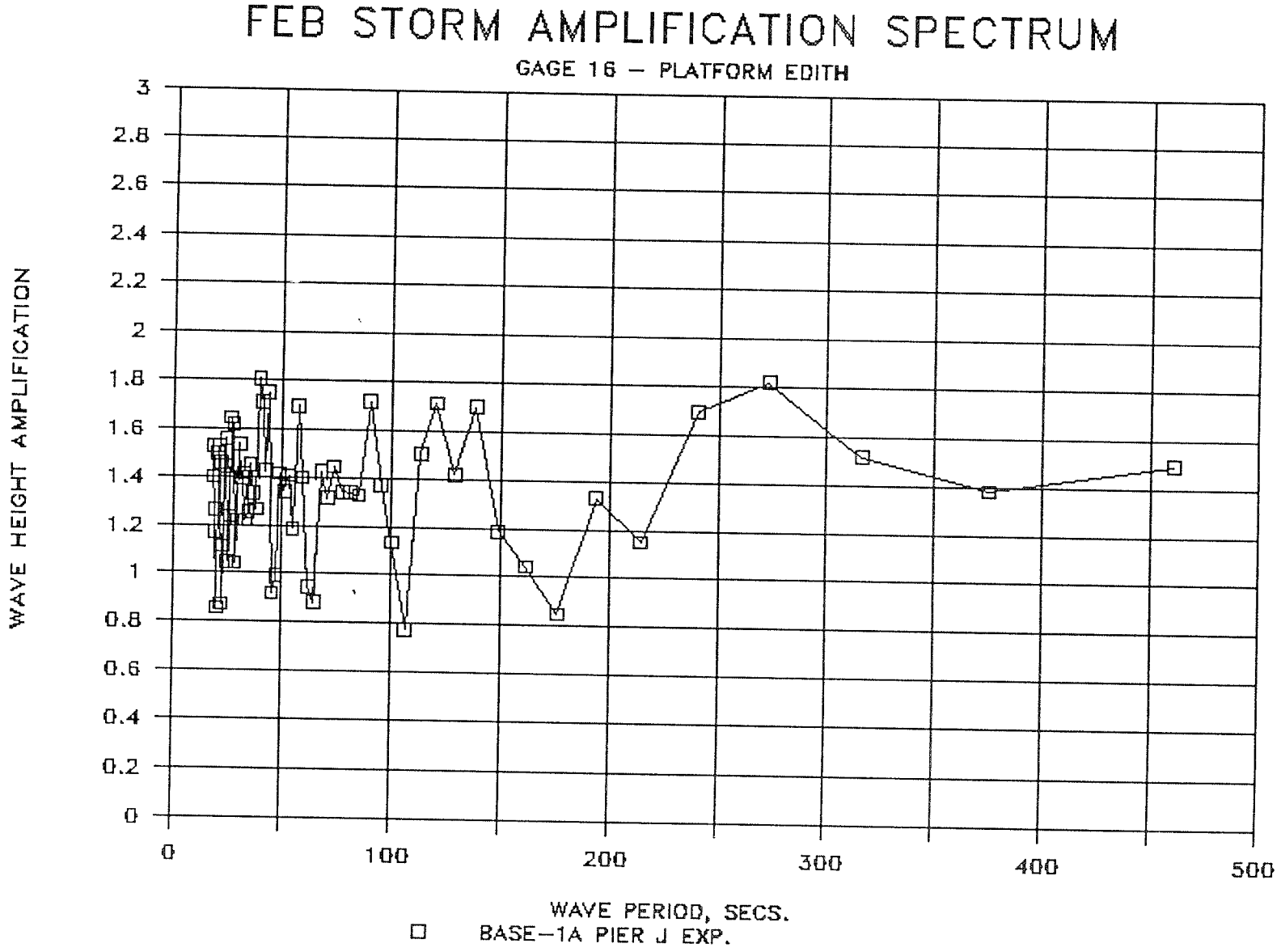

FEB STORM AMPLIFICATION SPECTRUM
GAGE 11 – SLIP 5
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

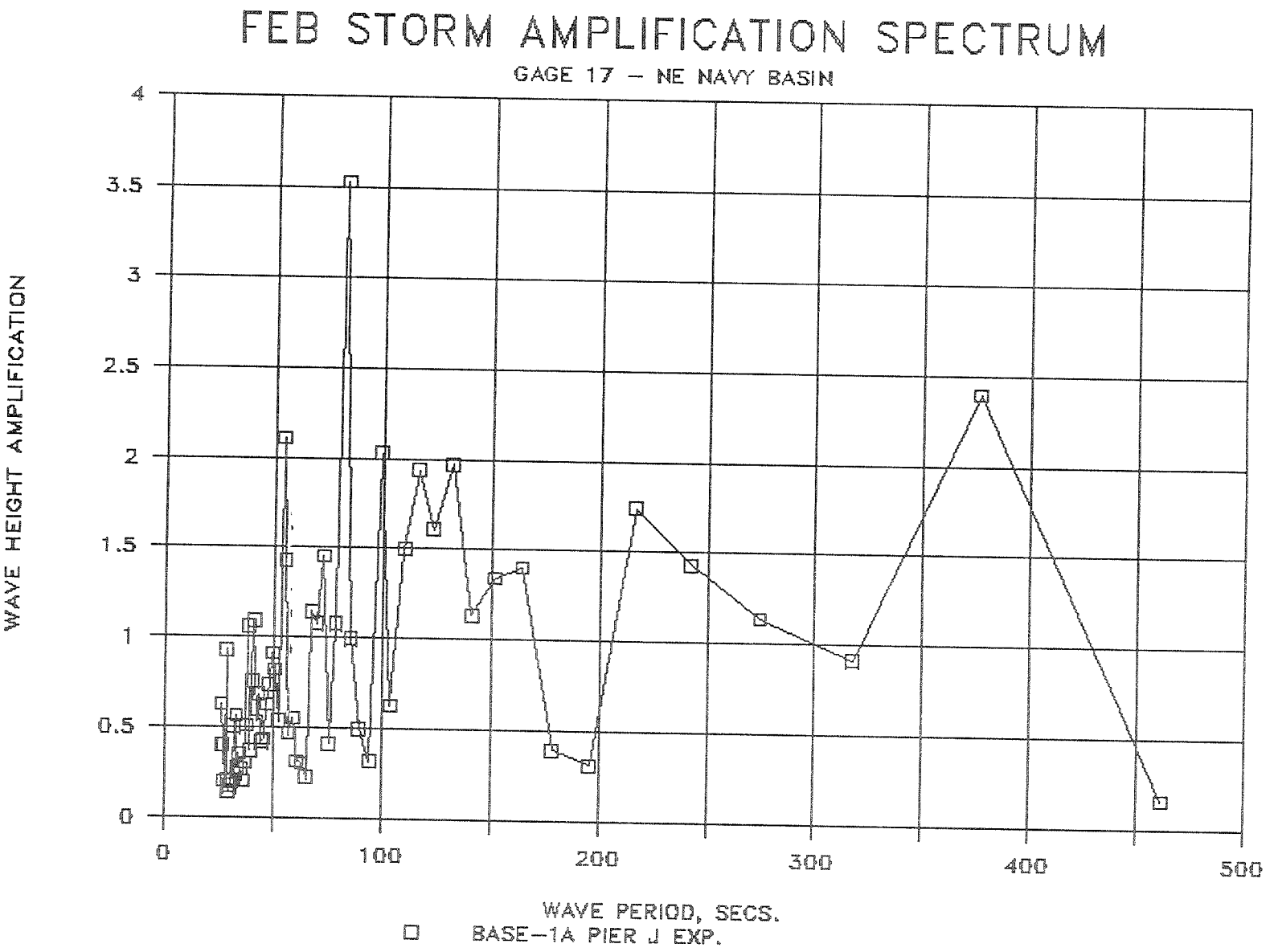

FEB STORM AMPLIFICATION SPECTRUM
GAGE 12 – INNER FISH HARBOR
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.


FEB STORM AMPLIFICATION SPECTRUM
GAGE 13 – OUTER FISH HARBOR
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.


FEB STORM AMPLIFICATION SPECTRUM
GAGE 14 – LA OUTER HBR BULK TERMINAL
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

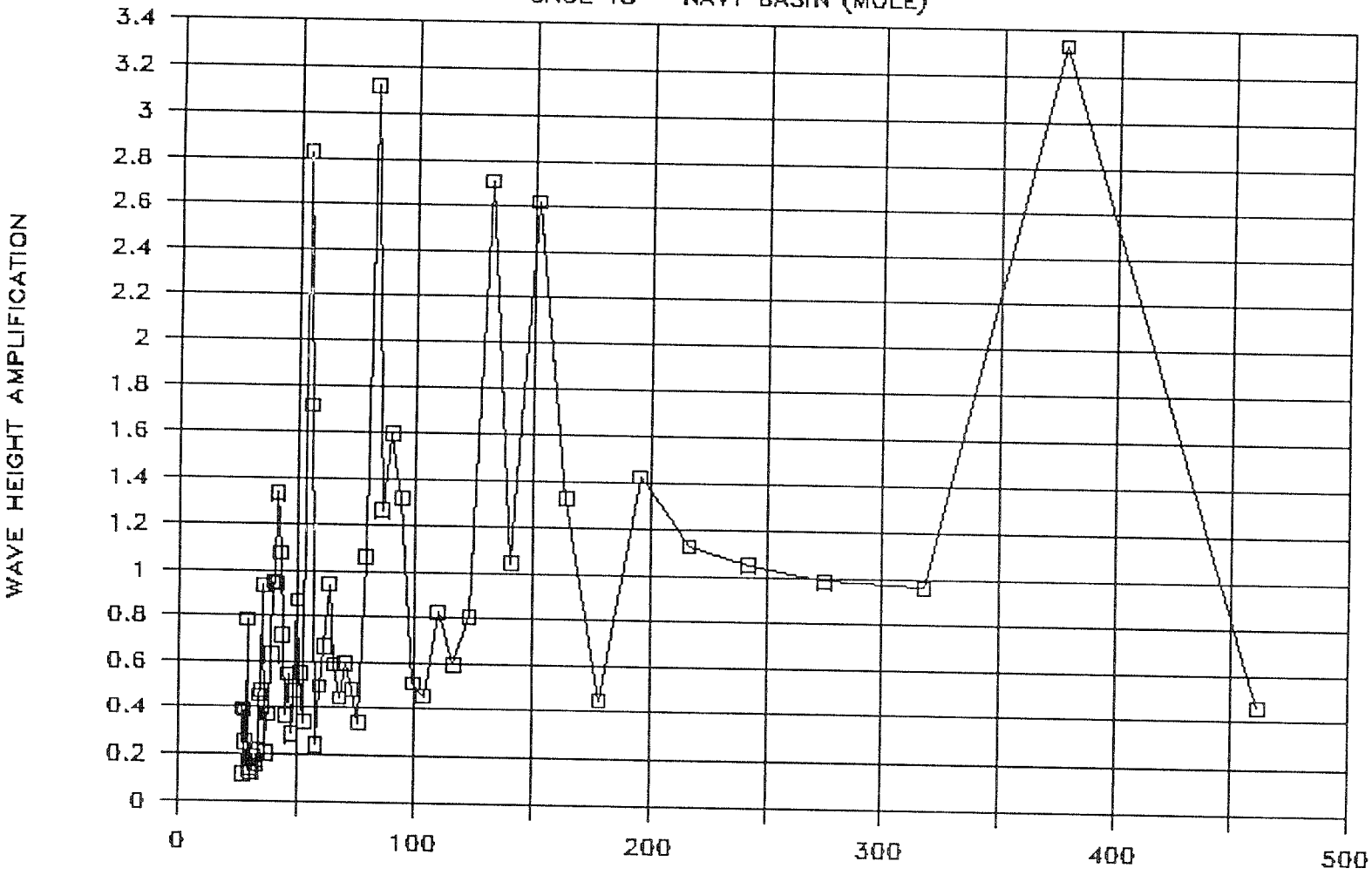

FEB STORM AMPLIFICATION SPECTRUM
GAGE 15 – OCEAN GAGE
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

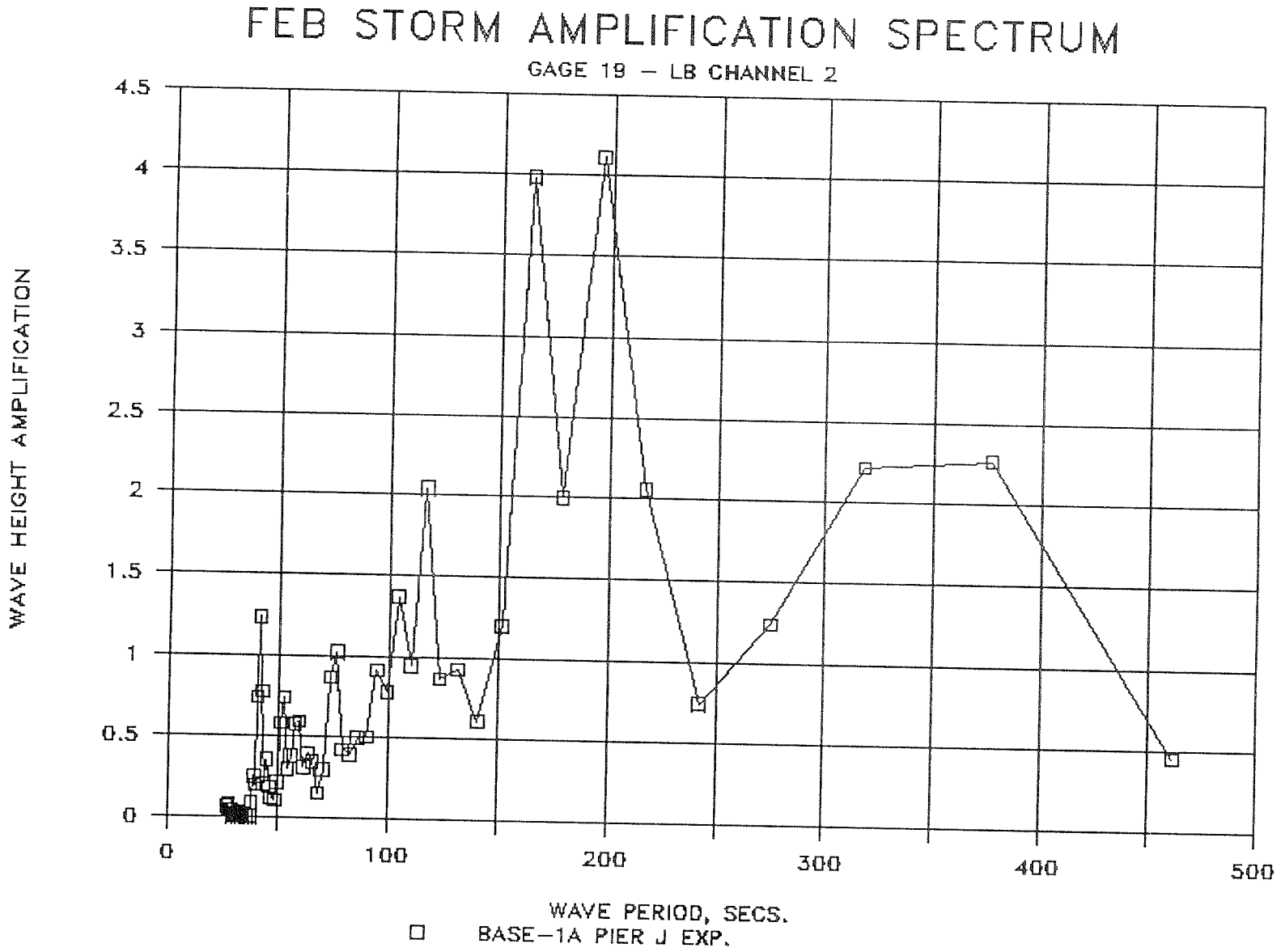

FEB STORM AMPLIFICATION SPECTRUM
GAGE 16 – PLATFORM EDITH
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

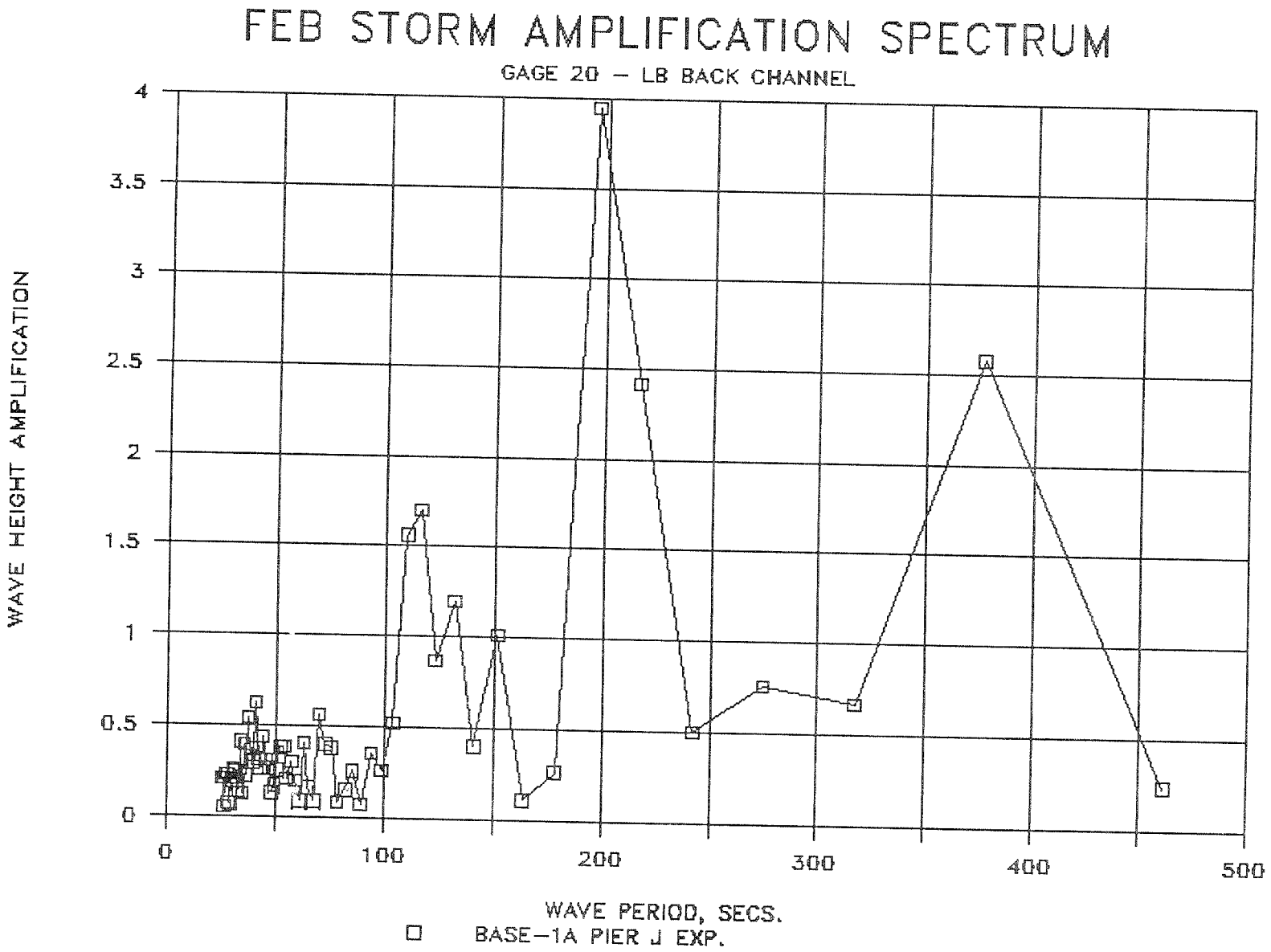

FEB STORM AMPLIFICATION SPECTRUM
GAGE 17 – NE NAVY BASIN
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

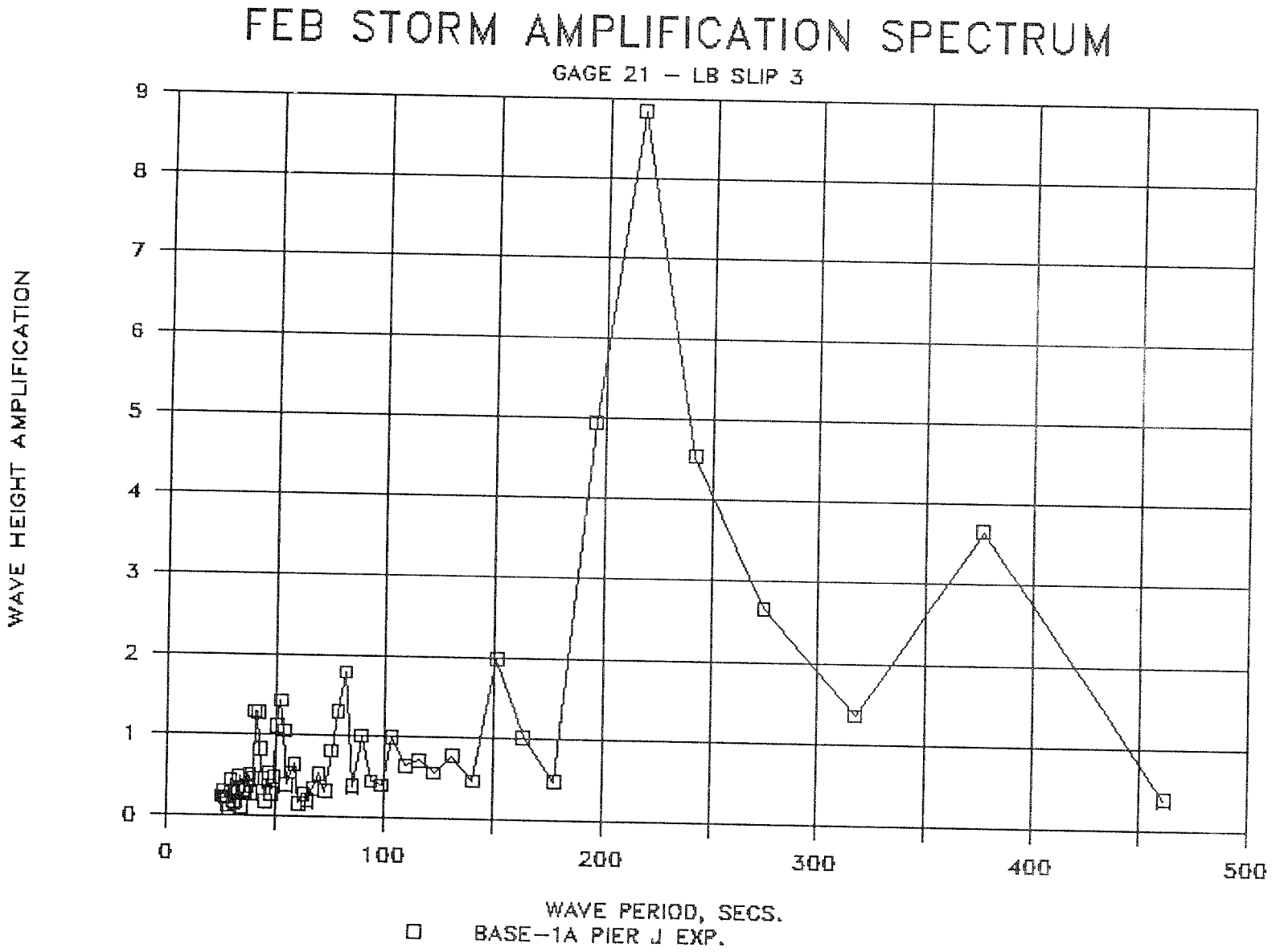
FEB STORM AMPLIFICATION SPECTRUM

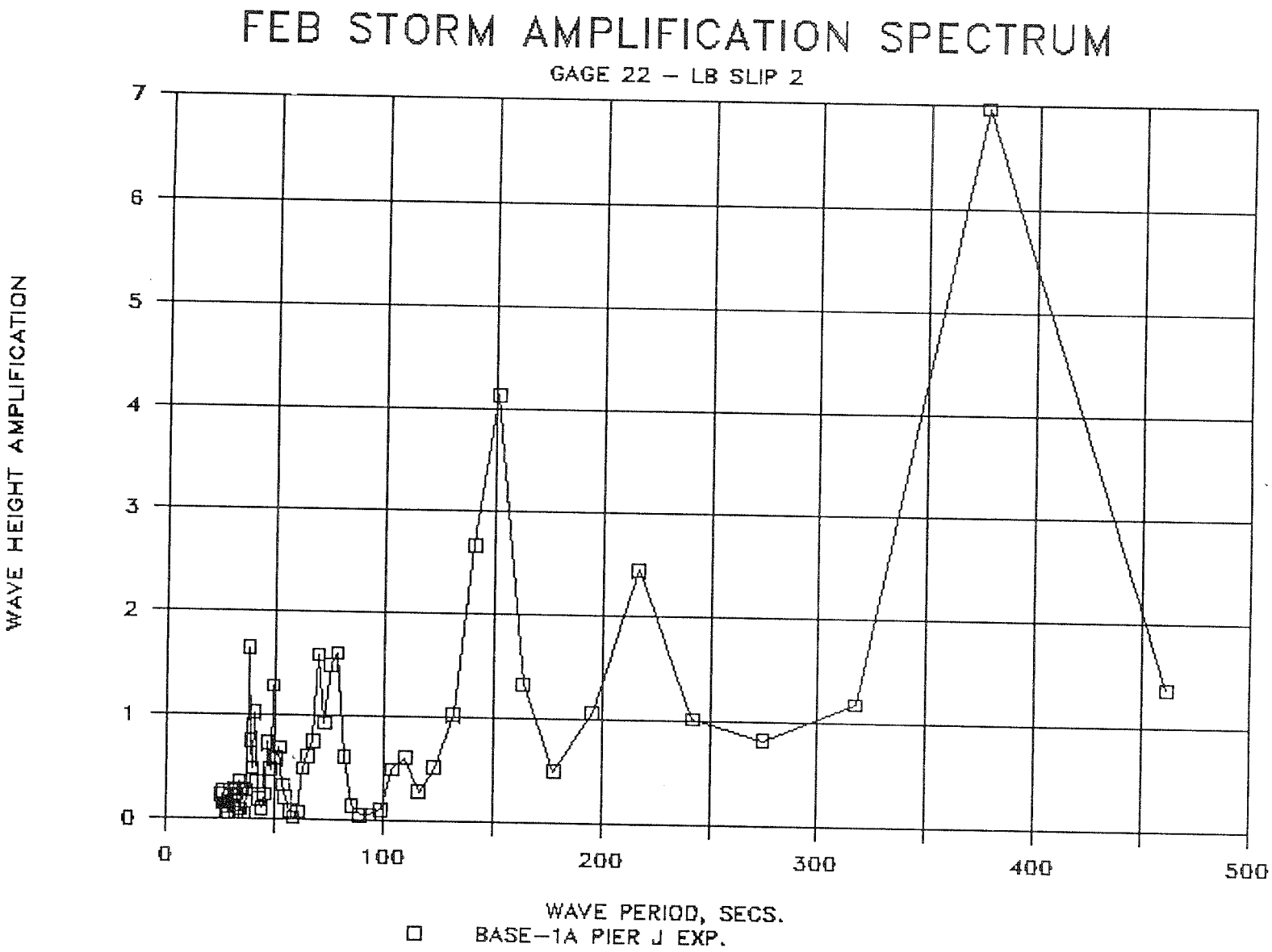
GAGE 18 – NAVY BASIN (MOLE)

