# THE DETERMINATION OF RELEASE TIME
# FOR OCEAN DISPOSED WASTEWATERS

A Report

Submitted to the Environmental Protection Agency,
Region II Edison, New Jersey

in support of

Application for a Special Ocean Disposal
Permit by E. I. Du Pont de Nemours and Company
Grasselli Plant, Linden, New Jersey

by

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## SUMMARY

Du Pont has performed studies which describe the biological effects and *in situ* dispersion characteristics of ocean-disposed wastewaters from its Grasselli Plant at Linden, New Jersey.

Results of these studies show that:

- Under oceanographic conditions least likely to enhance dispersion, peak wastewater concentration in the barge wake is, initially, about 450 parts per million (v/v) one minute after release
- Wastewater concentrations decline to a peak of about 80 parts per million within 4 hours after release, and to about 60 ppm after 12 hours.
- Chronic no effect level for *Mysidopsis bahia* (opossum shrimp) and *Cyprinodon variegatus* (sheepshead minnow) is 750 ppm.
- The wastewaters are not selectively toxic to a particular life stage of *Cyprinodon* or *Mysidopsis*.
- There is little difference in the toxicity of the wastewater to several species of marine organisms.

Conclusions are:

- that the Grasselli wastewaters can be discharged into the marine environment over a 5-hour period, at a barge speed of 5 knots, without adverse impact.
- that the approach to evaluating mixing zones recommended by the National Academy of Sciences/National Academy of Engineering is a valid means for calculating release times for ocean disposed wastewaters.

## INTRODUCTION AND HISTORICAL DEVELOPMENT

On February 12, 1975, Mr. R. D. Turner, Plant Manager of E. I. du Pont de Nemours and Company's (Du Pont) Grasselli Plant in Linden, N. J., applied for a special ocean dumping permit pursuant to section 102 of the Marine Protection, Research and Sanctuaries Act, PL-92-532. The requested special permit was for the disposal of wastewater generated during the manufacture of dimethylhydroxylamine and anisole. Du Pont maintained that these wastewaters met EPA's regulatory requirements for the issuance of a special permit. In support of the application and Du Pont's contention that the wastewaters meet the regulatory criteria, Mr. Turner, on June 10, 1975, transmitted to Mr. R. T. Dewling, Region II, EPA, a "Report on Release Conditions Based on Testing of Appropriate Sensitive Marine Organisms" prepared by Du Pont's Drs. W. C. Gaskill and J. R. Gibson (Appendix A). The report showed that, based on acute toxicity data, dispersion of Grasselli wastewaters over a 5-hour period, at a barge speed of at least 5 knots, would meet EPA's criteria for a special permit. Reports by John Ball and D. W. Hood referenced in Appendix A were transmitted to Mr. Dewling by Dr. L. L. Falk on June 13, 1975 (Appendix B).

At public hearing in New York, N. Y. on June 12, 1975, EPA, Region II issued a tenative determination to grant Du Pont a special permit for the disposal of the Grasselli wastewaters. At that hearing, EPA also issued a draft of the proposed permit (Appendix C).

EPA's tentative determination and draft permit supported Du Pont's contention that the wastewaters met all criteria for a special permit. However, EPA required that wastewater be released over a distance of 150 nautical miles (approximately 30 hours), while Du Pont maintained that their toxicity and predicted dispersion data allowed for a shorter -- 25 nautical miles -- release distance (approximately 5 hours release time).

Dr. Falk summarized Du Pont's position in his testimony at the June 12, 1975 hearing (Appendix D). The essence of Du Pont's position was that calculations for the limiting permissible concentration (LPC) and/or release time (or distance) include considerations of wastewater dispersion and wastewater toxicity as a function of time (i.e. a "time-toxicity" approach). This approach is similar to that recommended by the Committee on Water Quality Criteria, Environmental Studies Board, National Academy of Sciences - National Academy of Engineering (see Appendix F, Exhibit B).

Subsequent to the June 12, 1975 public hearing, Region II asked EPA's Ecological Effects Division (EED), Office of Research and Development (ORD) to review Du Pont's proposed approach for determining release time.

On July 8, 1975, Dr. A. J. McErlean (EPA-EED-ORD) responded to Region II in a memorandum addressed to Mr. Dewling (Appendix E). In that memorandum, Dr. McErlean indicated that Du Pont's proposed approach required validation.

On July 30, 1975, Mr. Turner transmitted to Mr. P. J. Bermingham (Region II Hearing Officer) Du Pont's response (Appendix F) to Dr. McErlean's memorandum.

On August 6, 1975, Du Pont and EPA representatives met in Edison, N. J. to review Du Pont's proposed approach in detail. During the meeting, ORD reiterated that the approach required validation.

To provide time to validate the time-toxicity concept, Mr. Turner indicated that Du Pont would accept an interim permit (letter of August 14, 1975 to Mr. Bermingham, Appendix G). Mr. Turner stated, however, that Du Pont still considered the proposed approach to be sound and technically valid, and that Du Pont would seek to obtain acceptance of the time-toxicity approach to establish release time for ocean-disposed wastewaters

On September 2, 1975, Mr. Bermingham recommended to Mr. G. M. Hansler, Regional Administrator, that Du Pont's proposed approach be accepted and that a special permit, which allowed for wastewater release over 25 nautical miles (5 hours) be issued (Appendix H).

Region II issued an interim permit to Du Pont effective November 20, 1975.

Du Pont and EPA met again on February 6, 1976 in Edison, N. J. to discuss the time-toxicity concept. EPA agreed that the proposed methodology had technical merit, but reiterated the need for validation of the concept. To validate the concept, EPA required that Du Pont:

1. Demonstrate actual dispersion rates at the 106 site under oceanographic conditions least likely to enhance dispersion rates, and

2. Assess sublethal effects of the Grasselli wastewater.

As a result of these discussions, Du Pont initiated a research program designed to fulfill EPA's requirements. Appendix I contains the following correspondence between Du Pont and EPA relative to the research program:

1. A letter (R. D. Turner (Du Pont) to W. J. Librizzi (EPA), March 23, 1976) which describes toxicological/ biological studies Du Pont intended to perform.

2 A letter (R. D. Turner to Dr. Richard D. Spear (EPA), July 13, 1976) which describes the dispersion tests to be done at the 106 site.

On May 18, 1976, Dr. Gibson met in Narragansett, R. I. to discuss Du Pont's proposed studies with the following EPA representatives:

Dr. J. H. Gentile - National Marine Water Quality Laboratory
Mr. D. J. Hansen - Gulf Breeze Environmental Research Laboratory
Dr. R. J. Nadeau - Region II
Mr. P. W. Anderson - Region II

Mr. P. R. Parrish of Bionomics' Marine Research Laboratory, Pensacola, Florida, attended the meetings.

During the meeting, several alterations in the research program were suggested by EPA resprsentatives. Du Pont accepted the suggested alterations, and documented them in a letter (July 19, 1976) from Dr. Gibson to the attendees (Appendix J). A preliminary progress report on the research program was sent to Drs. Nadeau and Gentile and to Mr. Hansen on August 31, 1976 (Appendix K). Drs. Falk and Gibson reported additional progress at the September 20, 1976 public hearing in New York, N. Y. (Appendix L).

This report contains the complete results of Du Pont's research program.

## MATERIALS AND METHODS

### A. Dispersion Study

On September 9, 1976, EG&G Environmental Consultants conducted a dispersion study of Grasselli wastewater at the 106-site.

Conditions at the time of the study were those least likely to enhance dispersion, i.e., the presence of a strong thermocline lying between the depths of 20 to 40 meters, and calm sea with light winds, about 10 mph. Wastewater was marked with a fluorescent dye tracer.

Dispersing wastewater in the wake of the barge was monitored for pH and dye concentration for about 11 hours after release. Complete methodology is detailed in Appendix M which is the report of that study submitted to Du Pont by EG&G in February, 1977.

### B. Toxicity Tests

Composited samples of actual barged wastewater were used for all experiments. Chemical analyses of the test material are presented in Appendix N.

Test species were *Cyprinodon variegatus* (sheepshead minnow), *Mysidopsis bahia* (opossum shrimp) and *Palaemonetes pugio* (grass shrimp).

All tests were conducted by Bionomics Marine Research Laboratory at Pensacola, Florida. Their complete report, including methodology, is attached as Appendix O.

Data analysis and pathological examinations were conducted at Du Pont's Haskell Laboratory for Toxicology and Industrial Medicine at Newark, Delaware.

## RESULTS

### A. Wastewater Dispersion

Under the calm sea and thermocline conditions, seawater pH in the barge wake was not measurably affected by the waste. This observation was confirmed by laboratory titrations of seawater with Grasselli wastewater (Figure 1). Within two minutes after release minimum dilution of the wastewater was about 5000-fold, and increased to 15,000 to 30,000 after 11 hours.

Figure 2 presents the data tabulated in EG&G's Table 3-3 (Appendix M, p. 3-20), but recalculated and plotted as maximum wastewater concentration (ppm by volume) as a function of time after release. Plotted data are maximum observed wastewater concentrations for all transects at each level where dye was measured. The line drawn in Figure 2 represents the peak wastewater concentration, under worst-case dispersion conditions, expected in the barge wake at any time after release, regardless of the depth at which it occurs.

### B. Wastewater Toxicity

Lethal Responses: Tables 1-5 summarize mortality data for lethality tests with *Cyprinodon*. Tables 6-8 summarize lethality data for *Mysidopsis*. These data show that there is little difference in the toxicities of raw and pH adjusted (to seawater pH) wastewater for exposure times longer than 4 hours. They also show that the wastewater is not selectively toxic to a particular life stage, nor is there any great difference in response between these species after about 4 hours exposure time.

Table 9 compares the responses of several species which have been tested for lethal responses to raw Grasselli wastewaters. While there are species differences in lethal response, these differences tend to become less apparent with longer exposure times.

Mortality data from the time-independent and subchronic tests with Cyprinodon (Tables 4 and 5) show that the wastewaters are not cumulatively toxic and establish estimates of lethal response threshold for the wastewaters. Based on these data, the mortality threshold (i.e. a concentration above which some mortality would be experienced) should be between 1000 and 2000 ppm, and the 50% response threshold should be between 1500 and 2500 ppm. Estimated time independent LC50 values lie between 1900 and 2300 ppm. Probit analyses of mortality data are contained in Appendix P.

Wastewater concentrations of 750 ppm or less caused no mortality among exposed Cyprinodon or Mysidopsis during chronic exposure. Wastewater concentrations of 1500 ppm caused slight mortality in both species during chronic exposure. Consideration of all mortality data collected to date suggests that mortality thresholds for continuous exposure in most species would be at concentrations greater than 1000 ppm.

Nonlethal Responses: Tables 10 and 11 present data on the effects of wastewater on egg hatchability and fry growth, respectively, for Cyprinodon. The wastewater, at concentrations up to 5000 ppm, had no effect on egg hatchability and, at concentrations less than 1687 ppm, had no effect on fry growth and development. Table 12 presents growth data for chronically exposed C. variegatus. Table 13 presents data on egg production by female Cyprinodon, during the chornic study. Analysis of variance revealed no significant ($p \leq 0.05$) differences in total egg production or in the number of eggs produced per female per day among the controls and treatment groups exposed to wastewater concentrations of 750 ppm or less. At 1500 ppm, there was a significant decrease in egg production per female day during the third spawning period. There was an effect on egg hatchability at 1500 ppm during all 3 spawning periods. The effect, however, was probably not a direct effect of the wastewater (Table 14).

Tables 15 and 16 summarize the results of the chronic test in Mysidopsis. There were no differences among control and exposed groups with respect to time-to-formation of brood pouches, release of young, numbers of young, survival and maturation of young or onset of reproduction in first generation mysids. There was an apparent effect on mysid behavior and slight mortality at 1500 ppm.

Appendix Q contains the results of histopathological examinations which were conducted on exposed and control fish. There were no histopathological effects noted which were attributable to wastewater exposure.

To supplement the studies which have been described, Du Pont performed additional toxicity tests which simulated disposal conditions. These tests, called pulsed exposures, were also performed to assess the validity of the NAS/NAE recommendation (Appendix F, Exhibit B).

Two species Cyprinodon variegatus and Palaemonetes pugio were tested under pulsed exposure conditions. Palaemonetes was selected because it had not been previously tested for wastewater toxicity and thus, its response could be used to test the applicability of the time-toxicity concept to untested species. The methods and raw data for these tests are contained in Appendix O. Figure 4 summarizes the exposure conditions and results of these experiments for both Cyprinodon and Palaemonetes. Under pulsed exposure conditions, both species responded similarly to simulated wastewater dispersions.

At an initial concentration (Ci) of 10000 ppm and a slow (10 ml/min) dilution rate, high mortality occurred among exposed individuals of both species. Rapid dilution rates (100 ml/min), at 10000 ppm initial concentration, substantially reduced lethality. Initial concentrations of 5000 ppm caused slight mortality in Palaemonetes but not in Cyprinodon, while 1000 ppm was non-toxic at both dilution rates for both species. Initial concentrations selected for these experiments were considerably greater than those observed in the dispersion study. Experimental dilution rates of 10 or 100 ml/min were respectively slower and faster than observed dispersion rates at the disposal site (Figure 4).

Cyprinodon variegatus was used as a model for testing the validity and/or applicability of the NAS/NAE recommendation. The procedure used for NAS/NAE calculations was basically the same as is presented in Appendix F. Stepwise, the procedure was:

- LC50 for Cyprinodon was plotted as a function of time, and a line of best fit constructed (Figure 5).
- A line of best fit for no-effect concentration (Co), was also constructed (Figure 5).
- Simulated dispersion curves (from Figure 4) were drawn.
- Time segments (T) were established as follows:

  $T_1 = t_1 - t_0;\ T_2 = t_2 - t_1;\ T_3 = t_3 - t_2;$ etc.

  where:

  t(n) is the exposure time (in hours) at which successive LC50's were determined.

- Average exposure concentration ($C\bar{x}$) for each time interval (T) was calculated by the formula:

$$C\bar{x}_{t(n)} = \frac{Ct_{(n)} + Ct_{(n+1)}}{2}$$

where:

$$Ct_{(n+1)} = Ct_{(n)} \times \left[\frac{V}{V+RU}\right]^{\Delta t}$$

where:

V = volume of the exposure chamber in ml

R = dilution rate in ml/min

$\Delta t$ = elapsed time between $Ct_1$ and $Ct_2$ in minutes (note: here $\Delta t$ = T expressed in minutes)

U = the units for $\Delta t$ (i. e. minutes)

or, $Ct_{(n)}$ and $Ct_{(n+1)}$ could have been read directly from the dilution curves in Figure 4.

Table 17 summarizes these calculations for the four simulated dispersion curves in Figure 5.

- $ET_0$ (the effective time for no effect) was determined for each $C\bar{x}$ (see example in Appendix F)

- The data for each of the simulated dispersion curves were fitted into the equation

$$\Sigma[T/ET_0]\leq 1$$

These calculations were also performed for $ET_{50}$ at the 100 ml/min dilution rates (i.e. the effective time of exposure to $C\bar{x}$, which produces a 50% response). The six example calculations:

EXAMPLE 1:

Ci = 10000 ppm
R = 10 ml/min
$ET_0$ = Test Criterion

| $C\bar{x}$ | $ET_0$ | $T/ET_0$ |
|---|---|---|
| 9750 | 0.96 | 0.260 |
| 9260 | 1.05 | 0.238 |
| 8790 | 1.10 | 0.227 |
| 8560 | 1.15 | 0.217 |
| 7770 | 1.30 | 0.769 |
| 5000 | 2.80 | 0.714 |
| 2190 | 33 | 0.121 |
| 960 | 1200 | 0.003 |
| 317 | ∞ | - |

| $\Sigma[T/ET_0]$ |
|---|
| 2.550 |

- Thus, the prediction is that the no effect level will be exceeded.
- Observed response = >60% mortality.
- The prediction is valid.

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EXAMPLE 2:

Ci = 10000 ppm
R = 10 ml/min
$ET_{50}$ = Test Criterion

| $C\bar{x}$ | $ET_{50}$ | $T/ET_0$ |
|---|---|---|
| 9750 | 1.30 | 0.192 |
| 9260 | 1.55 | 0.161 |
| 8790 | 1.60 | 0.156 |
| 8560 | 1.70 | 0.147 |
| 7770 | 2.10 | 0.476 |
| 5008 | 6.6 | 0.303 |
| 2190 | 350 | 0.011 |
| 960 | ∞ | - |

| $\Sigma[T/ET_0]$ |
|---|
| 1.446 |

- Thus, the prediction is that the LC50 will be exceeded.
- Observed response = >60% mortality.
- The prediction is valid.

EXAMPLE 3: $C_i$ = 10000 ppm
R = 100 ml/min
$ET_0$ = Test Criterion

| $C\bar{x}$ | $ET_0$ | $T/ET_0$ |
|---|---|---|
| 8010 | 1.25 | 0.200 |
| 4810 | 3.10 | 0.081 |
| 2900 | 12 | 0.020 |
| 1740 | 65 | 0.004 |
| 740 | ∞ | - |

$\Sigma[T/ET_0]$ = 0.305

- Thus, the prediction is that the no effect level will not be exceeded.
- Observed response = No mortality. .
- The prediction is valid.

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EXAMPLE 4: $C_i$ = 5000 ppm
R = 10 ml/min
$ET_0$ = Test Criterion

| $C\bar{x}$ | $ET_0$ | $T/ET_0$ |
|---|---|---|
| 4870 | 3.0 | 0.083 |
| 4630 | 3.4 | 0.074 |
| 4400 | 3.8 | 0.066 |
| 4170 | 4.0 | 0.063 |
| 3690 | 6.0 | 0.167 |
| 3750 | 14.0 | 0.143 |
| 1570 | 94 | 0.043 |
| 688 | ∞ | - |

$\Sigma[T/ET_0]$ = 0.637

- Thus, the prediction is that the no effect level will not be exceeded.
- Observed response = No mortality.
- The prediction is valid.