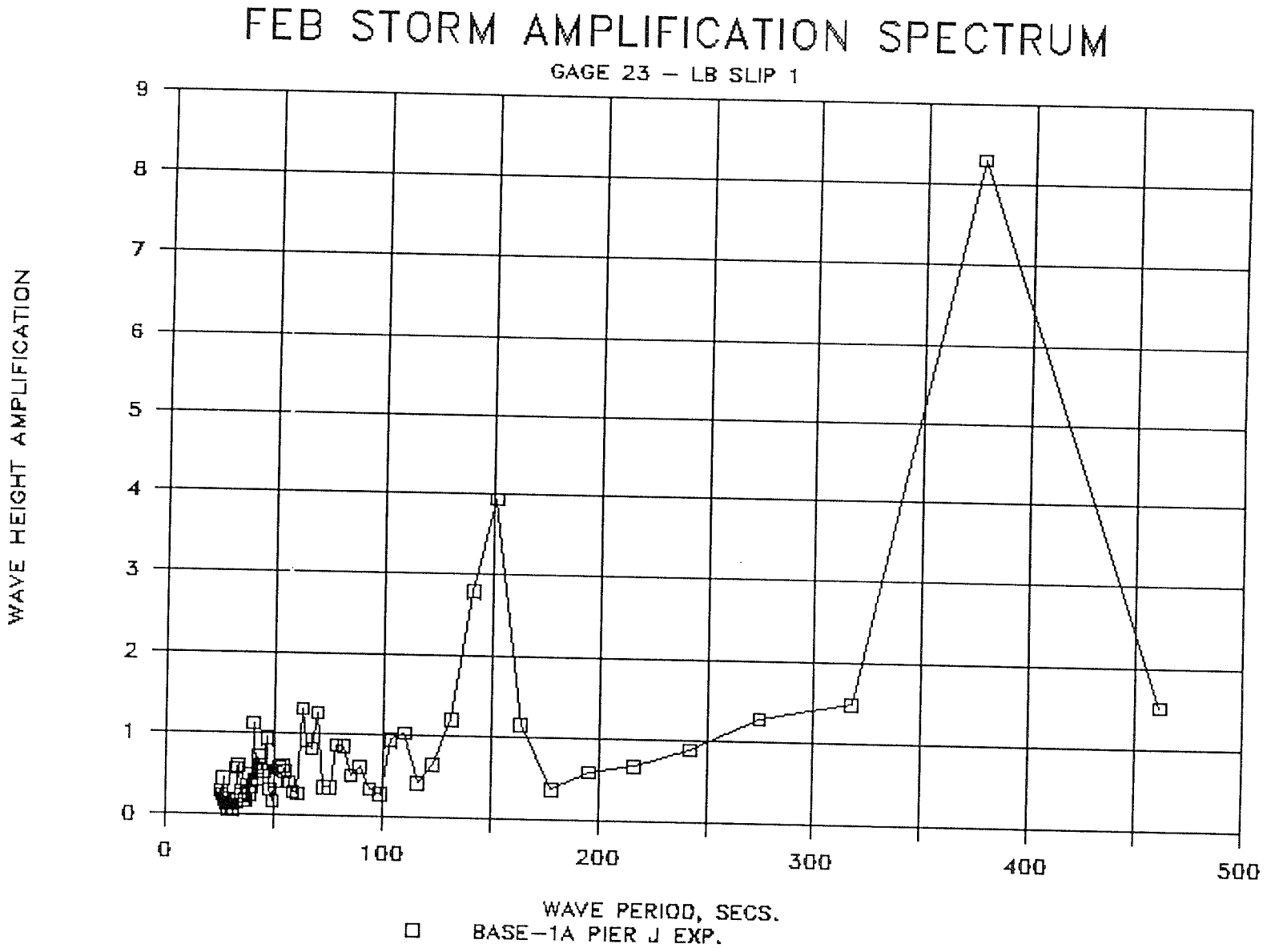


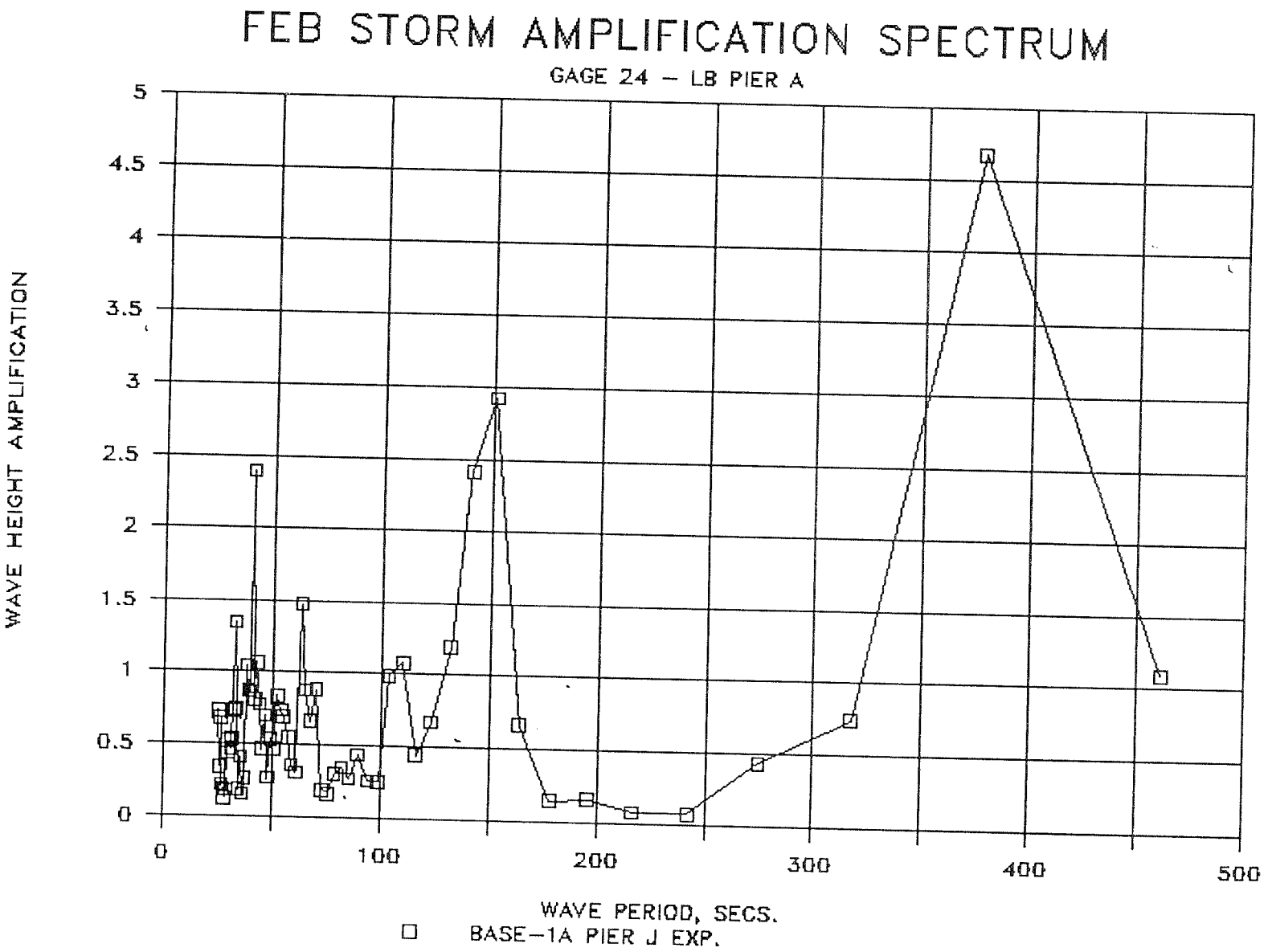

FEB STORM AMPLIFICATION SPECTRUM
GAGE 19 – LB CHANNEL 2
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

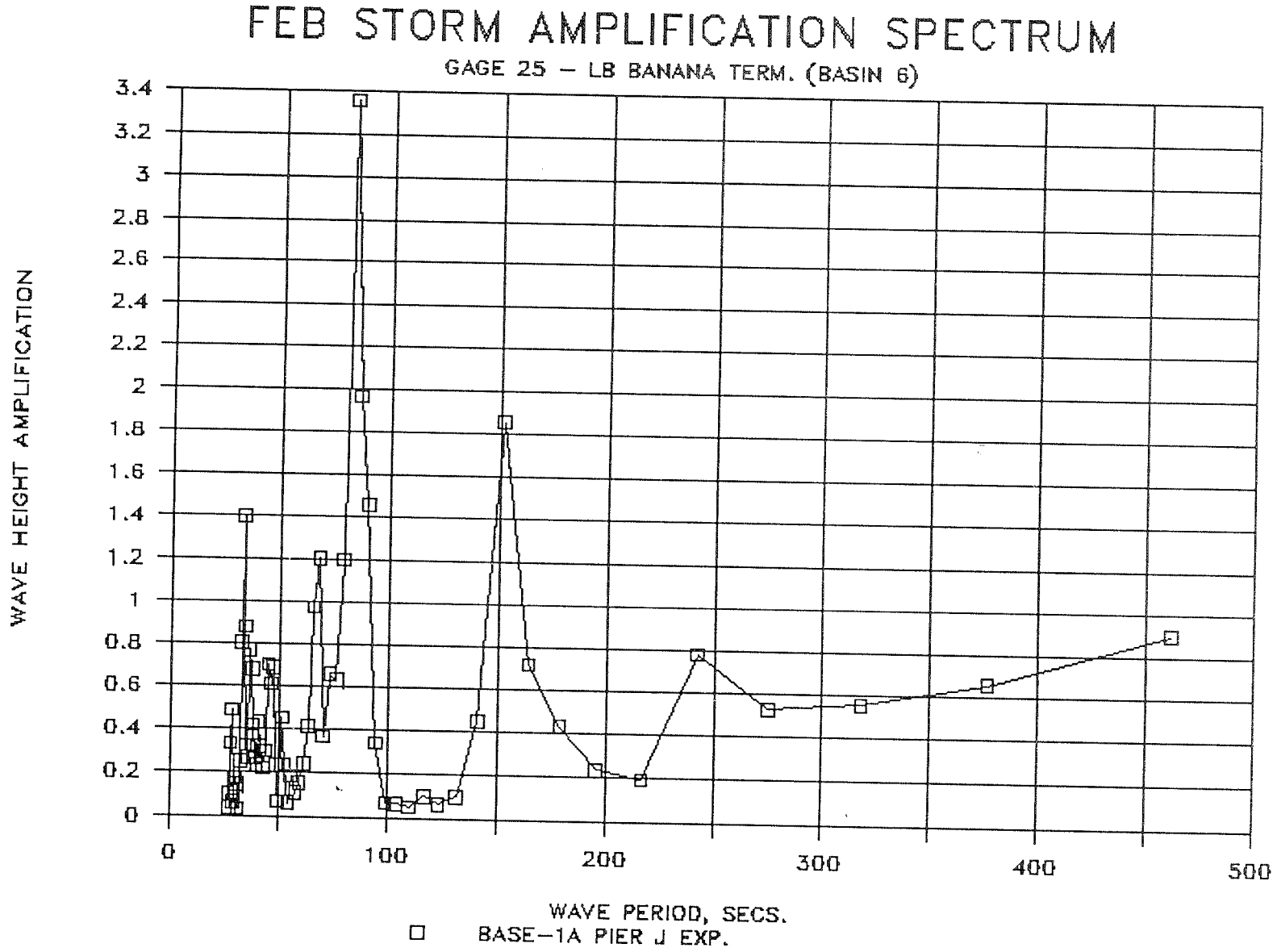

FEB STORM AMPLIFICATION SPECTRUM
GAGE 20 – LB BACK CHANNEL
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

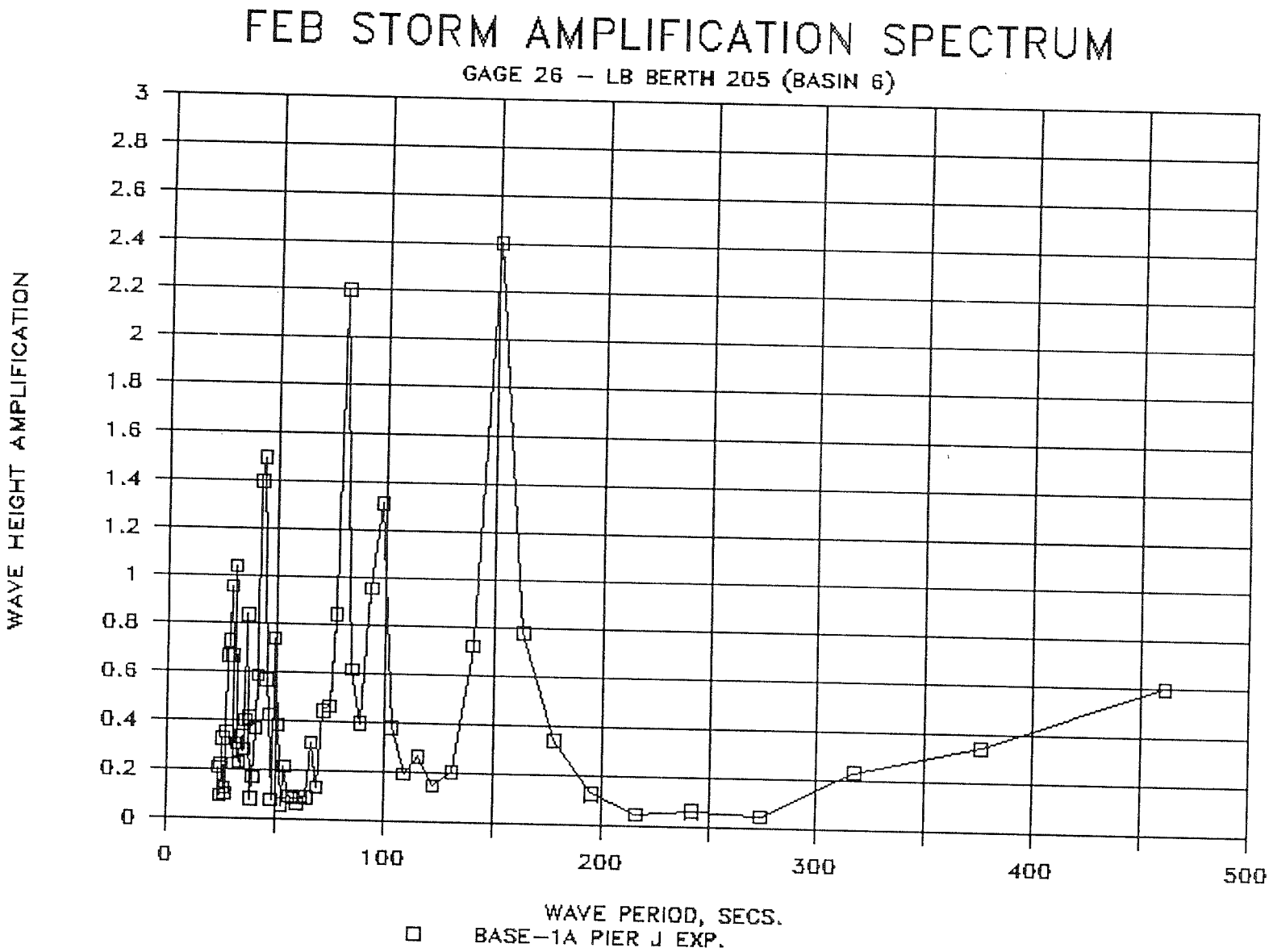

FEB STORM AMPLIFICATION SPECTRUM
GAGE 21 – LB SLIP 3
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

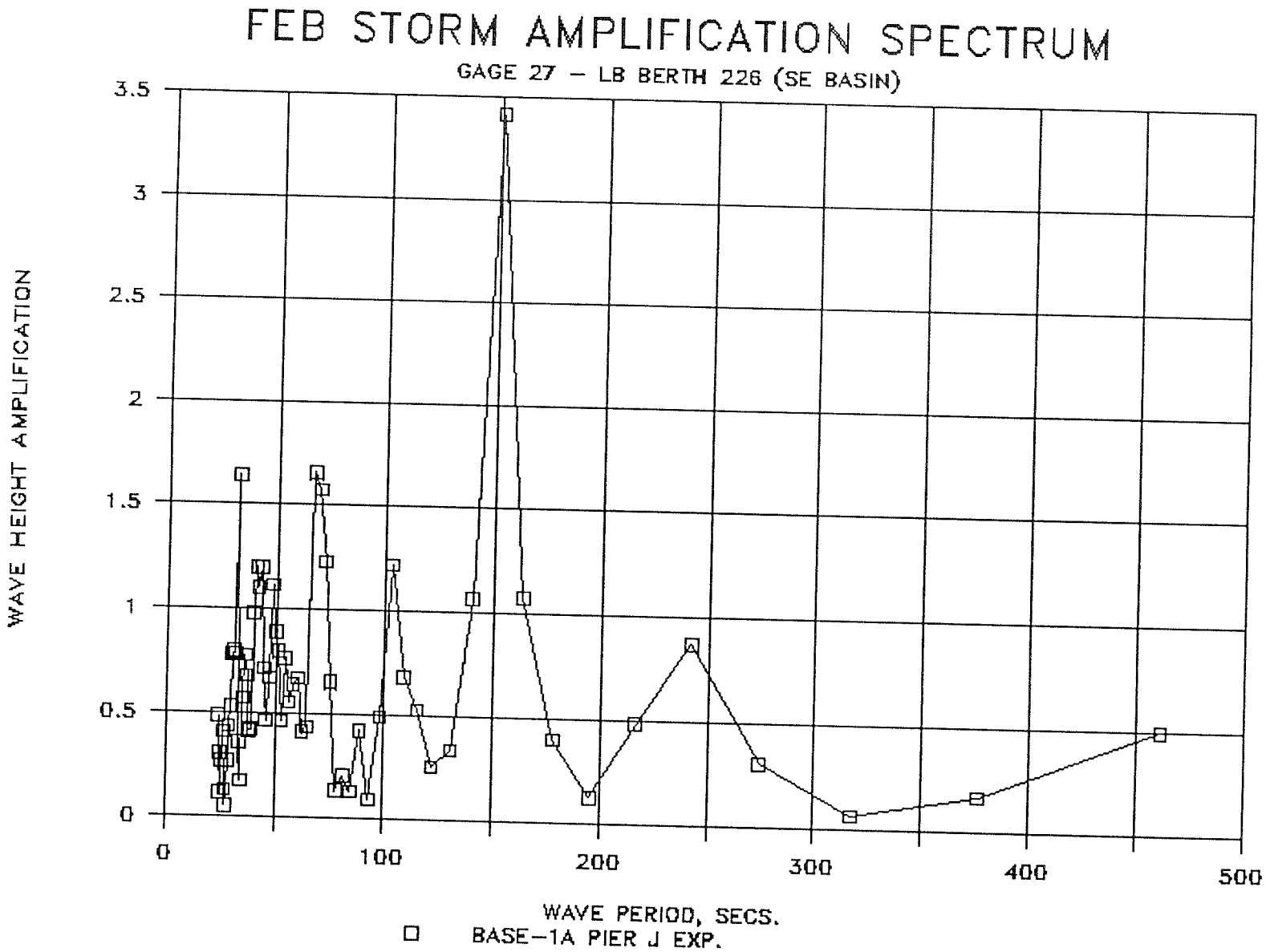

FEB STORM AMPLIFICATION SPECTRUM
GAGE 22 – LB SLIP 2
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

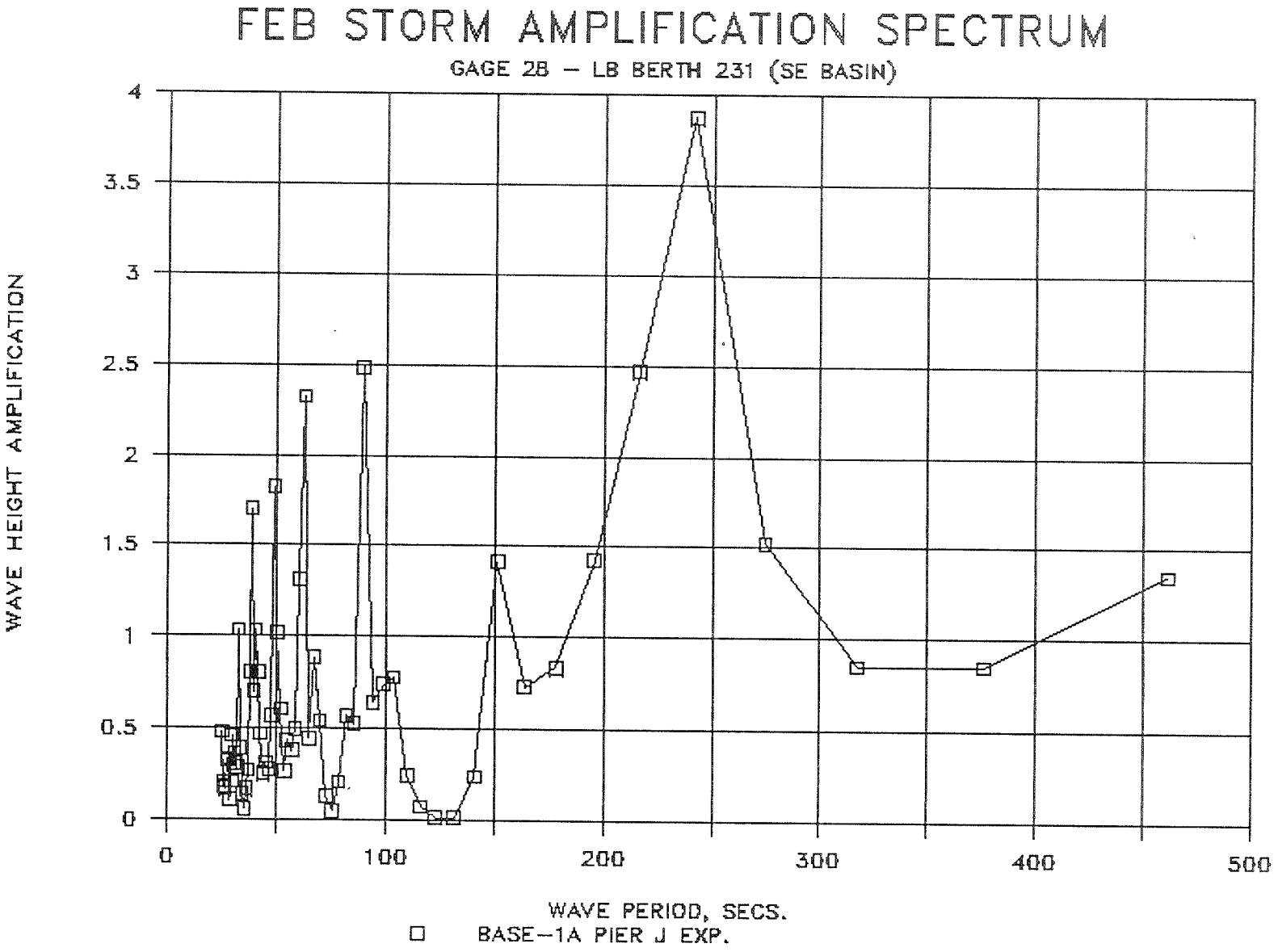

FEB STORM AMPLIFICATION SPECTRUM
GAGE 23 – LB SLIP 1
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

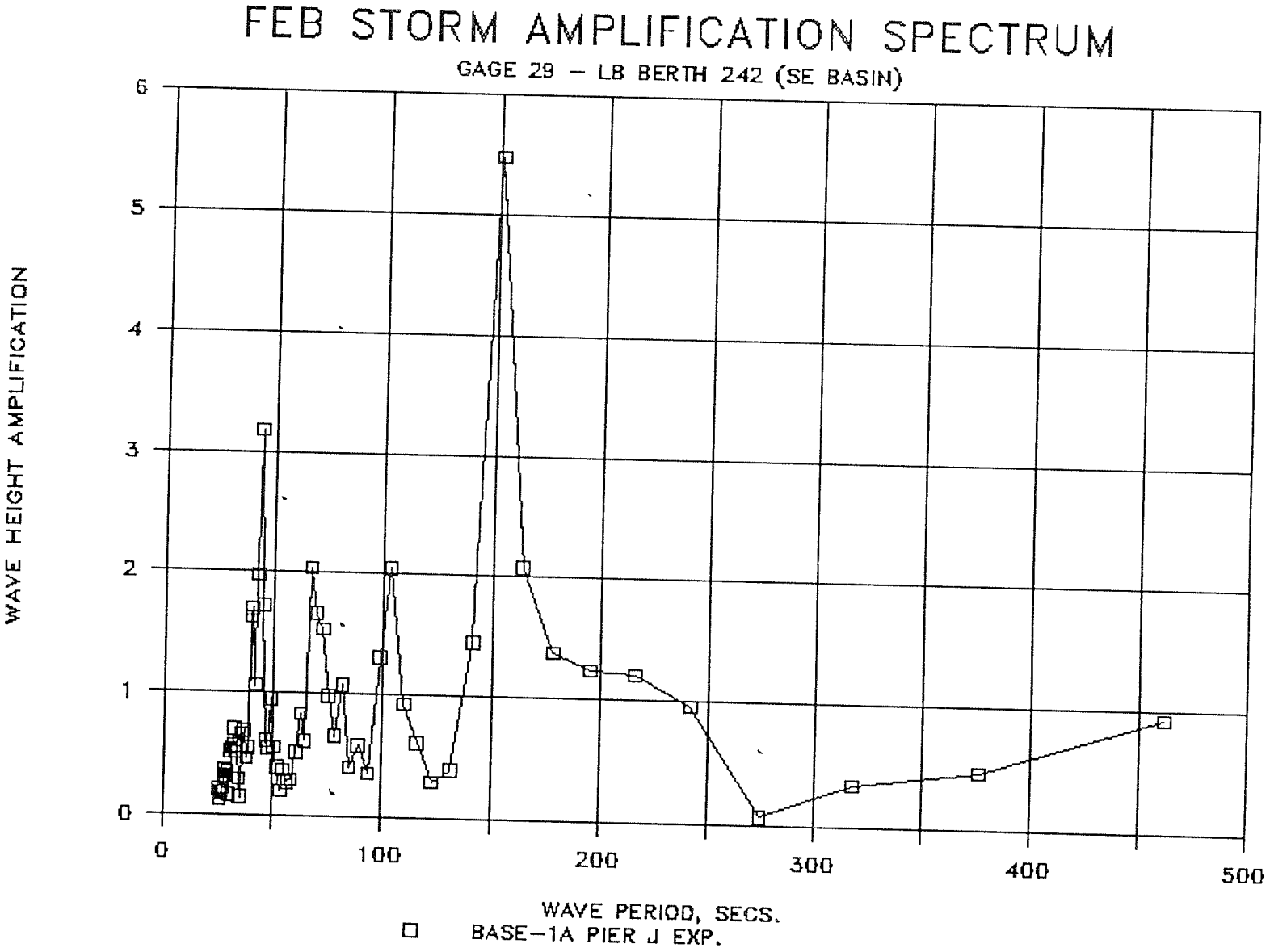

FEB STORM AMPLIFICATION SPECTRUM
GAGE 24 – LB PIER A
WAVE HEIGHT AMPLIFICATION
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

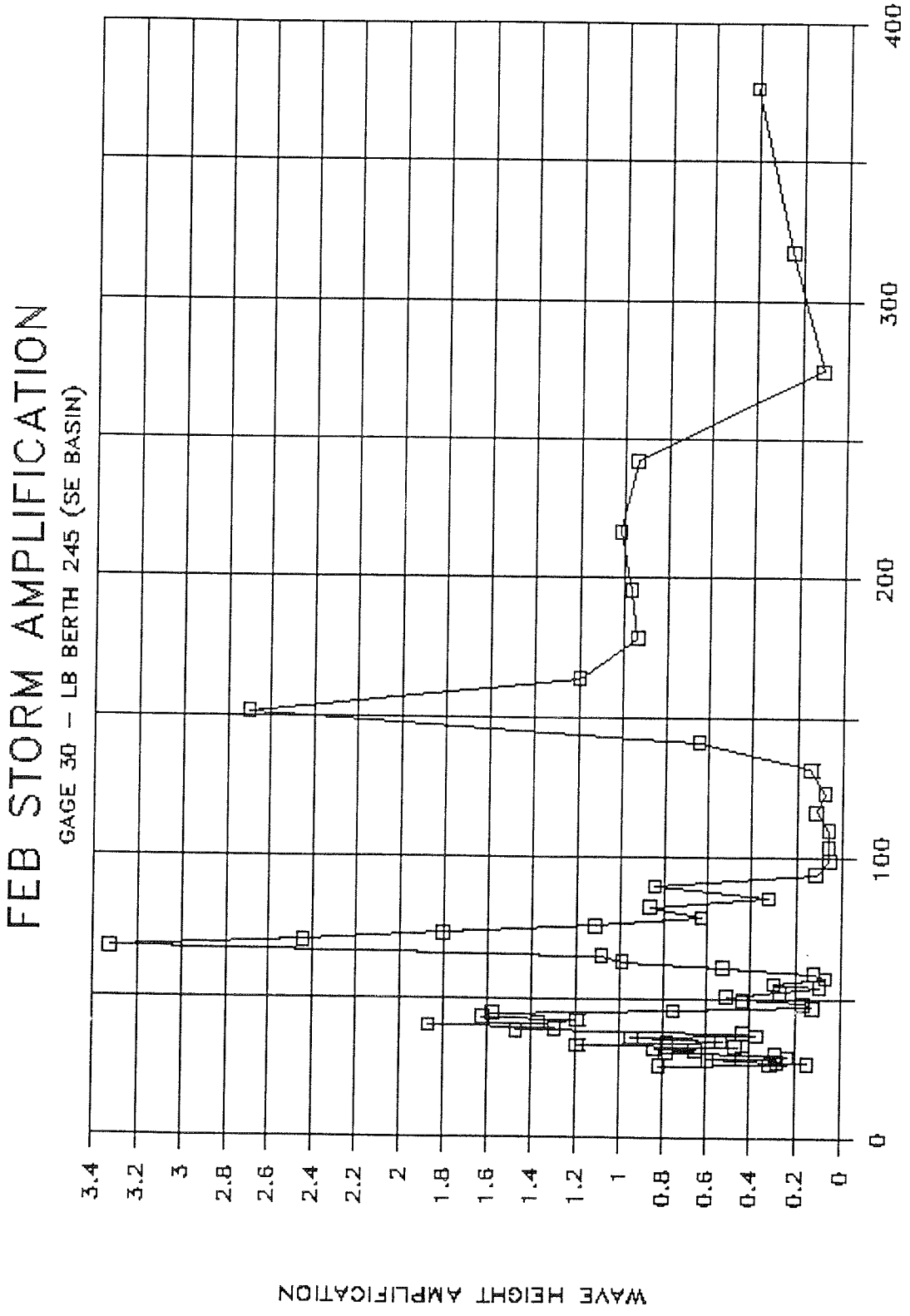

FEB STORM AMPLIFICATION SPECTRUM
GAGE 25 – LB BANANA TERM. (BASIN 6)
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

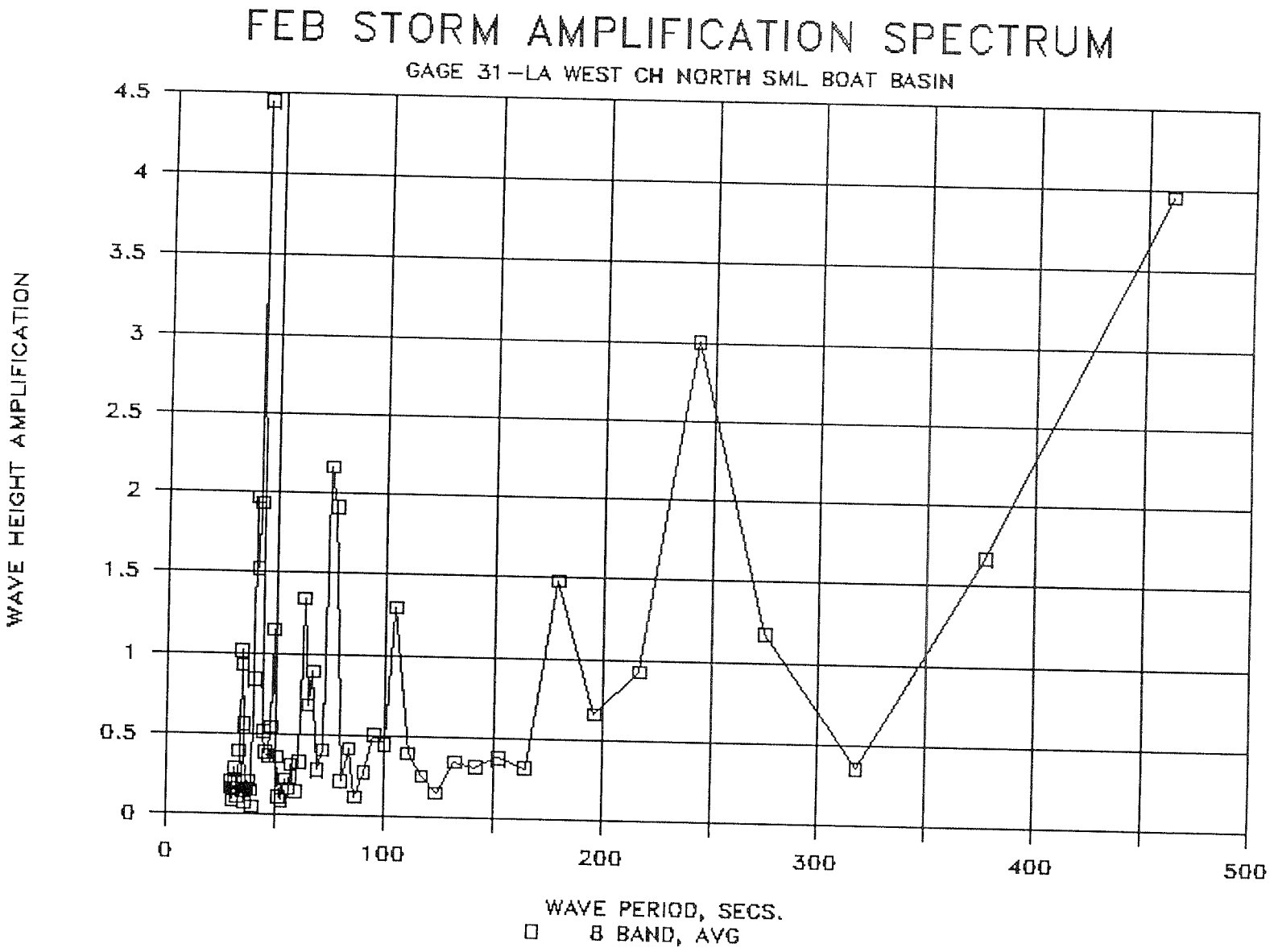

FEB STORM AMPLIFICATION SPECTRUM
GAGE 26 – LB BERTH 205 (BASIN 6)
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

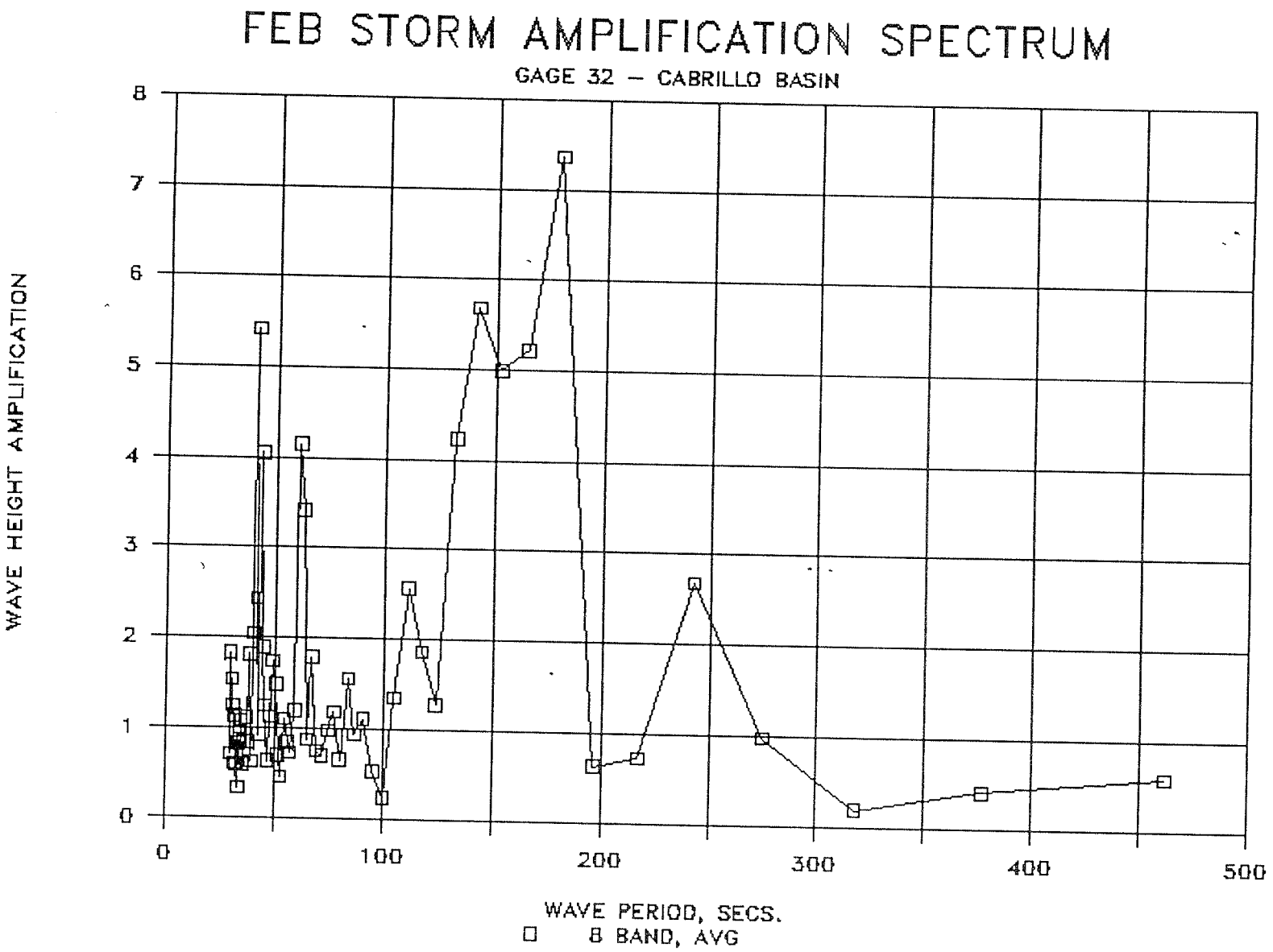

FEB STORM AMPLIFICATION SPECTRUM
GAGE 27 – LB BERTH 226 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

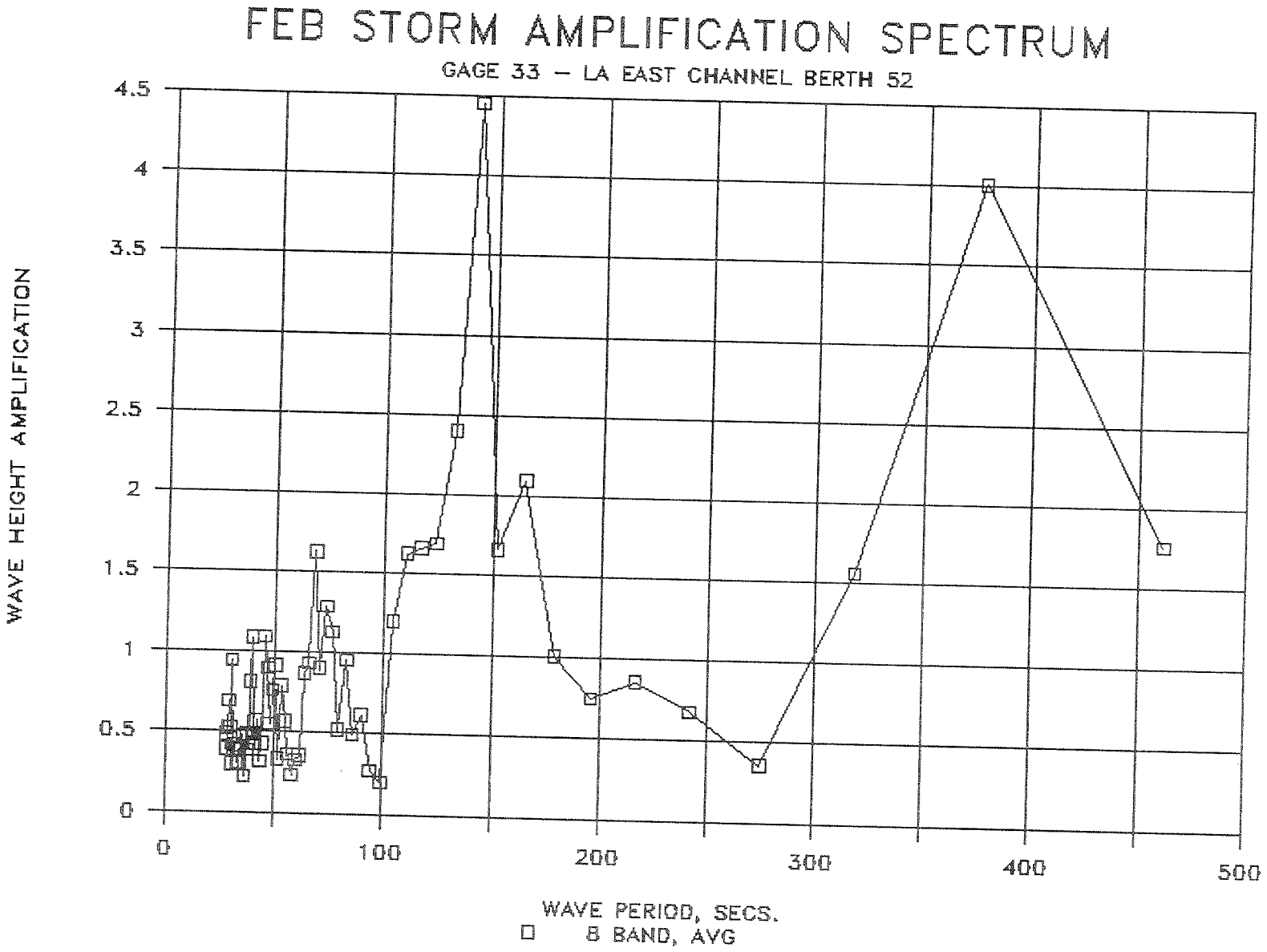

FEB STORM AMPLIFICATION SPECTRUM
GAGE 28 – LB BERTH 231 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

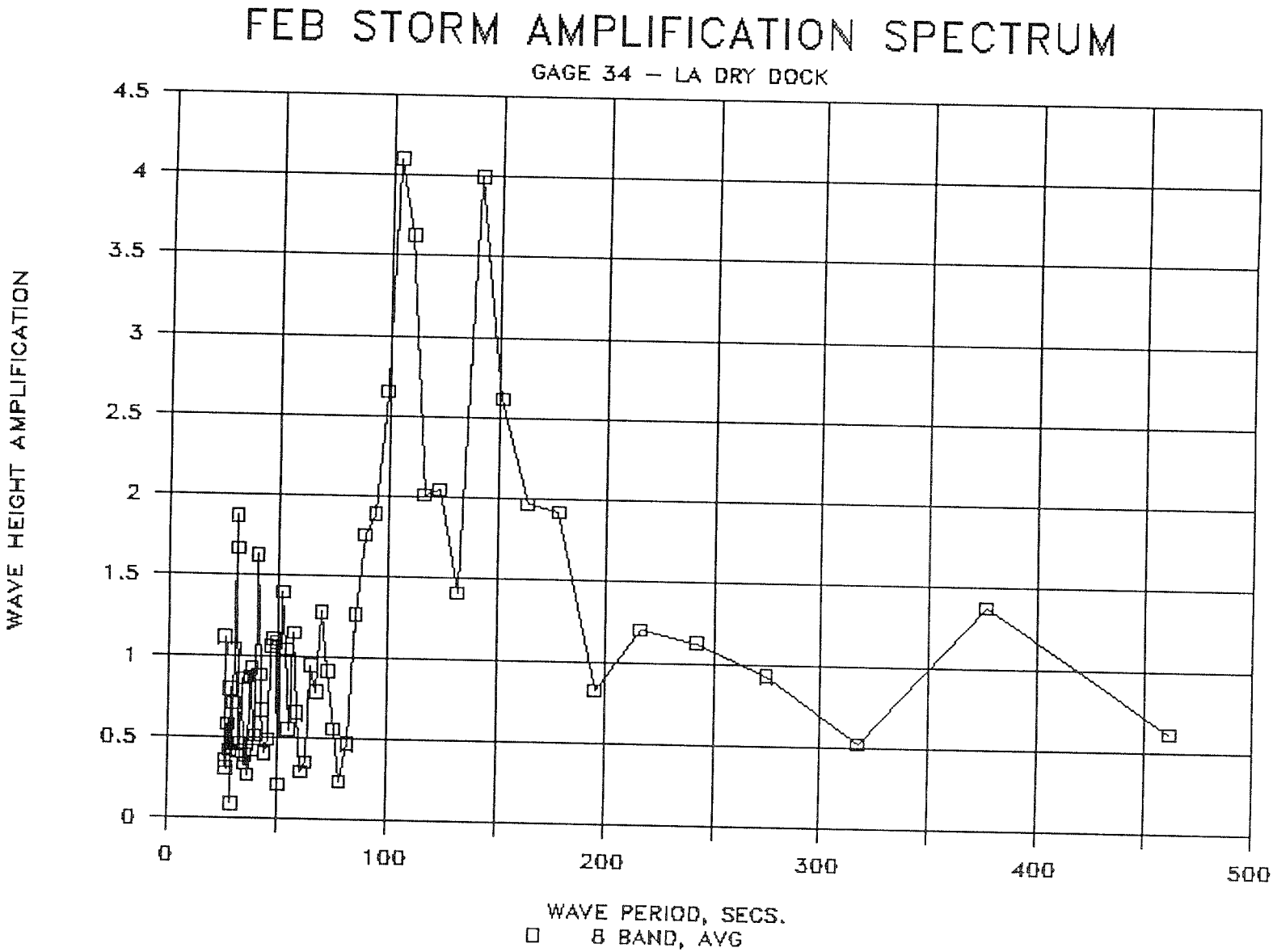

FEB STORM AMPLIFICATION SPECTRUM
GAGE 29 – LB BERTH 242 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

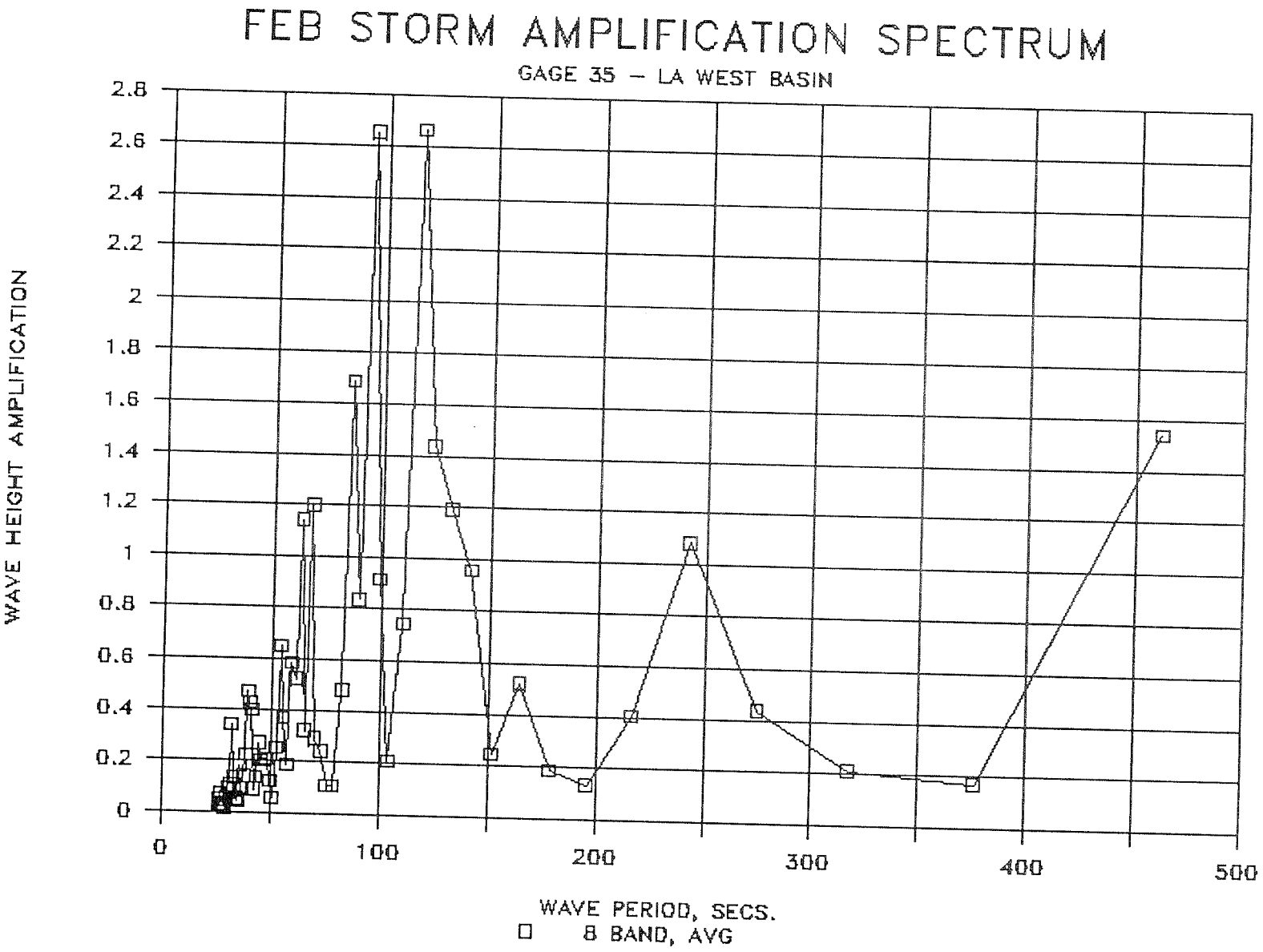

FEB STORM AMPLIFICATION
GAGE 30 – LB BERTH 245 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

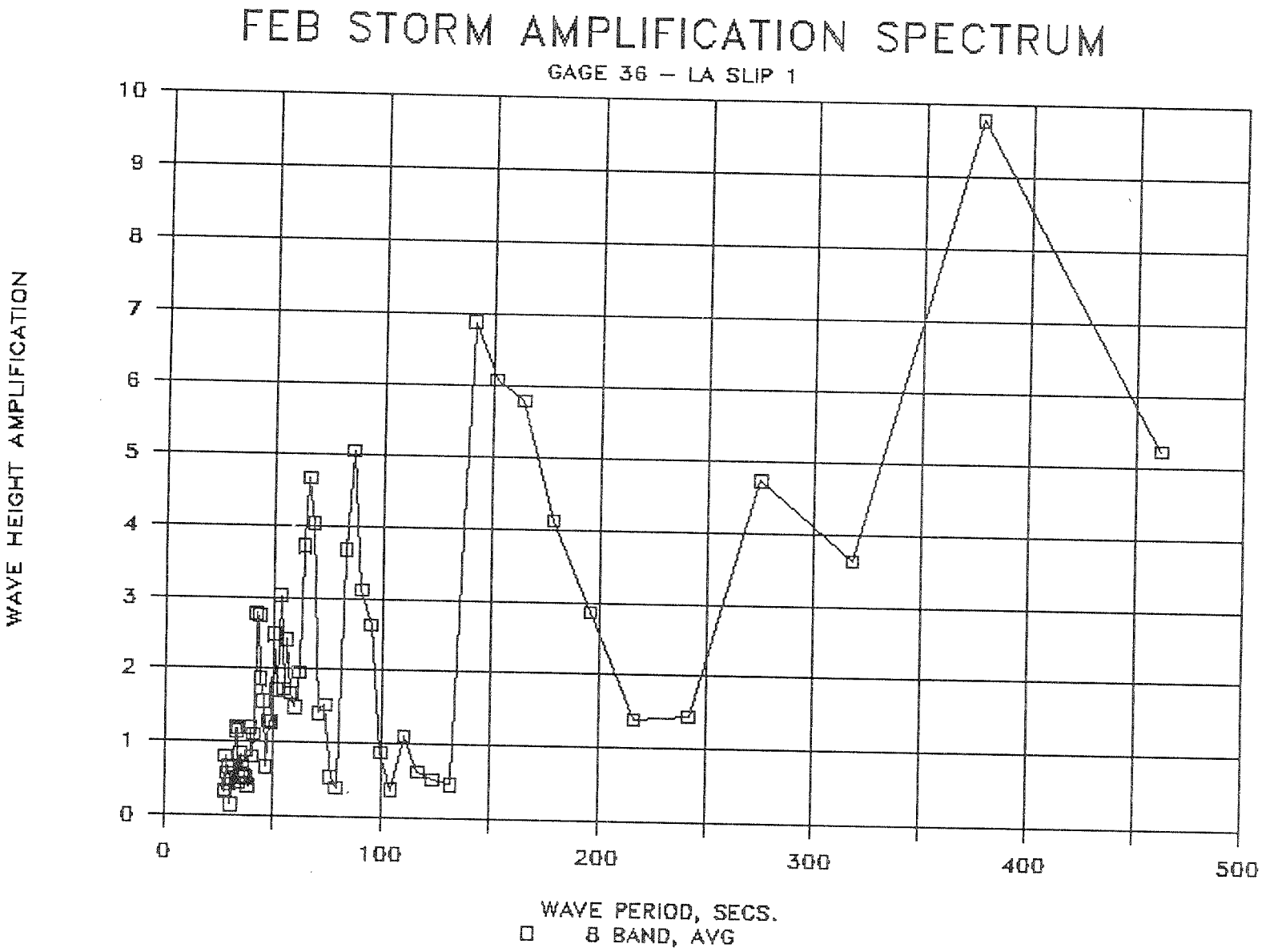

FEB STORM AMPLIFICATION SPECTRUM
GAGE 31 – LA WEST CH NORTH SML BOAT BASIN
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

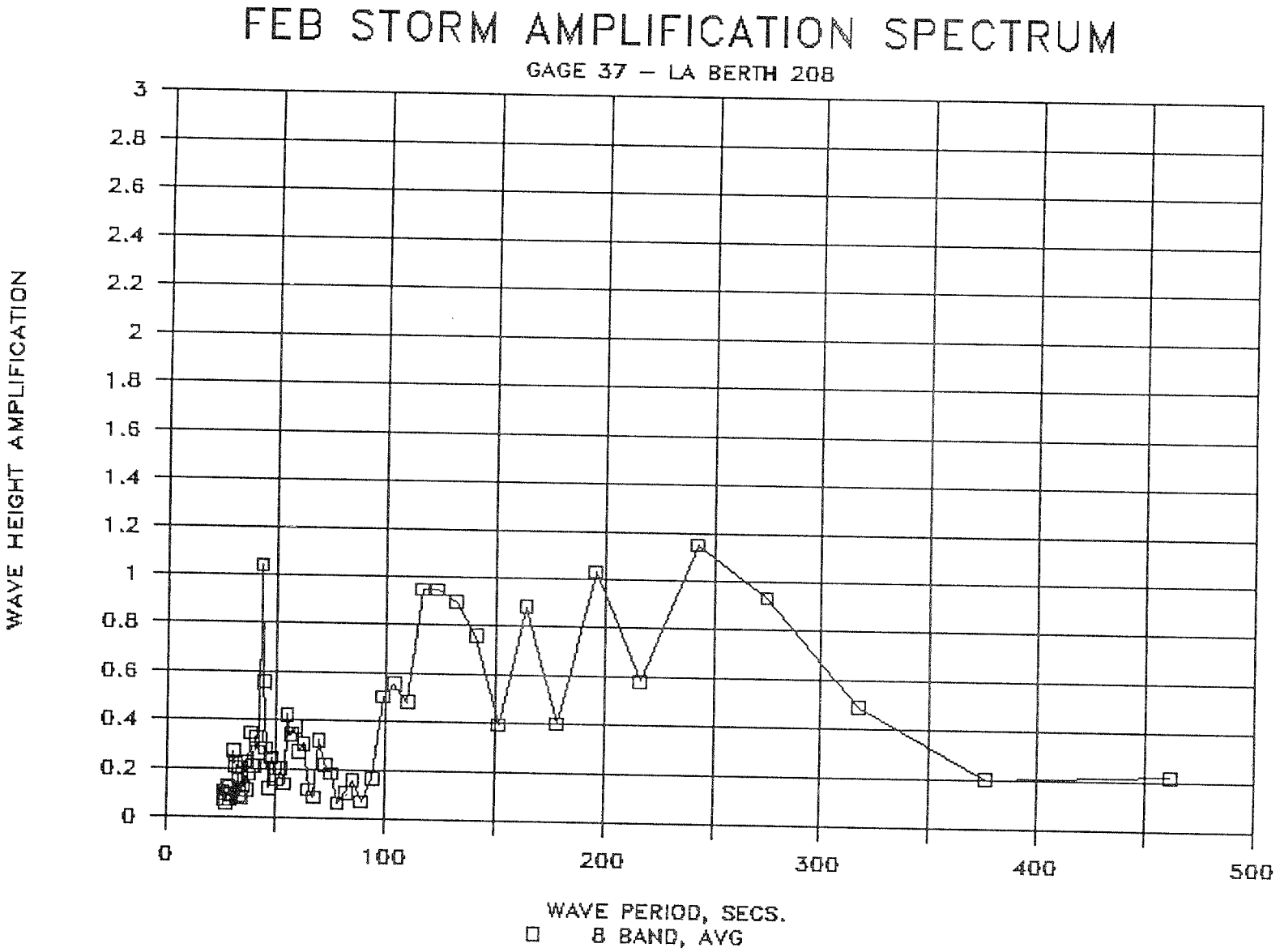

FEB STORM AMPLIFICATION SPECTRUM
GAGE 32 – CABRILLO BASIN
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

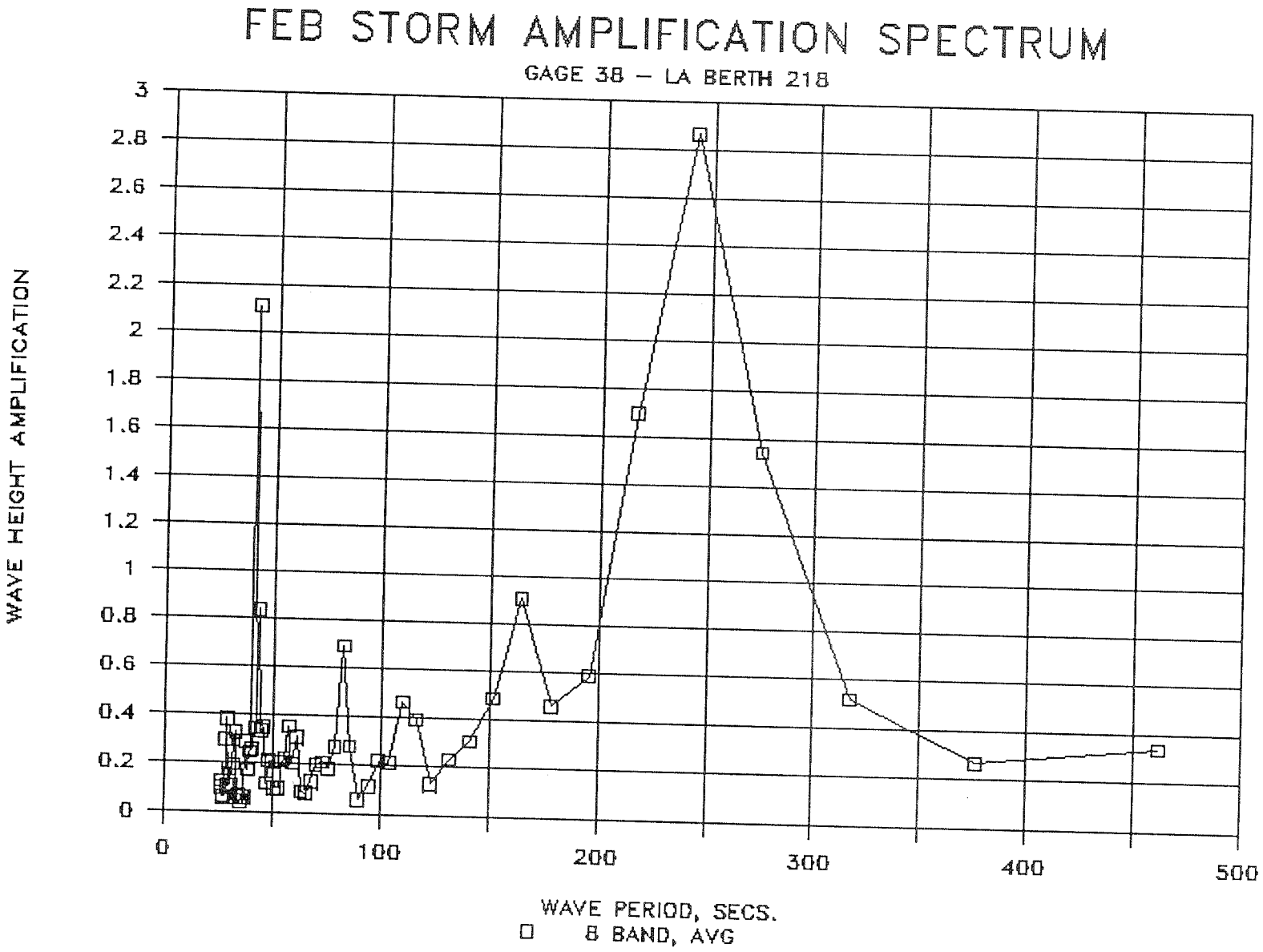

FEB STORM AMPLIFICATION SPECTRUM
GAGE 33 – LA EAST CHANNEL BERTH 52
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