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EXAMPLE 5: $C_i$ = 5000 ppm
R = 10 ml/min
$ET_{50}$ = Test Criterion

| $C\bar{x}$ | $ET_{50}$ | $T/ET_{50}$ |
|---|---|---|
| 4870 | 7.2 | .035 |
| 4630 | 8.6 | .029 |
| 4400 | 10 | .025 |
| 4170 | 13 | .019 |
| 3690 | 20 | .050 |
| 2750 | 75 | .026 |
| 1570 | ∞ | - |

$\Sigma[T/ET_{50}]$ = 0.184

- Thus, the prediction is that the LC50 will not be exceeded.
- Observed response = No mortality.
- The prediction is valid.

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EXAMPLE 6: $C_i$ = 5000 ppm
R = 100 ml/min
$ET_0$ = Test Criterion

| $C\bar{x}$ | $ET_0$ | $T/ET_0$ |
|---|---|---|
| 4000 | 2.8 | 0.052 |
| 2410 | 21 | 0.012 |
| 1450 | 103 | 0.002 |
| 870 | 2000 | - |
| 370 | $\infty$ | - |

$\Sigma[T/ET_0]$

0.066

- Thus, the prediction is that the no effect level will not be exceeded.
- Observed response = No mortality.
- The prediction is valid.

All six cases conform to the NAS/NAE prediction that when:

$$\Sigma[T/ET_{(x)}]>1$$

the effect level (x) will be exceeded and conversely, when:

$$\Sigma[T/ET_{(x)}]<1$$

the effect level (x) will not be exceeded.

Two additional experiments were conducted to assess (a) the effects of multiple pulsed exposures on *Cyprinodon* and *Palaemonetes*, and (b) the effect of pulsed exposure on spawning female *Cyprinodon*.

Multiple pulses, in general, did not appear to cause effects different from those observed in single-pulse experiments.

Exposure of spawning female *Cyprinodon* to single or multiple pulses (Ci = 3000 ppm) caused reduced egg production (Appendix O).

## DISCUSSION AND CONCLUSIONS

Results of the dispersion study show that peak concentrations for Grasselli wastewaters in the wake of a barge moving at approximately 5 knots and with a release time of 5 hours would be about 450 ppm one minute after release. Within 6 minutes, peak concentration declines to about 250 ppm; to about 80 ppm within 4 hours, and to about 60 ppm in 12 hours. These concentrations represent maxima under poor dispersion conditions which exist during summer months.

Observed dispersion correlates fairly well with dispersion predictions which were made in Appendix A. Comparison between observed and predicted dispersion (Figure 3) shows that:

- Wastewater dilution rates during the first half hour after release were more rapid than predicted.
- Wastewater concentrations observed between 1/2 and 4 hours after release were within the ranges predicted.
- Wastewater dispersion after 4 hours following release yielded concentrations greater than had been predicted in 1975. (A likely explanation is that calmer sea conditions prevailed during the 1976 test than during the studies on which the 1975 forecast was based).

The real significance of the dispersion data however, is that within 1 minute after release from the barge, wastewater concentration declines to levels which are below observed chronic no-effect concentrations for two species of sensitive marine organisms -- *Cyprinodon variegatus* and *Mysidopsis bahia*. Based on results of previous toxicity tests, similar no effect levels would be expected for other marine species.

We conclude that Du Pont's Grasselli wastewaters can be discharged into the marine environment, over a 5-hour period at a barge speed of 5 knots, without any adverse impact.

We also conclude that the NAS/NAE recommendation is a valid and applicable means for utilizing toxicity and wastewater dispersion data to derive release time (or discharge rates) for ocean-disposed wastewaters and further, that the "time-toxicity" concept has been validated.

## TABLE 1

LC50'S* OF GRASSELLI WASTEWATER TO 1-7 DAY OLD FRY OF *C. VARIEGATUS* FOR VARIOUS EXPOSURE TIMES

| Exposure Time (Hr.) | LC50 in ppm (95% Confidence Limits) | | | |
|---|---|---|---|---|
| | Raw Waste | | pH Adjusted Waste | |
| 0.25 | >100000 | | >100000 | |
| 0.5 | 37930 | (CL not defined) | >100000 | |
| 0.75 | 79740 | (51640-118600) | 67530 | (52380-77940) |
| 1.0 | 36040 | (CL not defined) | 38230 | (5620-71880) |
| 2.0 | 30810 | (19050-41970) | 18860 | (CL not defined) |
| 4.0 | 30720 | (CL not defined) | 42300 | (31980-49090) |
| 8.0 | 9010 | (6200-10720) | 8000 | (5870-9670) |
| 12.0 | 3980 | (3400-4530) | 7060 | (5950-8270) |
| 24.0 | 2730 | (2550-2920) | 4110 | (3790-4470) |
| 48.0 | 2440 | (CL not defined) | 4230 | (2620-4930) |
| 96.0 | 1270 | (1040-1470) | 978 | (442-1920) |

* LC50 values reflect mortality which occurred during exposure plus a 96-hour post-exposure period.

## TABLE 2

LC50'S* OF GRASSELLI WASTEWATER TO 30-DAY-OLD JUVENILE
*C. VARIEGATUS* FOR VARIOUS EXPOSURE TIME

| Exposure Time (Hr.) | LC50 in ppm (95% Confidence Limits) | | | |
|---|---|---|---|---|
| | Raw Waste | | pH Adjusted Waste | |
| 0.25 | 93590 | (73380-107360) | >100000 | |
| 0.5 | 23180 | (18130-27680) | 77740 | (CL not defined) |
| 0.75 | 30660 | (27730-36660) | 34090 | (26030-46280) |
| 1.0 | 19210 | (17590-20750) | 11130 | (8800-13700) |
| 2.0 | 12380 | (10830-14560) | 22570 | (19260-33860) |
| 4.0 | 10570 | (9270-11790) | 11830 | (10610-12840) |
| 8.0 | 11620 | (10720-12550) | 9350 | (8370-10740) |
| 12.0 | 6730 | (6130-7320) | 9560 | (8270-10310) |
| 24.0 | 3120 | (2880-3370) | 3990 | (3710-4320) |
| 48.0 | 1630 | (CL not defined) | 2540 | (CL not defined) |
| 96.0 | 1230 | (1050-1360) | 1960 | (1870-2050) |

* LC50 values reflect mortality which occurred during exposure plus a 96-hour post-exposure period.

## TABLE 3

### LC50'S* OF GRASSELLI WASTEWATER TO ADULT *C. VARIEGATUS* FOR VARIOUS EXPOSURE TIMES

| Exposure Time (Hr.) | LC50 in ppm (95% Confidence Limits) | | | |
|---|---|---|---|---|
| | Raw Waste | | pH Adjusted Waste | |
| 0.25 | >100000 | | >100000 | |
| 0.5 | 43890 | (CL not defined) | >100000 | |
| 0.75 | 39380 | (42370-80840) | 86400 | (CL not defined) |
| 1.0 | 20020 | (CL not defined) | 43480 | (34410-52180) |
| 2.0 | 20190 | (CL not defined) | 57730 | (CL not defined) |
| 4.0 | 14170 | (11690-16720) | 10410 | (CL not defined) |
| 8.0 | 8420 | (CL not defined) | 6350 | (5000-7500) |
| 12.0 | 6430 | (27-17560) | 6570 | (4330-7740) |
| 24.0 | 5220 | (4620-5730) | 5770 | (CL not defined) |
| 48.0 | 2700 | (CL not defined) | 3400 | (CL not defined) |
| 96.0 | 1950 | (CL not defined) | 1170 | (496-1680) |

* LC50 values reflect mortality which occurred during exposure plus a 96-hour post-exposure period.

TABLE 4

SUMMARY OF TIME-INDEPENDENT TOXICITY TEST WITH GRASSELLI pH-ADJUSTED WASTEWATER

| Nominal Concentration (ppm) | Mortality: Exposure 24 hr. No. (%) | 48 hr. No. (%) | 96 hr. No. (%) | 144 hr. No. (%) | 192 hr. No. (%) | 240 hr. No. (%) | Post-Exposure 336 hr. No. (%) |
|---|---|---|---|---|---|---|---|
| Control | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 1,050 ppm | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 1,440 ppm | 0 (0) | 0 (0) | 0 (0) | 3 (15) | 5 (25) | 5 (25) | 5 (25) |
| 1,867 ppm | 0 (0) | 0 (0) | 0 (0) | 4 (20) | 4 (20) | 4 (20) | 4 (20) |
| 2,489 ppm | 0 (0) | 0 (0) | 1 (5) | 9 (45) | 18 (90) | 18 (90) | 18 (90) |
| 3,319 ppm | 7 (35) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) |
| 4,425 ppm | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) |
| 5,900 ppm | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) |
| LC50 (95% Conf. Limits) | 3410 (No CL) | 2870 (No CL) | 2720 (No CL) | 2250 (2036-2480) | 1930 (1750-2120) | Same as 192 hr. | Same as 192 hr. |