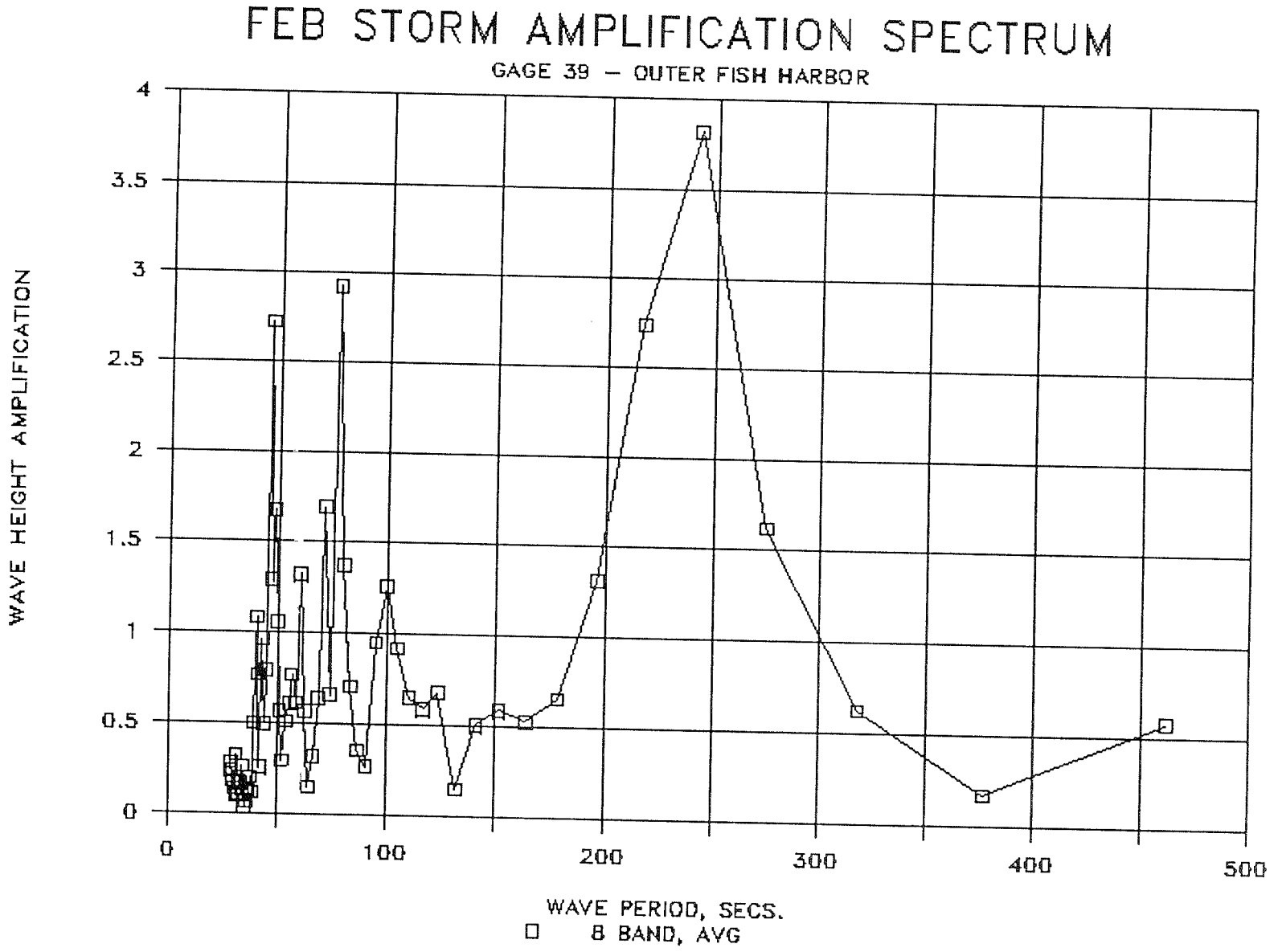

FEB STORM AMPLIFICATION SPECTRUM
GAGE 34 – LA DRY DOCK
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

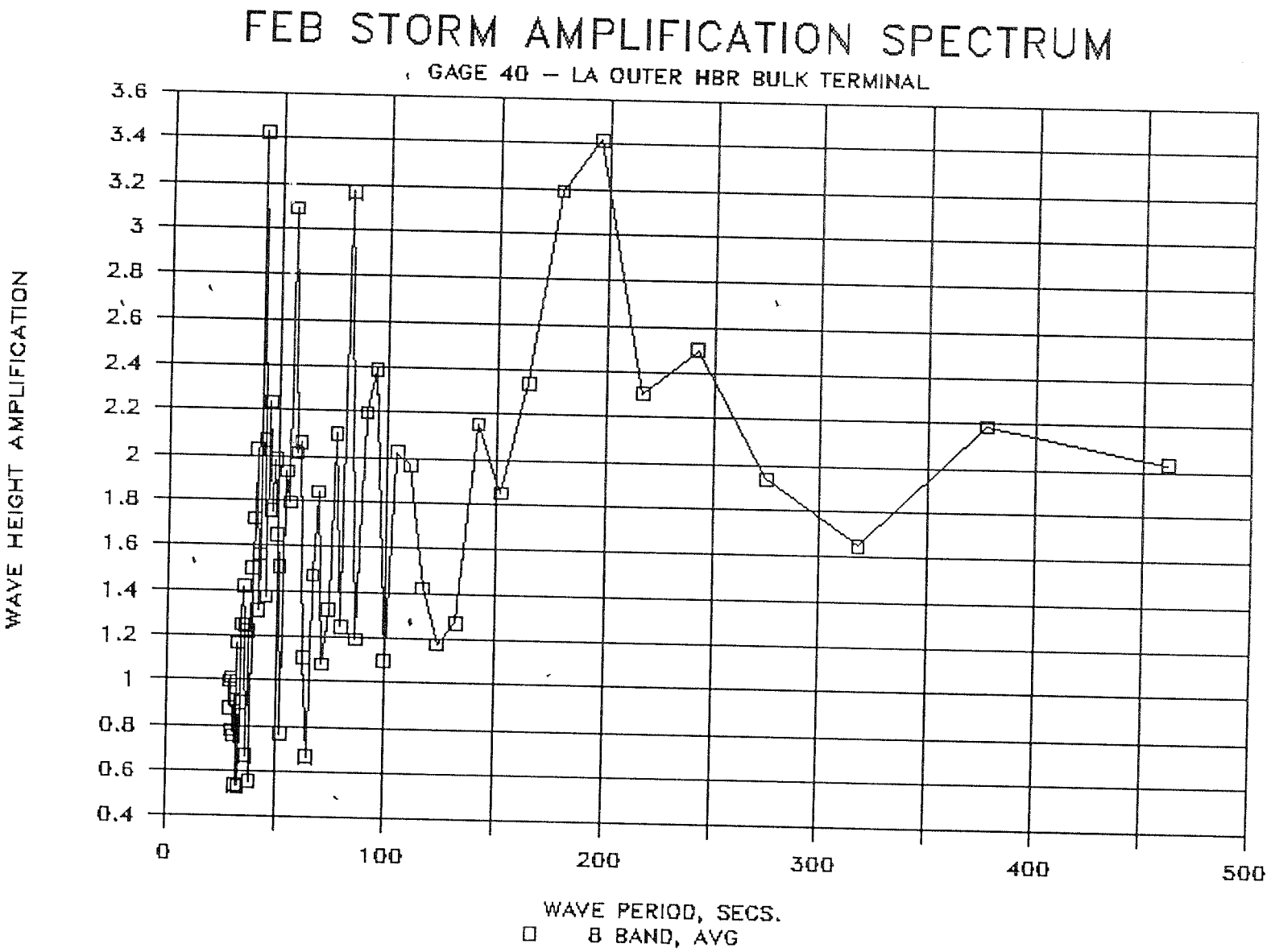

FEB STORM AMPLIFICATION SPECTRUM
GAGE 35 – LA WEST BASIN
WAVE HEIGHT AMPLIFICATION
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

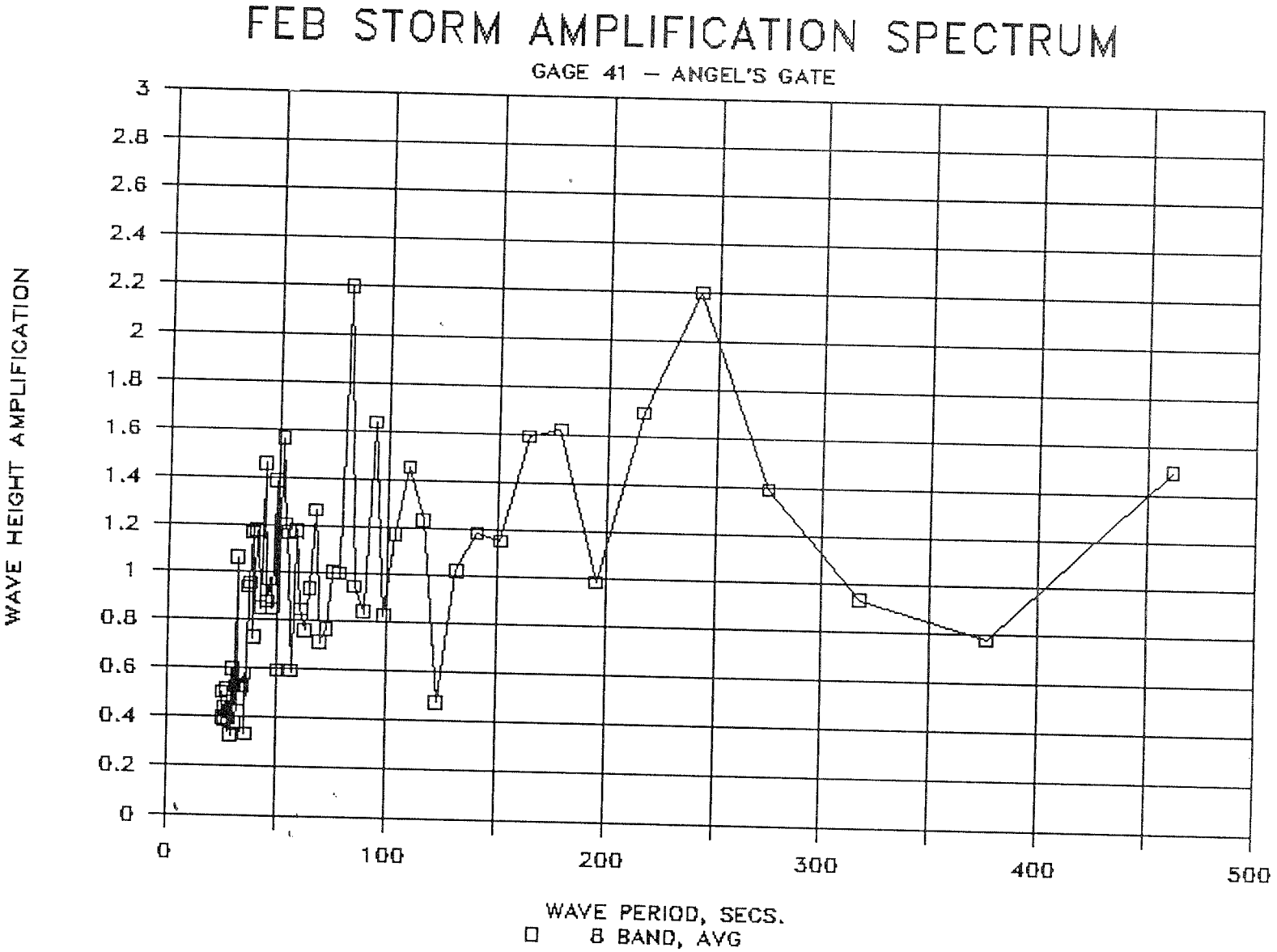

FEB STORM AMPLIFICATION SPECTRUM
GAGE 36 – LA SLIP 1
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
10
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

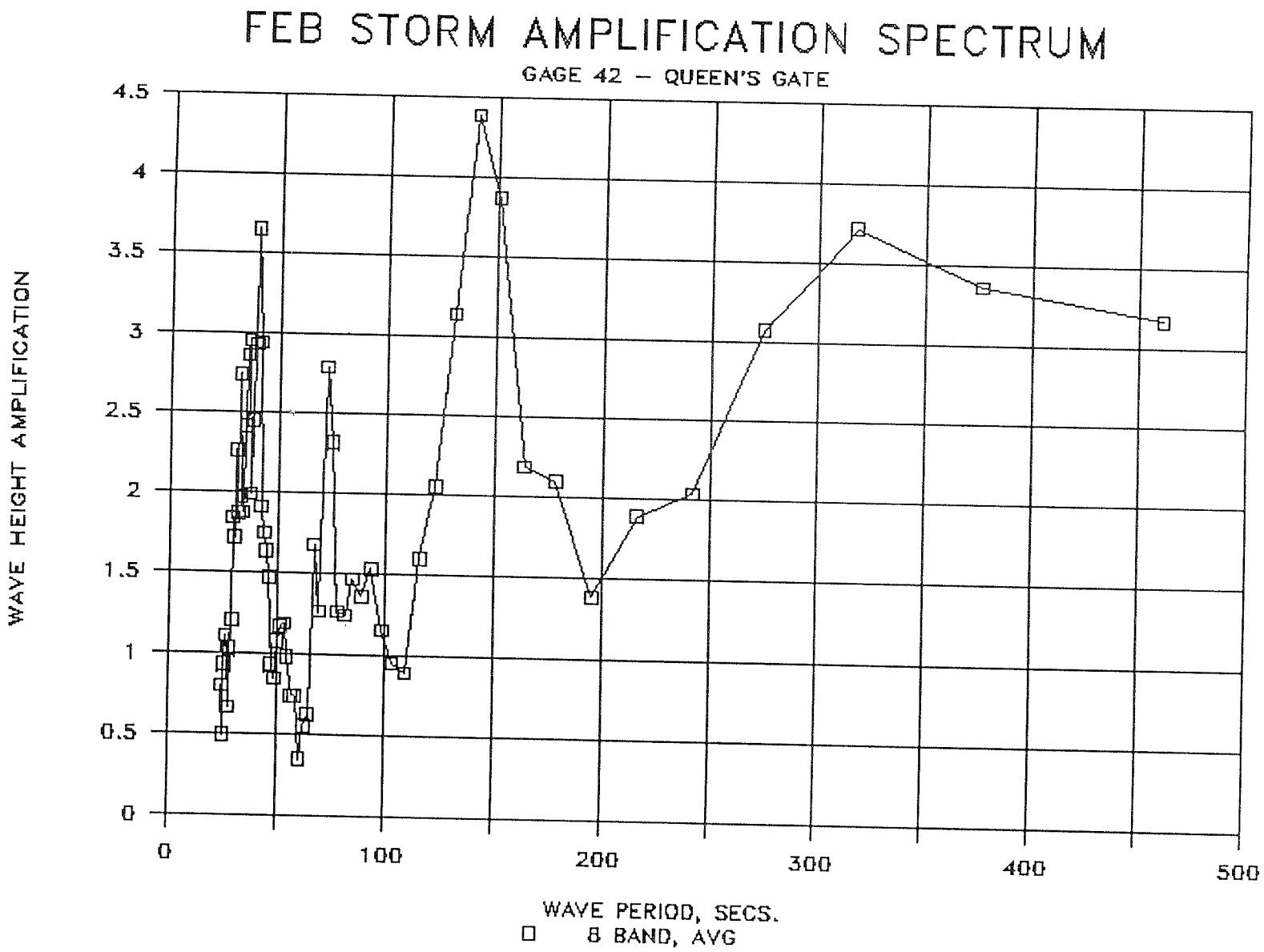

FEB STORM AMPLIFICATION SPECTRUM
GAGE 37 – LA BERTH 208
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG


FEB STORM AMPLIFICATION SPECTRUM
GAGE 38 – LA BERTH 218
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG


FEB STORM AMPLIFICATION SPECTRUM
GAGE 39 – OUTER FISH HARBOR
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

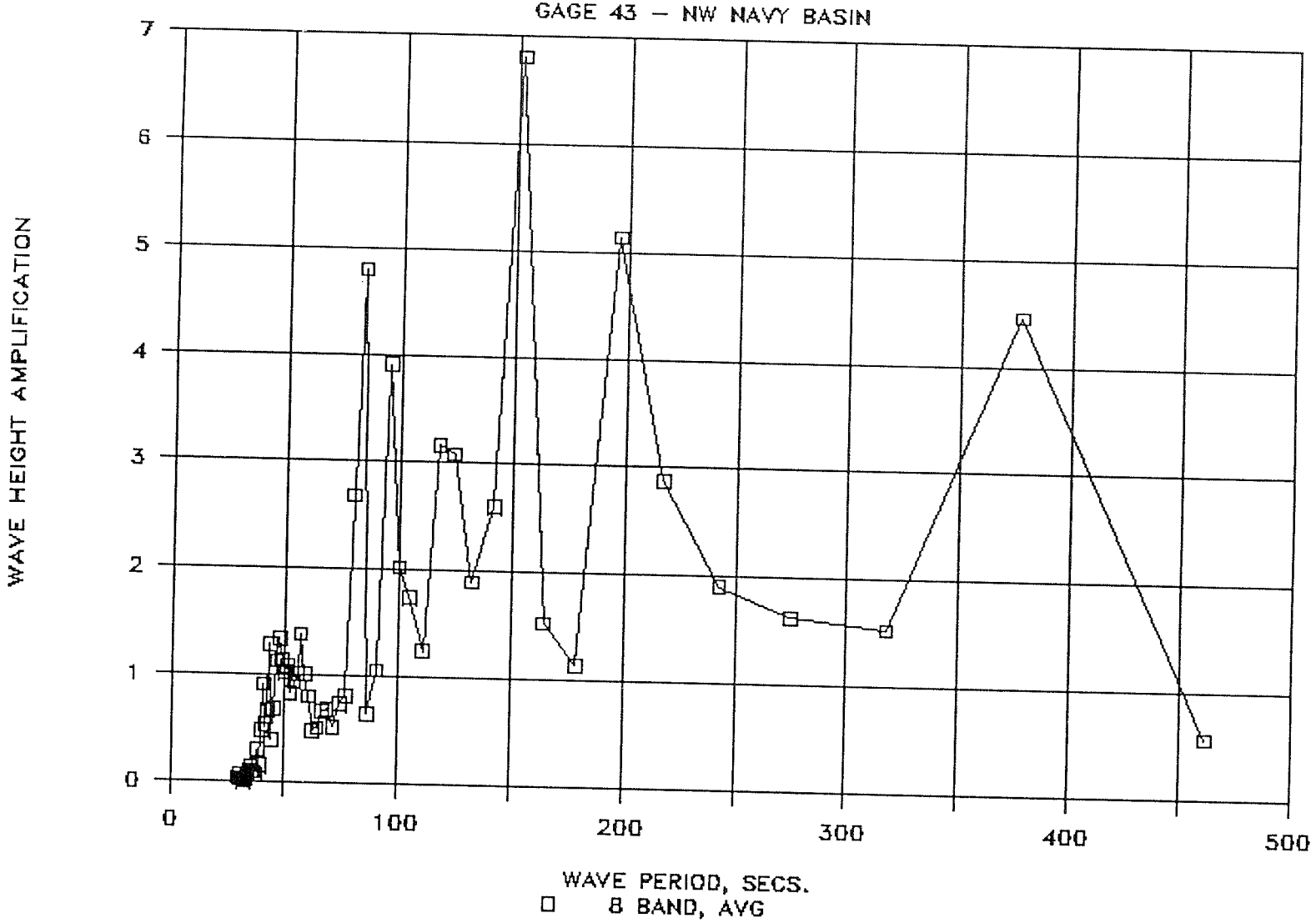

FEB STORM AMPLIFICATION SPECTRUM
GAGE 40 – LA OUTER HBR BULK TERMINAL
WAVE HEIGHT AMPLIFICATION
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