TABLE 5

SUMMARY OF MORTALITY EXPERIENCED BY *C. VARIEGATUS* DURING THE FIRST 28 DAYS POST-HATCH AS A RESULT OF EXPOSURE TO VARIOUS CONCENTRATIONS OF pH-ADJUSTED GRASSELLI WASTEWATER

| | Mortality | | | | | |
|---|---|---|---|---|---|---|
| | Exposure | | | | Post-Exposure | |
| Concentration | Day 14 | | Day 28 | | Day 42 | |
| (µl/1; ppm) | Number | (%) | Number | (%) | Number | (%) |
| Control A | 1 | (2.5) | 2 | (5.0) | 2 | (5.0) |
| Control B | 0 | (0) | 0 | (0) | 0 | (0) |
| 712 ppm A | 0 | (0) | 0 | (0) | 0 | (0) |
| 712 ppm B | 0 | (0) | 0 | (0) | 0 | (0) |
| 949 ppm A | 4 | (10.0) | 4 | (10.0) | 4 | (10.0) |
| 949 ppm B | 1 | (2.5) | 1 | (2.5) | 1 | (2.5) |
| 1,266 ppm A | 0 | (0) | 0 | (0) | 0 | (0) |
| 1,266 ppm B | 0 | (0) | 3 | (7.5) | 4 | (10.0) |
| 1,687 ppm A | 3 | (7.5) | 4 | (10.0) | 4 | (10.0) |
| 1,687 ppm B | 0 | (0) | 0 | (0) | 0 | (0) |
| 2,250 ppm A | 2 | (5.0) | 10 | (25.0) | 11 | (27.5) |
| 2,250 ppm B | 19 | (47.5) | 28 | (70.0) | 28 | (70.0) |
| 3,000 ppm A | 38 | (95.0) | 39 | (97.5) | 39 | (97.5) |
| 3,000 ppm B | 30 | (75.0) | 39 | (97.5) | 39 | (97.5) |
| 4,000 ppm A | 39 | (97.5) | 40 | (100) | 40 | (100) |
| 4,000 ppm B | 40 | (100) | 40 | (100) | 40 | (100) |
| LC50 (95% Confidence Limits) | 2550 (2320-2750) | | 2290 (2190-2380) | | 2290 (2190-2370) | |

## TABLE 6

LC50'S* OF GRASSELLI WASTEWATERS TO *MYSIDOPSIS BAHIA* FOR VARIOUS EXPOSURE TIMES

| Exposure Time (Hr.) | LC50 in ppm (95% Confidence Limits) Raw Waste | | pH Adjusted Waste | |
|---|---|---|---|---|
| 0.25 | 14030 | (14415-15711) | | |
| 0.50 | 11640 | (10887-12319) | 15860 | (15300-16390) |
| 0.75 | 10800 | (10172-11738) | 7620 | (6450-8670) |
| 1 | 6290 | (5688-6968) | 7590 | (6460-8530) |
| 2 | 6600 | (6213-6904) | 7230 | (6490-8060) |
| 4 | 5210 | (CL not defined) | 7450 | (6670-7970) |
| 8 | 5280 | (4813-5454) | 3430 | (3070-4050) |
| 96 | 898 | (506-1205) | 1320 | (1100-1530) |

* LC50 values reflect mortality which occurred during exposure plus 96-hour post exposure period.

## TABLE 7

CUMULATIVE PERCENT SURVIVAL OF *MYSIDOPSIS BAHIA* EXPOSED TO VARIOUS CONCENTRATIONS OF GRASSELLI WASTEWATER FOR 25 DAYS.

| Day | Wastewater Concentration (ppm) | | | | | |
|---|---|---|---|---|---|---|
| | 94 | 188 | 375 | 750 | 1500 | Control |
| 1-5 | 100 | 100 | 90 | 100 | 95 | 100 |
| 6-10 | 90 | 90 | 75 | 85 | 70 | 90 |
| 11-15 | 70 | 75 | 55 | 55 | 60 | 75 |
| 16-20 | 60 | 65 | 30 | 35 | 30 | 65 |
| 21-25 | 60 | 65 | 30 | 35 | 10 | 40 |

## TABLE 8

CUMULATIVE PERCENT SURVIVAL OF $F_1$ MYSIDS EXPOSED TO VARIOUS CONCENTRATIONS OF GRASSELLI WASTEWATER FOR 14 DAYS

| Day | Wastewater Concentration (ppm) | | | | | |
|---|---|---|---|---|---|---|
| | 94 | 188 | 375 | 750 | 1500 | Control |
| 1-5 | 100 | 100 | 100 | 100 | 100 | 100 |
| 6-10 | 100 | 100 | 100 | 94 | 100 | 95 |
| 11-14 | 100 | 90 | 100 | 87 | 80 | 95 |

TABLE 9

STATIC TOXICITY (LC50) OF RAW GRASSELLI WASTEWATER TO SEVERAL SPECIES OF MARINE ORGANISMS

| SPECIES | EXPOSURE TIME IN HOURS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | .25 | .5 | .75 | 1 | 4 | 8 | 12 | 24 | 48 | 96 |
| MENIDIA* | - | - | - | 4270 | 2360 | 2175 | - | 2002 | 1880 | 1660 |
| SKELETONEMA* | - | - | - | >10000 | >10000 | >10000 | - | 1375 | 803 | 1180 |
| ARTEMIA | - | - | - | - | - | - | - | >10000 | >10000 | - |
| ACARTIA∫ | - | - | - | 2519 | 1911 | 1542 | - | 559 | 462 | 400 |
| CYPRINODON† | >100000 | 35000 | 56000 | 25000 | 18000 | 8500 | 6600 | 4100 | 2700 | 1400 |
| MYSIDOPSIS | 14030 | 11640 | 10802 | 6286 | 5210 | 5276 | - | - | - | 898 |

* Mean of 15 Samples
∫ Mean of 10 Samples
† Mean of 3 Life Stages

## TABLE 10

EFFECT OF GRASSELLI WASTEWATER ON HATCHABILITY OF *CYPRINODON VARIEGATUS* EGGS

| Wastewater Concentration (ppm) | Mean Percent Hatch |
|---|---|
| 712 | 95 |
| 949 | 89 |
| 1266 | 95 |
| 1687 | 94 |
| 2250 | 94 |
| 3000 | 96 |
| 4000 | 98 |
| Control | 96 |

TABLE 11

MEAN LENGTH AMONG GROUPS OF C. VARIEGATUS FRY EXPOSED TO pH-ADJUSTED GRASSELLI WASTEWATER DURING THE FIRST 28 DAYS POST-HATCH

| Nominal Concentration (μl/1; ppm) | Mean Standard Length (in Centimeters) and Standard Deviation | | |
|---|---|---|---|
| | Exposure | | Post-Exposure |
| | Day 14 | Day 28 | Day 42 |
| Control A | 0.5 ± 0.1 | 1.2 ± 0.2 | 1.3 ± 0.2 |
| Control B | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 712 ppm A | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 712 ppm B | 0.8 ± 0.2 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 949 ppm A | 0.5 ± 0.1 | 1.2 ± 0.1 | 1.4 ± 0.1 |
| 949 ppm B | 0.6 ± 0.2 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 1,266 ppm A | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 1,266 ppm B | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 1,687 ppm A | 0.5 ± 0.2 | 1.2 ± 0.2 | 1.3 ± 0.2 |
| 1,687 ppm B | -[a] | 1.3 ± 0.1 | 1.3 ± 0.1 |
| 2,250 ppm A | 0.5 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.2 |
| 2,250 ppm B | 0.5 ± 0.1 | 1.4 ± 0.1 | 1.7 ± 0.2 |
| 3,000 ppm A | 0.5 ± 0.1 | 1.6 ± 0.0 | 2.4 ± 0.0 |
| 3,000 ppm B | 0.5 ± 0.0 | 1.8 ± 0.0 | 2.5 ± 0.0 |
| 4,000 ppm A | -[b] | - | - |
| 4,000 ppm B | -[b] | - | - |

[a] No measurements

[b] No fish

## TABLE 12

STANDARD LENGTH (CM) AND IN-WATER WEIGHT (G) OF SHEEPSHEAD MINNOWS (*CYPRINODON VARIEGATUS*) EXPOSED FOR 178 DAYS TO GRASSELLI WASTEWATER IN FLOWING, NATURAL SEA WATER.

| Nominal concentration (μℓ/ℓ;ppm) | Day 33 | | Day 89 | | Day 178 | |
|---|---|---|---|---|---|---|
| | Length | Weight | Length | Weight | Length | Weight |
| Control | 1.6 ± 0.3 | 0.2 | 2.8 ± 0.4 | 0.8 | 3.3 ± 0.3 | 0.9 |
| 180 (Raw) | 1.6 ± 0.2 | 0.2 | 2.7 ± 0.3 | 0.7 | 3.2 ± 0.4 | 1.0 |
| 188 | 1.5 ± 0.1 | 0.1 | 2.8 ± 0.3 | 0.7 | 3.3 ± 0.3 | 1.0 |
| 375 | 1.6 ± 0.1 | 0.1 | 2.8 ± 0.3 | 0.8 | 3.2 ± 0.3 | 0.9 |
| 750 | 1.6 ± 0.1 | 0.2 | 2.8 ± 0.3 | 0.8 | 3.3 ± 0.3 | 0.9 |
| 1,500 | 1.6 ± 0.1 | 0.2 | 2.7 ± 0.3 | 0.8 | 3.2 ± 0.3 | 0.9 |
| 3,000 | -[a] | | - | | - | |

[a] All fish had died.