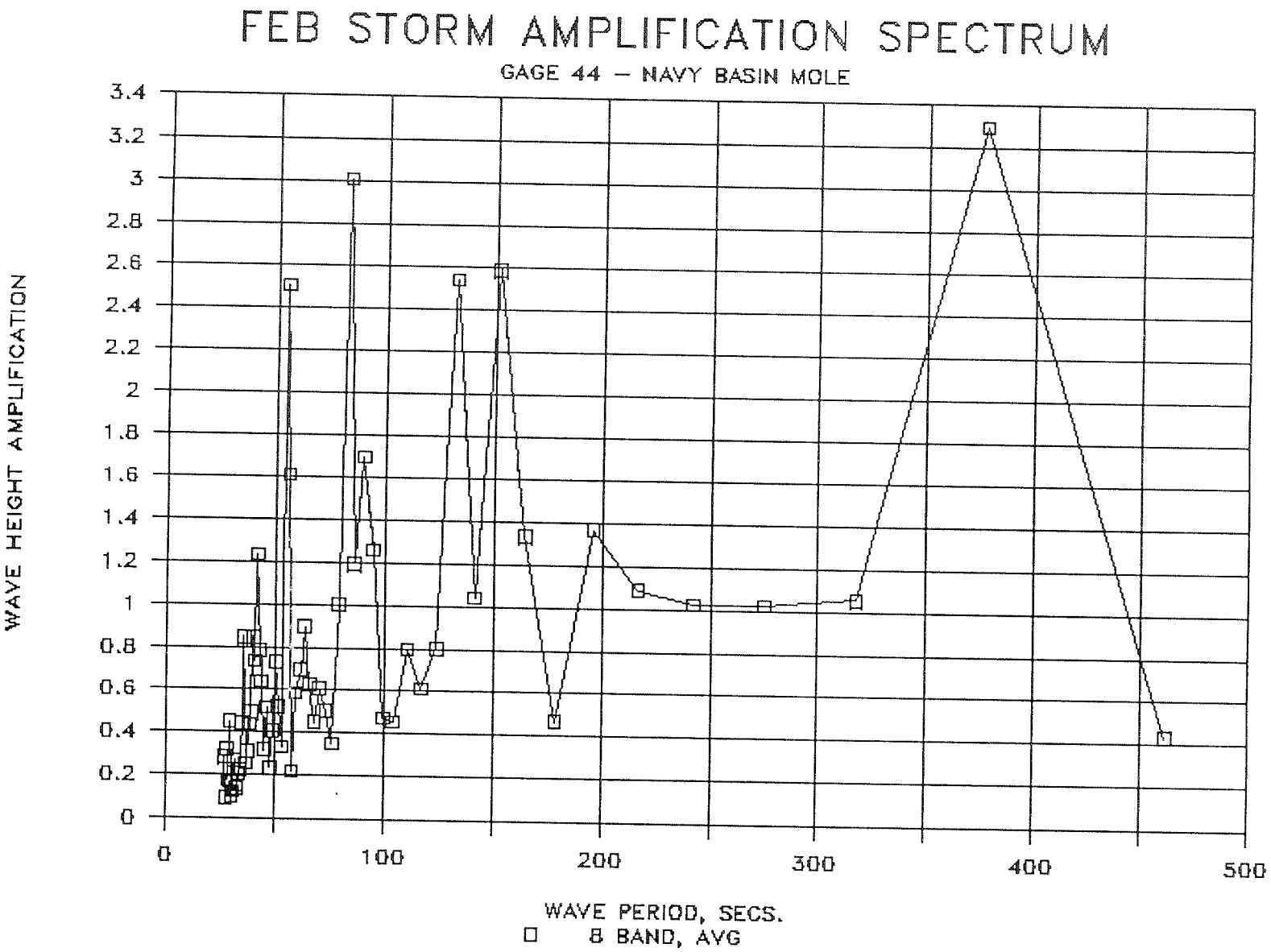

FEB STORM AMPLIFICATION SPECTRUM
GAGE 41 – ANGEL'S GATE
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

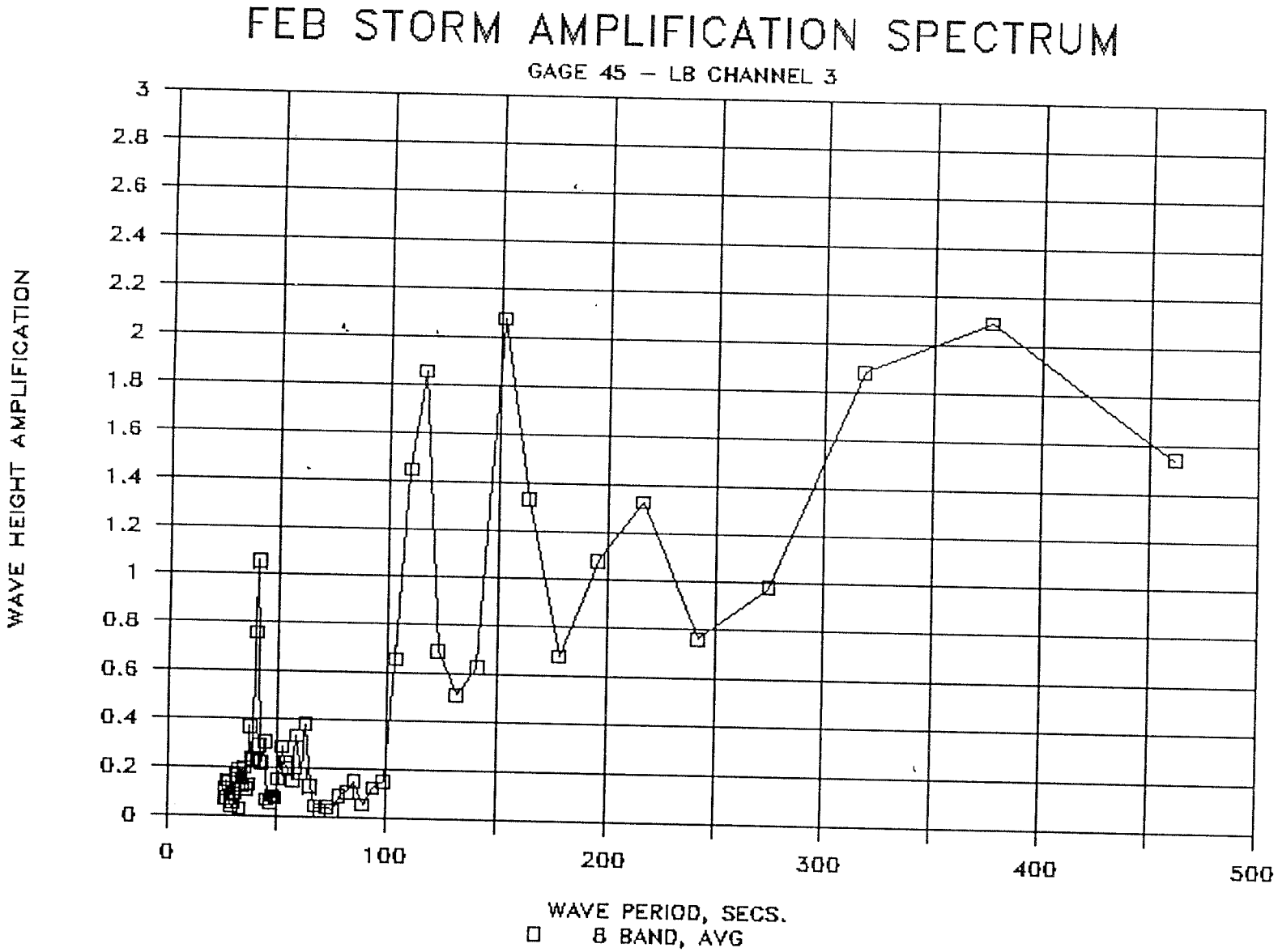

FEB STORM AMPLIFICATION SPECTRUM
GAGE 42 – QUEEN'S GATE
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

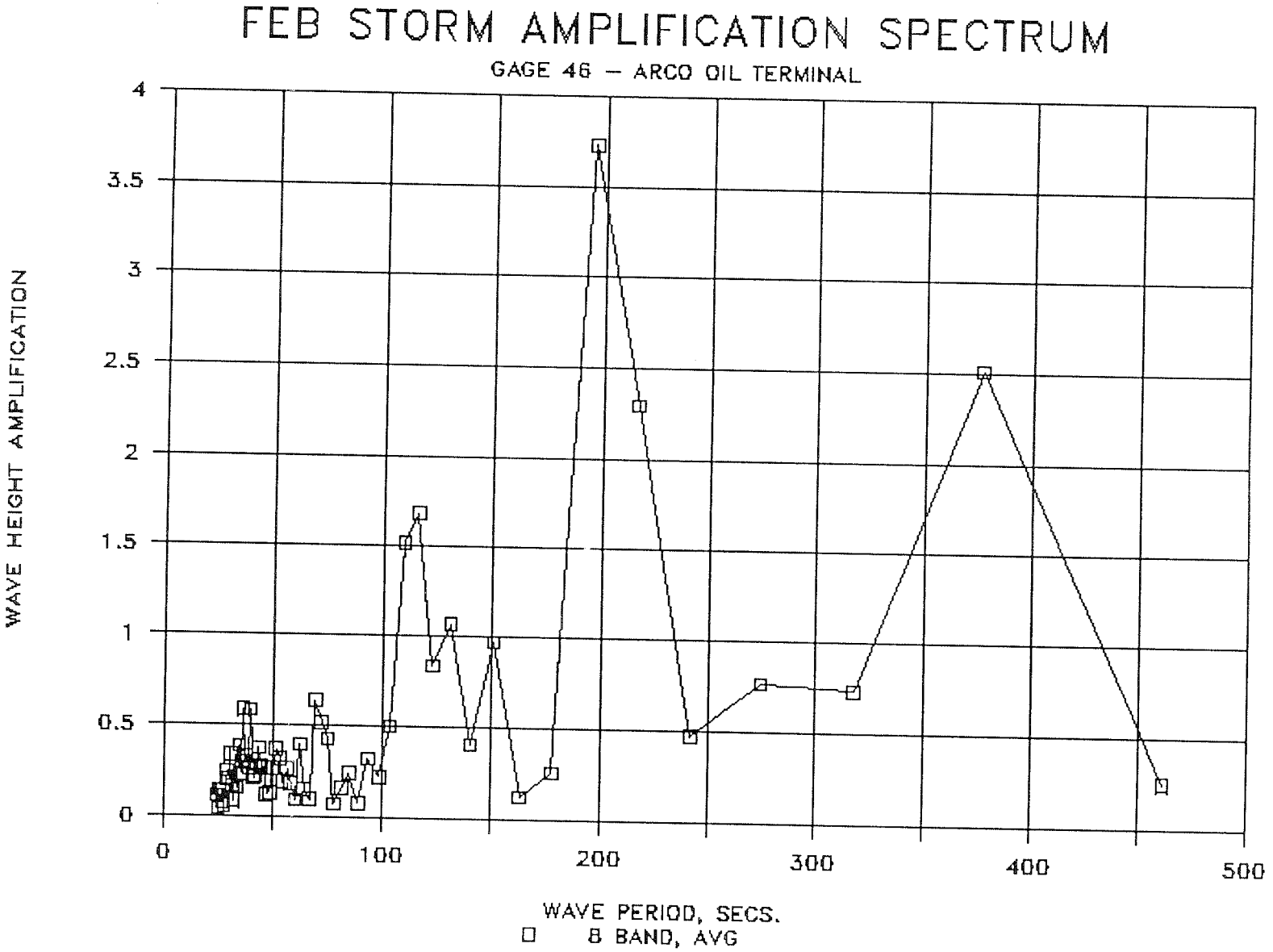
FEB STORM AMPLIFICATION SPECTRUM

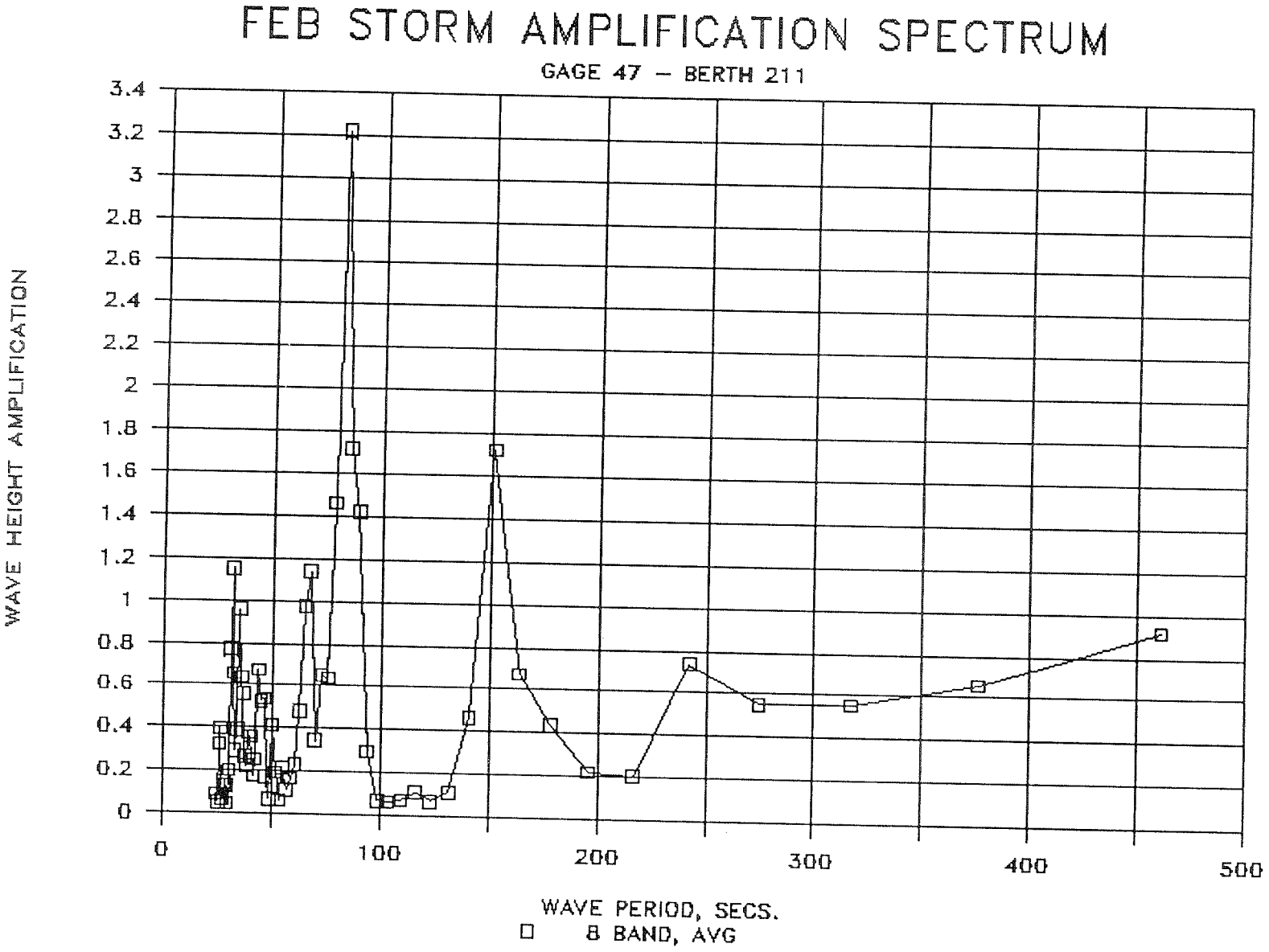
GAGE 43 – NW NAVY BASIN




FEB STORM AMPLIFICATION SPECTRUM
GAGE 44 – NAVY BASIN MOLE
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

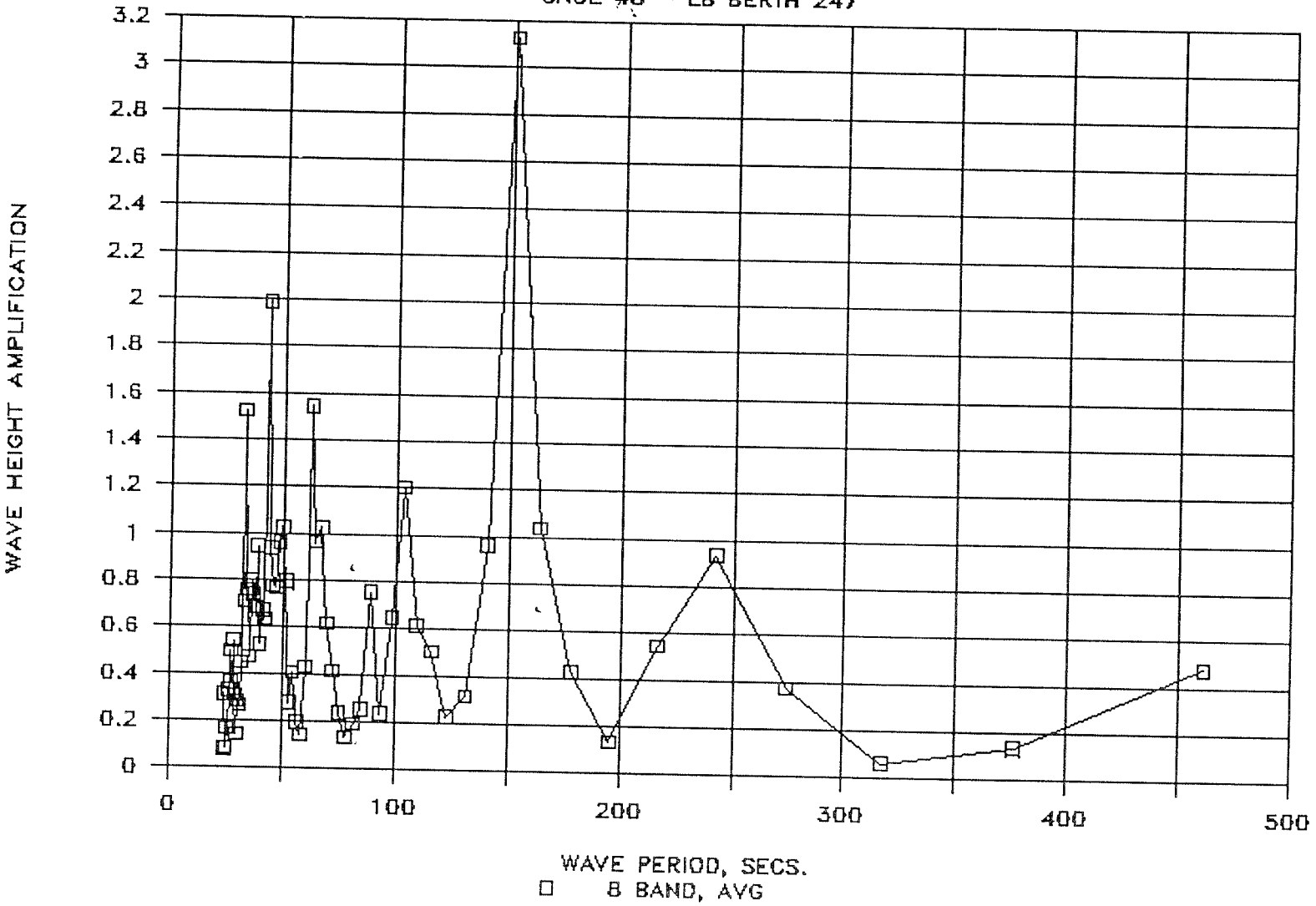

FEB STORM AMPLIFICATION SPECTRUM
GAGE 45 – LB CHANNEL 3
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

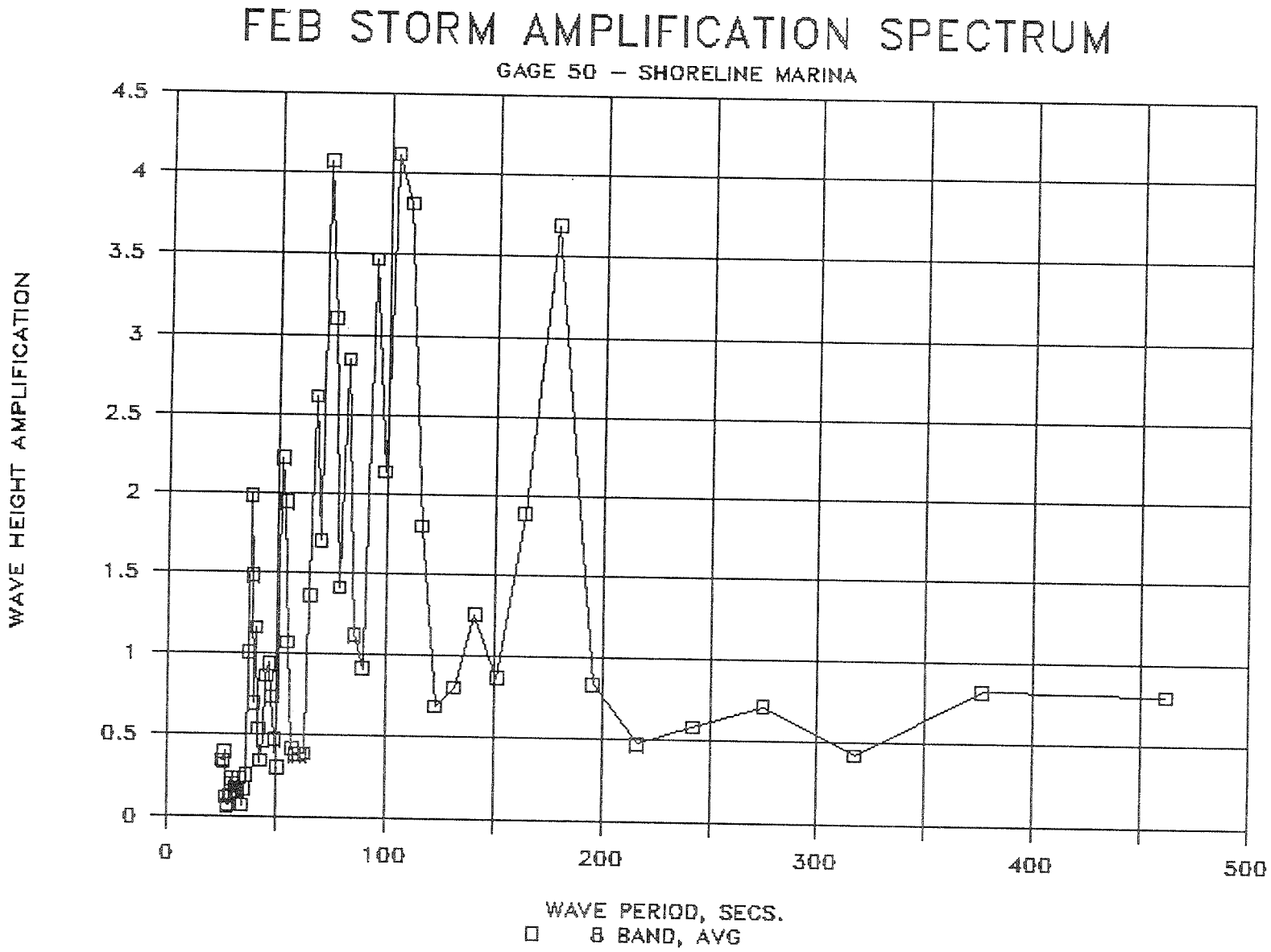

FEB STORM AMPLIFICATION SPECTRUM
GAGE 46 – ARCO OIL TERMINAL
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

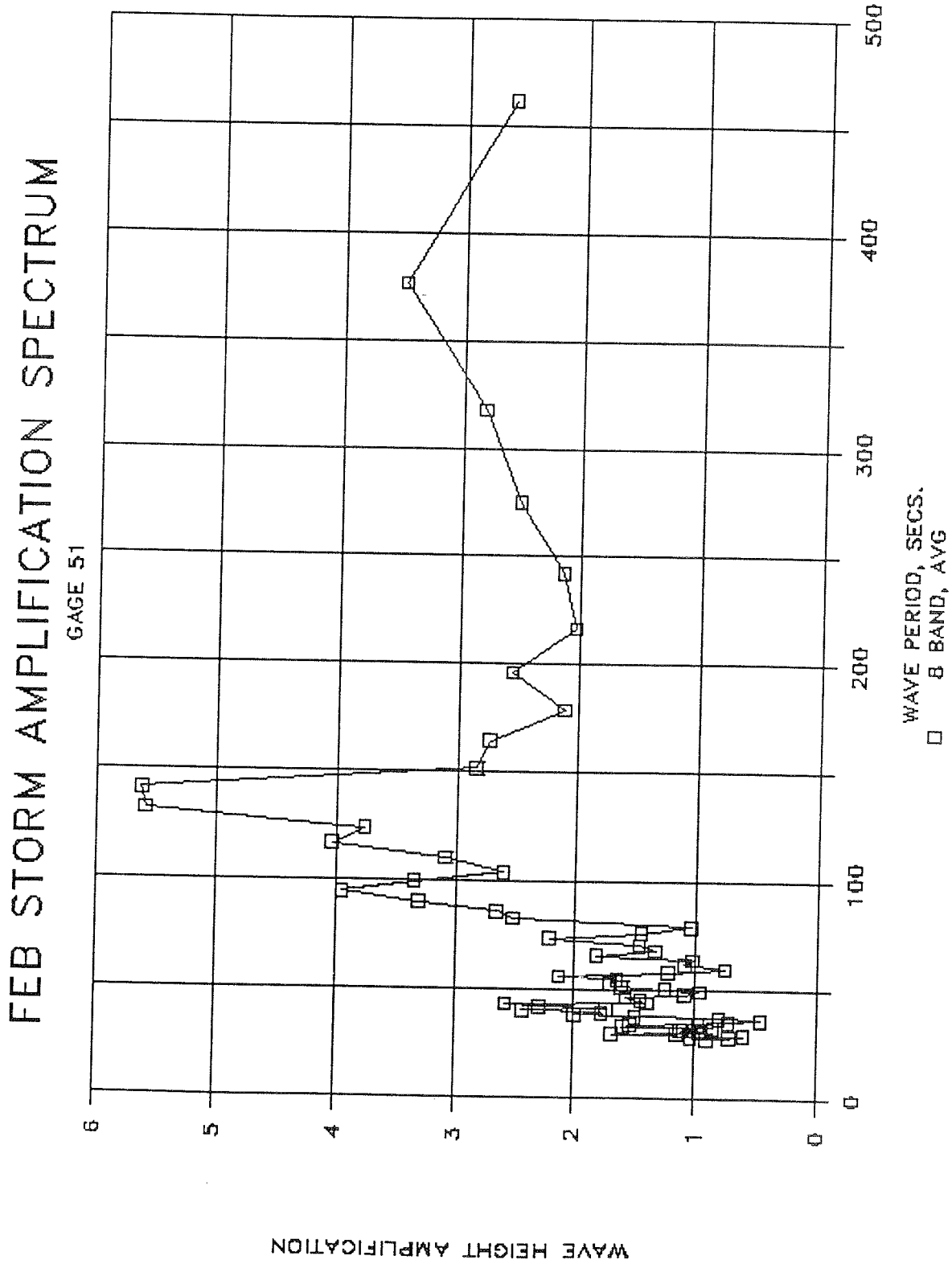

FEB STORM AMPLIFICATION SPECTRUM
GAGE 47 – BERTH 211
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

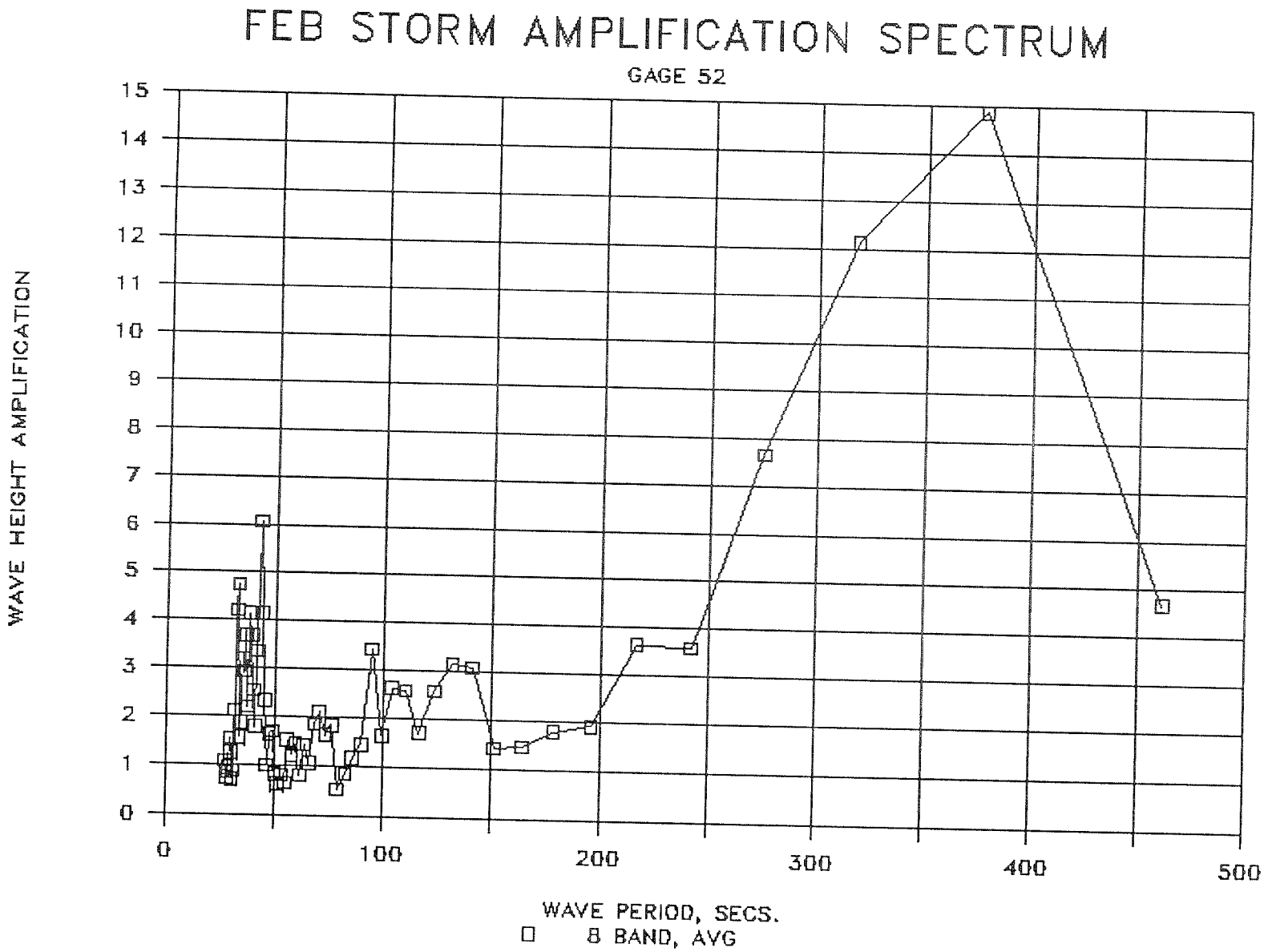
FEB STORM AMPLIFICATION SPECTRUM

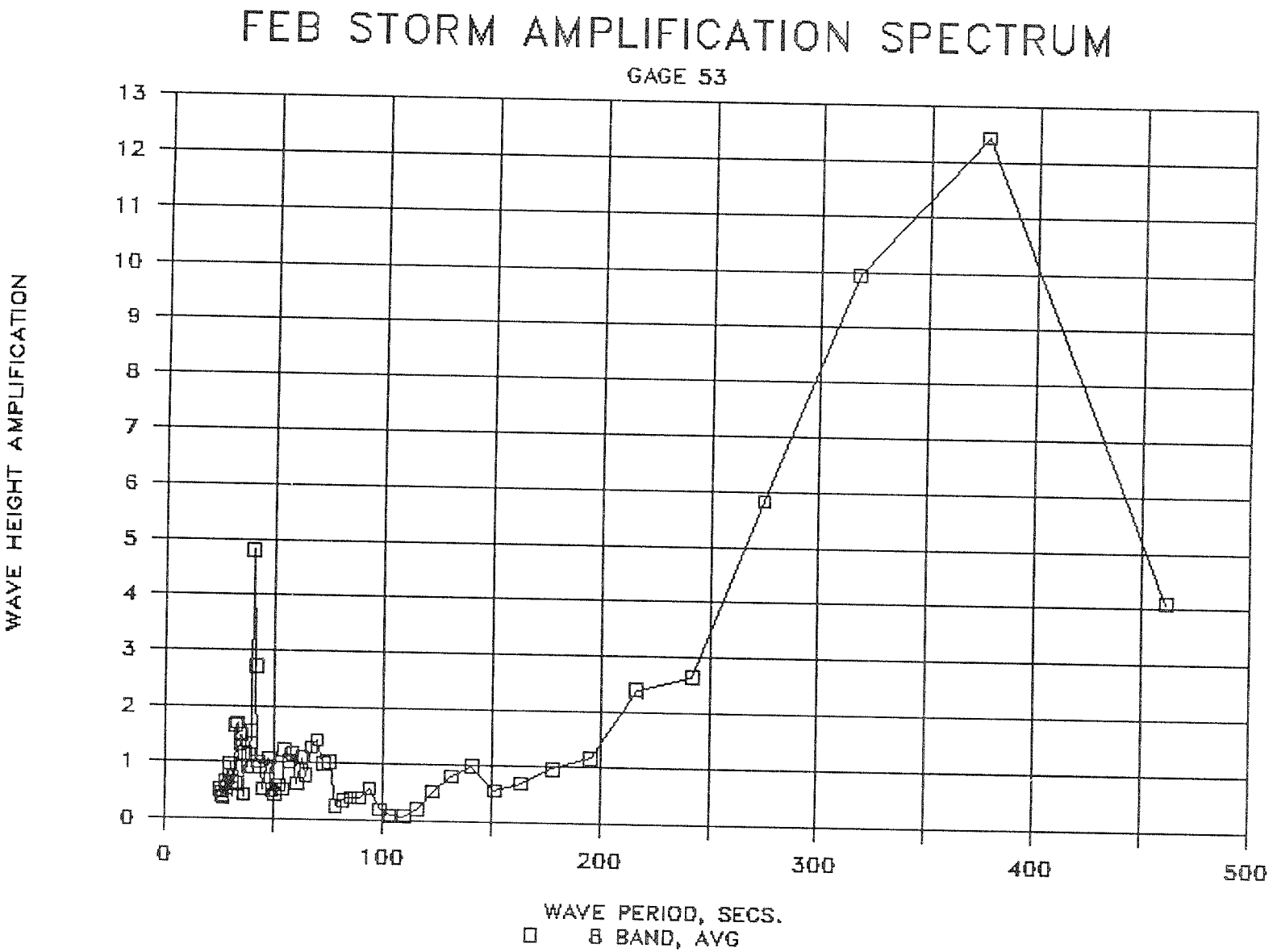
GAGE #8 – LB BERTH 247

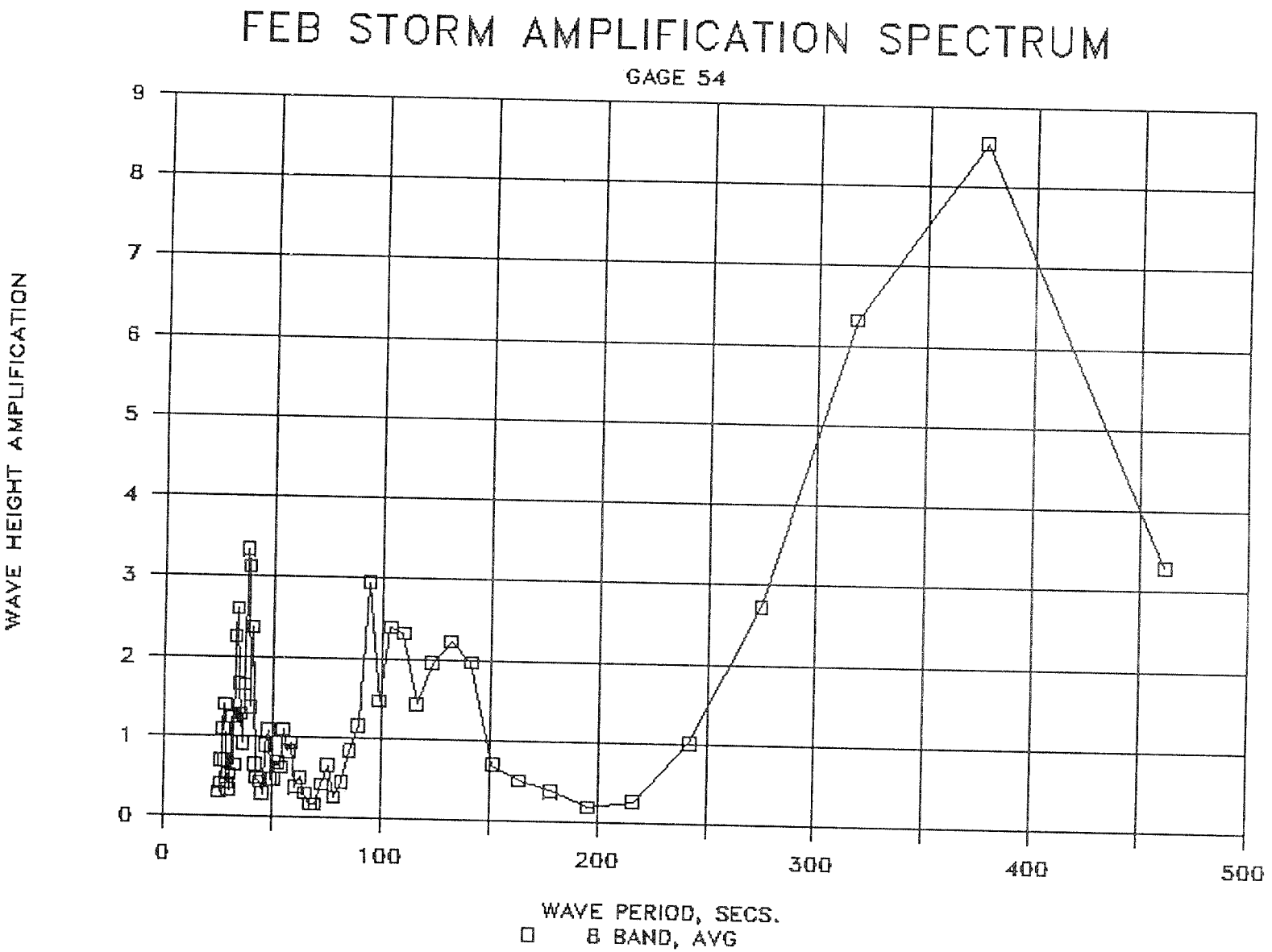



FEB STORM AMPLIFICATION SPECTRUM
GAGE 50 – SHORELINE MARINA
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG


FEB STORM AMPLIFICATION SPECTRUM
GAGE 51
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

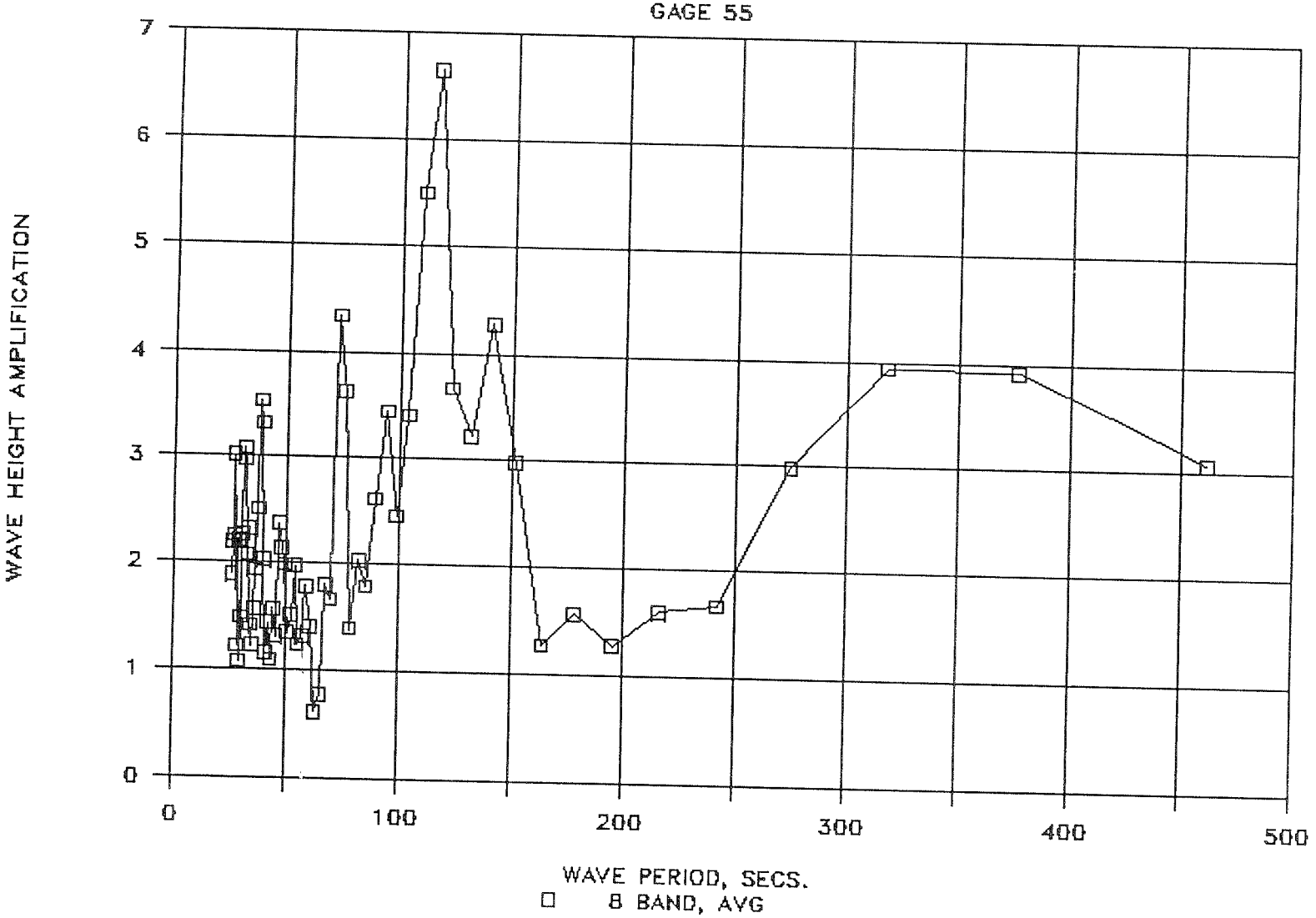

FEB STORM AMPLIFICATION SPECTRUM
GAGE 52
WAVE HEIGHT AMPLIFICATION
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

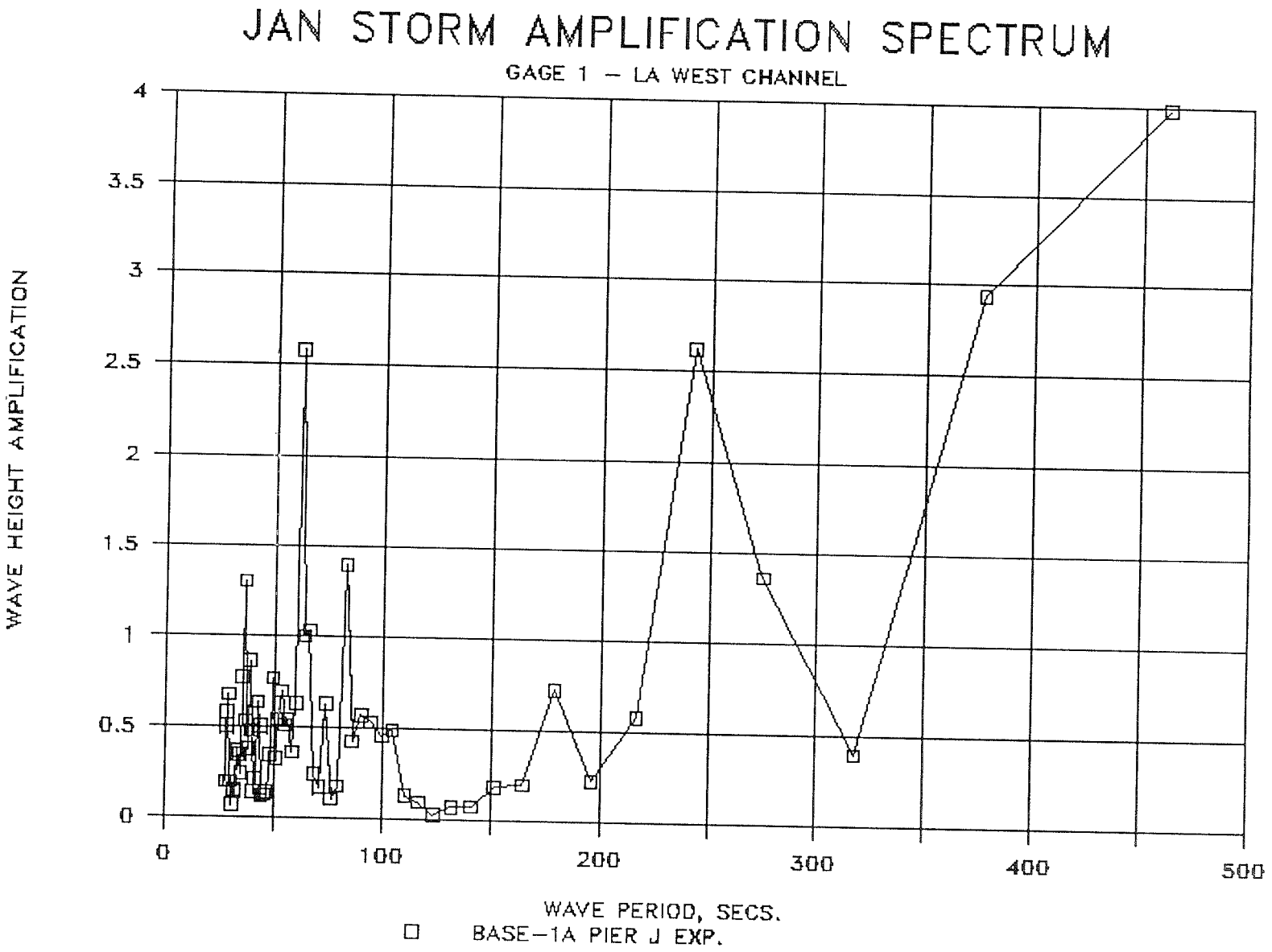

FEB STORM AMPLIFICATION SPECTRUM
GAGE 53
WAVE HEIGHT AMPLIFICATION
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

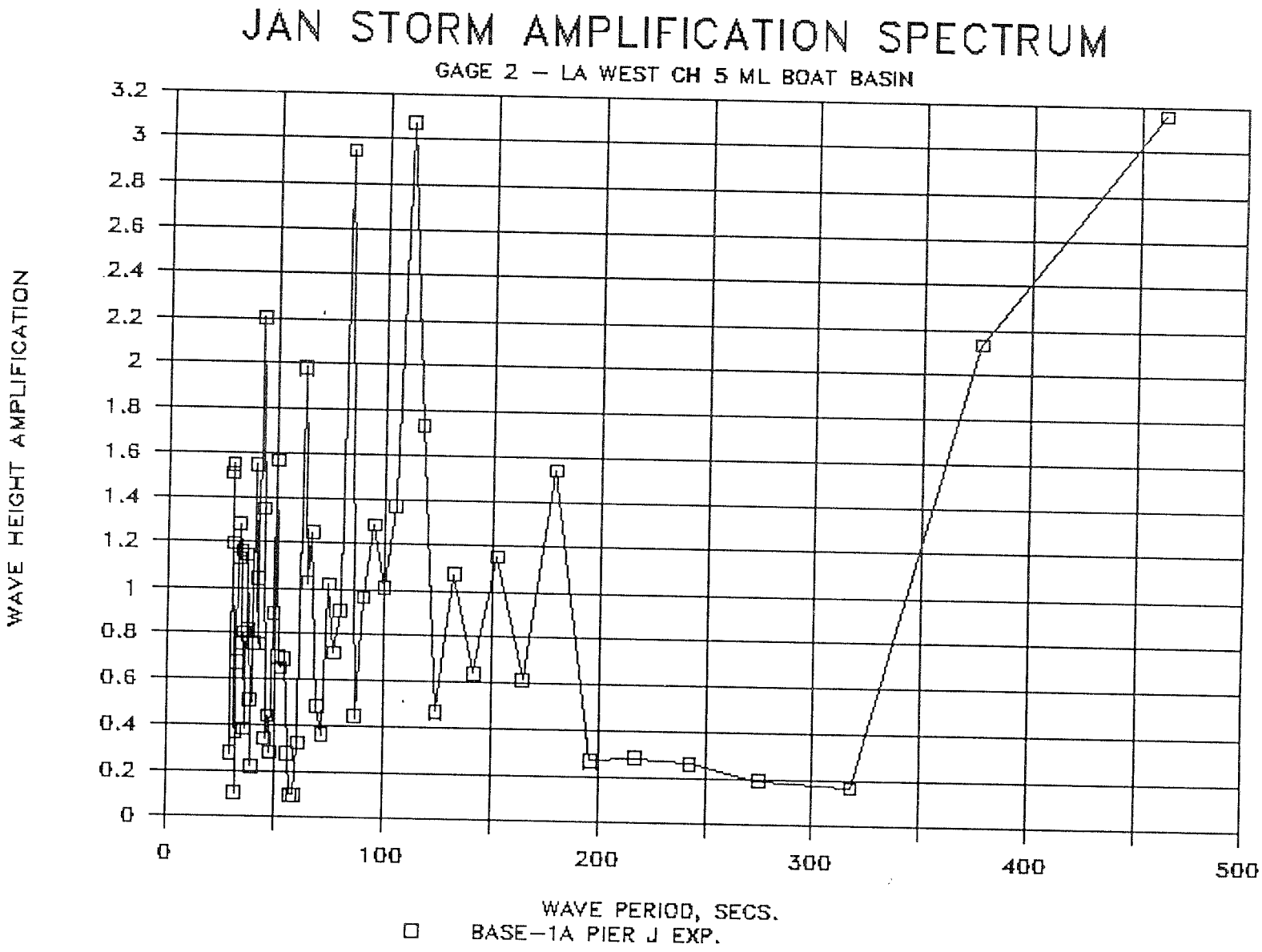

FEB STORM AMPLIFICATION SPECTRUM
GAGE 54
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
WAVE PERIOD, SECS.
8 BAND, AVG

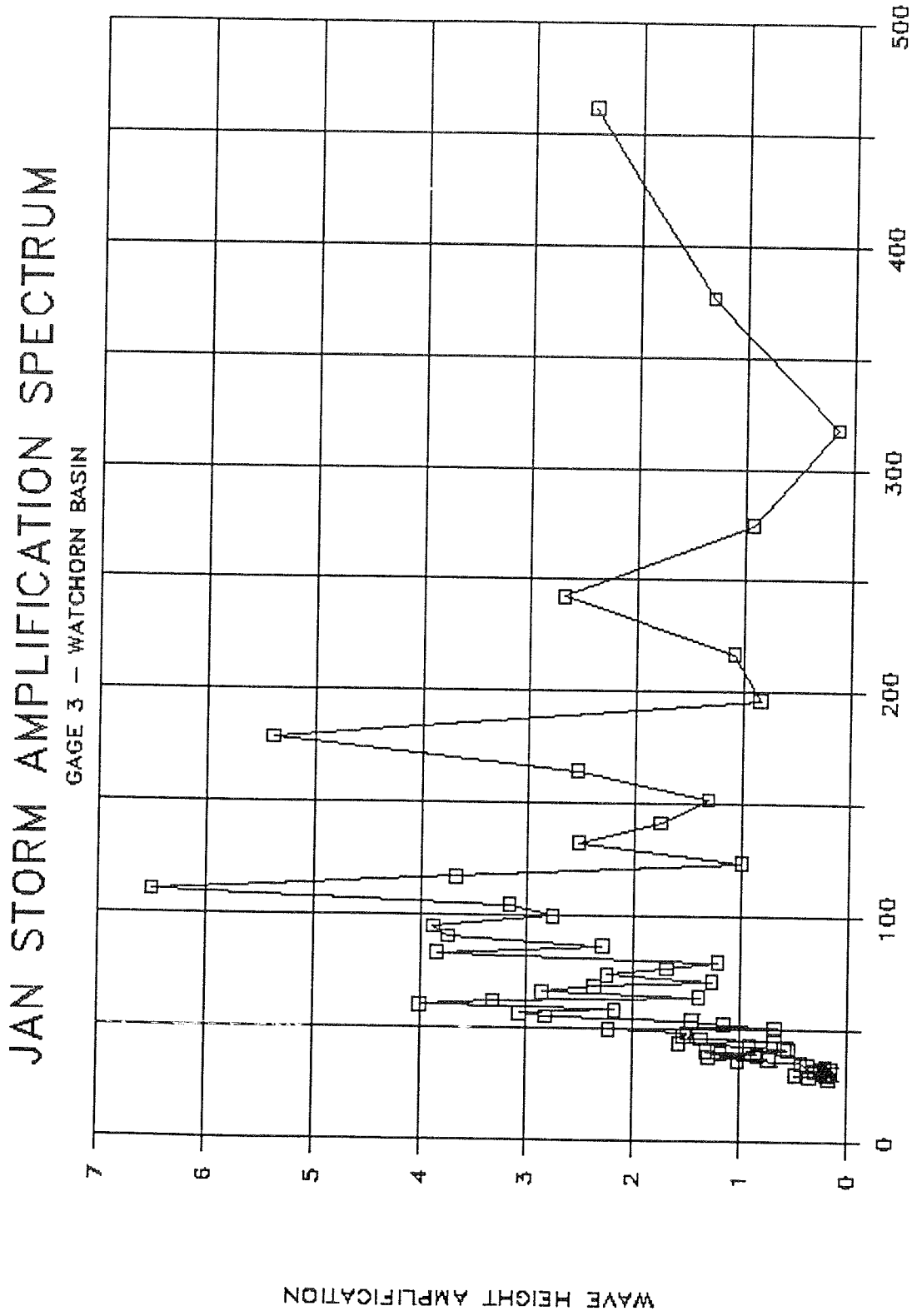
FEB STORM AMPLIFICATION SPECTRUM

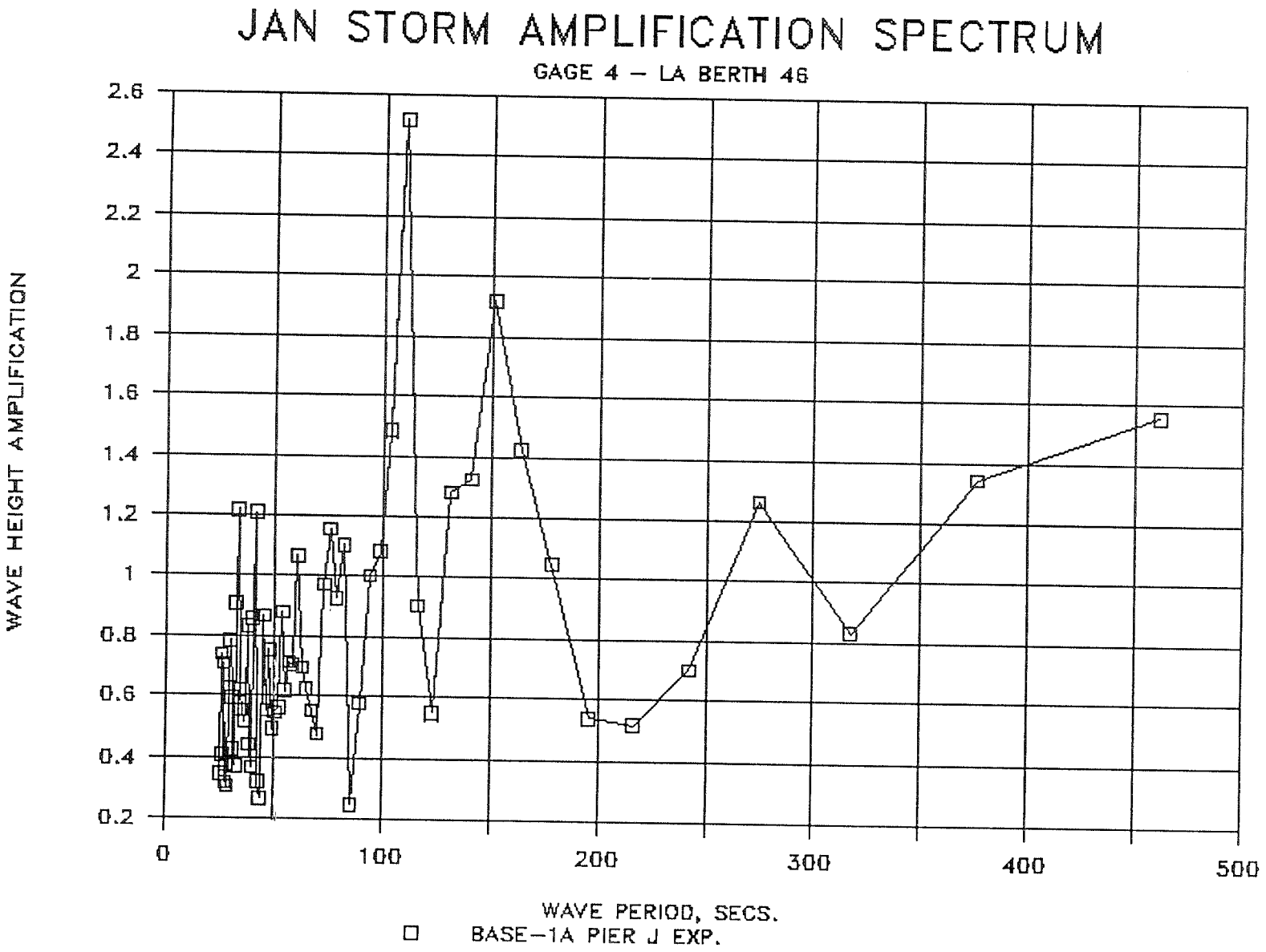
GAGE 55

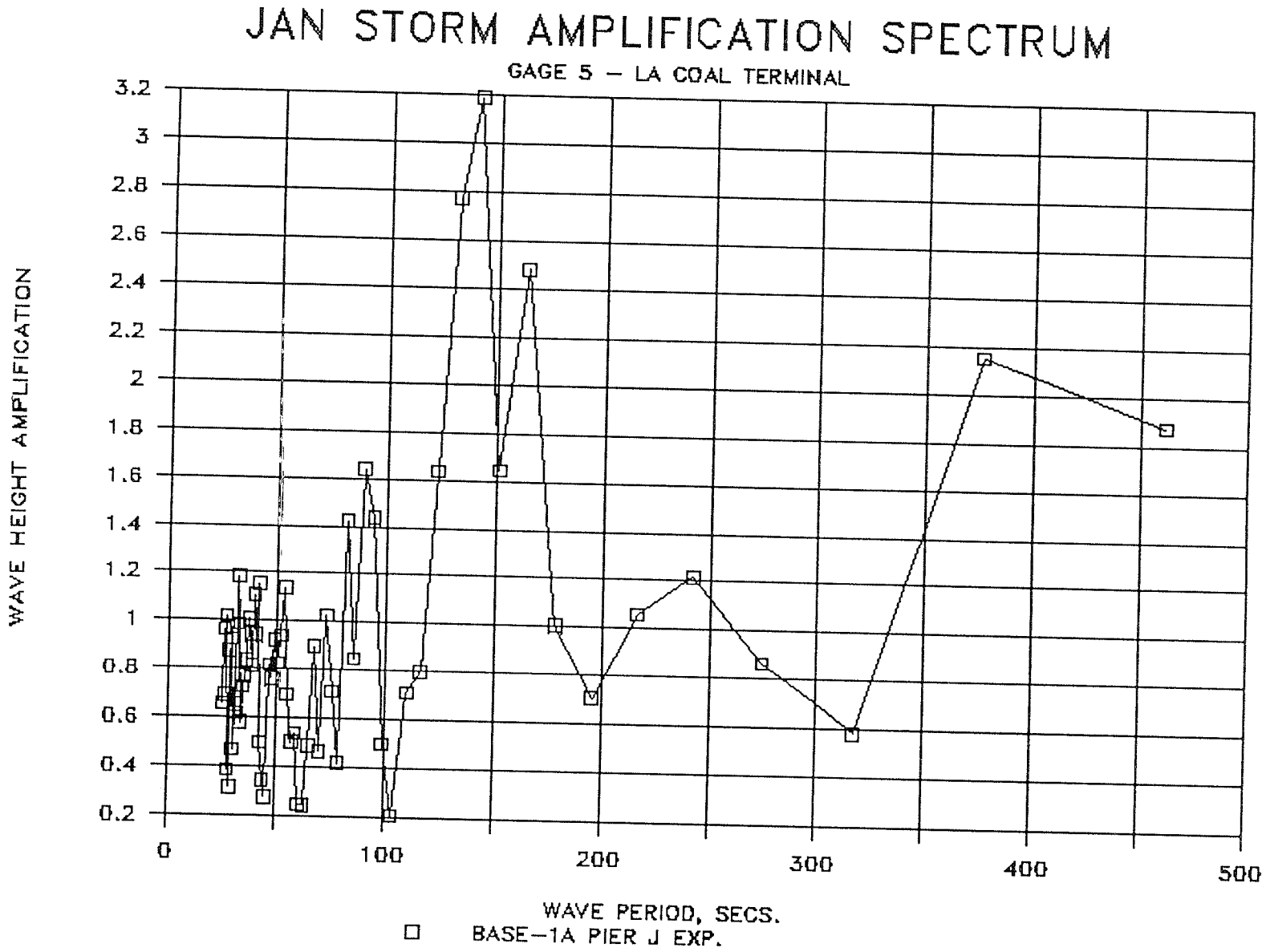


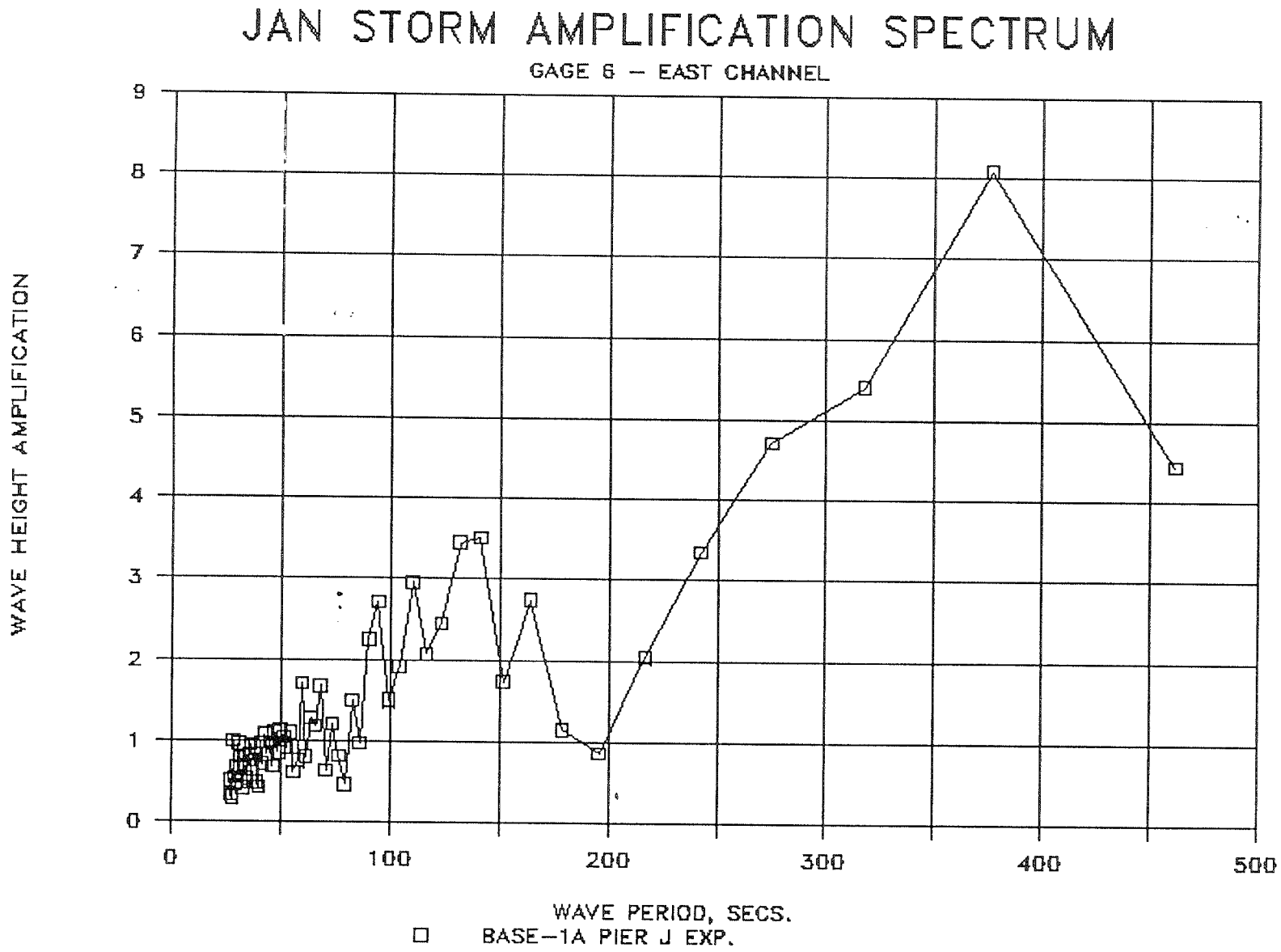

JAN STORM AMPLIFICATION SPECTRUM
GAGE 1 – LA WEST CHANNEL
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

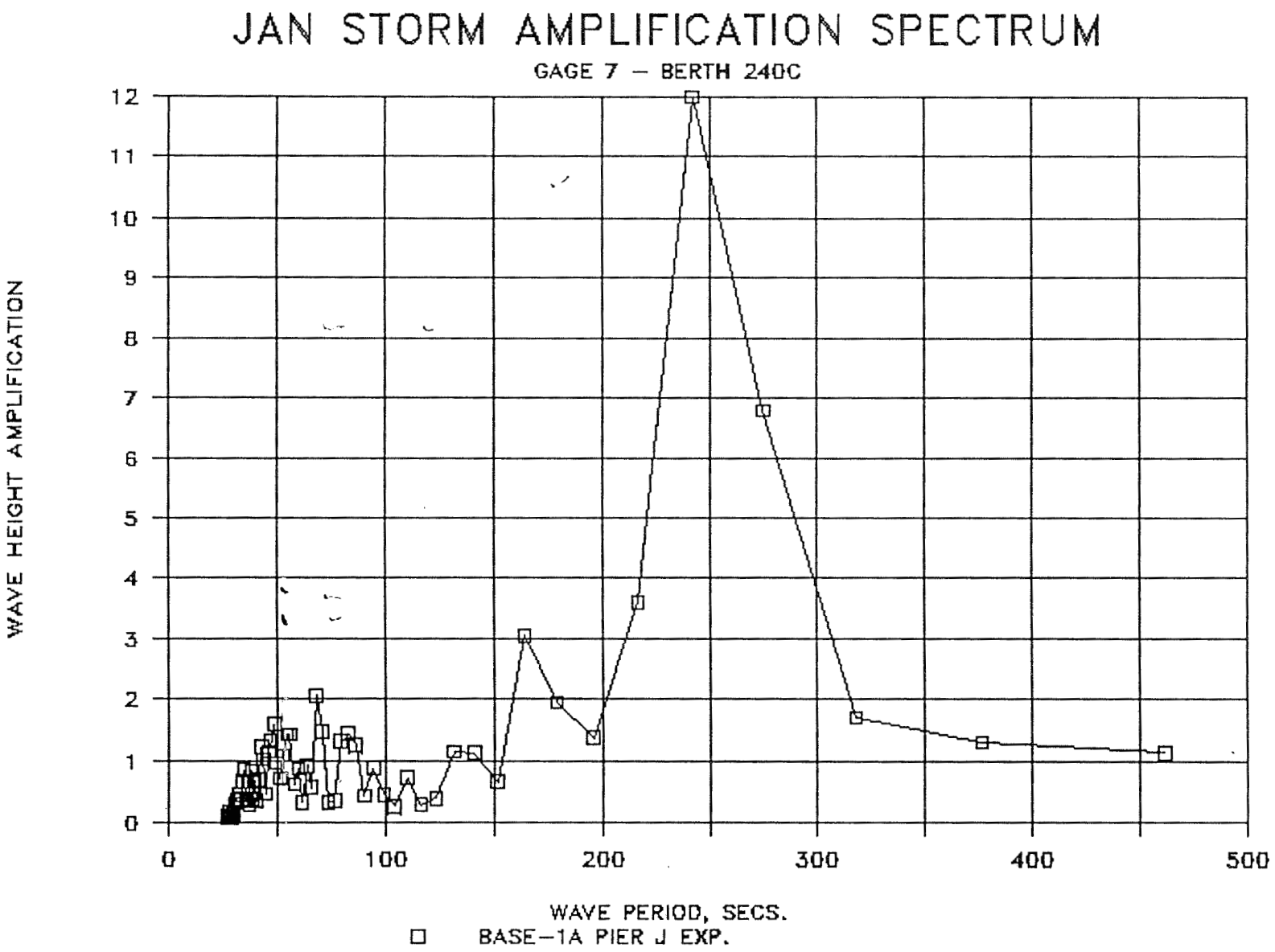

JAN STORM AMPLIFICATION SPECTRUM
GAGE 2 – LA WEST CH 5 ML BOAT BASIN
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