TABLE 13

EGG PRODUCTION AMONG FEMALE *C. VARIEGATUS* EXPOSED TO VARIOUS CONCENTRATIONS OF pH-ADJUSTED GRASSELLI WASTEWATER

| | Total Number of Eggs Produced* (No. per Female per Day) | | |
|---|---|---|---|
| Wastewater Concentration (ppm) | First Spawning | Second Spawning | Third Spawning |
| 188 | 1010 (18.5) | 1095 (18.4) | 659 (12.5) |
| 375 | 999 (16.7) | 1177 (19.6) | 1274 (21.2) |
| 750 | 1162 (19.4) | 908 (15.0) | 1034 (17.2) |
| 1500 | 1064 (20.7) | 1373 (22.9) | 364 (6.5) |
| Control | 2270 (37.3) | 848 (14.5) | 936 (15.6) |

* Two replications at each spawning period.

# TABLE 14

SUMMARY OF EFFECTS OBSERVED DURING
CHRONIC EXPOSURE OF *C. VARIEGATUS* TO VARIOUS CONCENTRATIONS
OF pH-ADJUSTED GRASSELLI WASTEWATER

| Wastewater Concentration (ppm) | Observed Effects Through 178 Days of Exposure |
|---|---|
| 188 | None |
| 375 | None |
| 750 | None |
| 1500 | - Slight Mortality<br>- Slightly Impaired Egg Hatchability*<br>- Impaired Feeding Behavior |
| 3000 | Complete Mortality |
| Control | None |

* This effect may not be due to direct action of the wastewaters.

## TABLE 15

SUMMARY OF EFFECTS NOTED DURING A CHRONIC STUDY IN WHICH *MYSIDOPSIS BAHIA* WERE EXPOSED TO VARIOUS CONCENTRATIONS OF GRASSELLI WASTEWATER.

| Exposure Concentration (ppm) | Observed Effects |
|---|---|
| 94 | None |
| 188 | None |
| 375 | None |
| 750 | None |
| 1500 | - Abnormal behavior<br>- Mortality rate greater than control |
| Control | None |

## TABLE 16

AVERAGE NUMBER OF OFFSPRING PER HATCH OF MYSID SHRIMP (*MYSIDOPSIS BAHIA*) EXPOSED TO pH-ADJUSTED GRASSELLI WASTEWATER IN A CHRONIC TEST.

| Nominal concentration (µℓ/ℓ;ppm) | Average number of offspring per hatch |
|---|---|
| Control | 5.3 |
| 94 | 4.7 |
| 188 | 6.0 |
| 375 | 4.5 |
| 750 | 5.3 |
| 1,500 | 5.0 |

## TABLE 17

VALUES FOR LC50, $C_o$ AND T FOR GRASSELLI WASTEWATERS TESTED AGAINST *C. VARIEGATUS* IN PULSED EXPOSURES

| Exposure Time in Hours | LC50 (ppm) | $C_o$ (ppm) | T (Hours) |
|---|---|---|---|
| 0.25 | 93590* | 30890 | 0.25 |
| 0.50 | 23180* | 7650 | 0.25 |
| 0.75 | 30660* | 10120 | 0.25 |
| 1.0 | 11130* | 3670 | 0.25 |
| 2 | 12380* | 4080 | 1 |
| 4 | 10410* | 3440 | 2 |
| 8 | 6350* | 2100 | 4 |
| 12 | 3980* | 1310 | 4 |
| 24 | 3410$^{\delta}$ | 1120 | 12 |
| 48 | 2870$^{\delta}$ | 948 | 24 |
| 96 | 2720$^{\delta}$ | 897 | 48 |
| 144 | 2250$^{\delta}$ | 743 | 48 |
| 192 | 1930$^{\delta}$ | 636 | 48 |
| 336 | 2550$^{\delta}$ | 840 | 144 |
| 672 | 2290$^{\delta}$ | 756 | 336 |

* Lowest observed static LC50, regardless of life stage exposed or pH state of wastewater.

$\delta$ Dynamic exposure to pH adjusted wastewater.

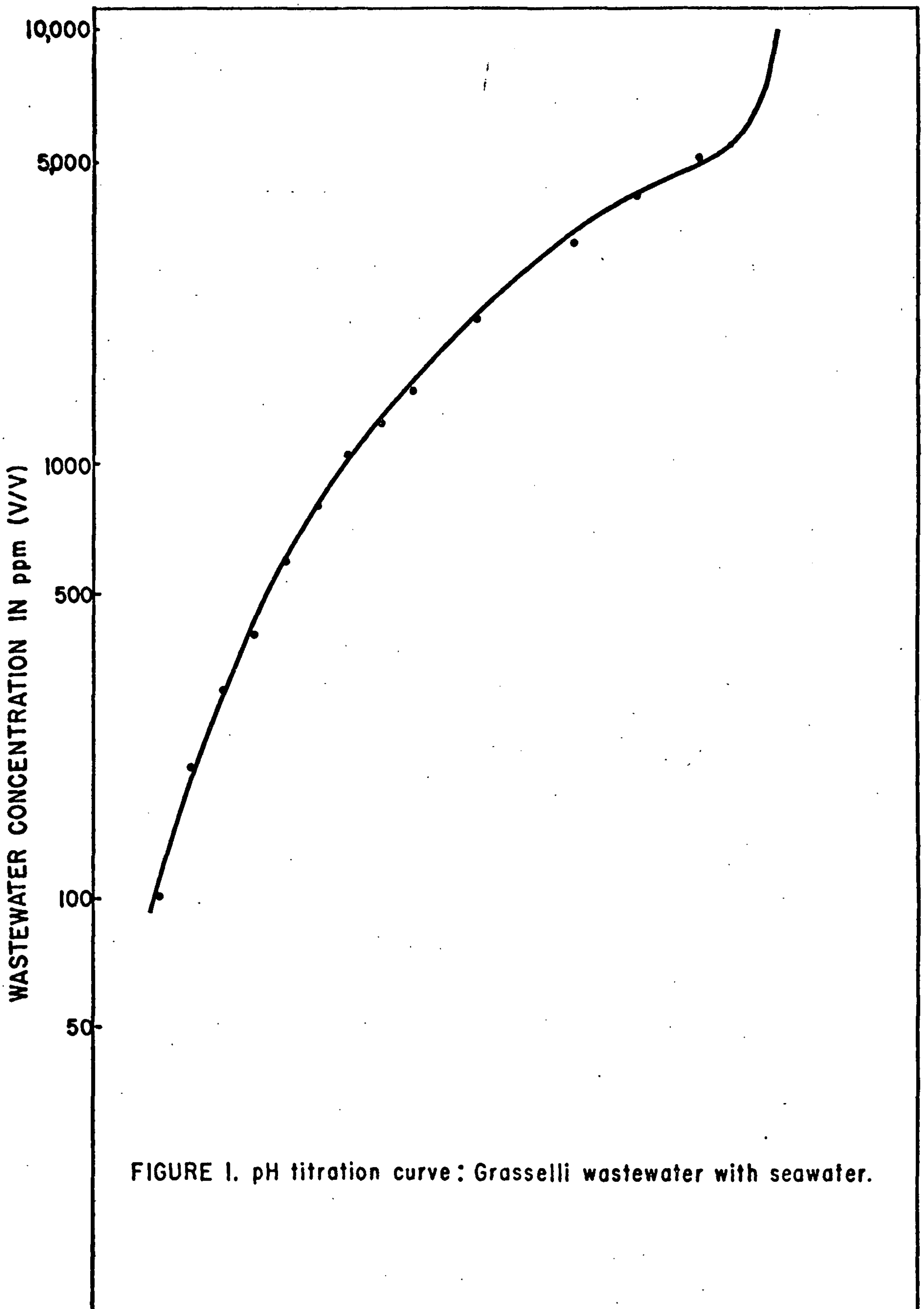


FIGURE I. pH titration curve: Grasselli wastewater with seawater.