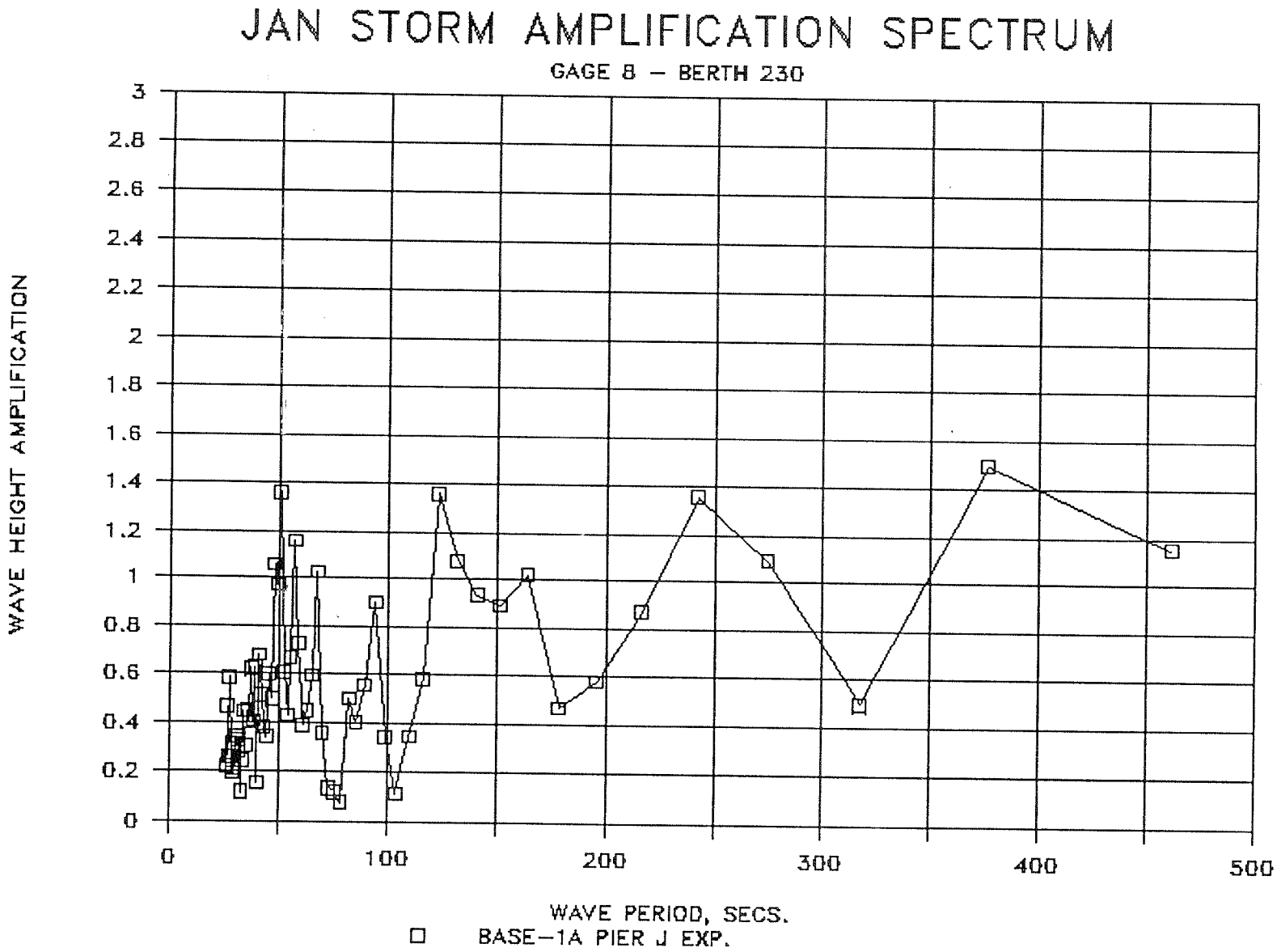

JAN STORM AMPLIFICATION SPECTRUM
GAGE 3 – WATCHORN BASIN
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

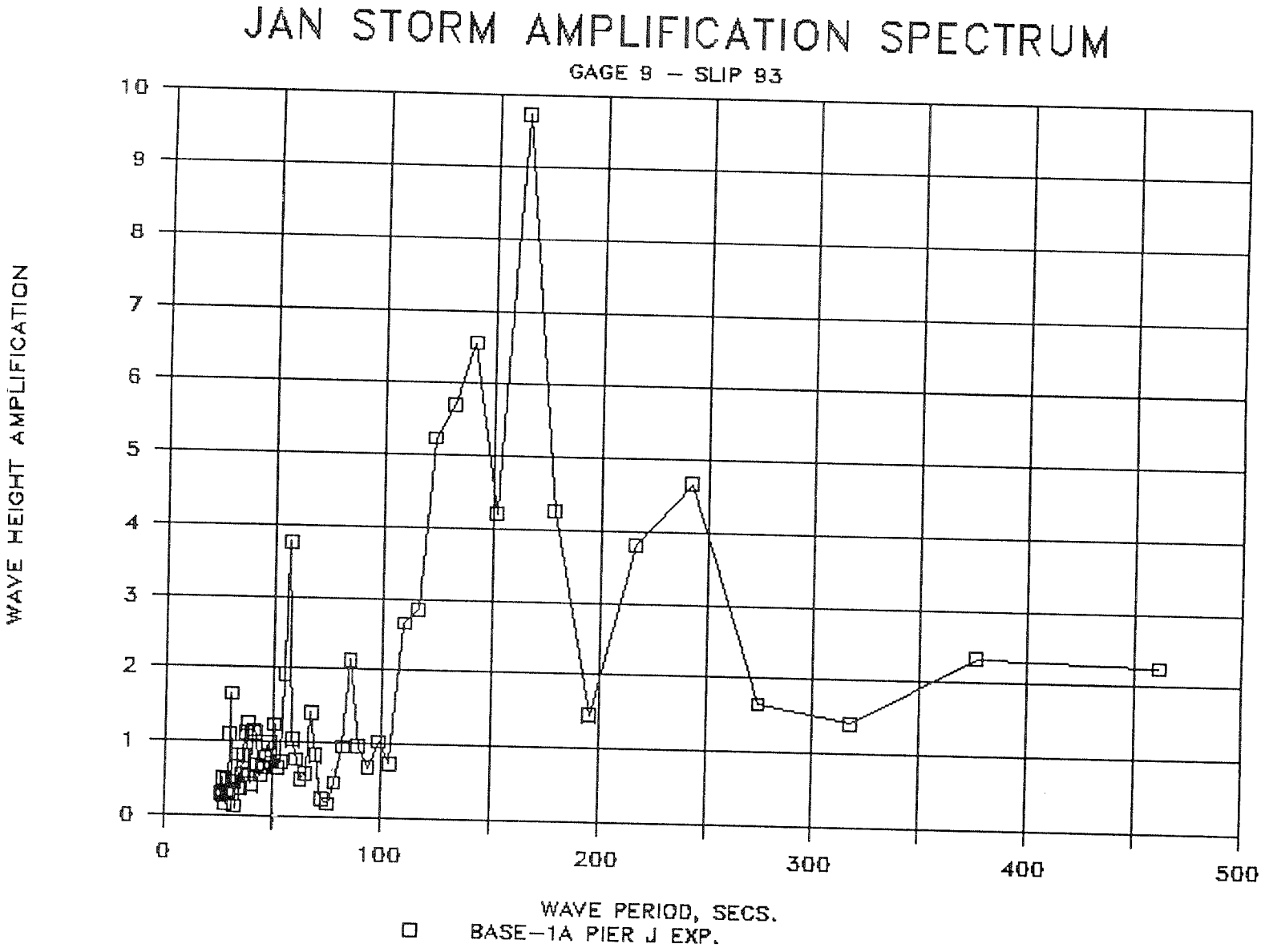

JAN STORM AMPLIFICATION SPECTRUM
GAGE 4 – LA BERTH 46
WAVE HEIGHT AMPLIFICATION
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

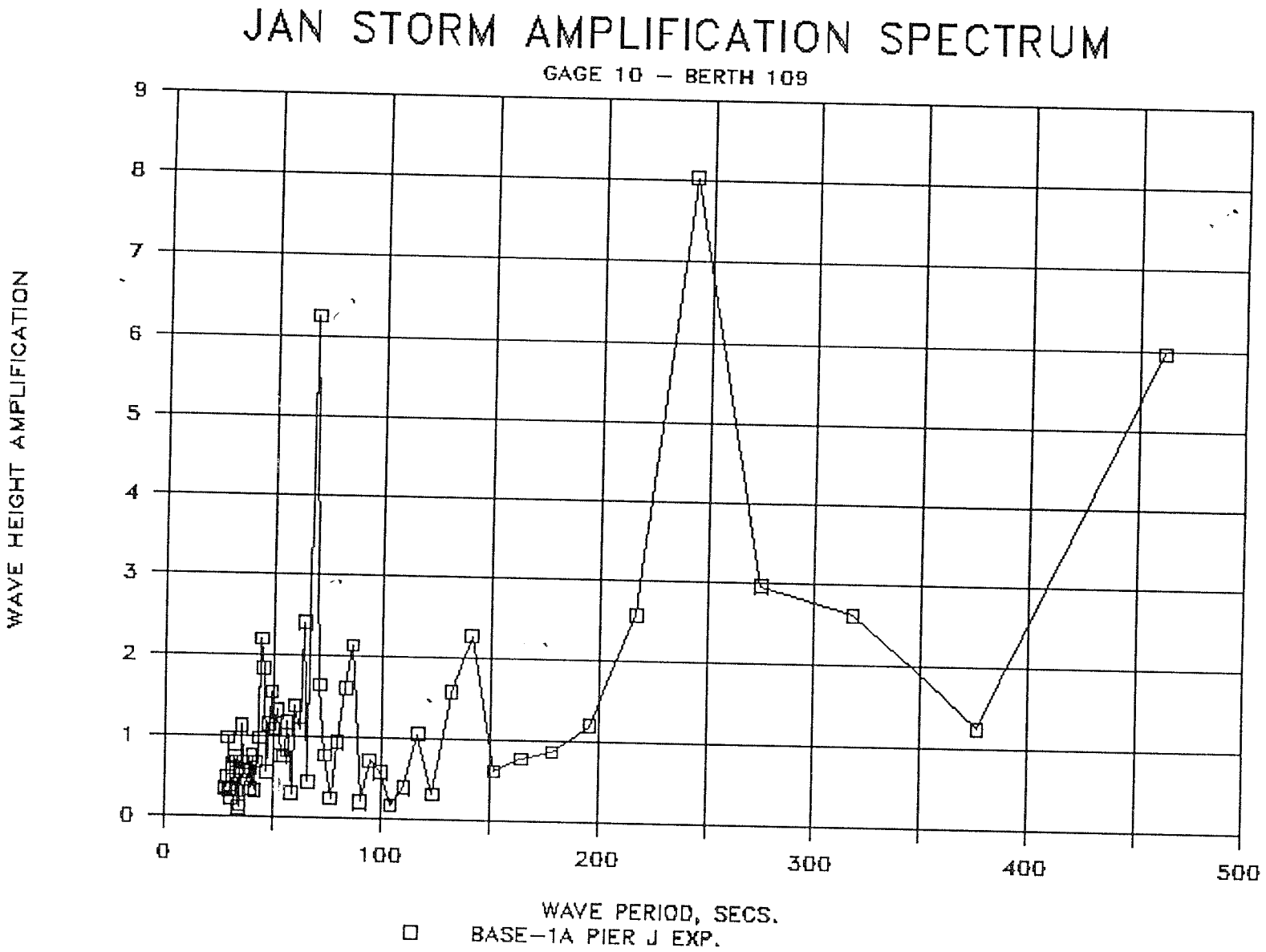

JAN STORM AMPLIFICATION SPECTRUM
GAGE 5 – LA COAL TERMINAL
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

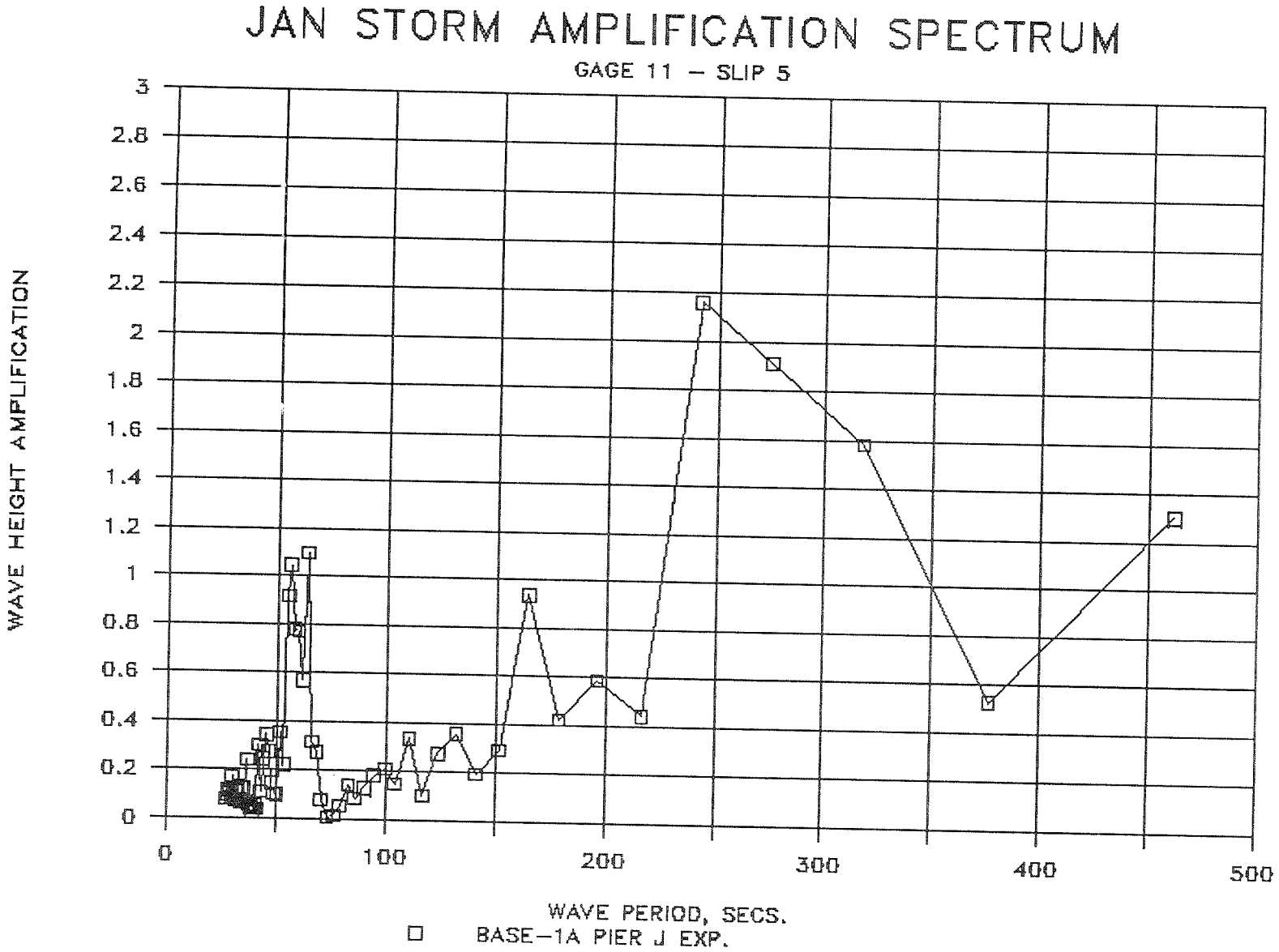

JAN STORM AMPLIFICATION SPECTRUM
GAGE 6 — EAST CHANNEL
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE—1A PIER J EXP.

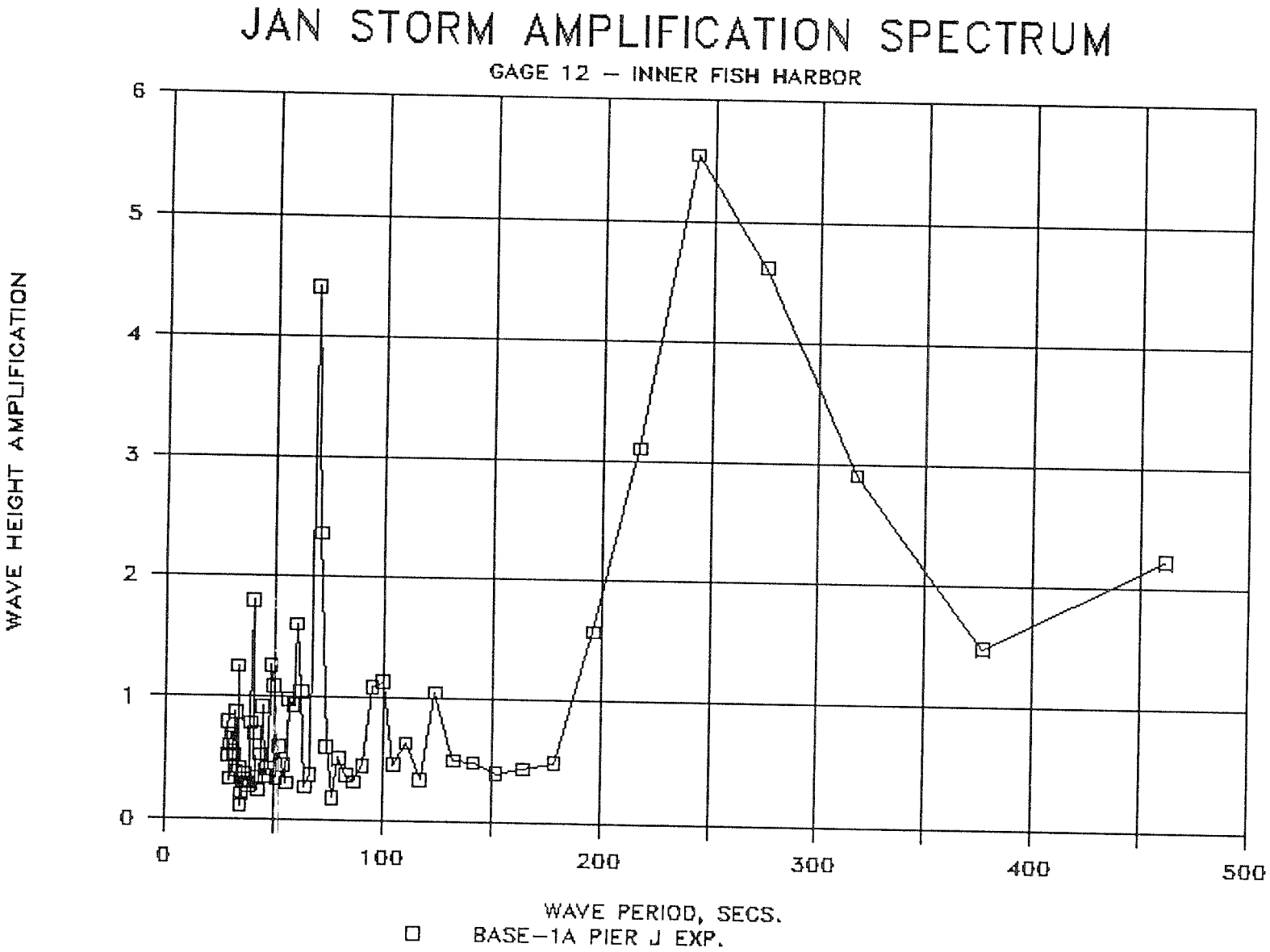

JAN STORM AMPLIFICATION SPECTRUM
GAGE 7 — BERTH 240C
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
10
11
12
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE—1A PIER J EXP.

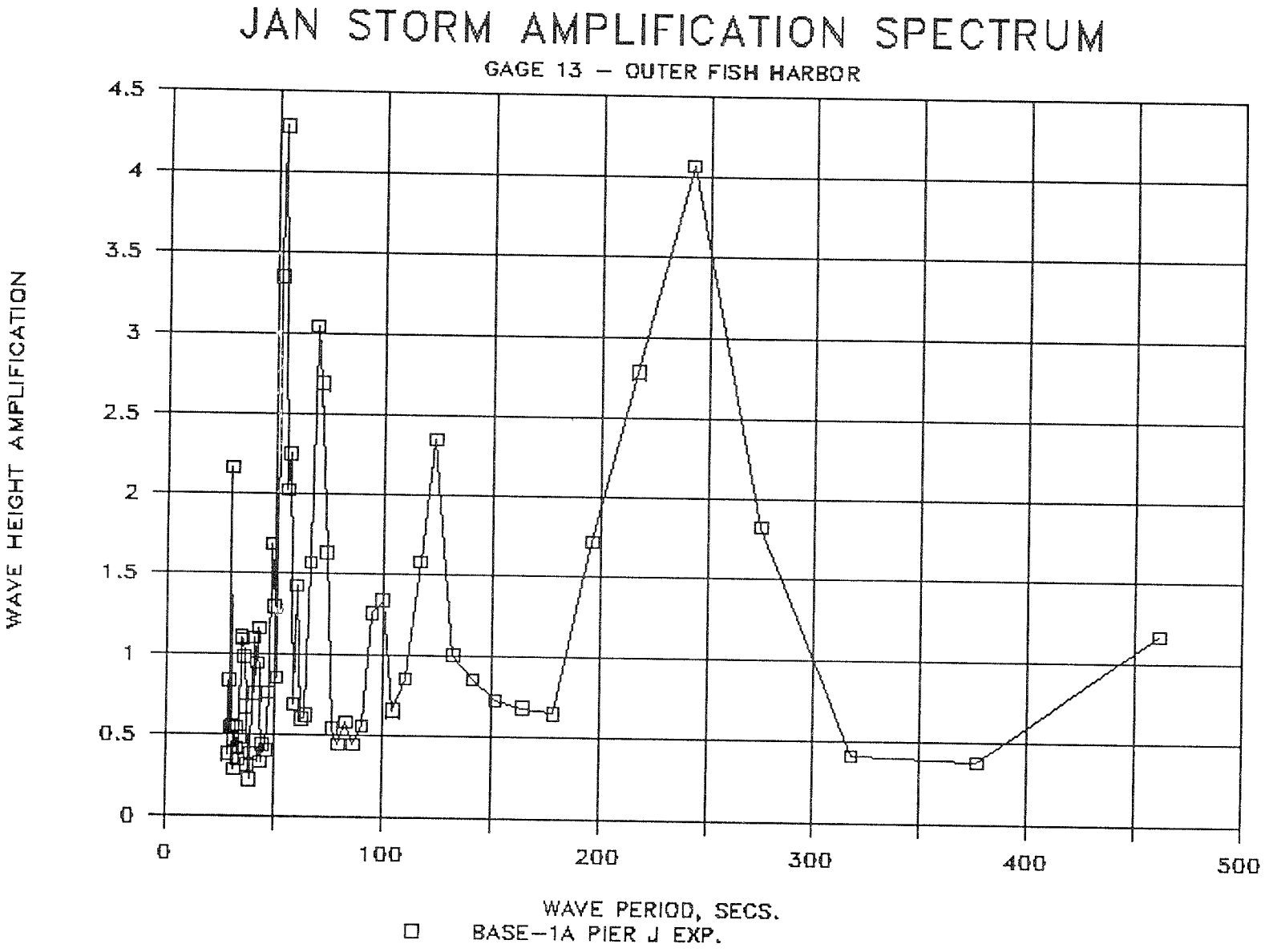

JAN STORM AMPLIFICATION SPECTRUM
GAGE 8 – BERTH 230
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

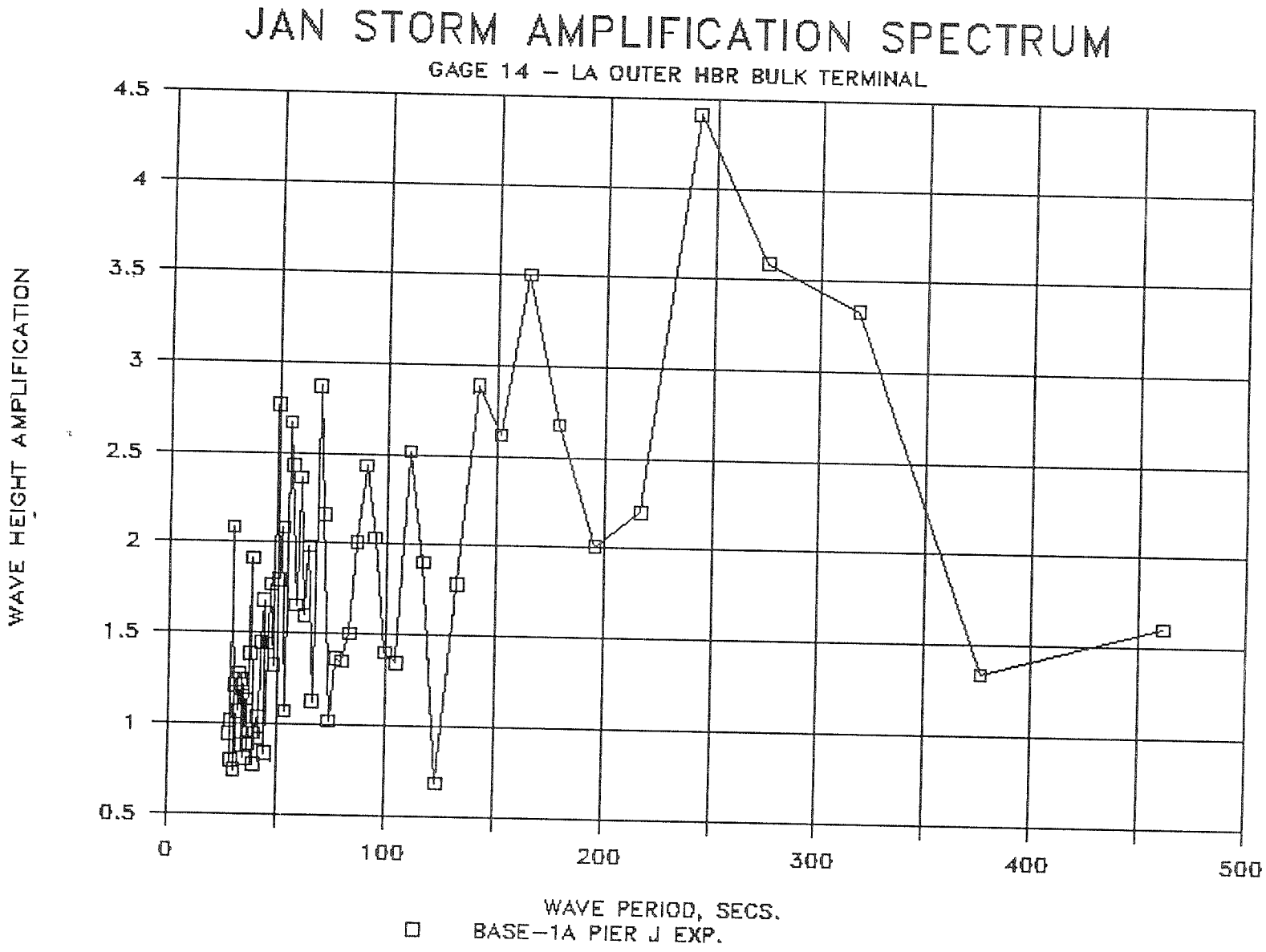

JAN STORM AMPLIFICATION SPECTRUM
GAGE 9 – SLIP 93
WAVE HEIGHT AMPLIFICATION
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

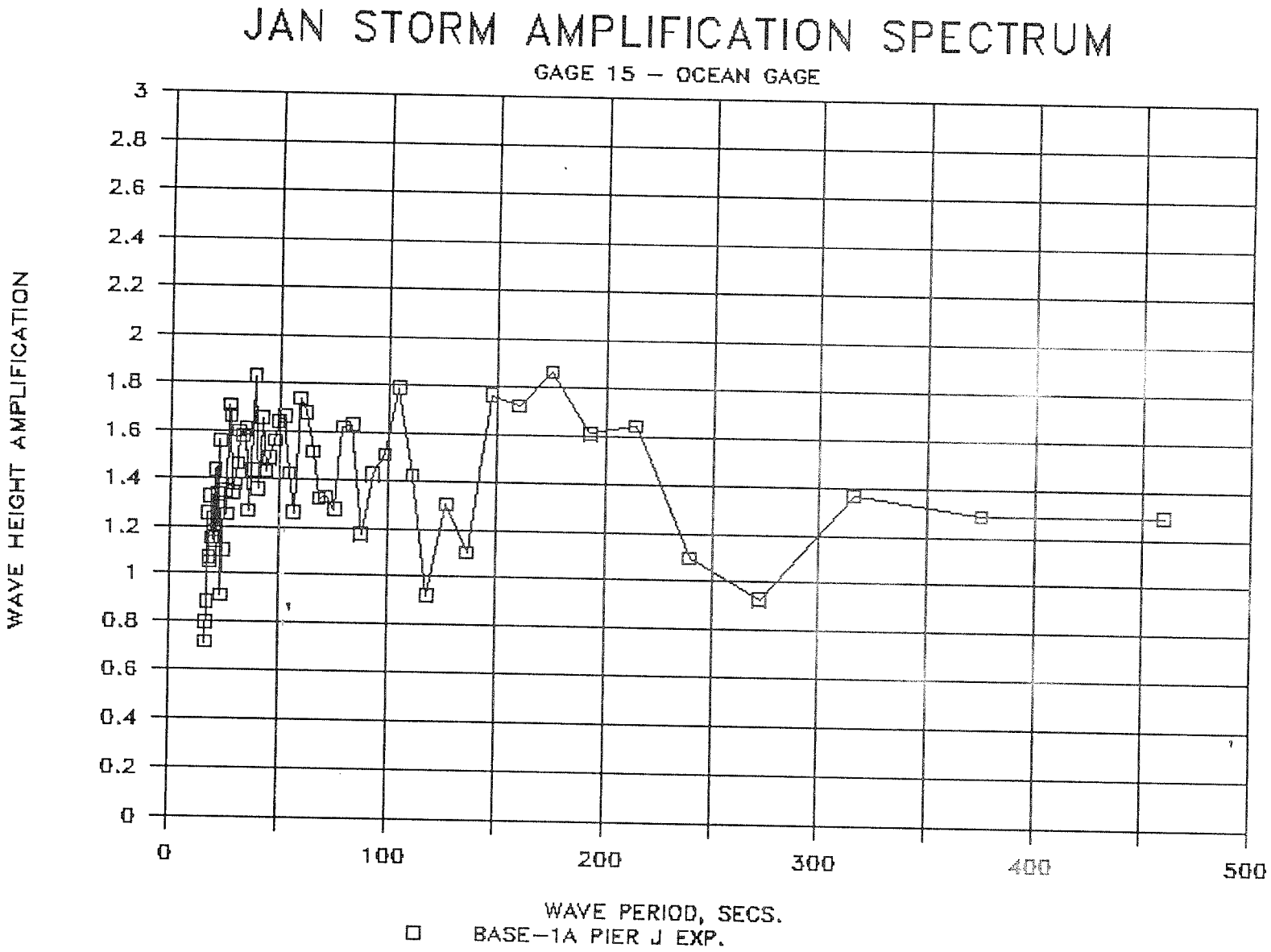

JAN STORM AMPLIFICATION SPECTRUM
GAGE 10 – BERTH 109
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

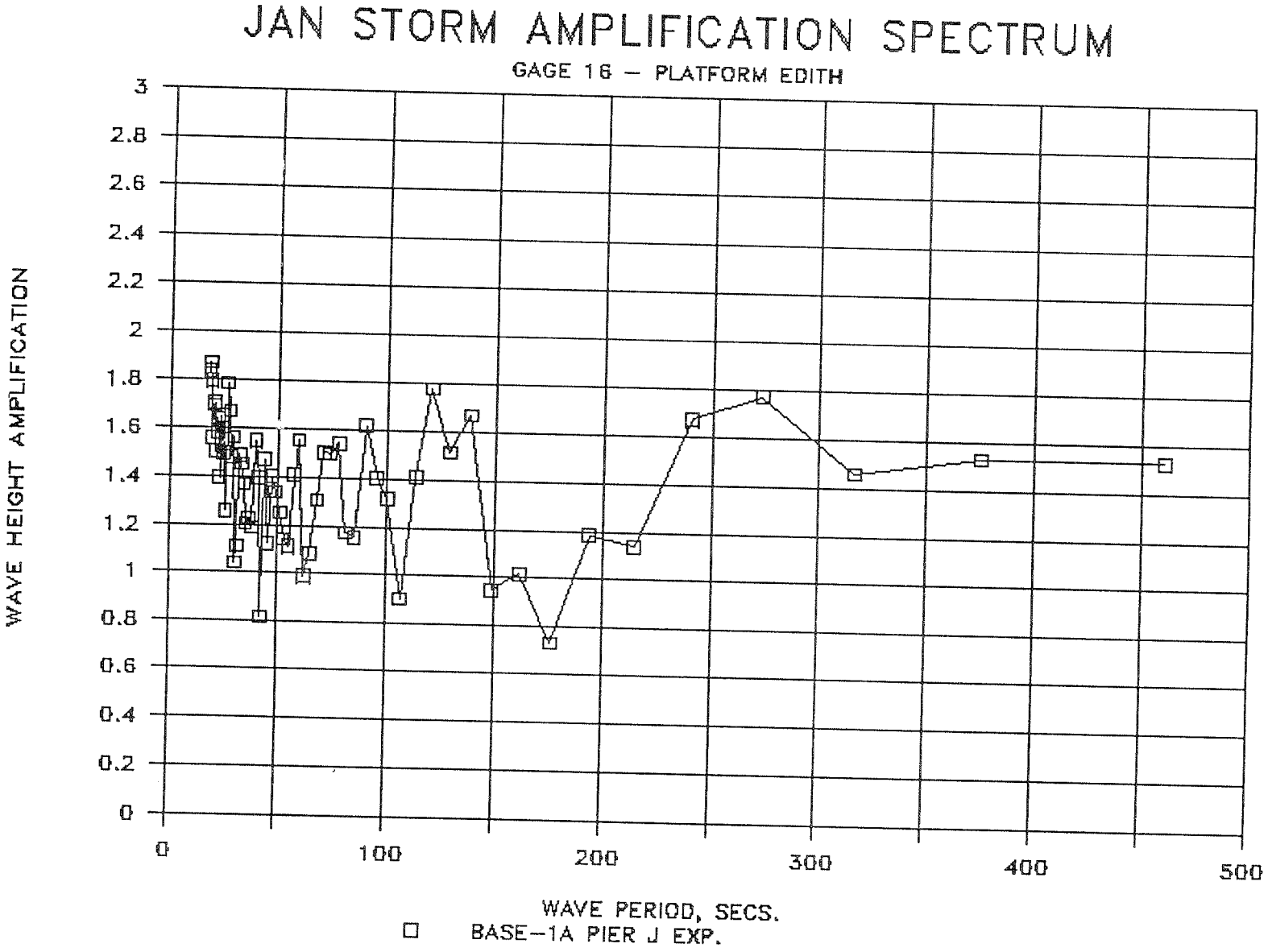

JAN STORM AMPLIFICATION SPECTRUM
GAGE 11 – SLIP 5
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

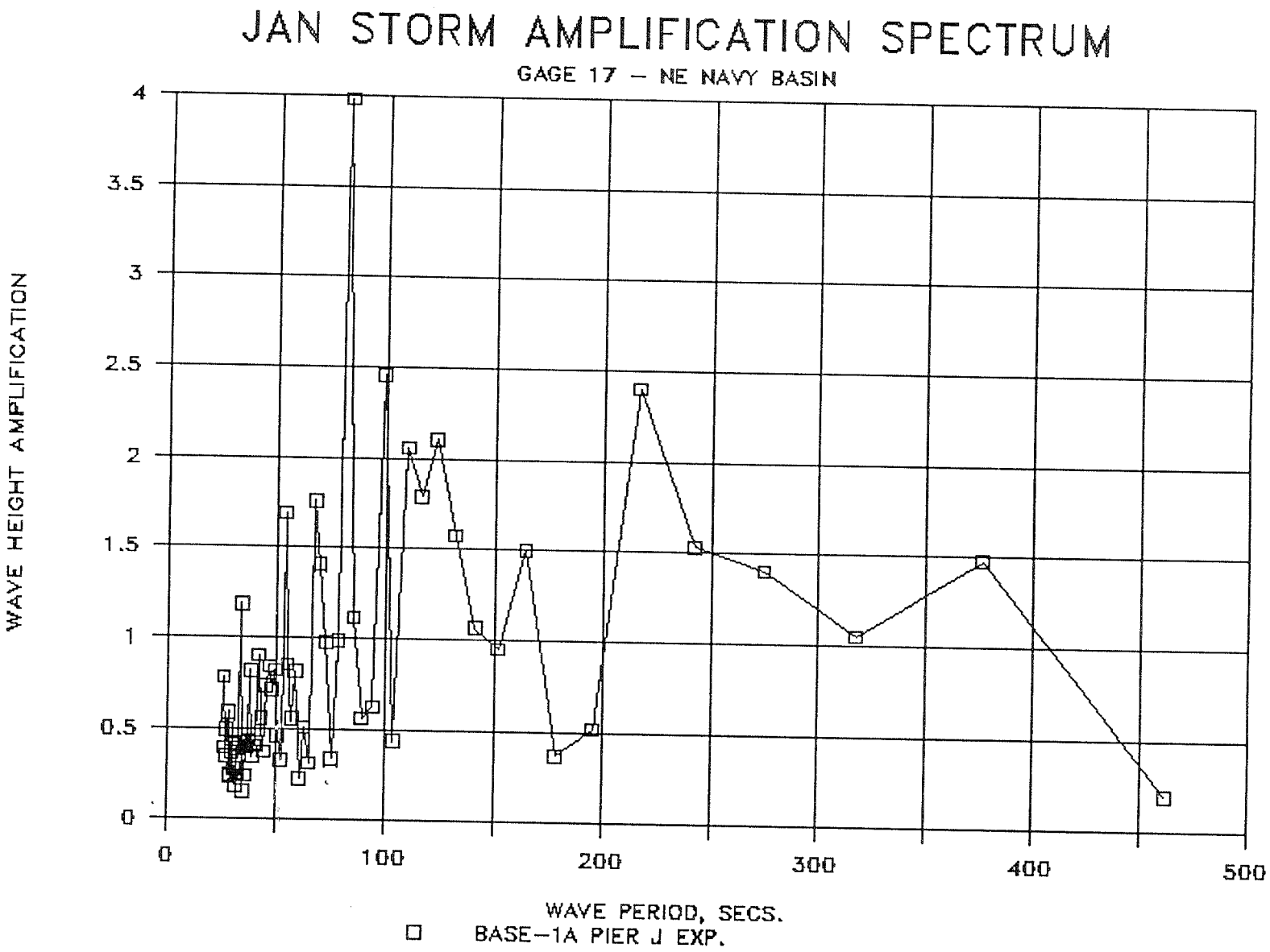

JAN STORM AMPLIFICATION SPECTRUM
GAGE 12 – INNER FISH HARBOR
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

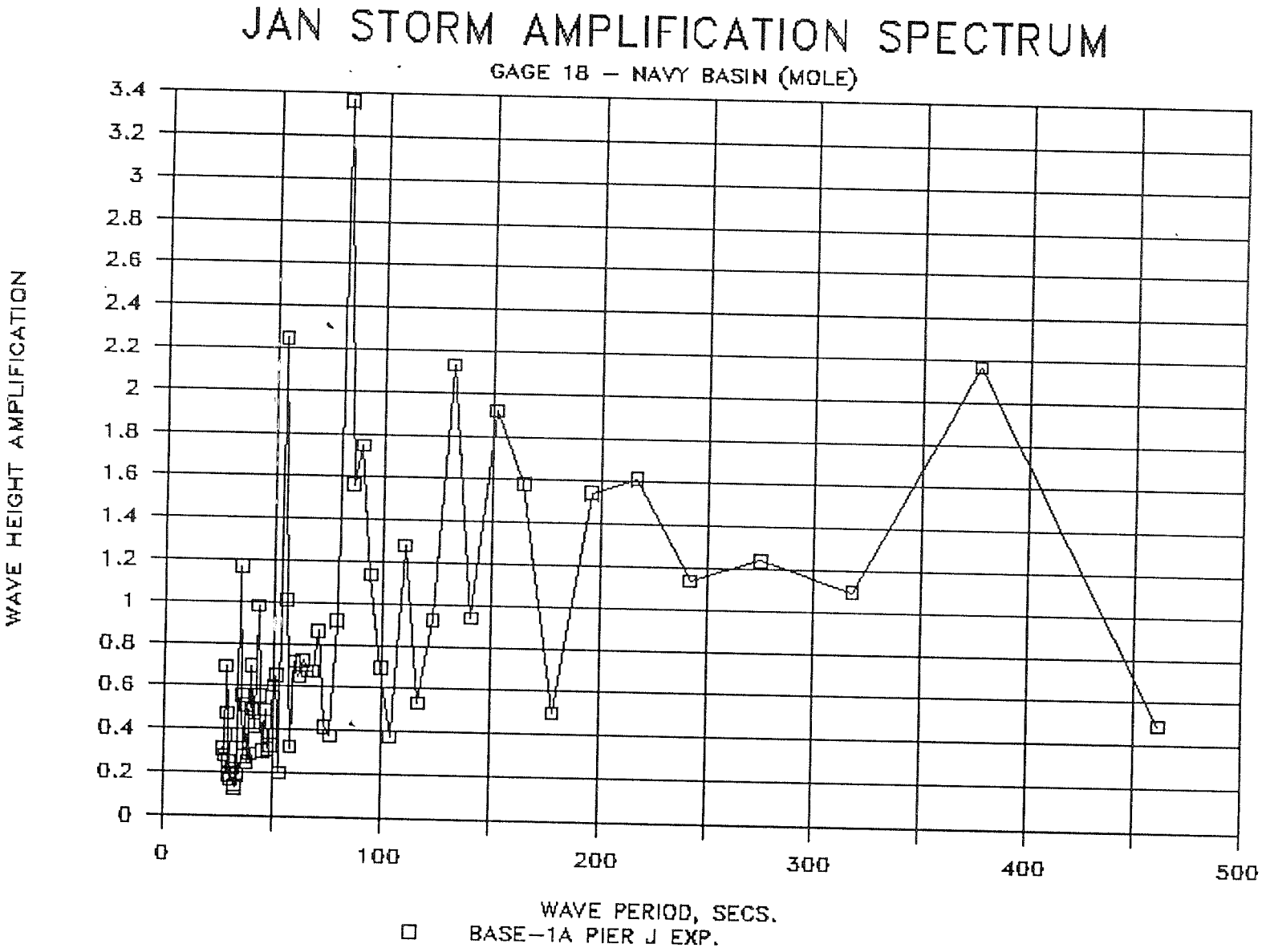

JAN STORM AMPLIFICATION SPECTRUM
GAGE 13 – OUTER FISH HARBOR
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

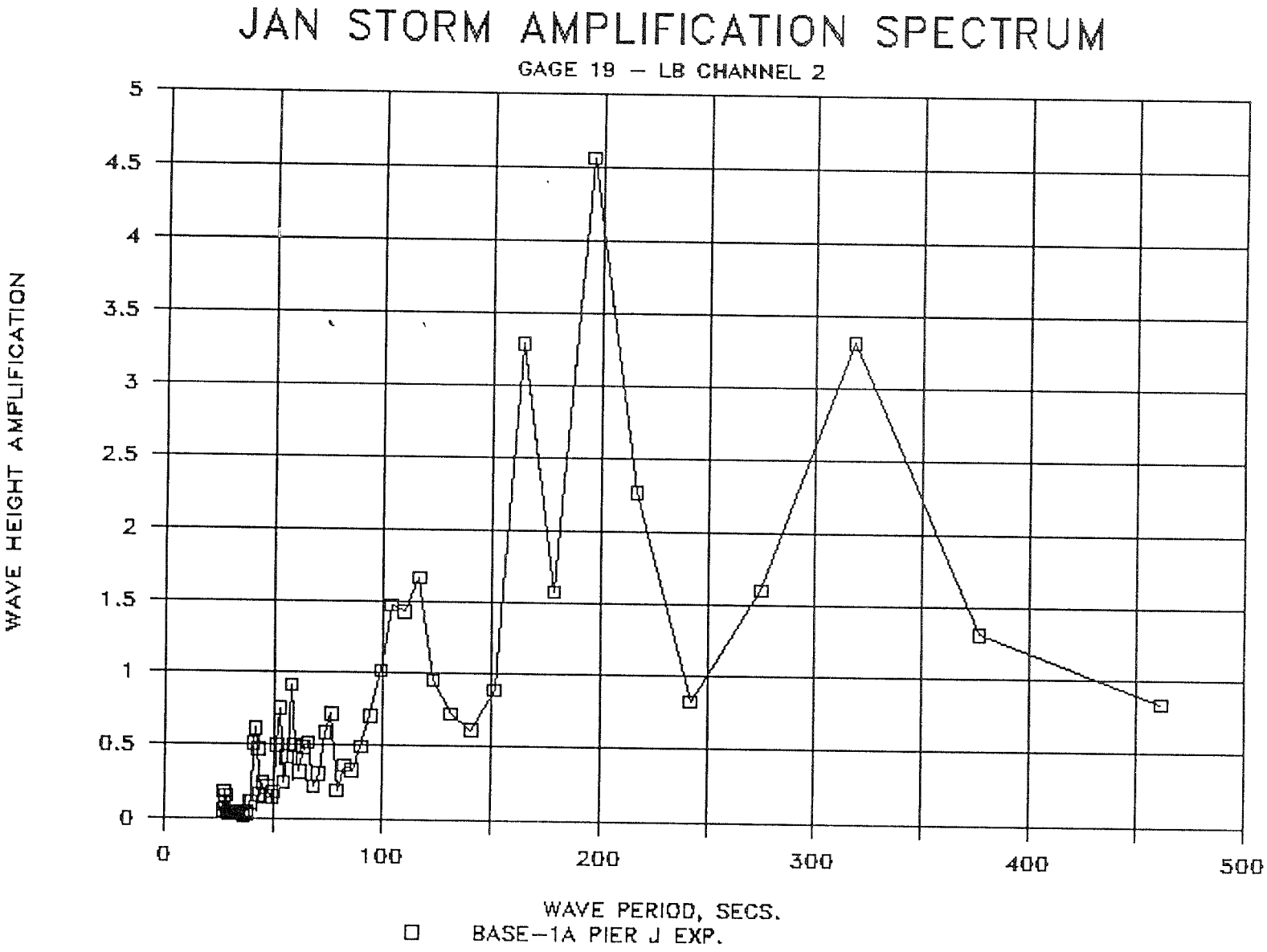

JAN STORM AMPLIFICATION SPECTRUM
GAGE 14 – LA OUTER HBR BULK TERMINAL
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