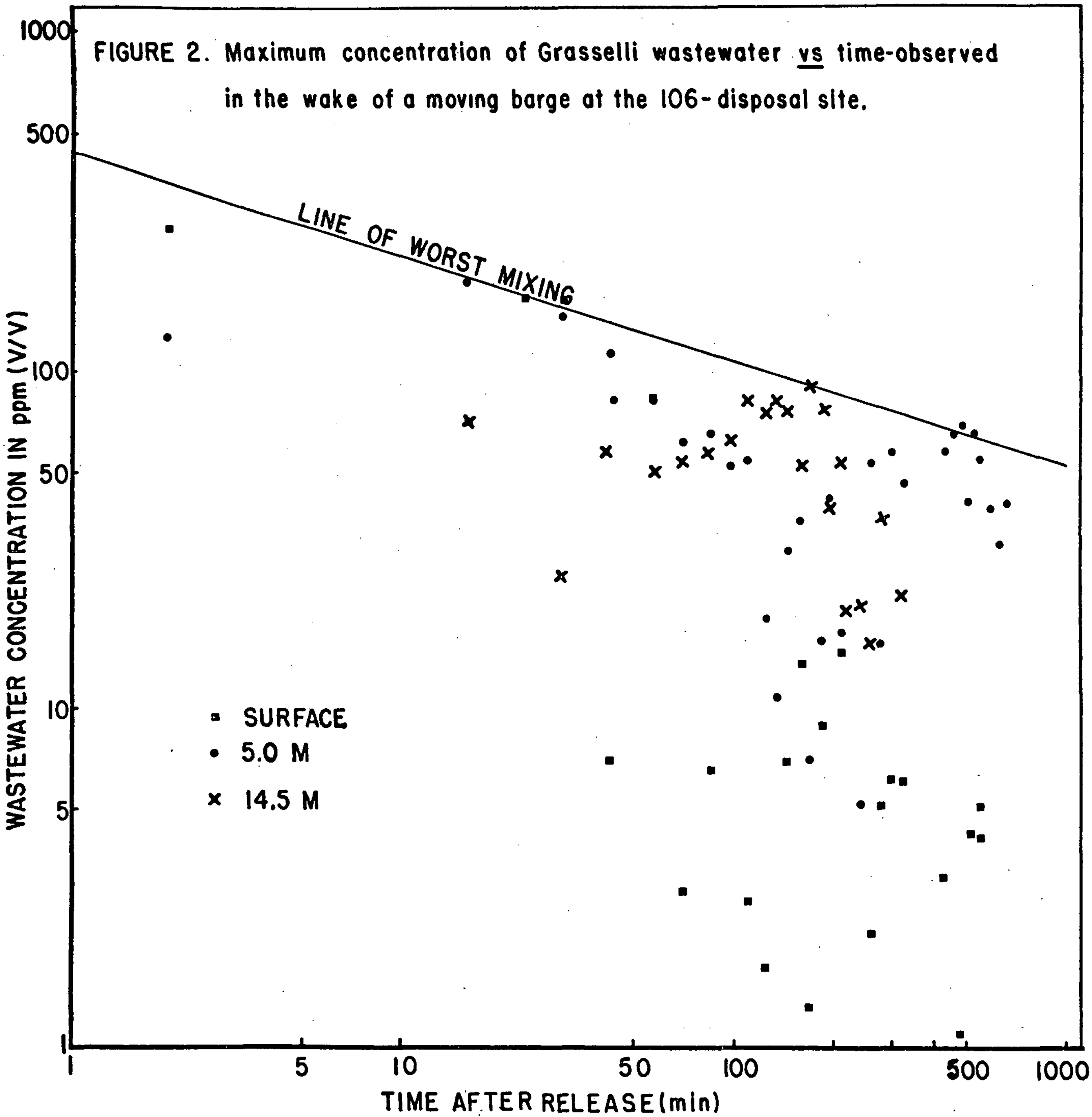
FIGURE 2. Maximum concentration of Grasselli wastewater vs time-observed in the wake of a moving barge at the 106-disposal site.
LINE OF WORST MIXING
WASTEWATER CONCENTRATION IN ppm (V/V)
1000
500
100
50
10
5
1
5
10
50
100
500
1000
TIME AFTER RELEASE (min)
SURFACE
5.0 M
14.5 M

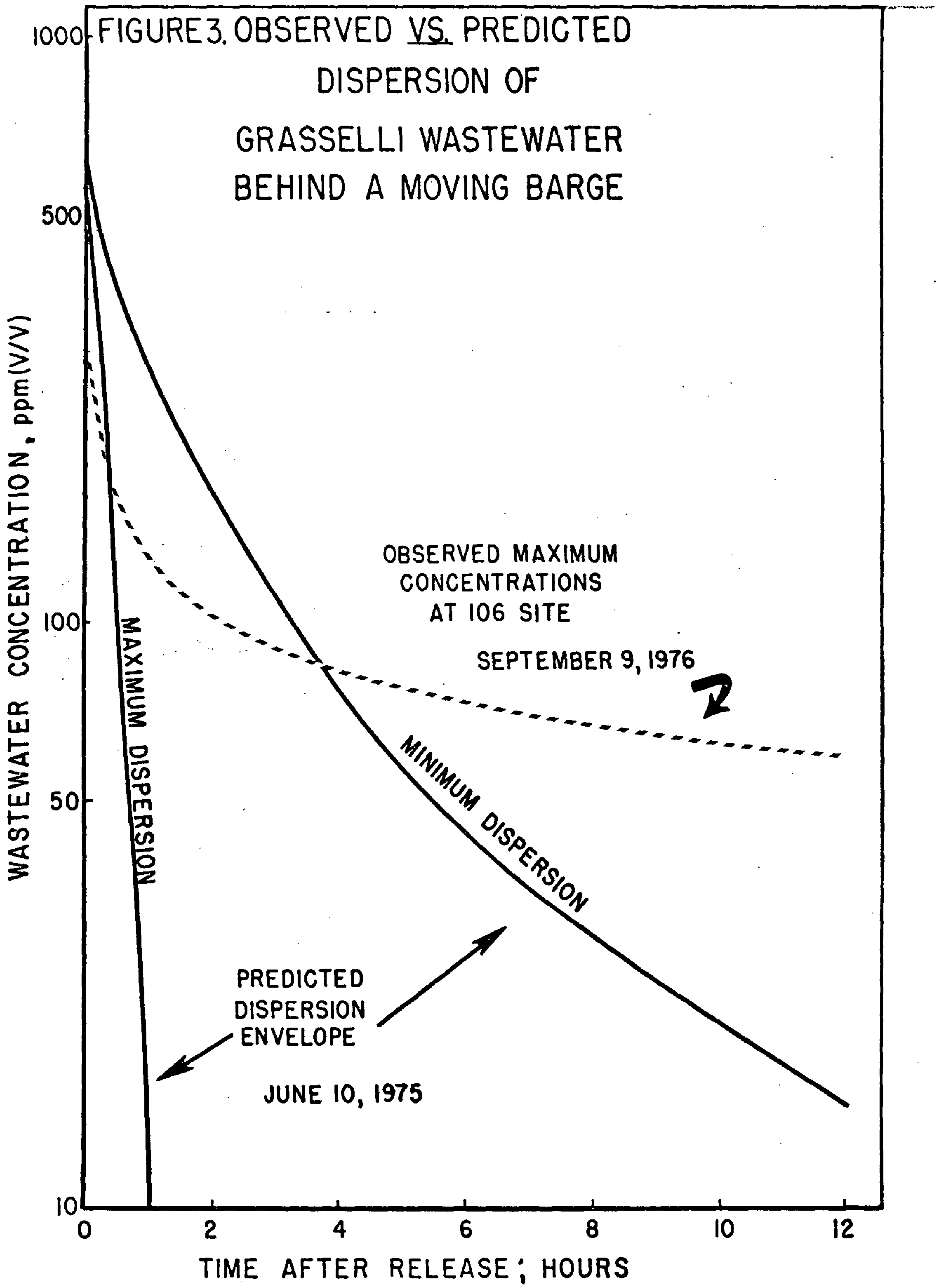
FIGURE 3. OBSERVED VS. PREDICTED DISPERSION OF GRASSELLI WASTEWATER BEHIND A MOVING BARGE
WASTEWATER CONCENTRATION, ppm(V/V)
1000
500
100
50
10
0
2
4
6
8
10
12
TIME AFTER RELEASE; HOURS
OBSERVED MAXIMUM CONCENTRATIONS AT 106 SITE
SEPTEMBER 9, 1976
MAXIMUM DISPERSION
MINIMUM DISPERSION
PREDICTED DISPERSION ENVELOPE
JUNE 10, 1975

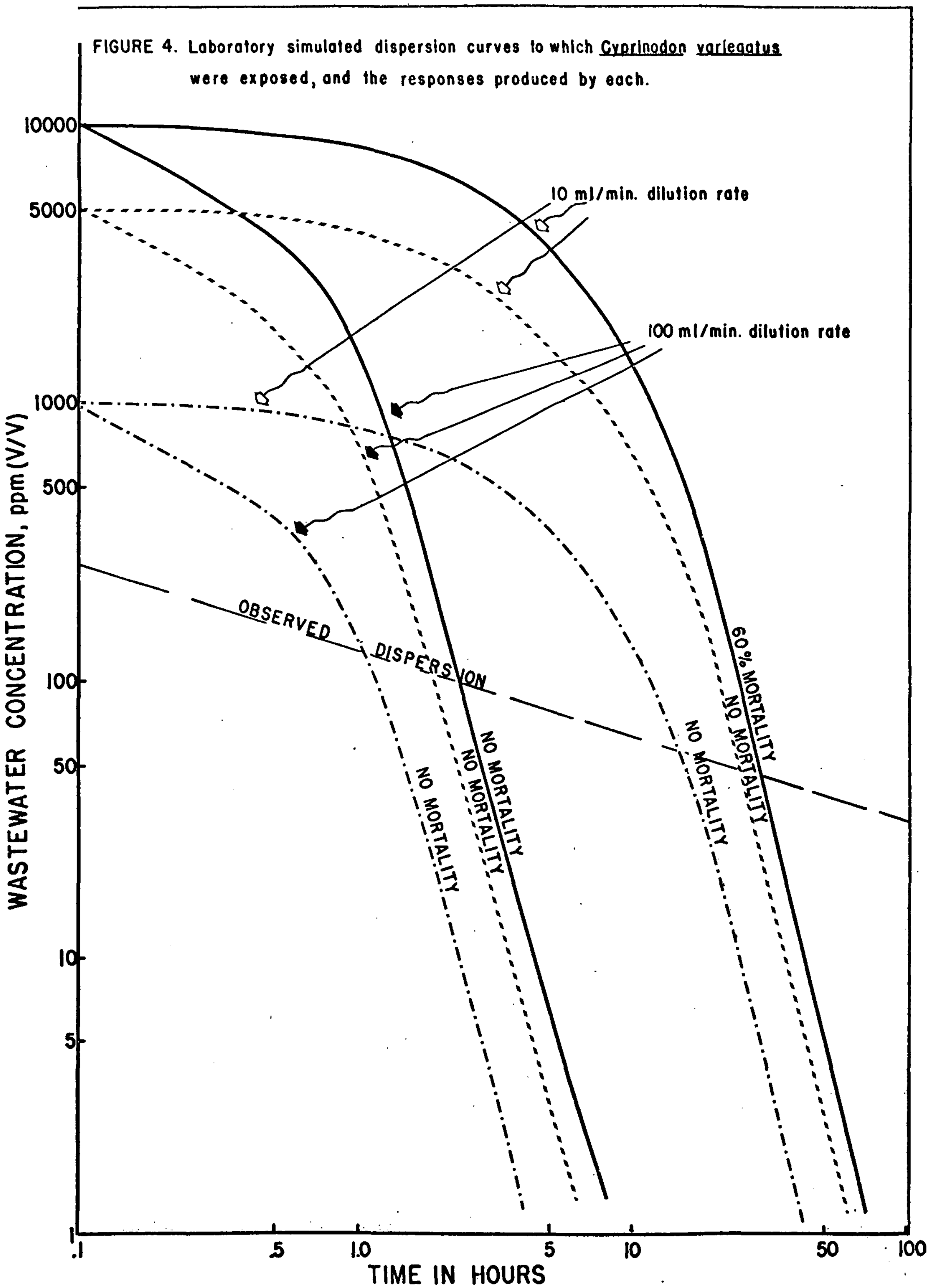


FIGURE 4. Laboratory simulated dispersion curves to which *Cyprinodon variegatus* were exposed, and the responses produced by each.

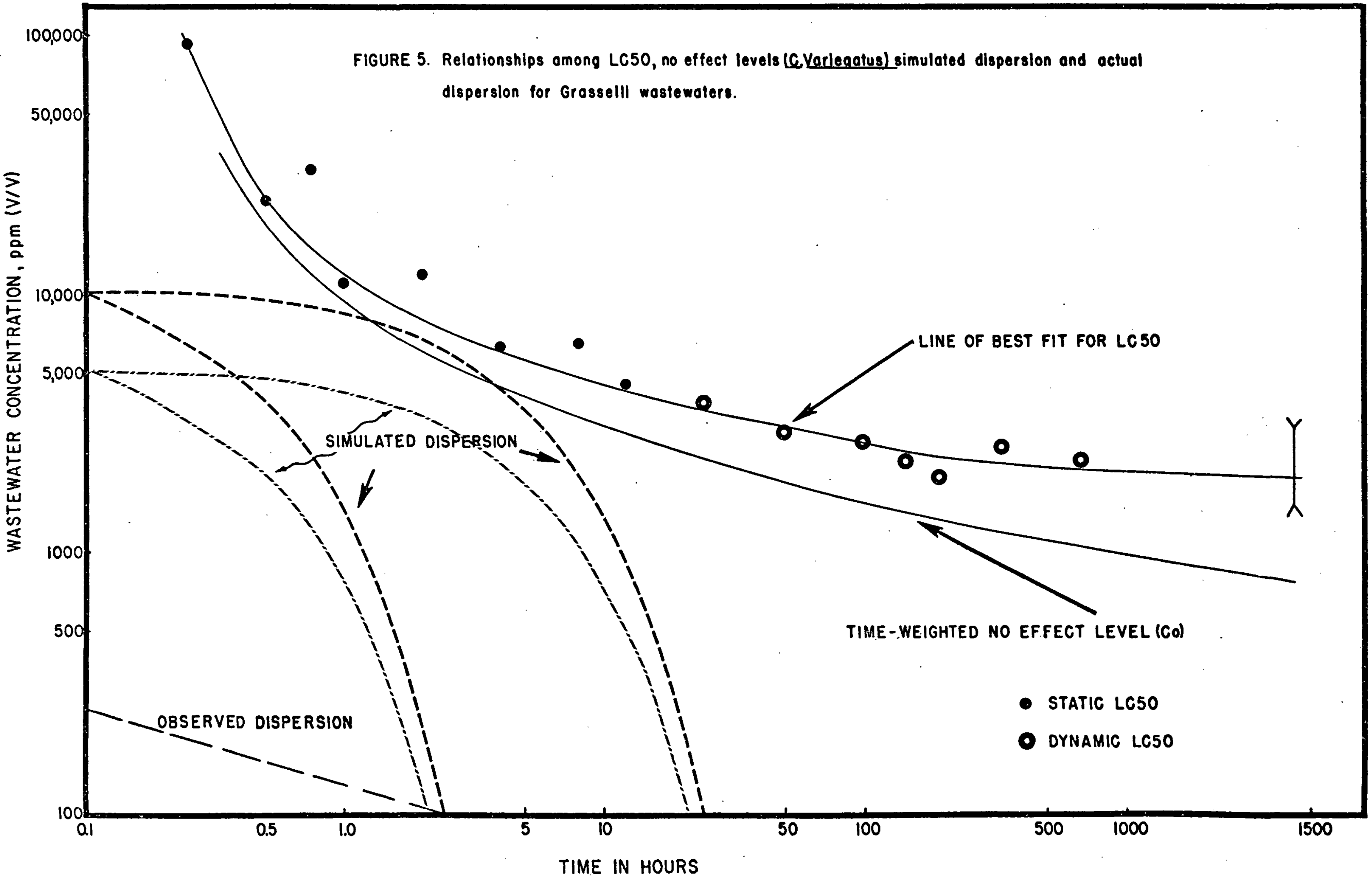

FIGURE 5. Relationships among LC50, no effect levels (*C. Variegatus*) simulated dispersion and actual dispersion for Grasselli wastewaters.

APPENDICES

TABLE OF CONTENTS

<u>Appendix</u>

| | |
|---|---|
| O | Toxicity Test Report, EG&G, Bionomics, January, 1977. |
| P | Computer Printouts, Probit Analyses of EG&G, Bionomics data. |
| Q | Histopathology Report. |

A

# APPENDIX A

# REPORT ON RELEASE CONDITIONS

BASED ON TESTING OF
APPROPRIATE SENSITIVE MARINE ORGANISMS

IN SUPPORT OF

E.I. DU PONT DE NEMOURS & COMPANY
GRASSELLI (LINDEN), NJ PLANT'S

APPLICATION FOR A SPECIAL PERMIT
TO
THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

UNDER THE
MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT

(P.L. 92-532)

JUNE 10, 1975

BY

W. C. GASKILL, ENGINEERING SERVICE DIVISION
ENGINEERING DEPARTMENT (DU PONT)

J. R. GIBSON, HASKELL LABORATORY FOR INDUSTRIAL
MEDICINE AND TOXICOLOGY
CENTRAL RESEARCH & DEVELOPMENT DEPARTMENT (DU PONT)

## SUMMARY

This report is submitted in support of E. I. du Pont de Nemours and Company's application for a Special Permit to continue ocean disposal of industrial wastes from its Grasselli Plant at Linden, New Jersey. Specifically, Du Pont requests that the determination of Limiting Permissible Concentration (LPC) as defined in 40 CFR 227.71 and the associated release procedure be made as follows:

1) The LPC be established by applying the 0.01 factor to the 4-hour LC50 to *Acartia tonsa* (the most sensitive organism of those specified by EPA for testing).

2) The mixing-release zone configuration set forth in 40 CFR 227.72 and 227.73 (i.e., 100 meters (M) on each side of the vessel to a depth of 20 meters) be applied in determining the volume available for dispersion.

Determination of LPC for the Grasselli Plant waste in this manner results in a permitted release of waste over a period of 5 hours at a speed of at least 5 knots, weather permitting.

The attached report of the requested release conditions shows that:

a) negligible, if any, harm will accrue to the environment under the requested conditions,

b) the calculated LPC provides for an adequate margin of safety when analyzed in terms of accepted time-toxicity-dispersion concepts,

c) dispersion rapidly reduces concentrations of the waste to well below safe levels within 10 to 20 hours,

d) the time frame during which the greatest potential for mortality exists is the first 10 hours after release,

e) increasing release time results in a negligible reduction in potential mortality.