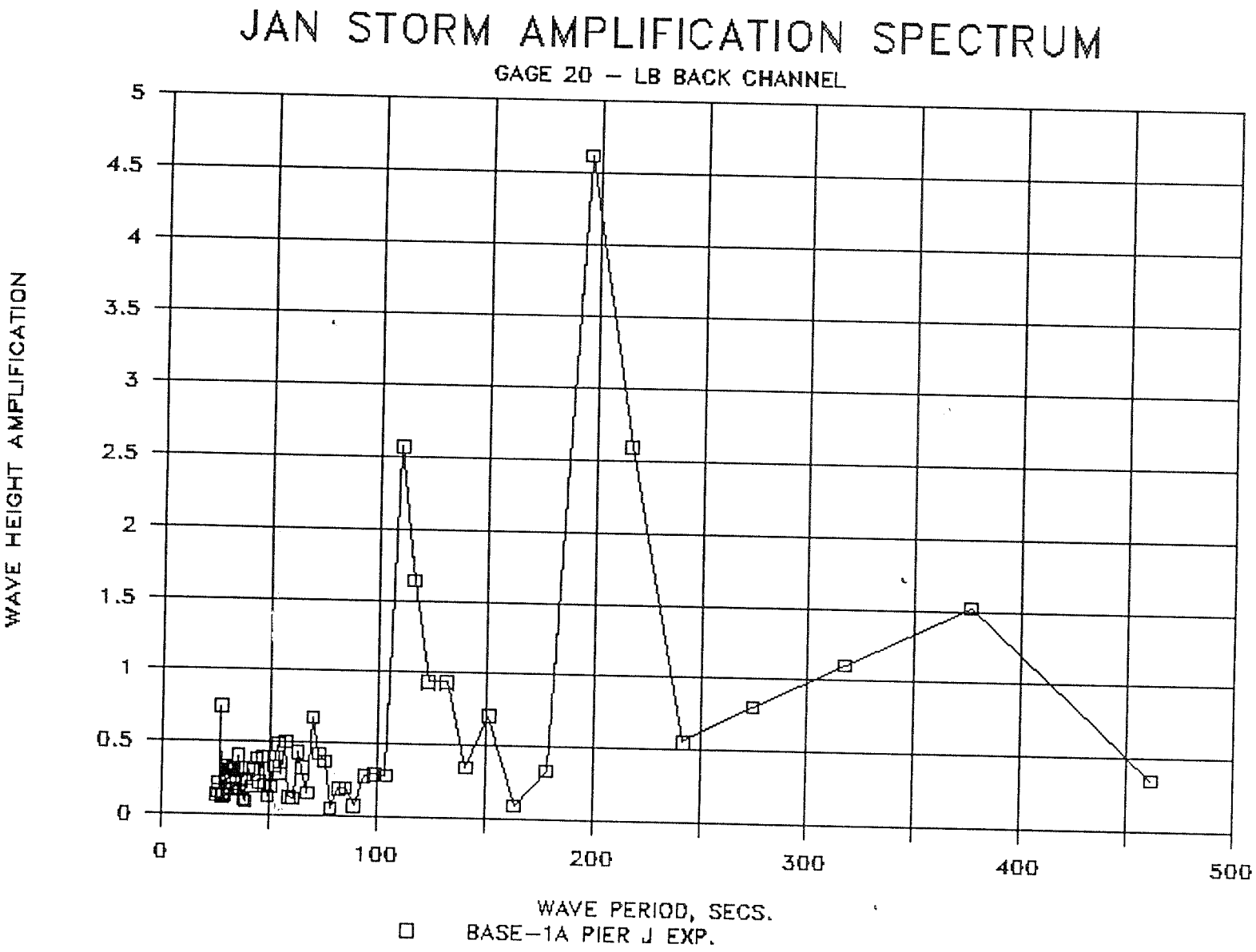

JAN STORM AMPLIFICATION SPECTRUM
GAGE 15 – OCEAN GAGE
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

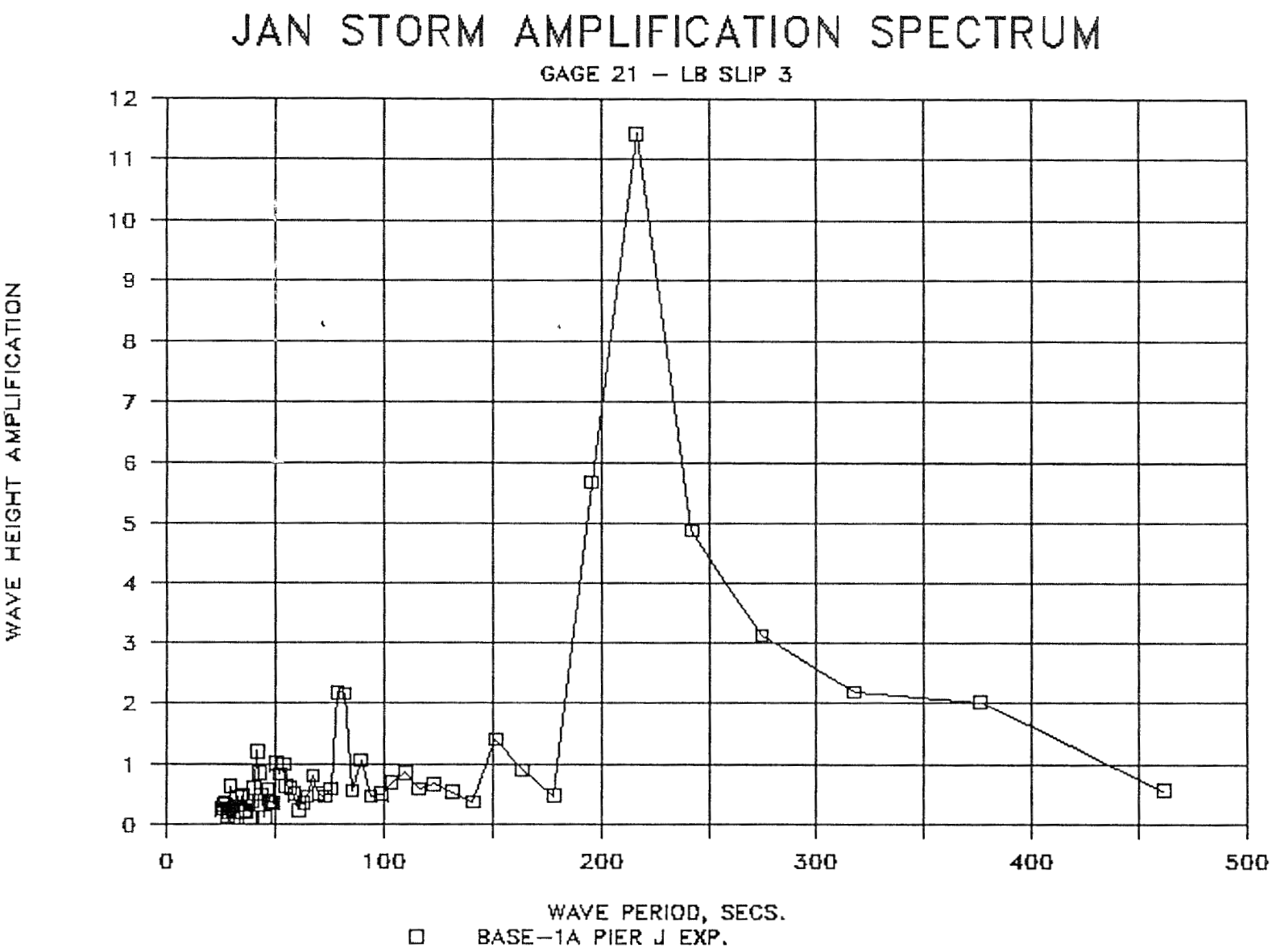

JAN STORM AMPLIFICATION SPECTRUM
GAGE 16 – PLATFORM EDITH
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

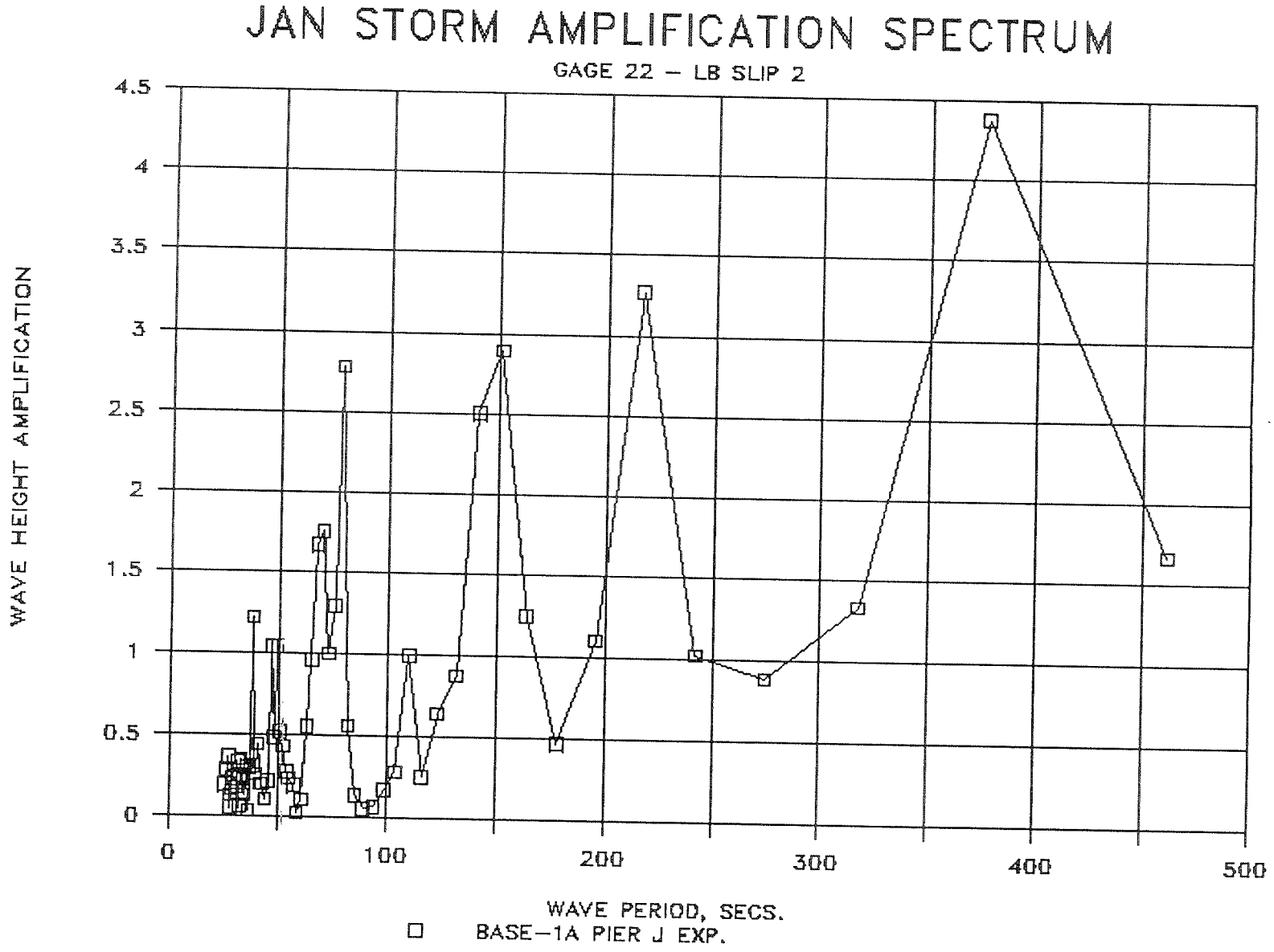

JAN STORM AMPLIFICATION SPECTRUM
GAGE 17 – NE NAVY BASIN
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

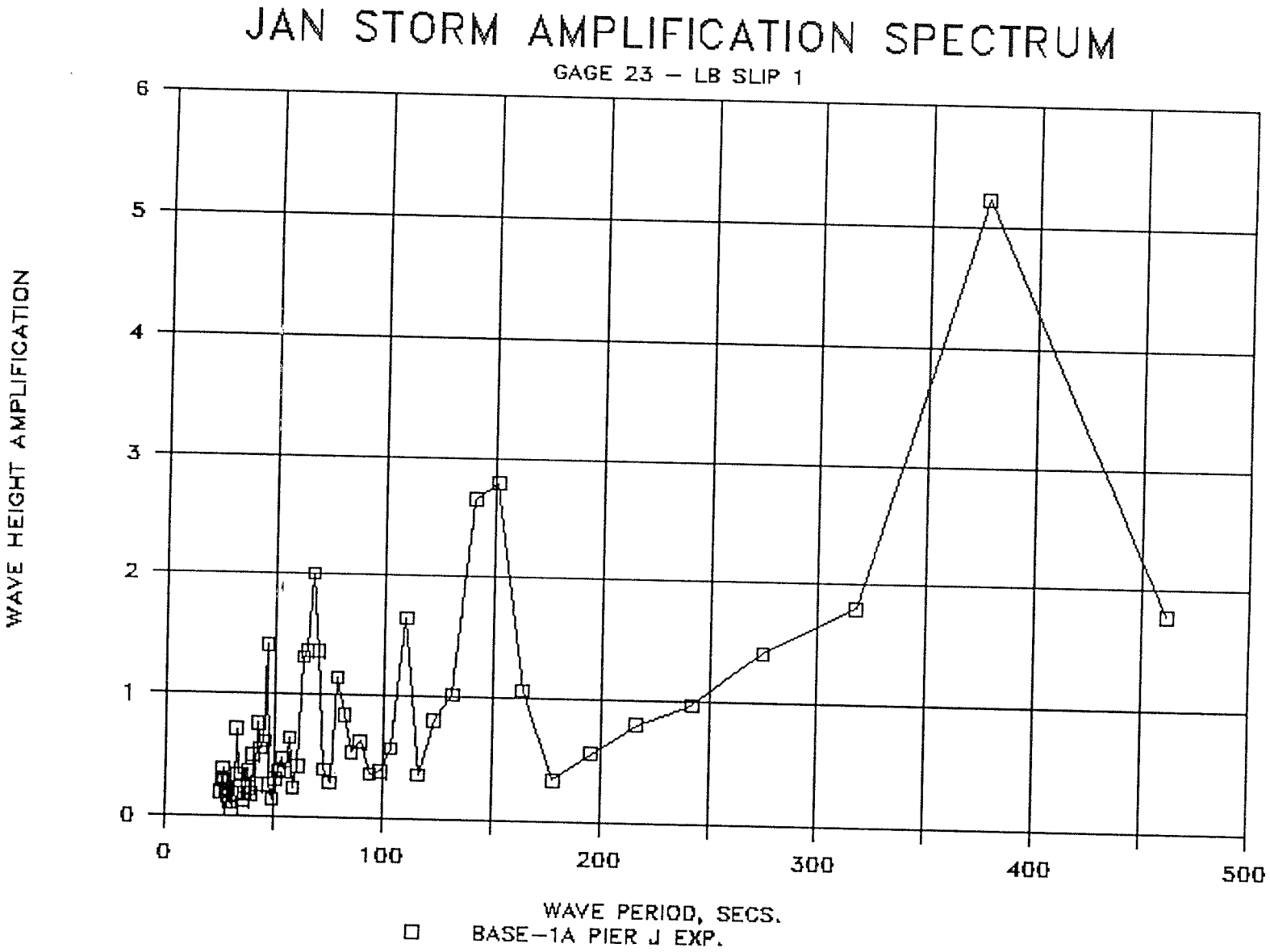

JAN STORM AMPLIFICATION SPECTRUM
GAGE 18 – NAVY BASIN (MOLE)
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

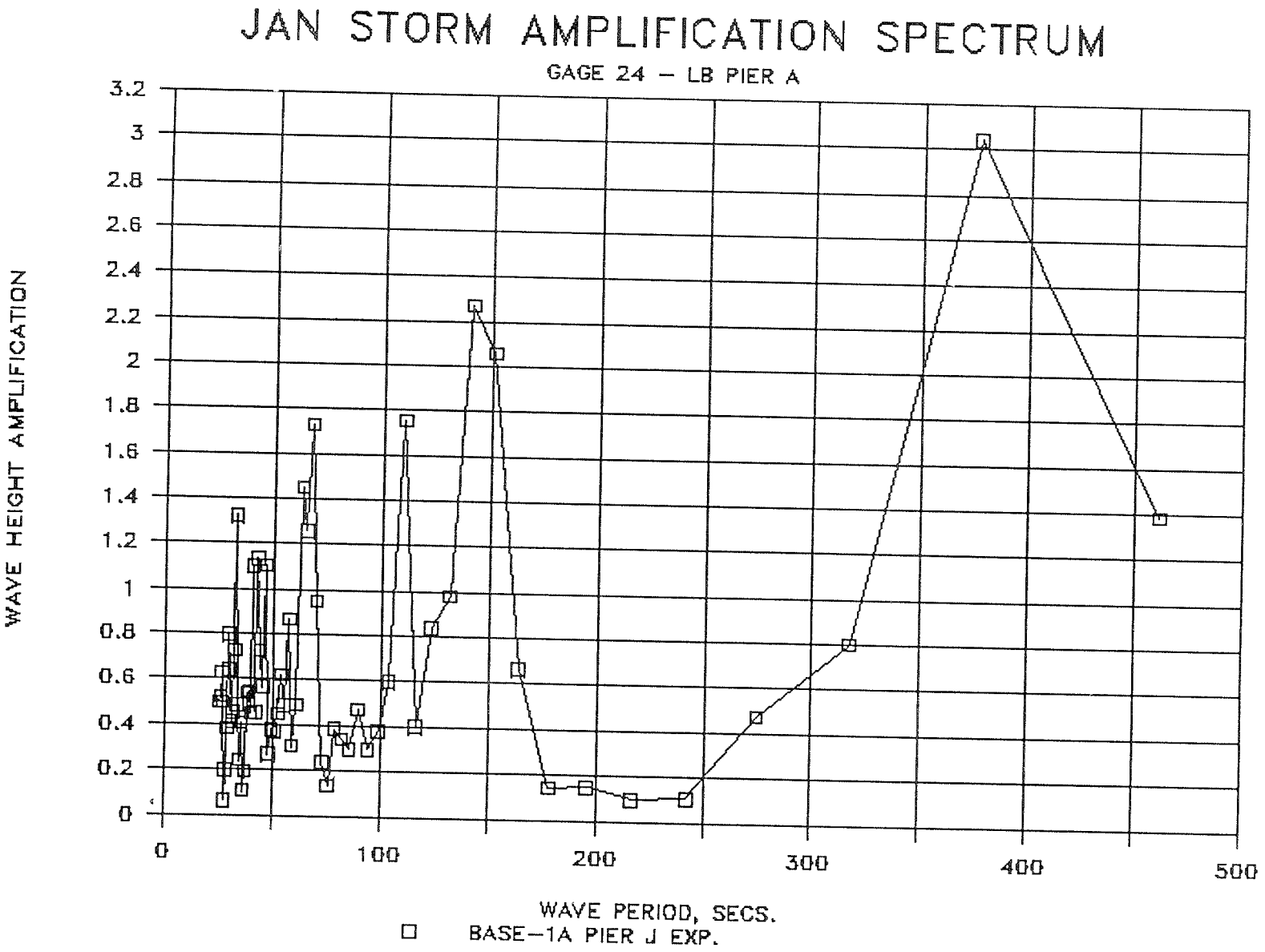

JAN STORM AMPLIFICATION SPECTRUM
GAGE 19 – LB CHANNEL 2
WAVE HEIGHT AMPLIFICATION
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

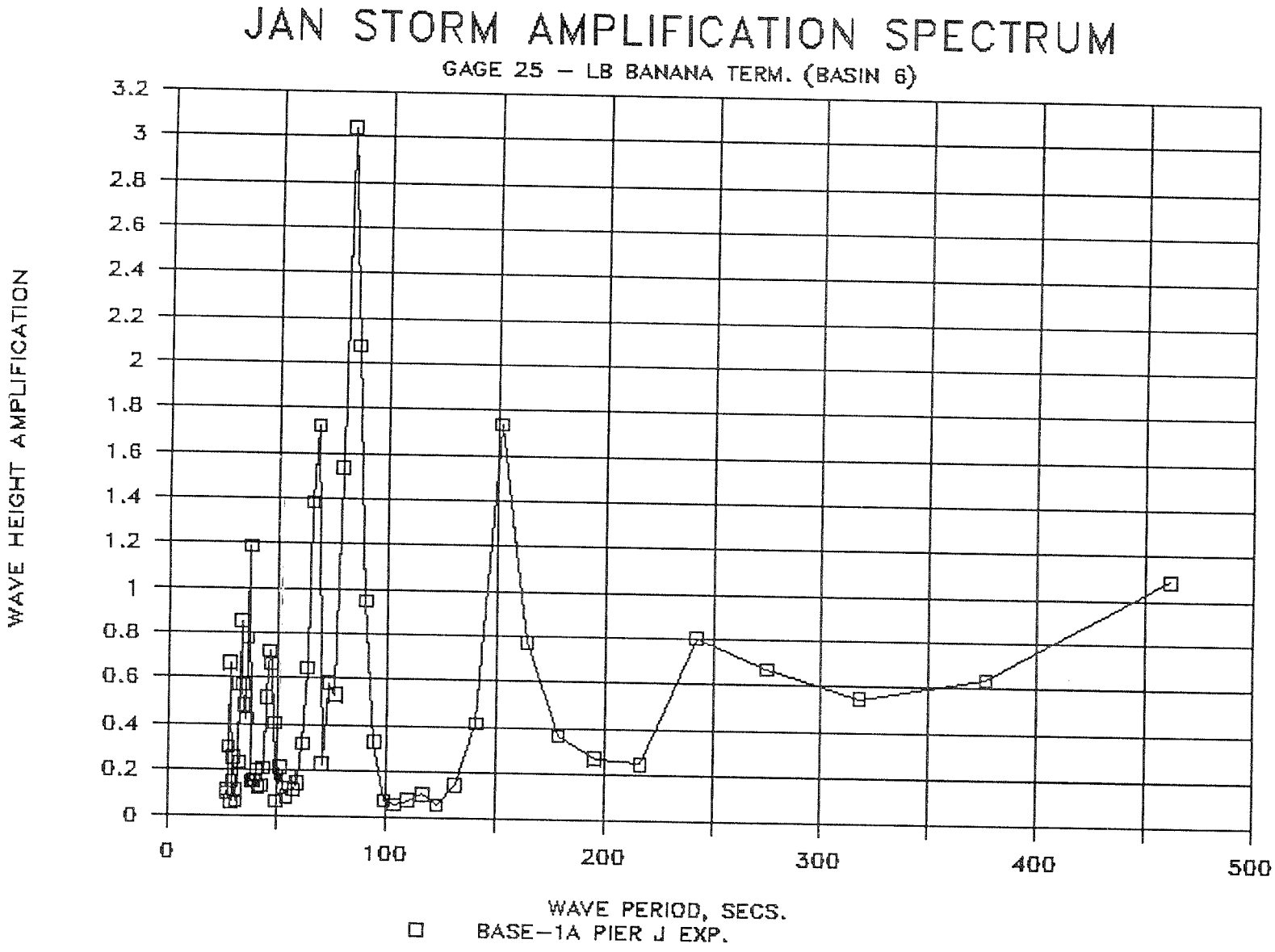

JAN STORM AMPLIFICATION SPECTRUM
GAGE 20 – LB BACK CHANNEL
WAVE HEIGHT AMPLIFICATION
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

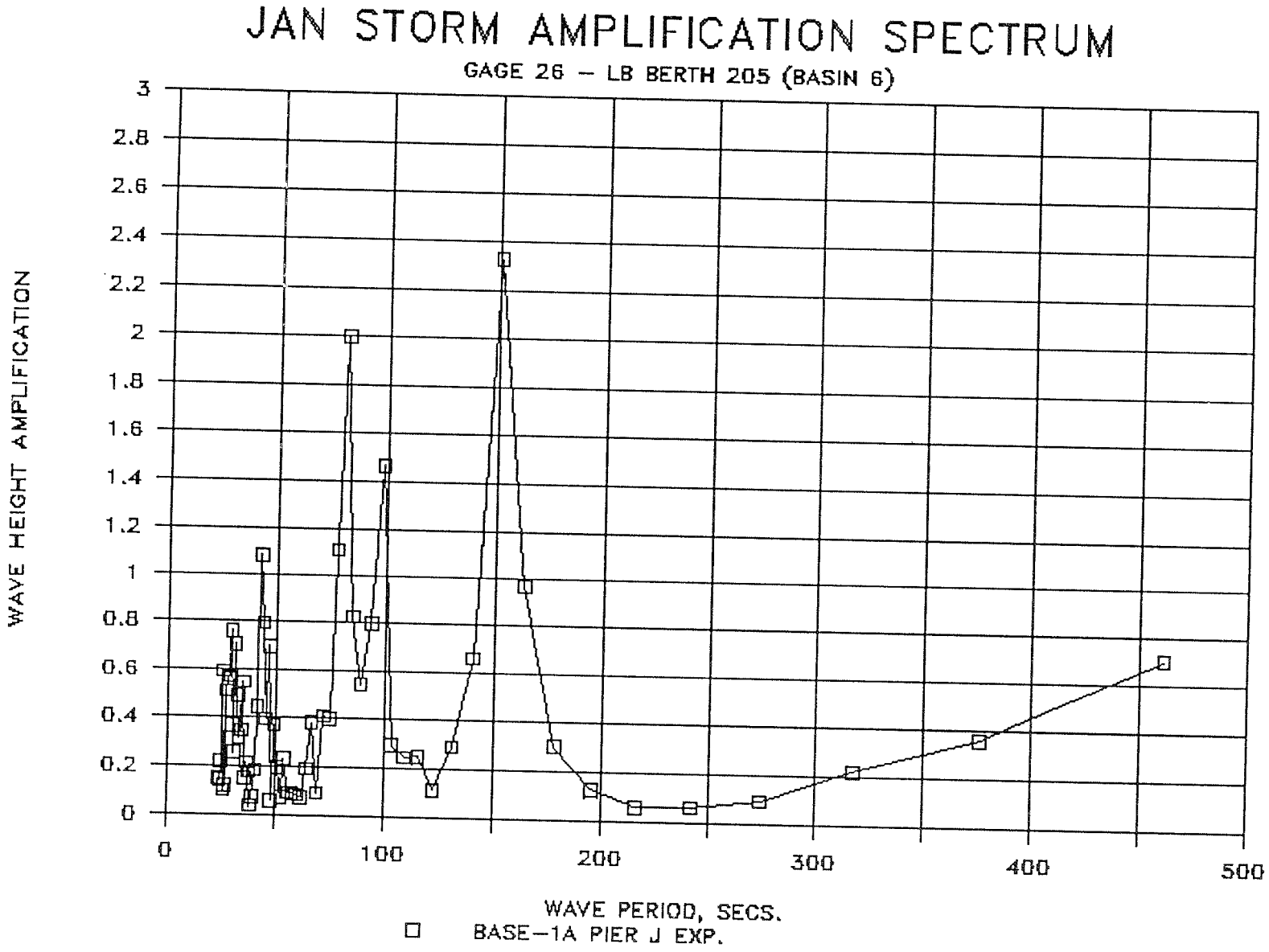

JAN STORM AMPLIFICATION SPECTRUM
GAGE 21 – LB SLIP 3
WAVE HEIGHT AMPLIFICATION
12
11
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

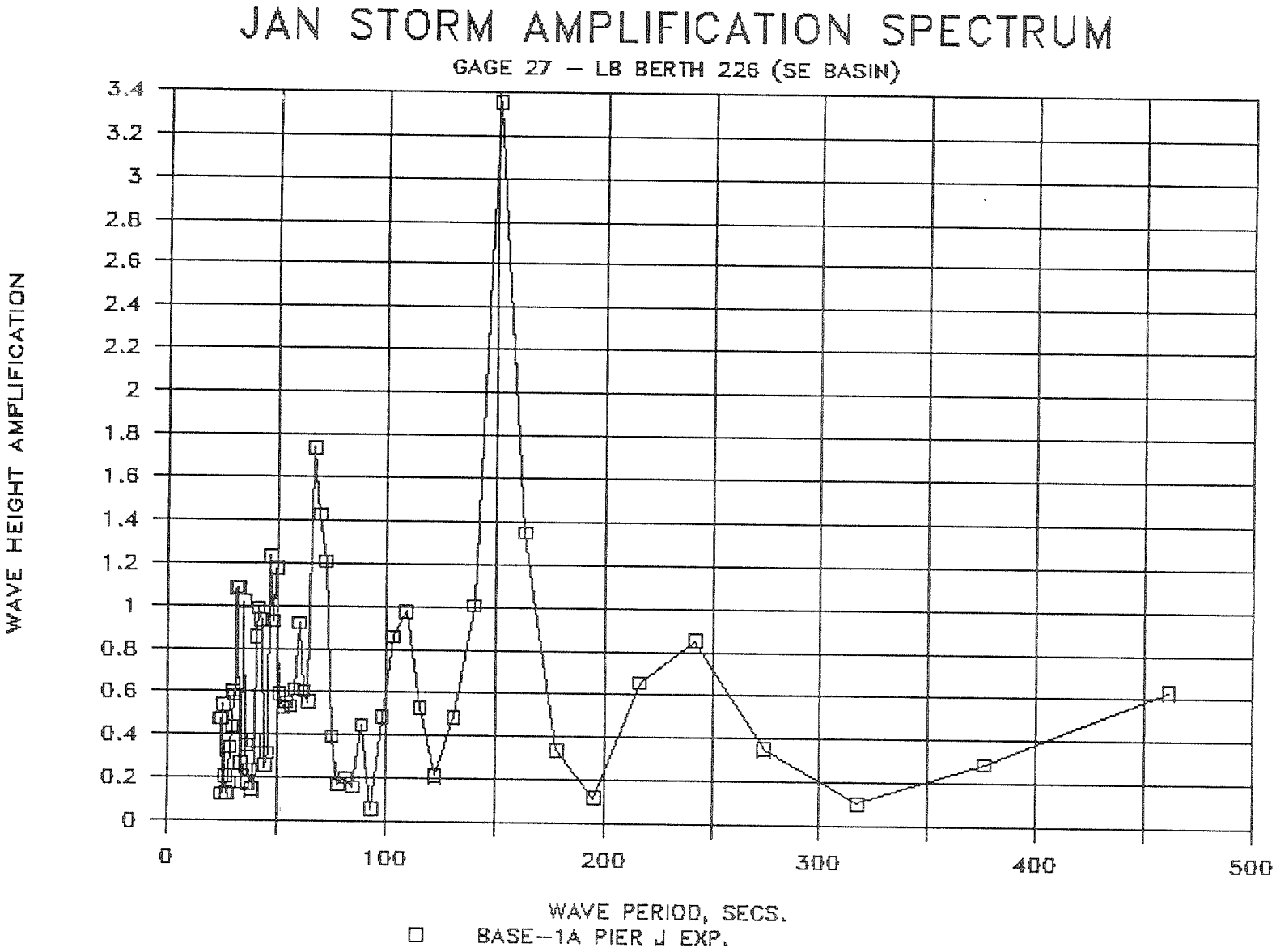

JAN STORM AMPLIFICATION SPECTRUM
GAGE 22 – LB SLIP 2
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

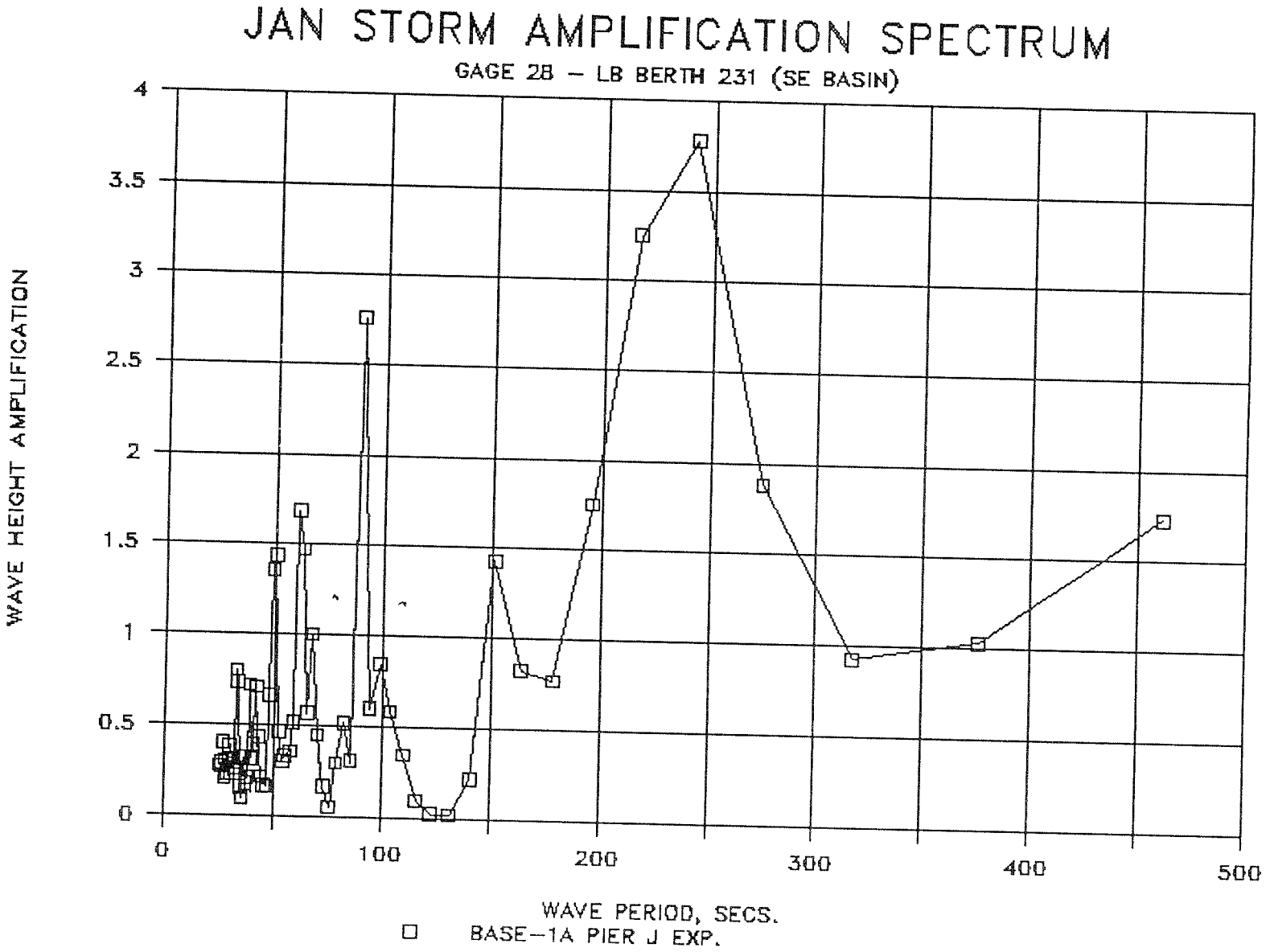

JAN STORM AMPLIFICATION SPECTRUM
GAGE 23 – LB SLIP 1
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

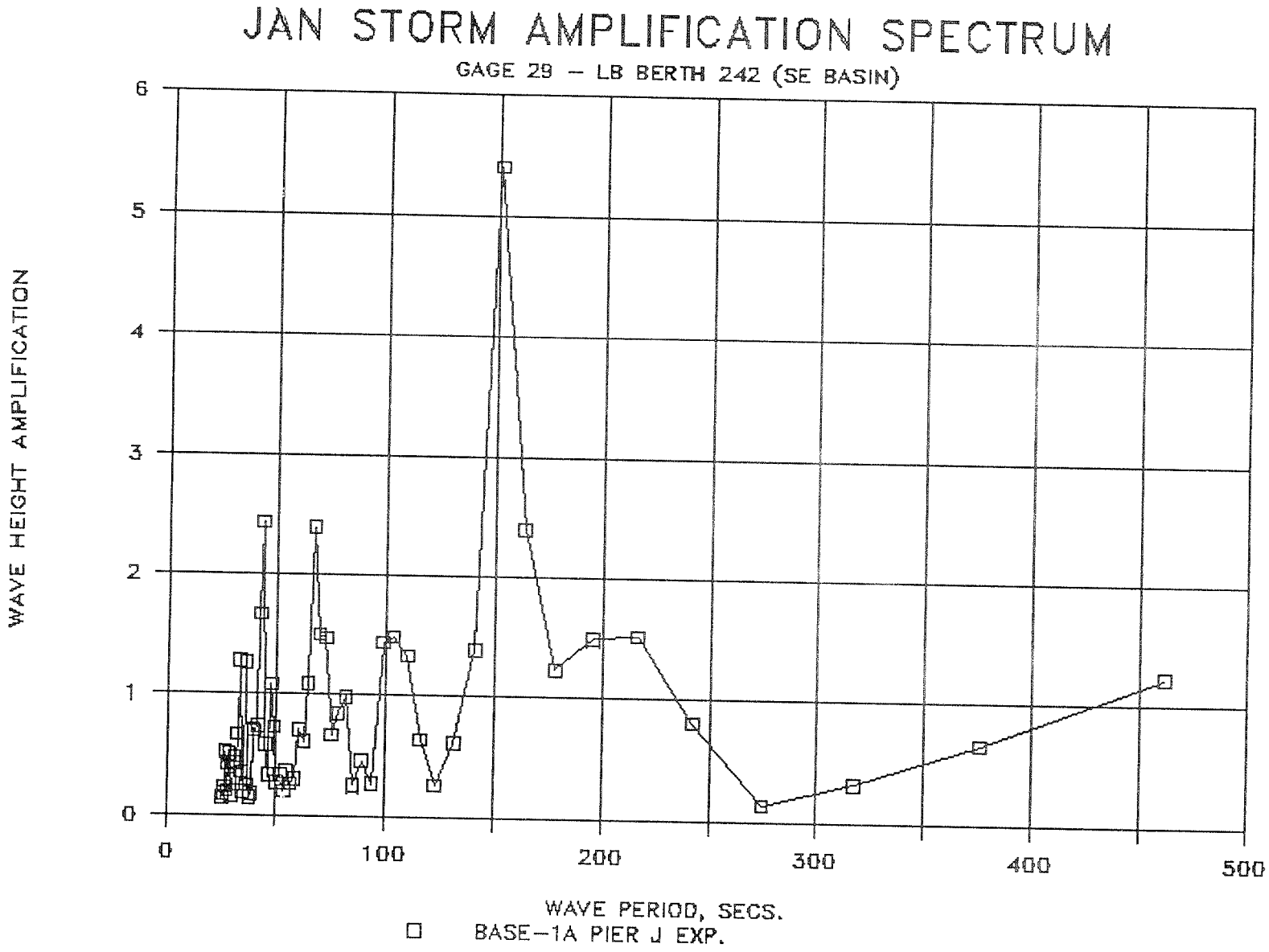

JAN STORM AMPLIFICATION SPECTRUM
GAGE 24 – LB PIER A
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

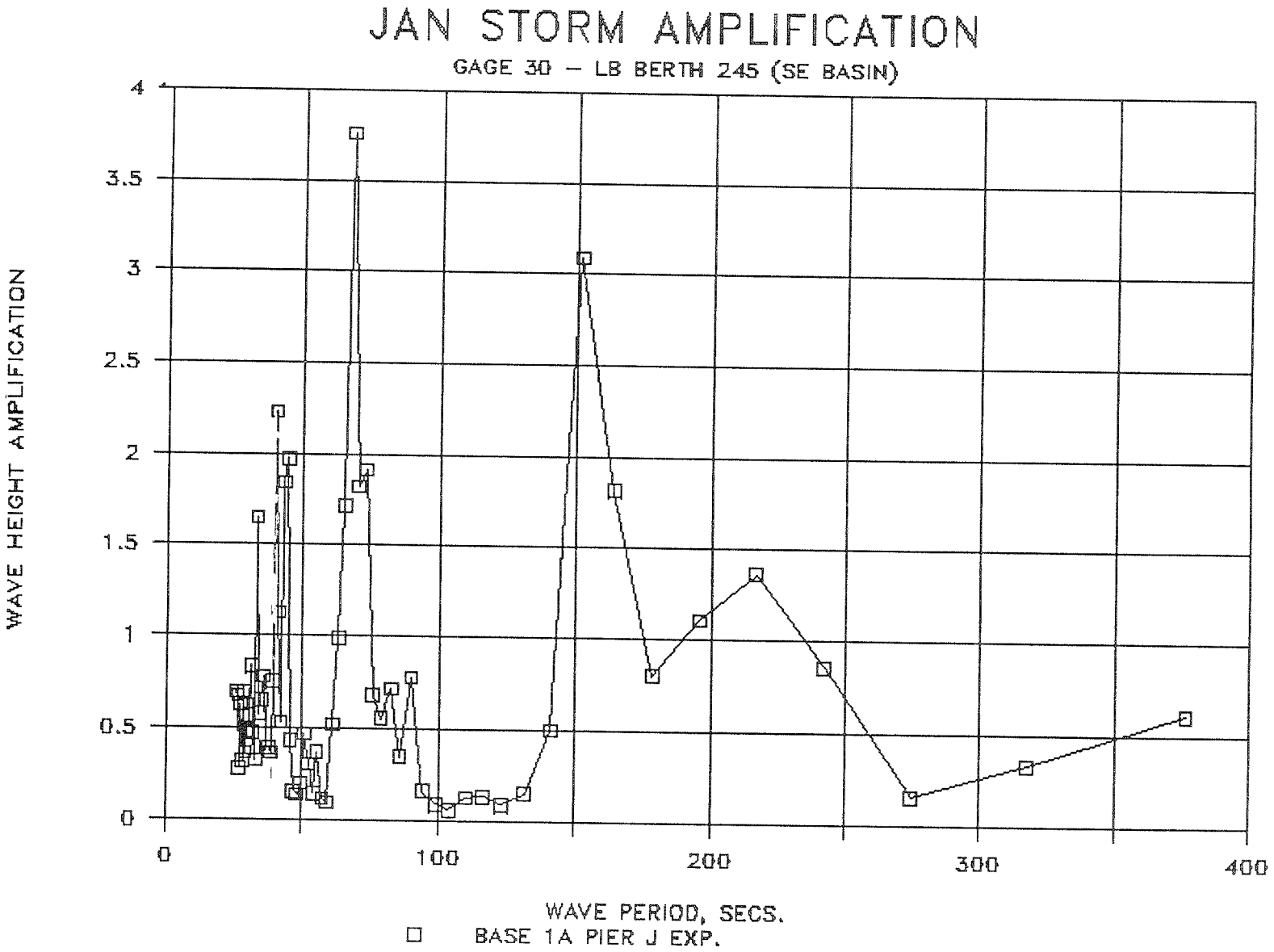

JAN STORM AMPLIFICATION SPECTRUM
GAGE 25 – LB BANANA TERM. (BASIN 6)
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

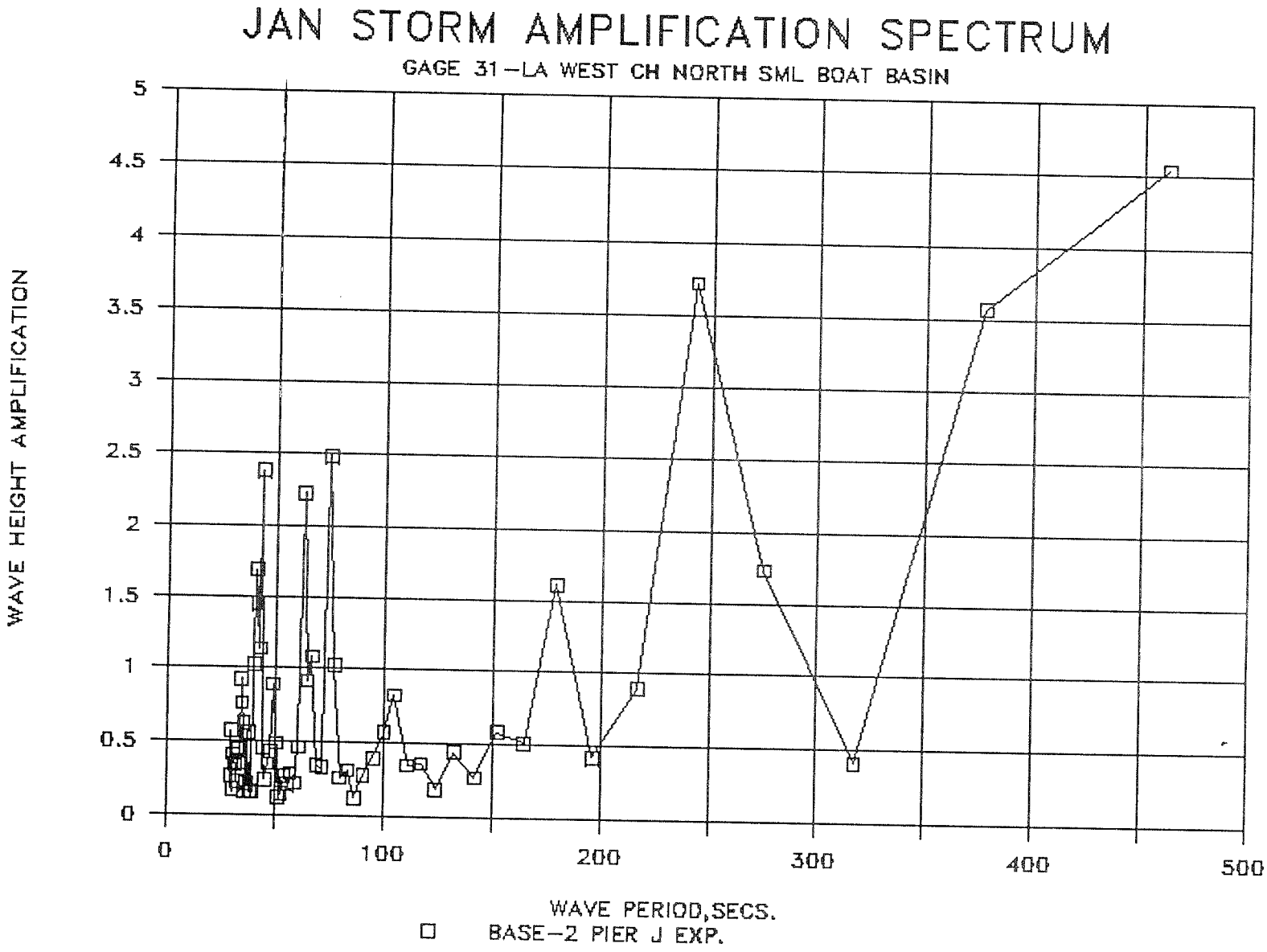

JAN STORM AMPLIFICATION SPECTRUM
GAGE 26 – LB BERTH 205 (BASIN 6)
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

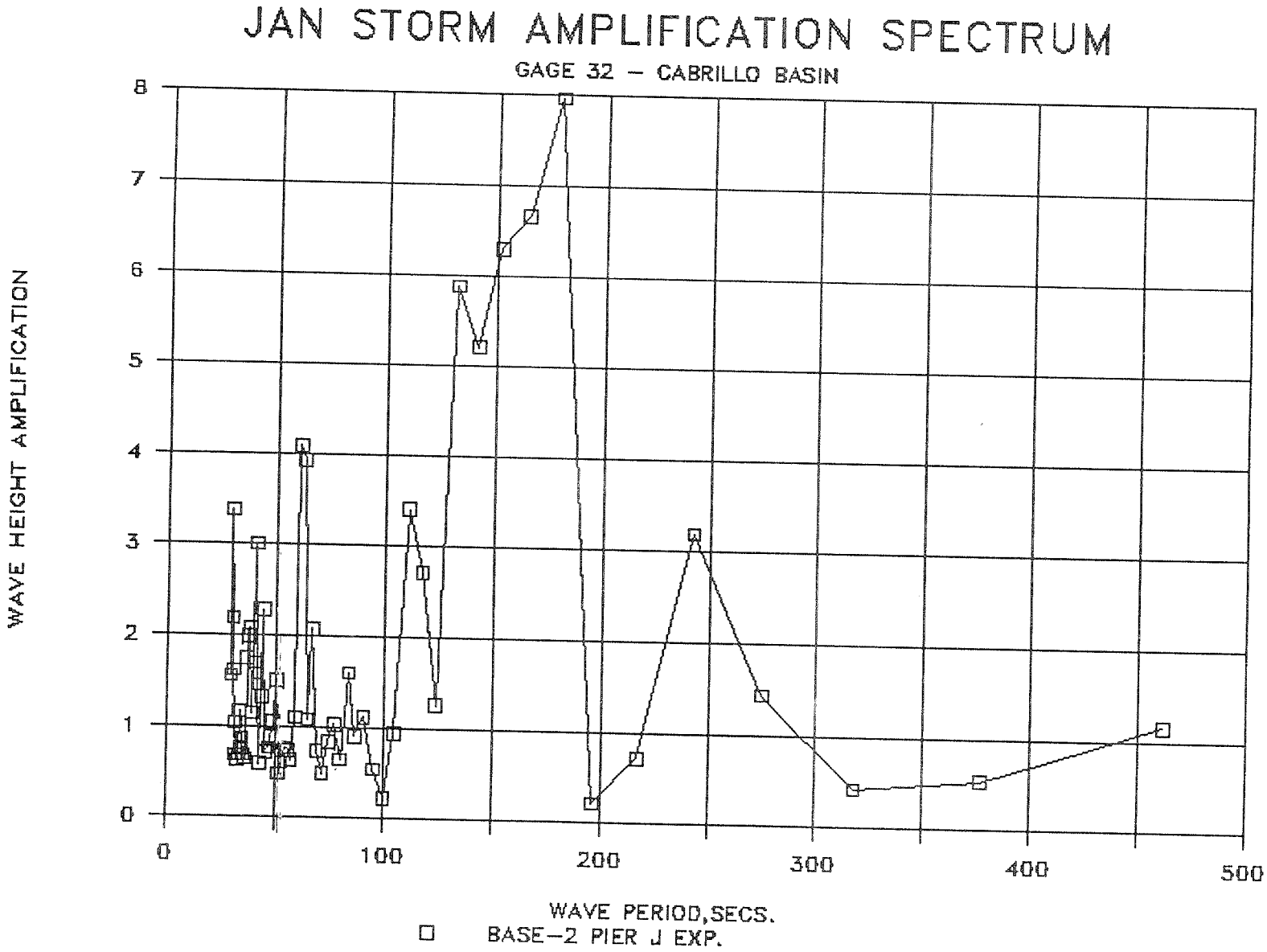

JAN STORM AMPLIFICATION SPECTRUM
GAGE 27 – LB BERTH 226 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.

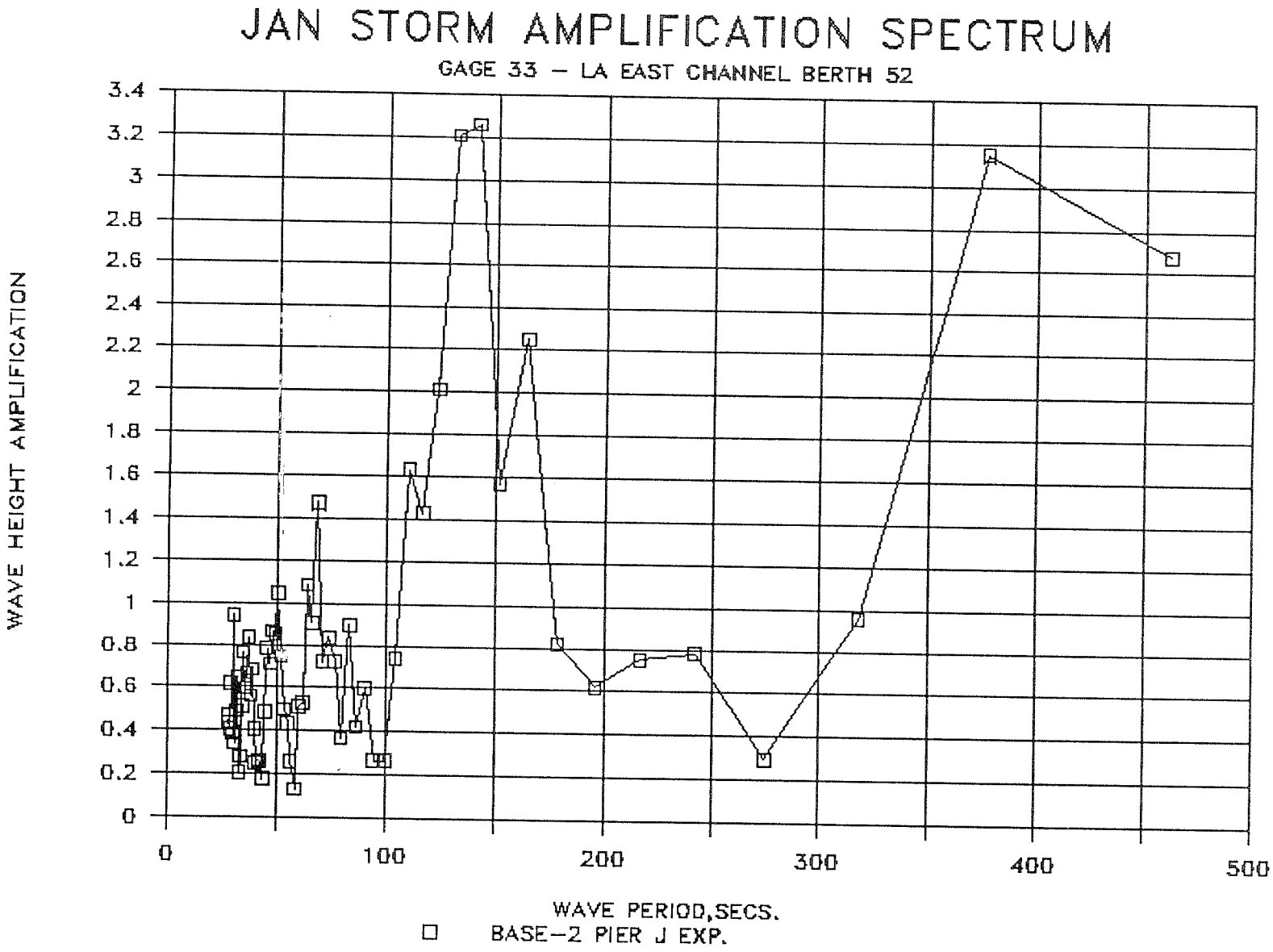

JAN STORM AMPLIFICATION SPECTRUM
GAGE 28 – LB BERTH 231 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.


JAN STORM AMPLIFICATION SPECTRUM
GAGE 29 – LB BERTH 242 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE–1A PIER J EXP.


JAN STORM AMPLIFICATION
GAGE 30 – LB BERTH 245 (SE BASIN)
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
WAVE PERIOD, SECS.
BASE 1A PIER J EXP.

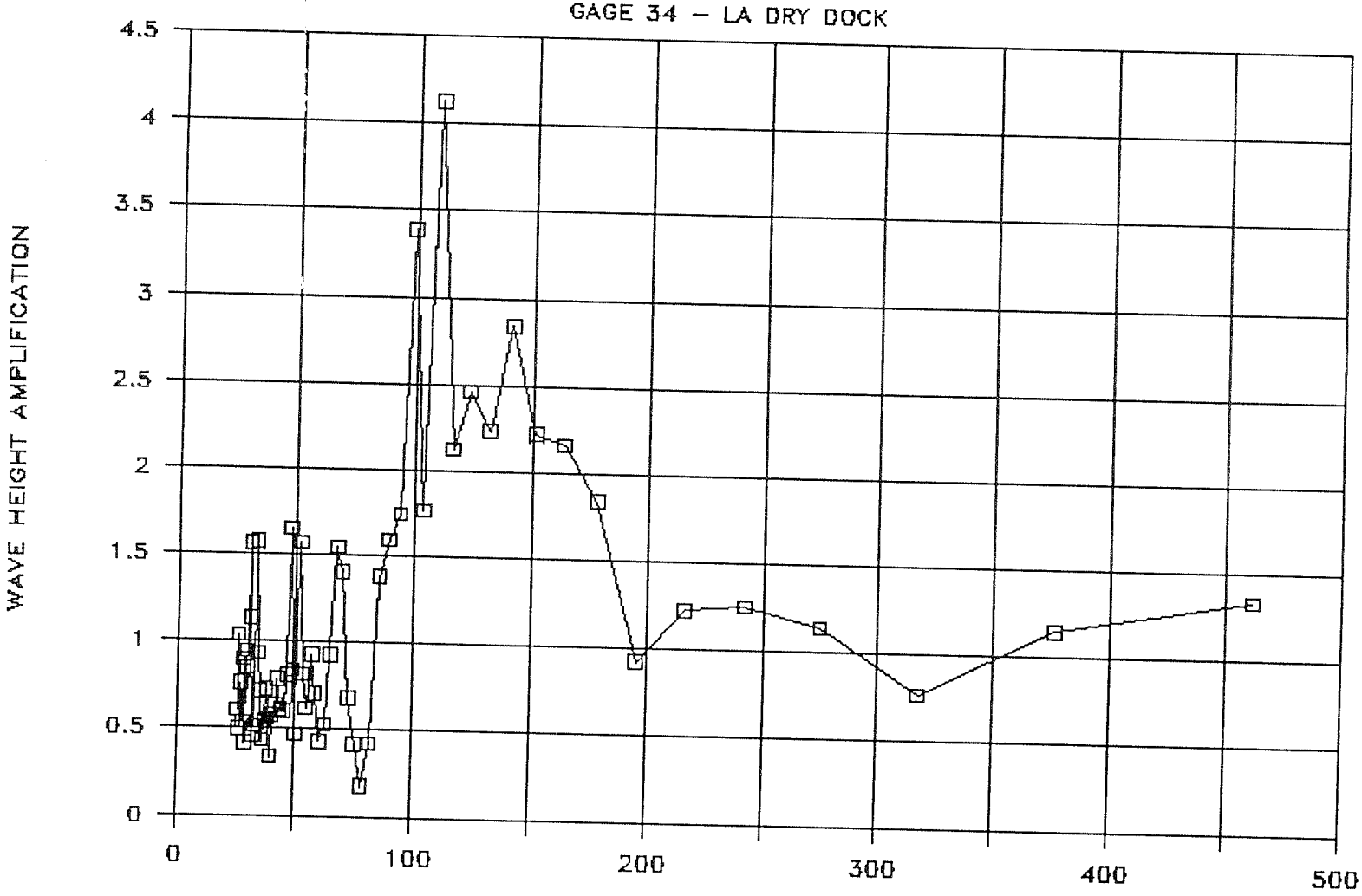

JAN STORM AMPLIFICATION SPECTRUM
GAGE 31 –LA WEST CH NORTH SML BOAT BASIN
WAVE HEIGHT AMPLIFICATION
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

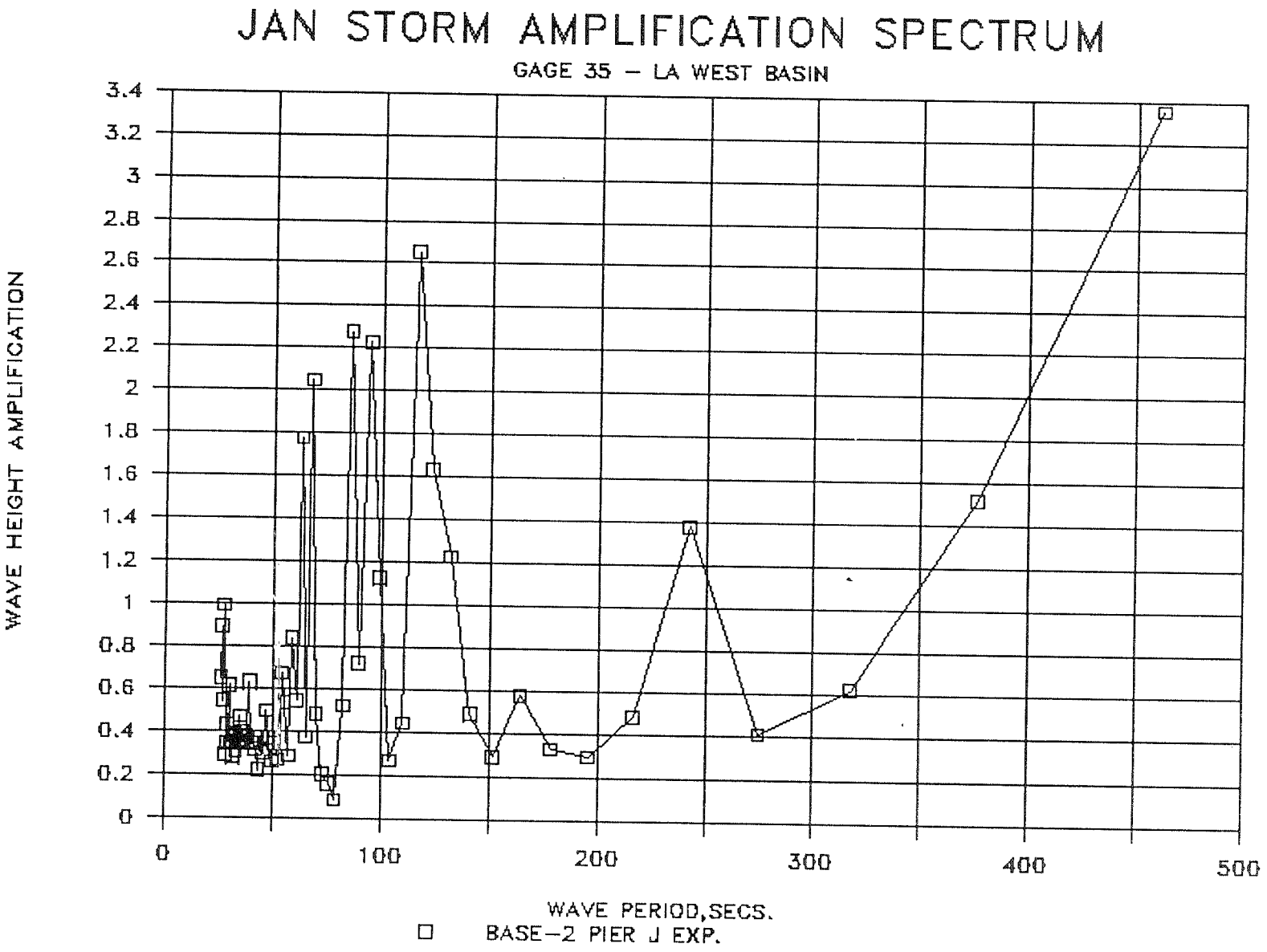

JAN STORM AMPLIFICATION SPECTRUM
GAGE 32 – CABRILLO BASIN
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

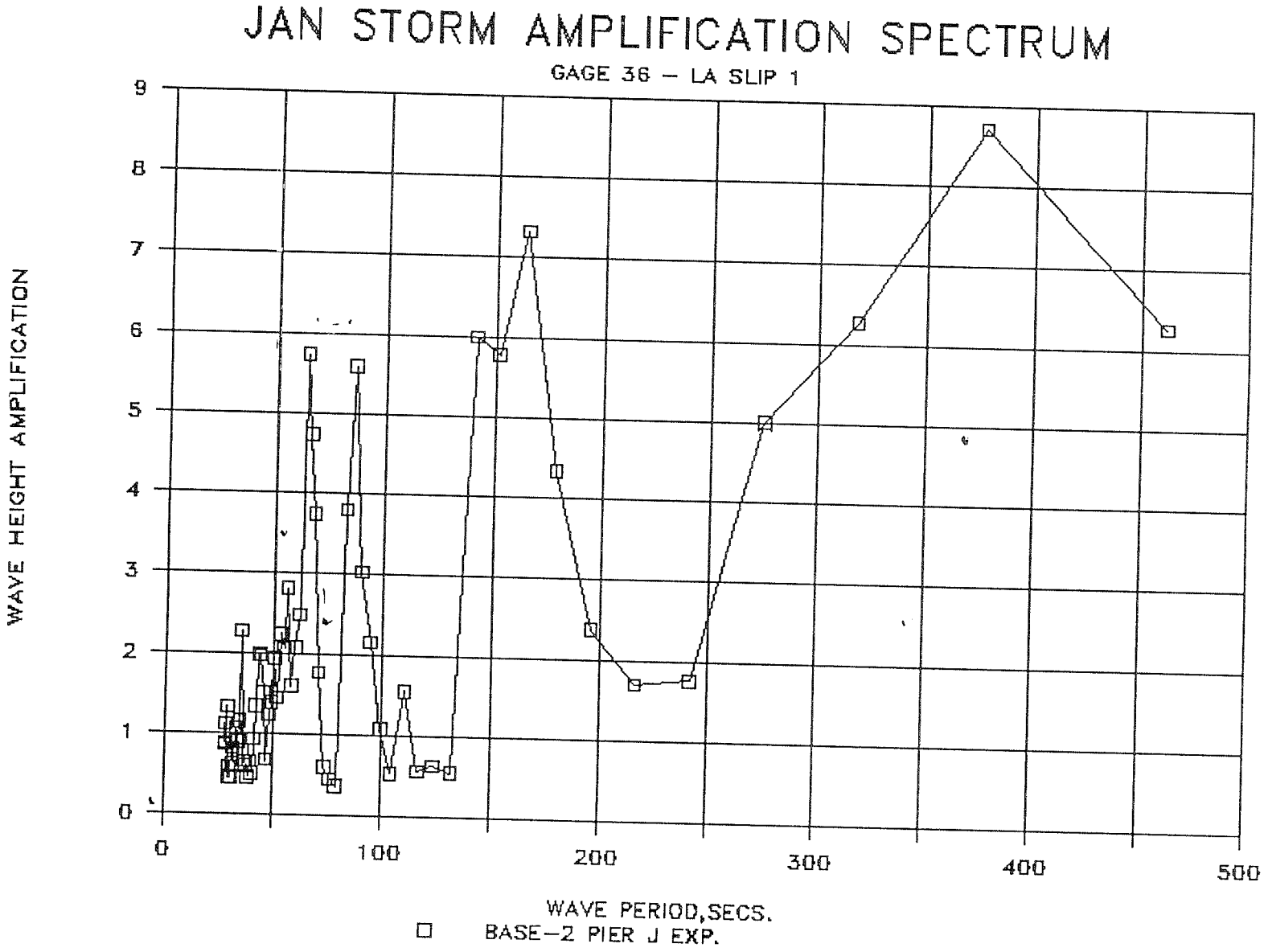

JAN STORM AMPLIFICATION SPECTRUM
GAGE 33 – LA EAST CHANNEL BERTH 52
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

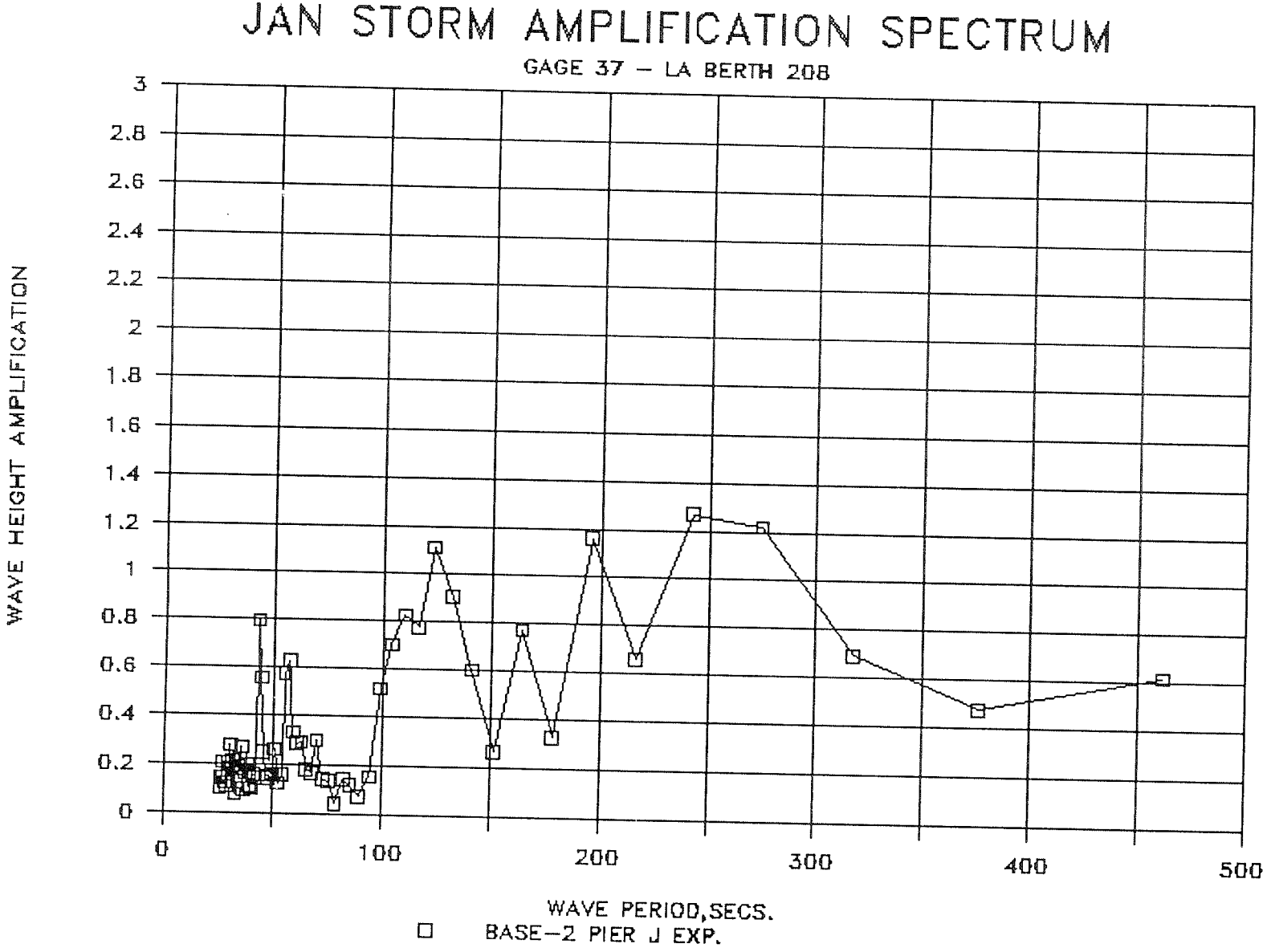
JAN STORM AMPLIFICATION SPECTRUM

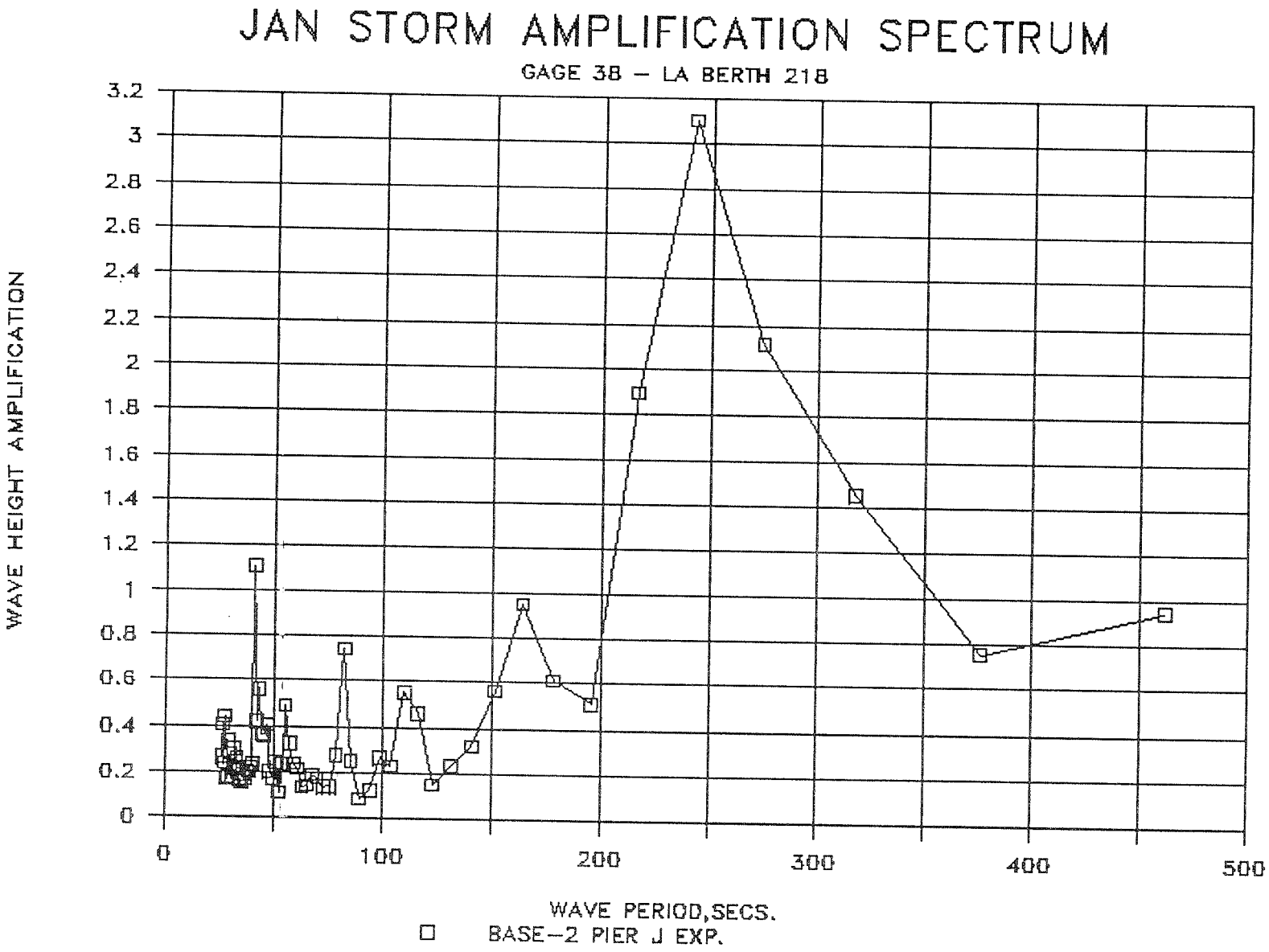
GAGE 34 – LA DRY DOCK




JAN STORM AMPLIFICATION SPECTRUM
GAGE 35 – LA WEST BASIN
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

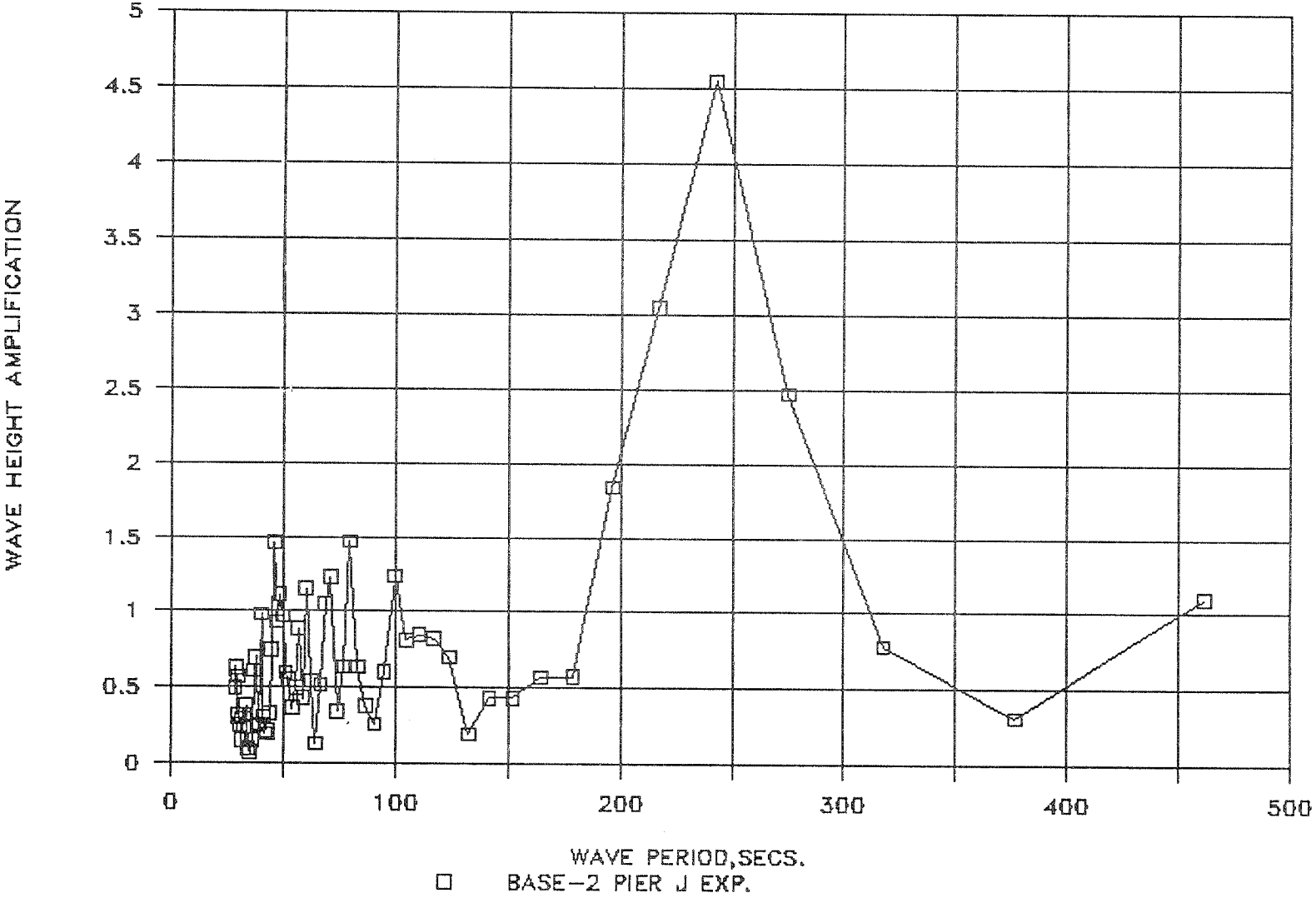

JAN STORM AMPLIFICATION SPECTRUM
GAGE 36 – LA SLIP 1
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

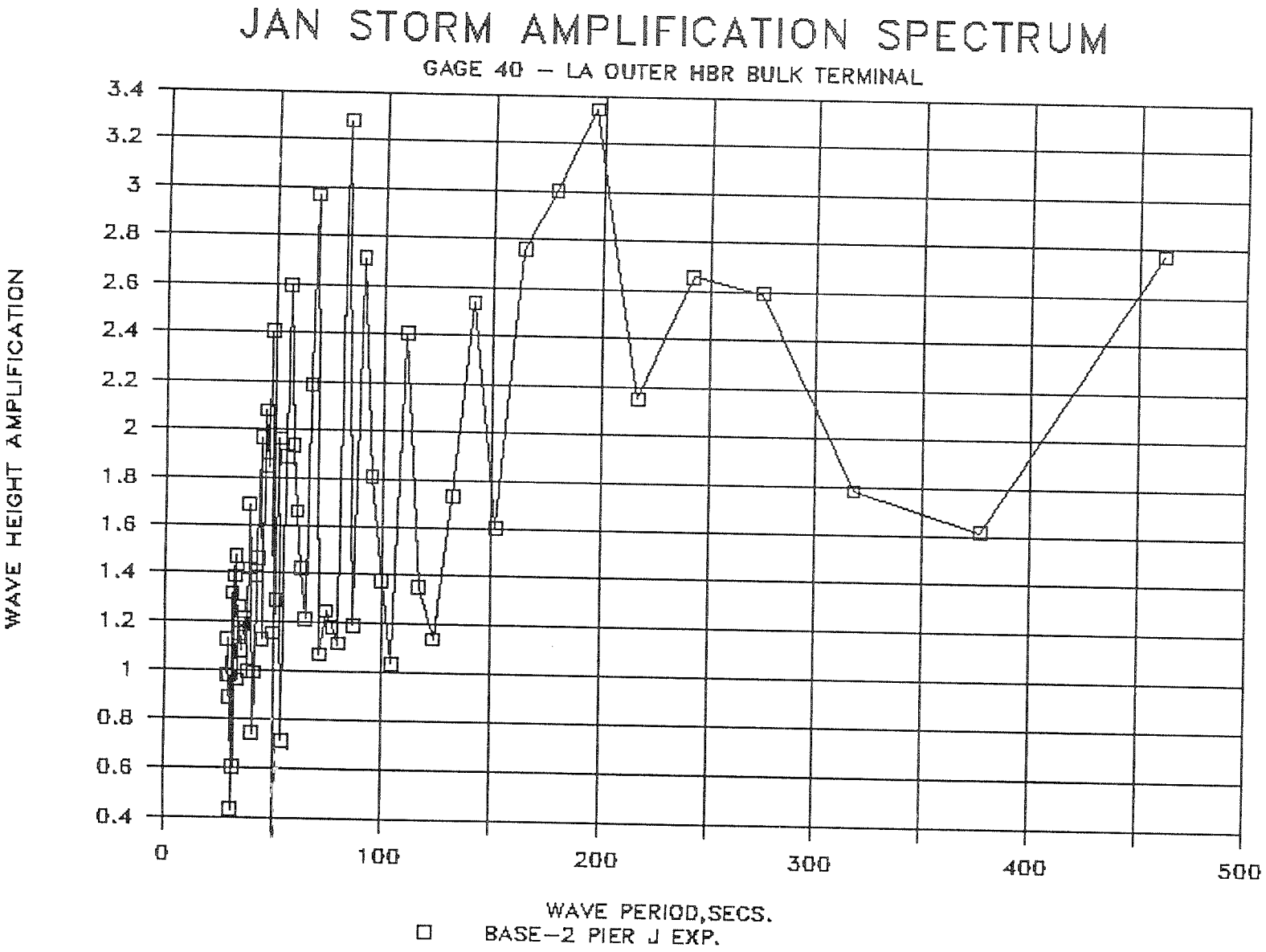

JAN STORM AMPLIFICATION SPECTRUM
GAGE 37 – LA BERTH 208
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

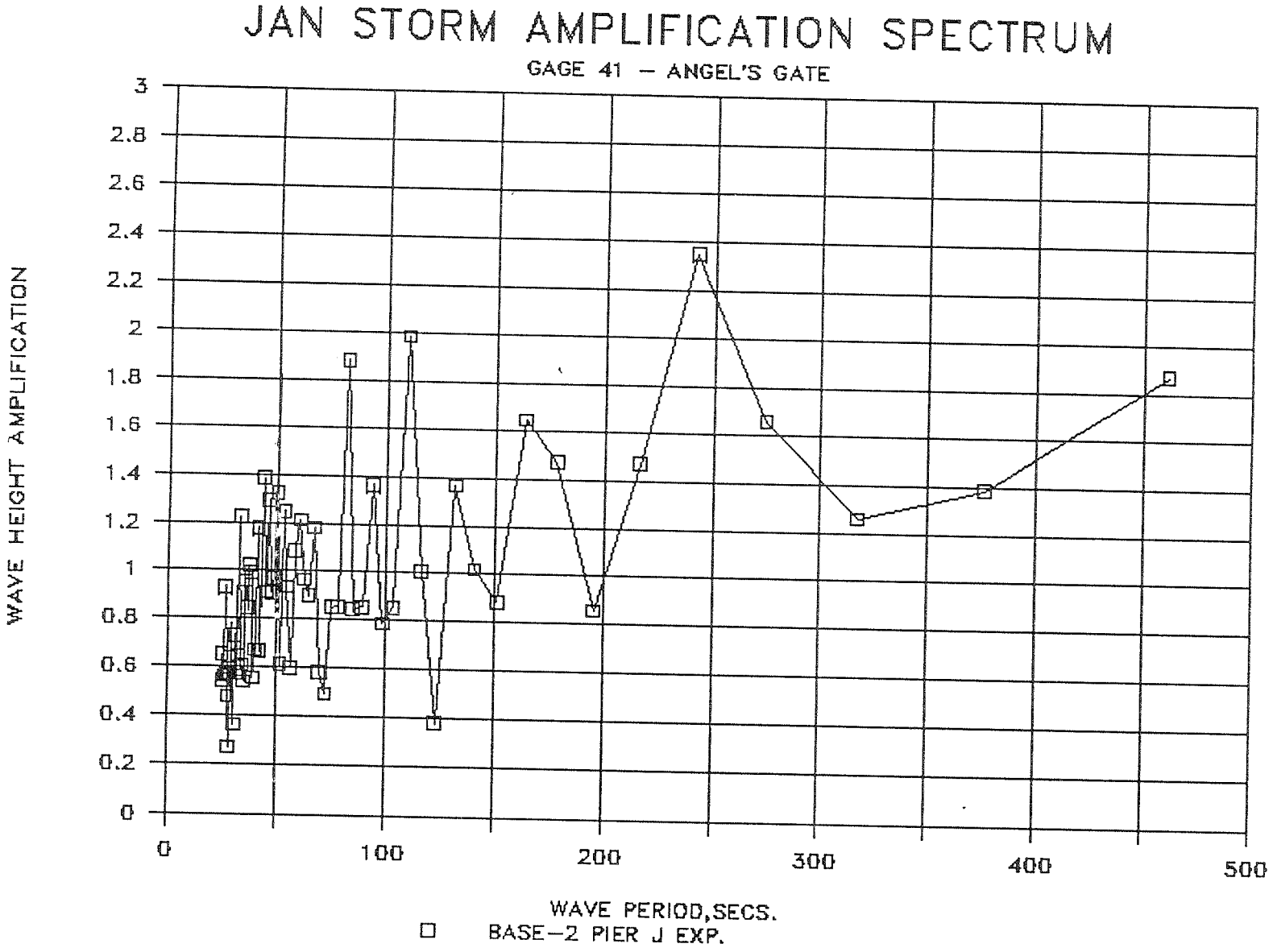

JAN STORM AMPLIFICATION SPECTRUM
GAGE 38 – LA BERTH 218
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

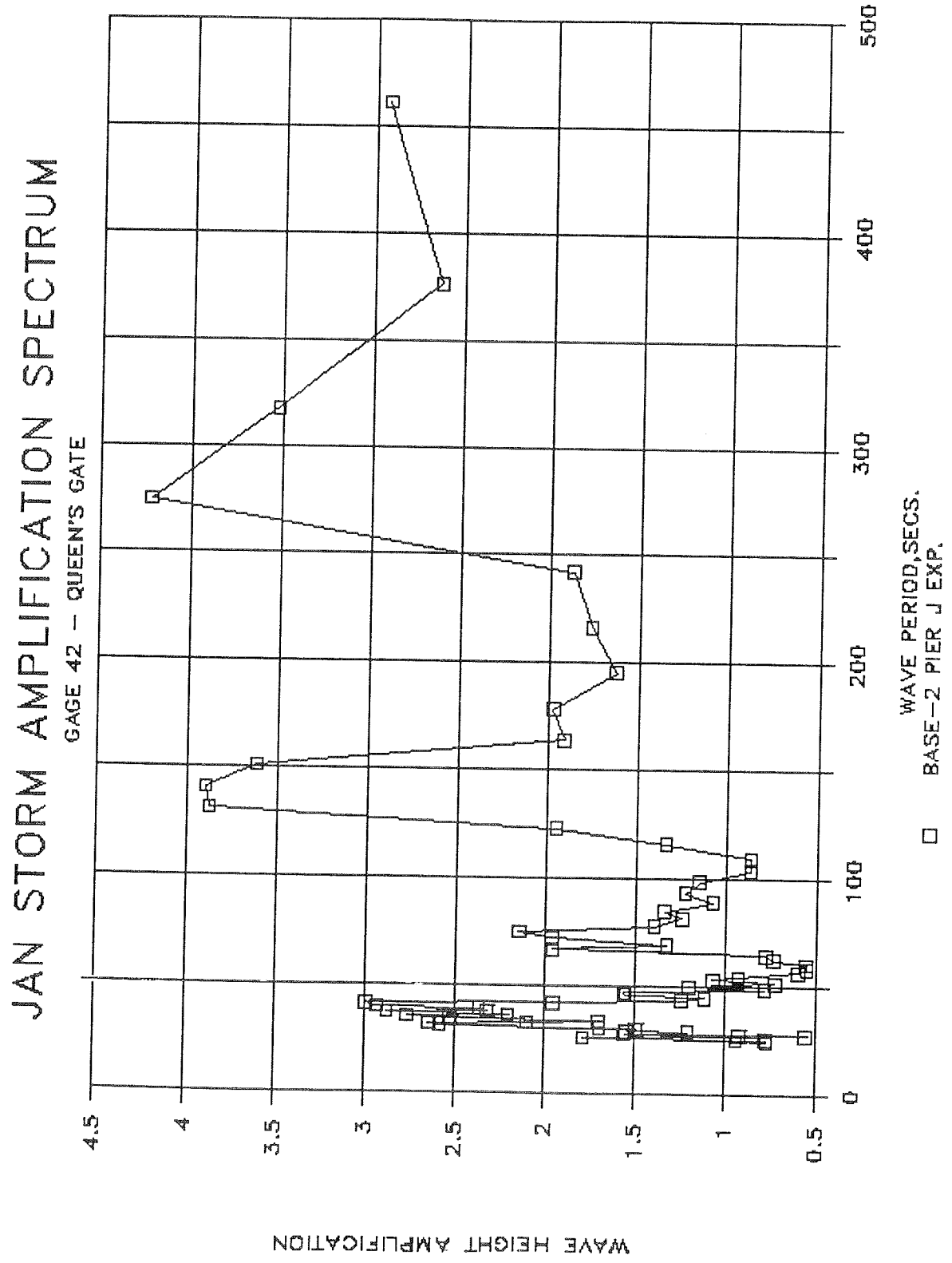
JAN STORM AMPLIFICATION SPECTRUM

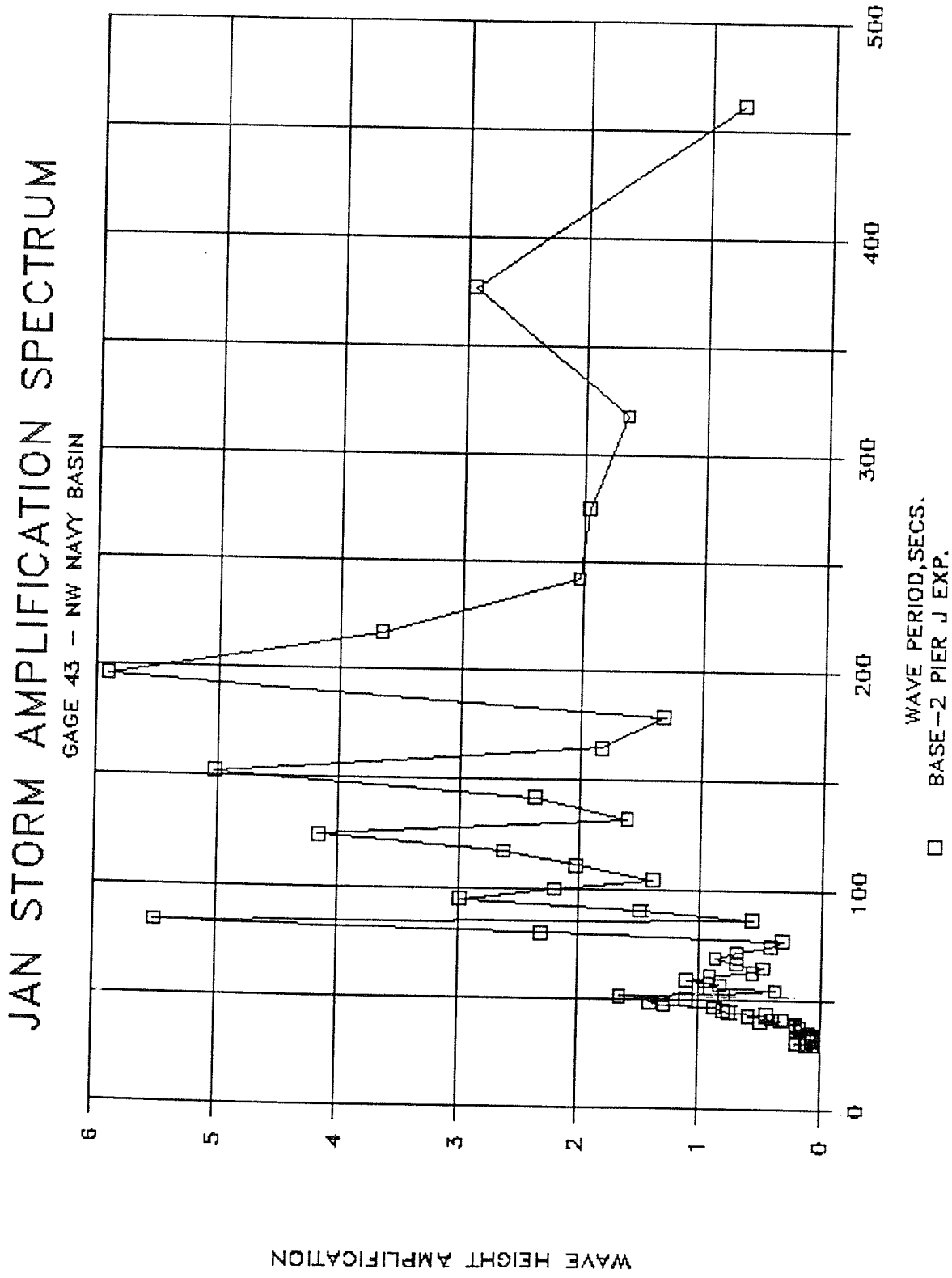
GAGE 39 – OUTER FISH HARBOR

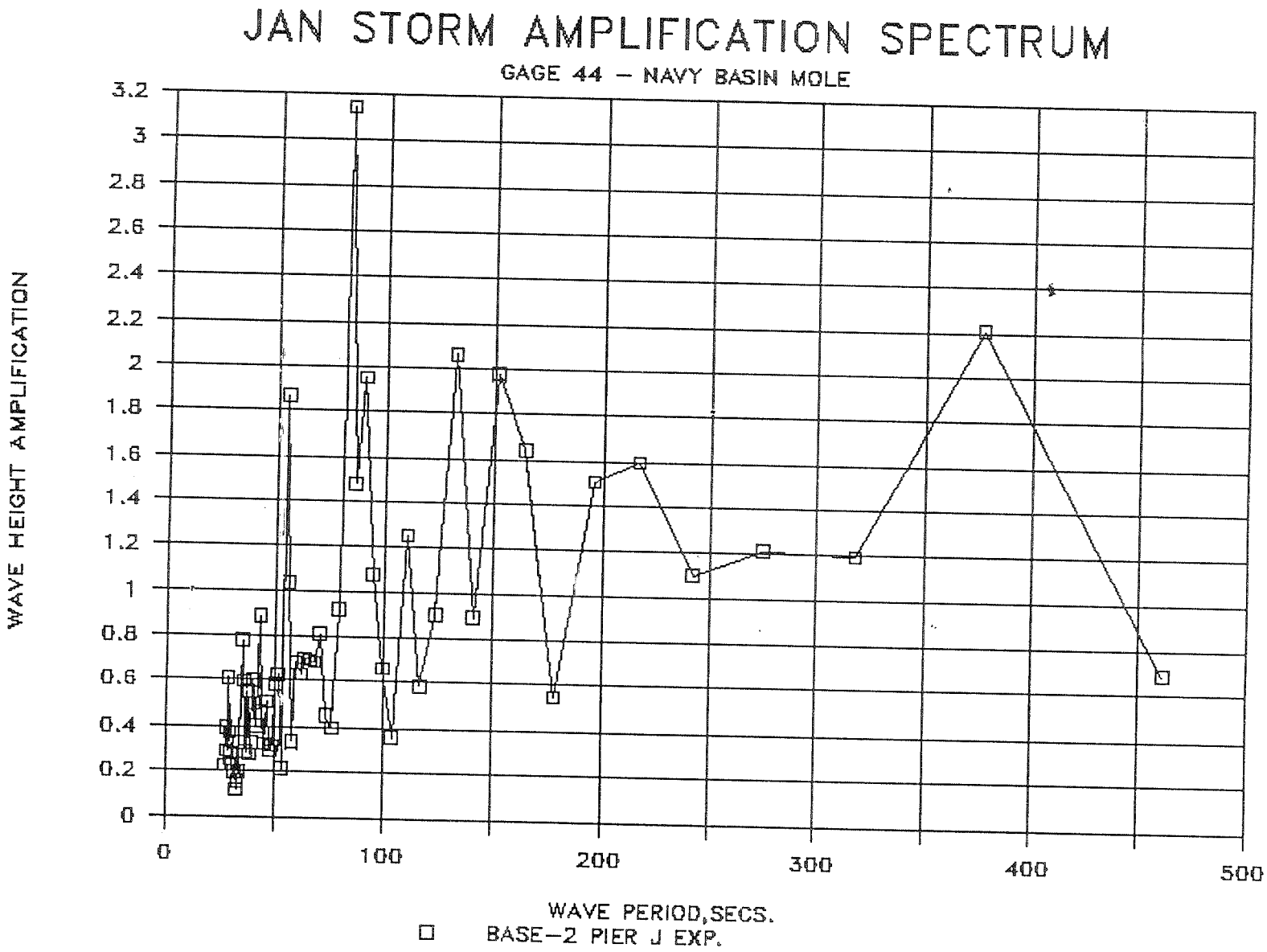


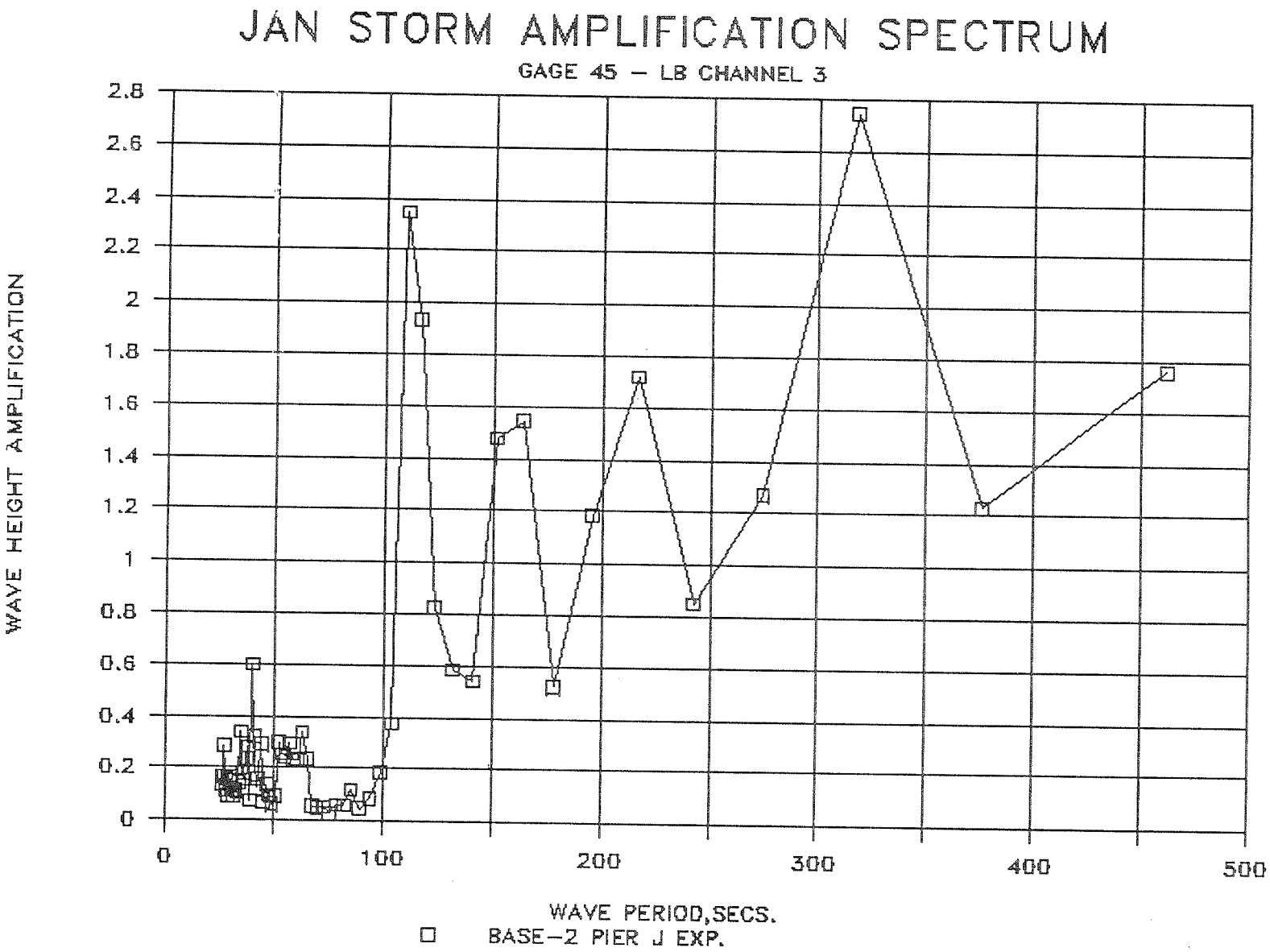

JAN STORM AMPLIFICATION SPECTRUM
GAGE 40 – LA OUTER HBR BULK TERMINAL
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

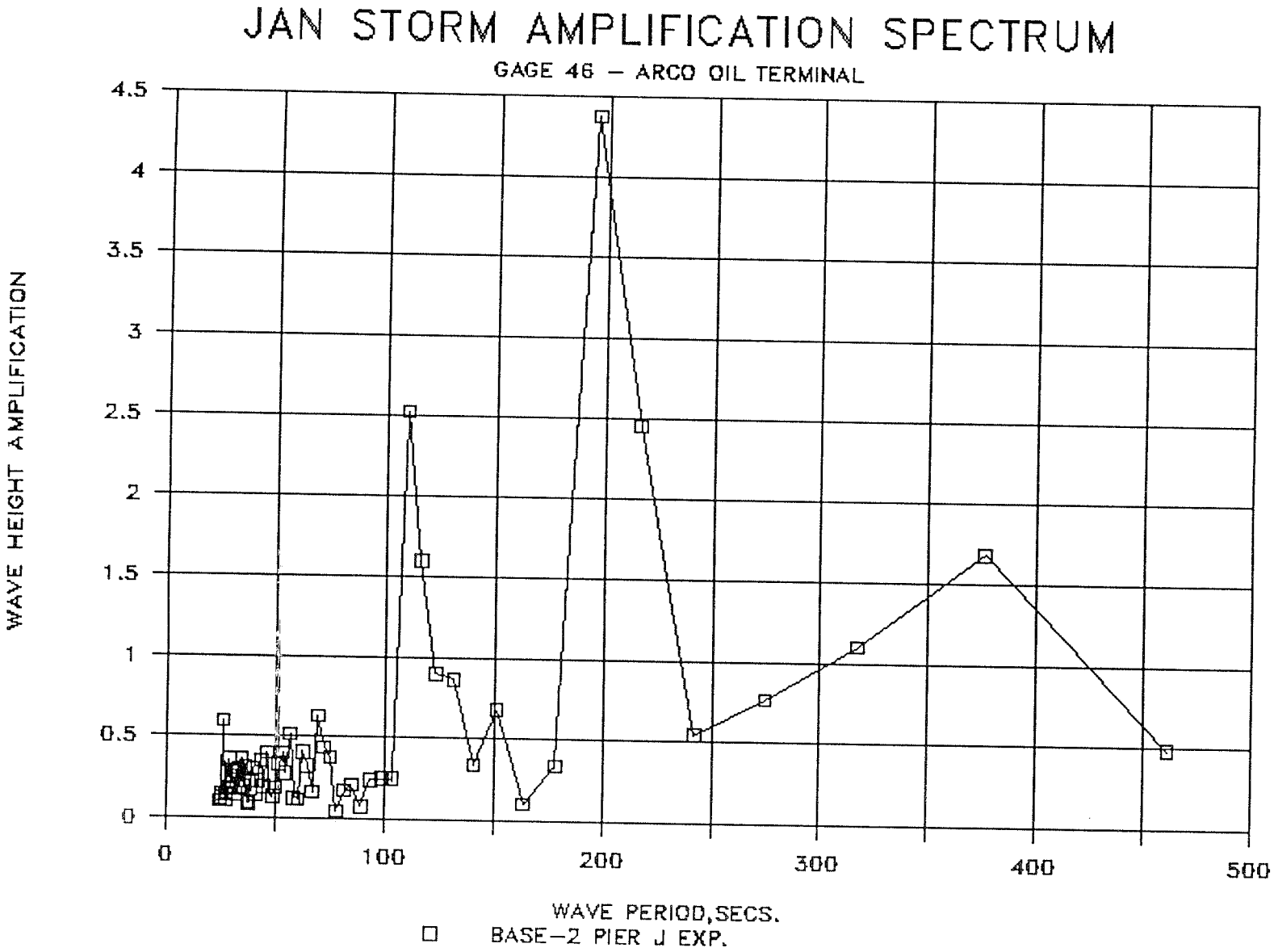

JAN STORM AMPLIFICATION SPECTRUM
GAGE 41 – ANGEL'S GATE
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

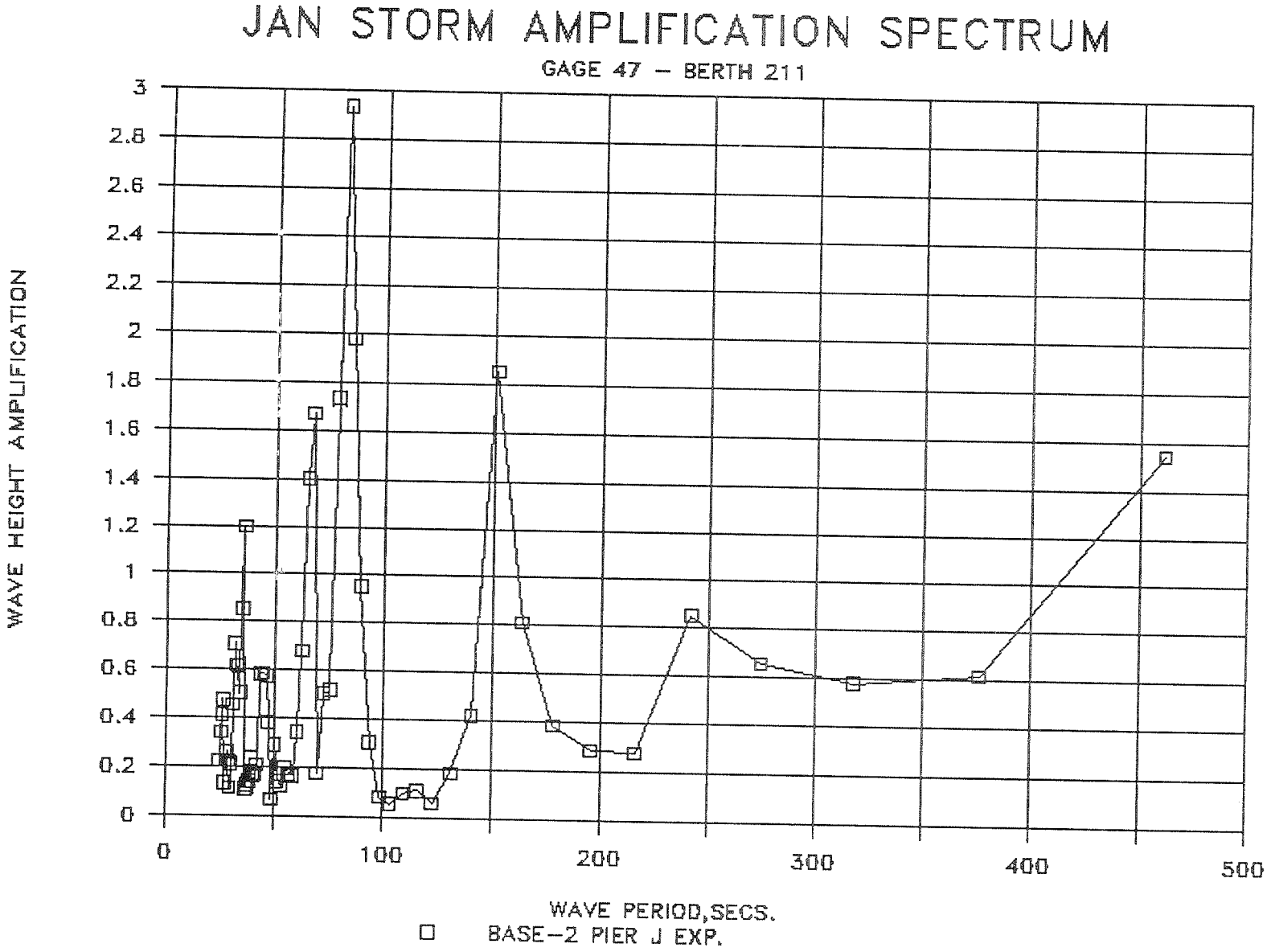

JAN STORM AMPLIFICATION SPECTRUM
GAGE 42 - QUEEN'S GATE
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.

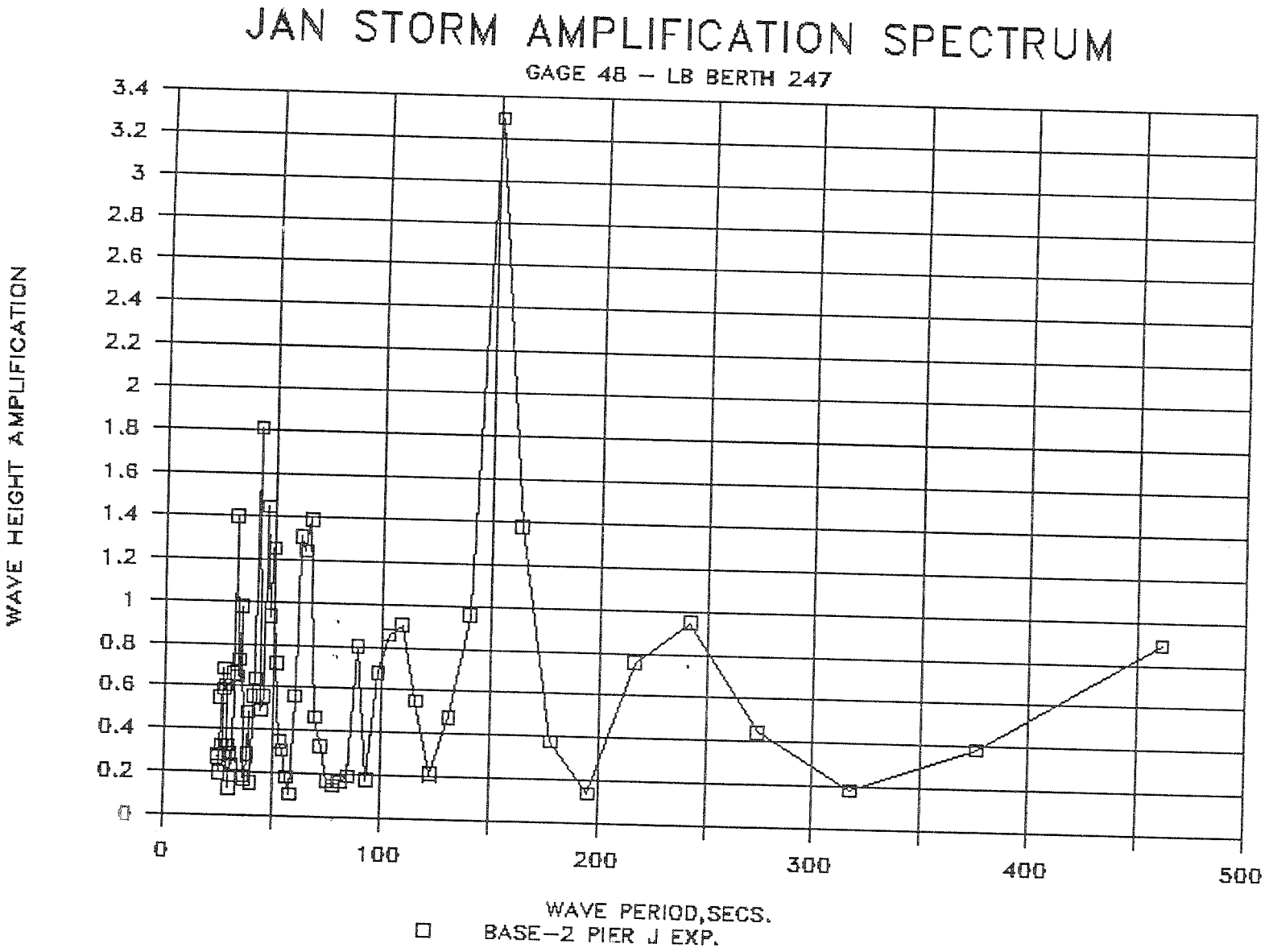

JAN STORM AMPLIFICATION SPECTRUM
GAGE 43 - NW NAVY BASIN
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
0
100
200
300
400
500
WAVE PERIOD, SECS.
BASE-2 PIER J EXP.

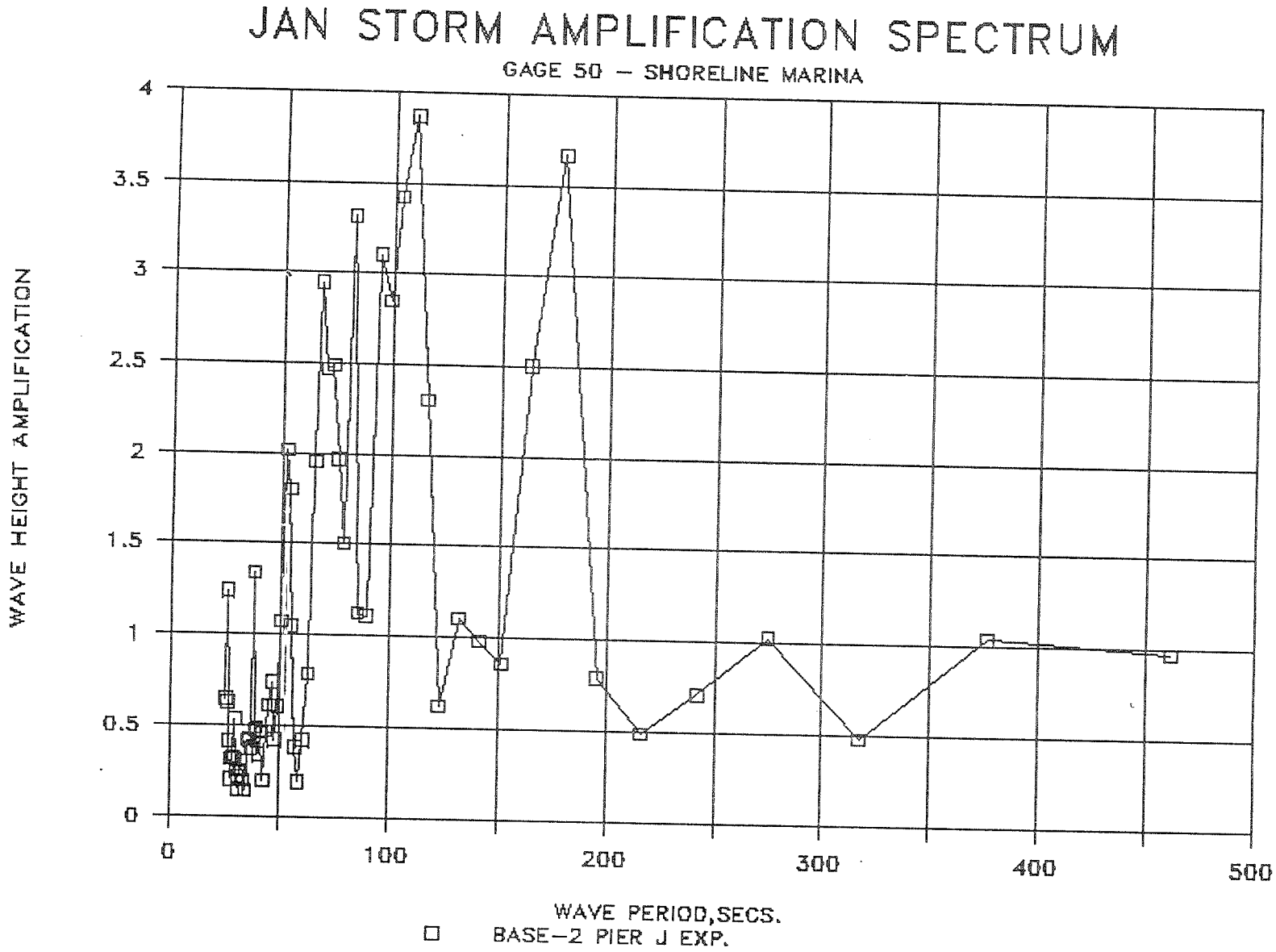

JAN STORM AMPLIFICATION SPECTRUM
GAGE 44 – NAVY BASIN MOLE
WAVE HEIGHT AMPLIFICATION
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

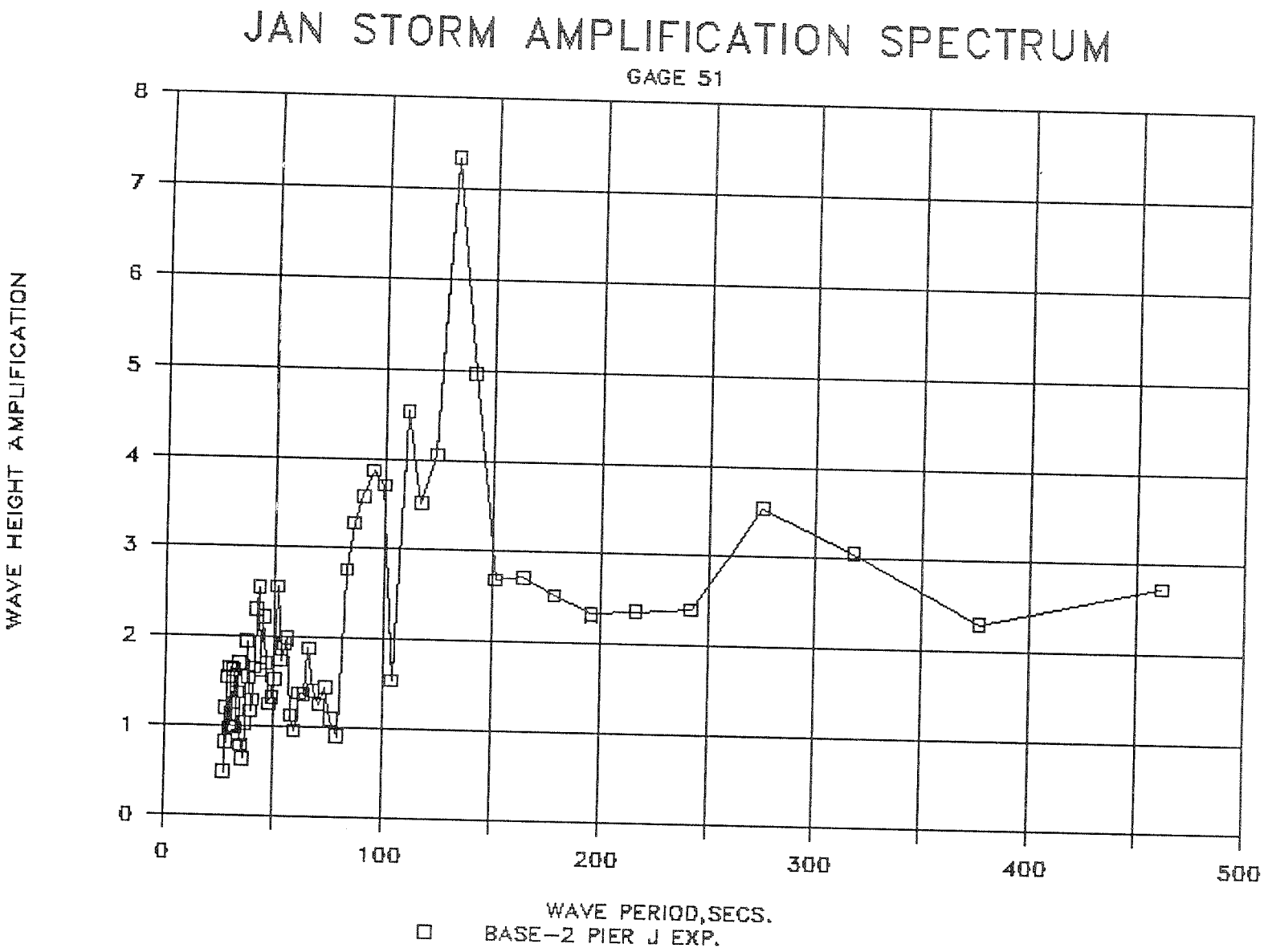

JAN STORM AMPLIFICATION SPECTRUM
GAGE 45 – LB CHANNEL 3
WAVE HEIGHT AMPLIFICATION
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

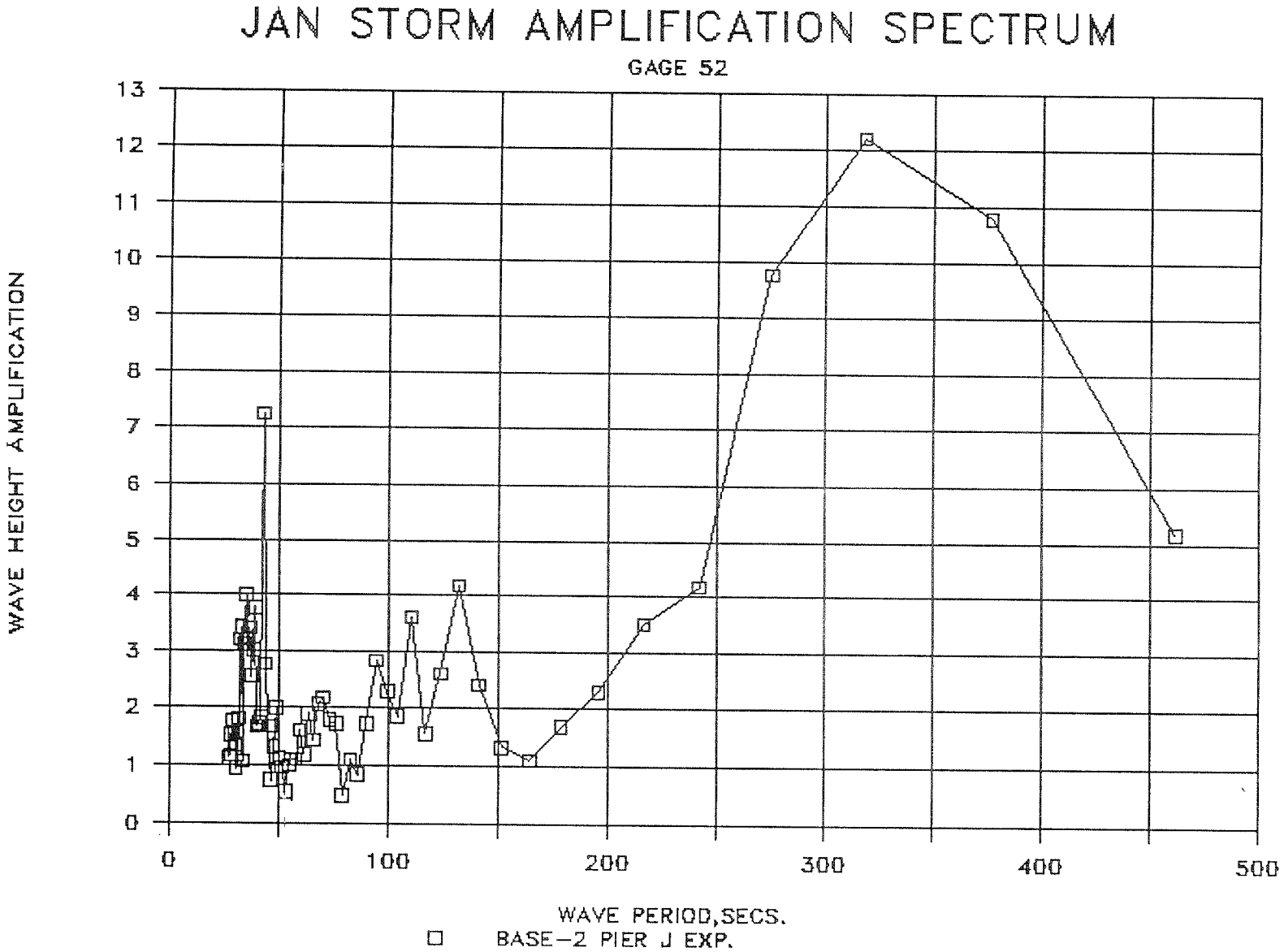

JAN STORM AMPLIFICATION SPECTRUM
GAGE 46 – ARCO OIL TERMINAL
WAVE HEIGHT AMPLIFICATION
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

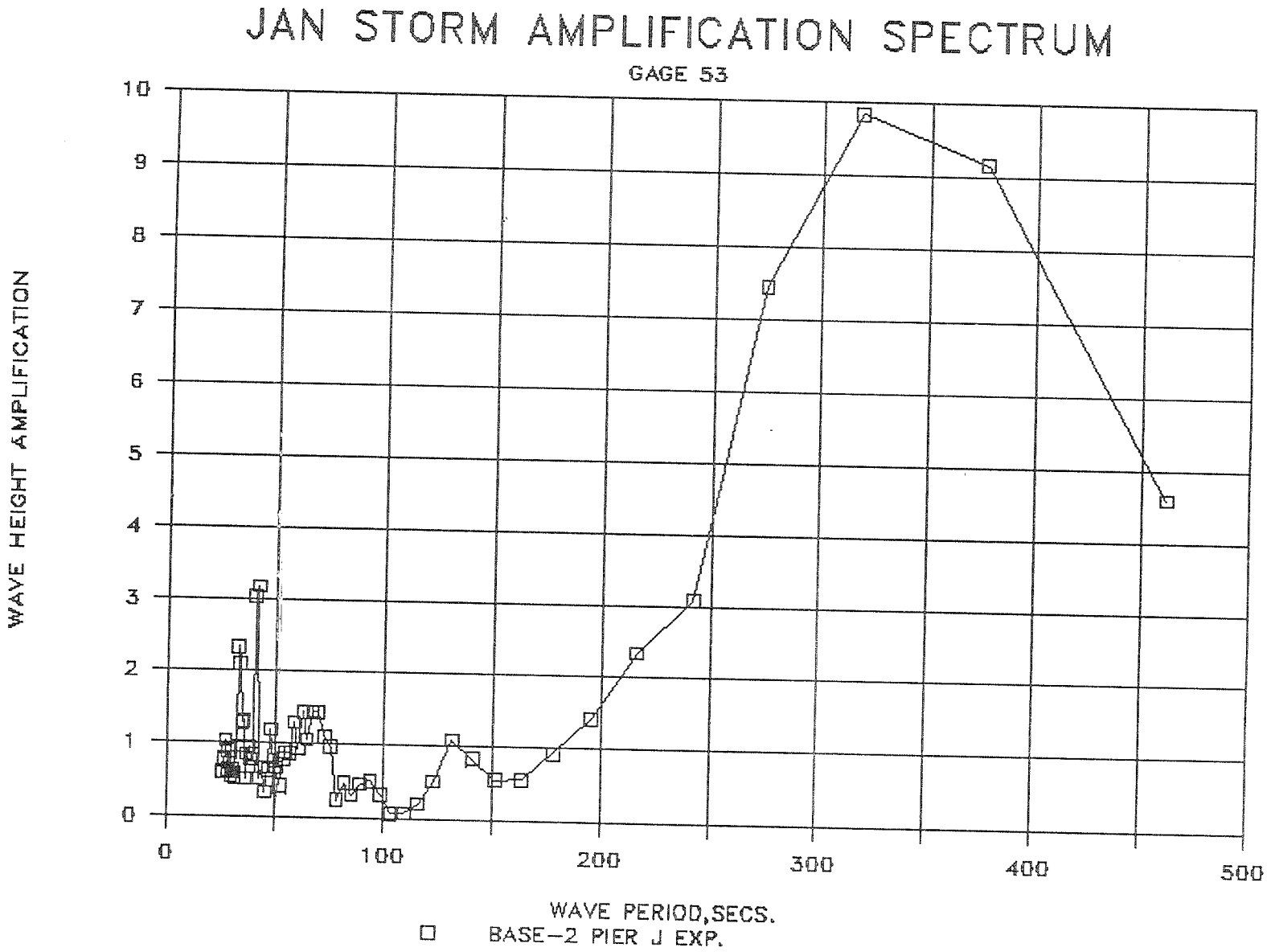

JAN STORM AMPLIFICATION SPECTRUM
GAGE 47 – BERTH 211
WAVE HEIGHT AMPLIFICATION
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

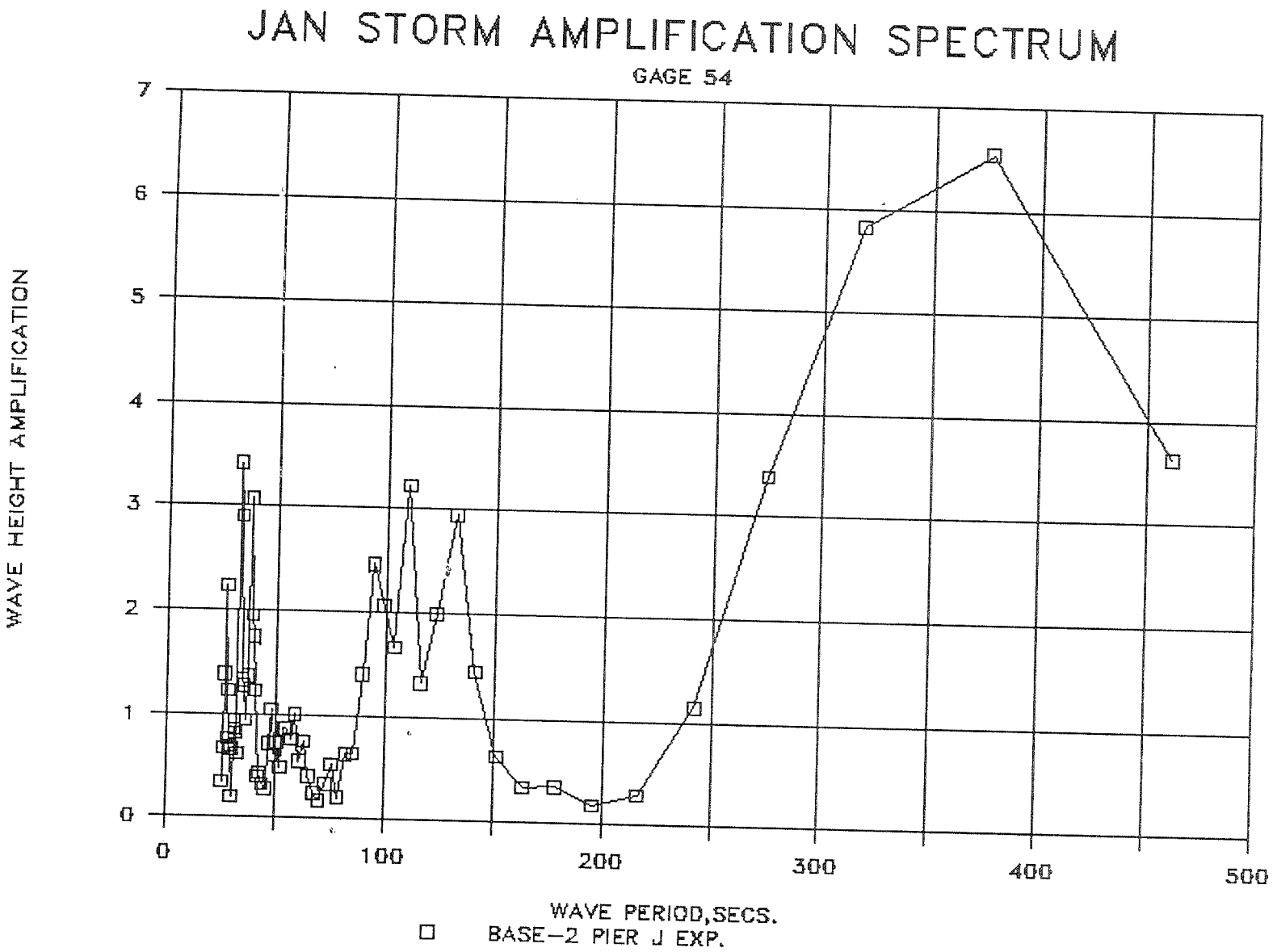

JAN STORM AMPLIFICATION SPECTRUM
GAGE 48 – LB BERTH 247
WAVE HEIGHT AMPLIFICATION
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.

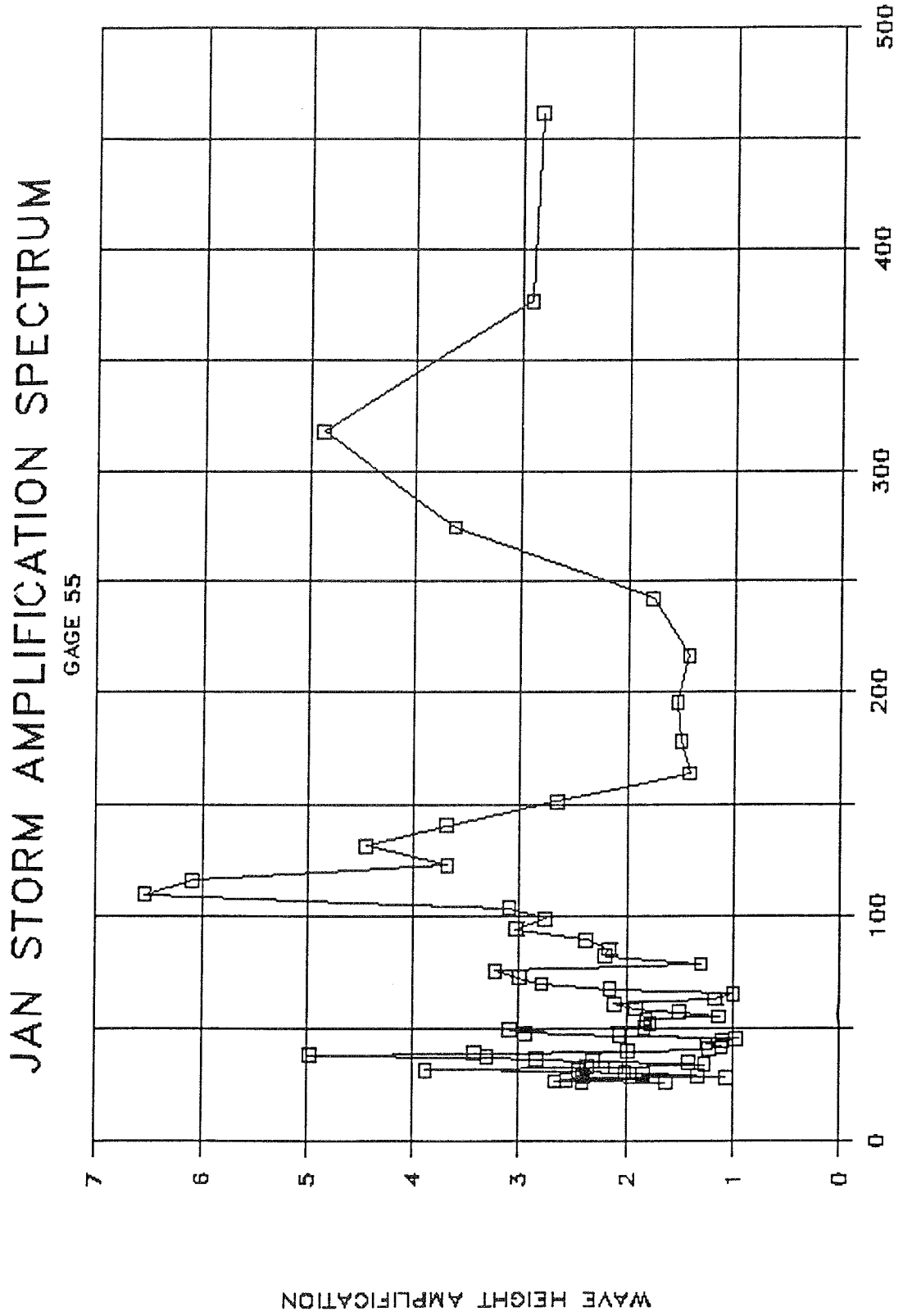

JAN STORM AMPLIFICATION SPECTRUM
GAGE 50 – SHORELINE MARINA
WAVE HEIGHT AMPLIFICATION
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE–2 PIER J EXP.


JAN STORM AMPLIFICATION SPECTRUM
GAGE 51
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.


JAN STORM AMPLIFICATION SPECTRUM
GAGE 52
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.


JAN STORM AMPLIFICATION SPECTRUM
GAGE 53
WAVE HEIGHT AMPLIFICATION
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.


JAN STORM AMPLIFICATION SPECTRUM
GAGE 54
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
6
7
0
100
200
300
400
500
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.


JAN STORM AMPLIFICATION SPECTRUM
GAGE 55
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD,SECS.
BASE-2 PIER J EXP.
0
1
2
3
4
5
6
7
0
100
200
300
400
500

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1993	Final report

4. TITLE AND SUBTITLE
Los Angeles and Long Beach Harbors Model Enhancement Program, Improved Physical Model Harbor Resonance Methodology

5. FUNDING NUMBERS

6. AUTHOR(S)
William C. Seabergh and Leonette J. Thomas

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USAE Waterways Experiment Station
Coastal Engineering Research Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Report
CERC-93-17

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
USAED, Los Angeles, PO Box 2711,
Los Angeles, CA 90053-2325
Port of Los Angeles, San Pedro, CA 90733-0151
Port of Long Beach, Long Beach, CA 90801-0570

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Three long-period wave spectra were selected for use in the Los Angeles - Long Beach Harbors physical model for harbor resonance studies. They included two storms: 1 February 1986 and the Martin Luther King Day Storm on 17 January 1988. An average condition wave spectrum was developed based on long-term wave information. These spectra were used to program the wave generators, and wave data were collected at seven harbor gages in the model where prototype data had been collected. A comparison of model and prototype data indicated good correlation. The model was constructed to the most recent harbor configuration and included Long Beach Harbor's Pier J expansion. Additional long-period wave data were collected at berth locations throughout the harbors for the three wave spectra conditions in order to have base data to compare with data collected for proposed plans of harbor development. This work will minimize time and cost for Los Angeles and Long Beach Harbors' harbor resonance studies.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Harbor resonance Long-period wave Physical model	210
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		