In view of the above, Du Pont requests approval of the requested release procedure.

## RESULTS

The determination of rates at which industrial wastes can be discharged from a moving barge without unacceptable adverse environmental impact is essential to the conduct of an environmentally sound ocean dumping program. Inherent to these determinations is the establishment of toxicological parameters which ensure a negligible effect of such wastes on marine organisms. This proposal serves to outline procedures for evaluating acute toxicity data and the application of data in formulating environmentally acceptable discharge rates. The methods and procedures are consistent with the Final Regulations and Criteria on Ocean Dumping published pursuant to PL 92-532, on October 15, 1973.

### A. Bioassay

The Final Regulations and Criteria (October 15, 1973) under PL 92-532 require use of bioassays on appropriate sensitive marine organisms in establishing permissible concentrations of wastes during ocean disposal operations. Region II, EPA (R. T. Dewling, EPA, to R. D. Turner, Du Pont, Feb. 21, 1975) has specified the appropriate sensitive marine organisms as:

- Acartia tonsa (zooplankton),
- Skeletonema costatum (phyloplankton),
- Menidia menidia (finfish).

Du Pont has tested all three organisms using EPA-approved methodology and submitted data to Region II in May 1975. Since the zooplankton (Acartia tonsa) exhibited the most sensitivity to the subject wastes, this report addresses itself to that organism and the calculated safe release time based on that organism.

Acute bioassays were performed on Acartia tonsa to provide data which specifically defined LC50 (TLm) as a function of time, with emphasis on the initial exposure period. The time periods for these bioassays were 1, 4, and 8 hours. Additional LC50 values for 24 and 48 hours were determined from 96-hour data. Bioassays on 8 to 10 replicate waste samples were performed.

After all data had been obtained, LC50 calculations were made by Probit Analysis (Finney, 1952) so that the precision of the LC50 estimate could be determined (i.e., 95% Confidence Limits.) Slopes of the probit-mortality plots were statistically compared in order to determine whether or not there was significant variation in toxicity among the samples. Calculations of the LC01 concentrations were also made.

Computer printouts for all probit analyses are presented in Appendix I. Comparison of slopes for all probit-mortality lines revealed no significant differences among the observed LC50's at a given point in time. Thus, indicating no difference in the toxicity of replicate waste samples, and allowing use of the mean LC50 or LC01 as being representative of waste toxicity at each point in time. Distributions of observed LC50 values for the respective samples at each exposure time are presented in Figures 1-6. Mean LC50 and LC01 values are summarized in Table I and are graphically displayed in Figure 7.

B. Anticipated Dispersion

Du Pont has monitored the dispersion patterns of similar wastes discharged from a moving barge in the Gulf of Mexico. From this work, we have been able to conclude that the initial dispersion of wastes (up to 10 minutes) can be calculated with a high degree of accuracy. This dispersion has been shown to be a function of barge speed and discharge rate. The initial waste concentration in the wake of the barge has been shown to be described by the expression (See Figure 8):

$$Co = 0.1\ Q/V;$$ where

Co = the initial waste concentration in ppm

Q = discharge rate, in lb./min., and

V = barge speed, in knots.

Under the requested release conditions, Q = 31,000 lbs./min., and a barge speed of 5 knots, the initial concentration is expected to be 620 ppm.

The results of Du Pont's monitoring in the Gulf of Mexico have been reviewed relative to the dispersion models of Hydroscience, Inc. and Clark, et al (1971). The measured dispersion patterns are consistent with the behavior predicted by both models. Figure 9 shows how wastes were diluted behind a moving barge during those dispersion tests. Subsequent to initial mixing in the immediate barge wake, additional dispersion to 0.1 of the initial wake concentration occurred in from 0.5 to 3.5 hours. Typically, dispersion reduced the initial concentration by 0.01 in 6 to 8 hours.

C. Calculated Release Time

Du Pont has requested that LPC be derived from the 4-hour LC50 to *Acartia tonsa*. Thus, based upon the mean 4-hour LC50, LPC is determined to be 19.1 ppm (0.01 x 1911 ppm).

Applying to this value, the release/mixing zone concept as specified by the regulations, the following calculations are performed:

LPC = 19.1 ppm (V/V)

Total volume of waste to be discharged = $1 \times 10^6$ gallons

- Thus,

Volume of dilution water required to reach LPC = $\frac{1 \times 10^6 \text{ gal.}}{19.1 \text{ gal.}/10^6 \text{ gal.}}$

= $5.23 \times 10^{10}$ gal.

$1 \; M^3 = 264.17$ gal.

- Thus,

Volume of diluent sea water = volume of required release/

mixing zone =

$$\frac{5.23 \times 10^{10} \text{ gal.}}{2.6417 \times 10^2 \text{ gal.}/M^3} = 1.98 \times 10^8 \; M^3$$

Release zone = 100 M + 100 M + 15 M = 215 M Wide

Mixing zone = 20 M Deep

- Thus,

$$\text{Length of release/mixing zone} = \frac{1.98 \times 10^8 \; M^3}{(215M)\;(20M)} = 46{,}000M$$

1 M = 3.28 ft.

- Thus,

Length of zone - 3.28 ft./M x 46,000 M = 151,000 ft.

1 Nautical mile = 6,076 ft.

- Thus,

$$\text{Length of zone} = \frac{151{,}000 \text{ ft.}}{6{,}076 \text{ ft./mile (naut.)}} = 24.9 \text{ Nautical miles}$$

Barge speed = 5 knots = 5 nautical miles/hour

- Thus,

$$\text{Release time} = \frac{24.9\text{NM}}{5\text{NM/hr.}} = 4.97 \text{ hours (i.e., 5 hours)}$$

The Final Regulations and Criteria for Ocean Disposal contain the following definitions:

§ 227.7 Definitions.

§ 227.71 Limiting permissible concentrations.

The limiting permissible concentration is:

(a) That concentration of a waste material or chemical constituent in the receiving water which, after reasonable allowance for initial mixing in the mixing zone, will not exceed 0.01 of a concentration shown to be toxic to appropriate sensitive marine organisms in a bioassay carried out in accordance with approved EPA procedures; or

(b) 0.01 of a concentration of a waste material or chemical constituent otherwise shown to be detrimental to the marine environment.

§ 227.72 Release zone.

A release zone is the area swept out by the locus of points constantly 100 meters from the perimeter of the conveyance engaged in dumping activities, beginning at the first moment in which dumping is scheduled to occur and ending at the the last moment in which dumping is scheduled to occur. For disposal through an outfall or other fixed stucture, the release zone is measured from the point at which the waste material enters the ocean if no diffuser is used, or from the length of outfall along which diffuser ports are located.

§ 227.73 Mixing zone.

(a) The mixing zone is the region into which a waste is initially dumped or otherwised discharged, and into which the waste will mix to a relatively uniform concentration within four hours after dumping. It is required that the concentration of all waste materials or trace contaminants be at, or below, the limiting permissible concentration at the boundaries of the mixing zone at all times and within the mixing zone four hours after discharge. The actual configuration of a mixing zone will depend upon vessel speed, method of disposal, type of waste, and ocean current and wave conditions. For the purposes of these regulations a volume equivalent to that of a mixing zone is the column of water immediately contiguous to the release zone, beginning at the surface of the water and ending at the ocean floor, the thermocline or halocline, if one exists, or 20 meters, whichever is the shortest distance.

(b) For disposal through an outfall or other structure, the volume of the mixing zone will be measured by projecting the release zone at the depth of the point of release or the waste to the nearest hydrodynamic discontinuities above and below that point, but in no case exceeding 20 meters in total distance. Diffusion of wastes beyond the limits of the mixing zone will be estimated by standard oceanographic methods of calculation acceptable to the Administrator or his designee.

Using the 4-hour LC50 as the basis for determining LPC is consistent with Section 227.71. An LPC determined on the basis of the 4-hour LC50 of the Grasselli waste to Acartia tonsa is appropriate and provides the margins of safety necessary for obviating toxicity as a result of a 5-hour release time. Figure 10 shows the relationship of LC50 and LC01 from 1 through 96 hours to the LPC derived from the 4-hour LC50 (i.e., 19.1 ppm). The significant feature of this Figure is the greater than tenfold difference between LC01 and LPC at all points in time after discharge. However, the regulatory concept of LPC assumes instantaneous dilution within the mixing zone to a uniform concentration (LPC) -- a phenomenon which does not occur in actual practice. Thus, until such time as dispersion and dilution mechanisms reduce waste concentrations to the LPC, higher-than-LPC concentrations will be realized within the mixing zone.

Figure 11 superimposes the Phase II dispersion envelope (Figure 9) upon LC50, LC01, and LPC (Figure 10). Significant features of Figure 11 are:

- LPC is attained within approximately 1 to 10 hours after discharge.
- At no point in time before attainment of LPC is an LC01 concentration for that point in time realized.

Thus, when either LPC or actual dispersion is considered in light of time and toxicity, there is clear evidence that margins of safety, which will obviate deleterious effects are achieved; even when the 4-hour LC50 is used as the basis for determining LPC.

Finally, it is appropriate to examine the effect of increasing release time (i.e., lowering LPC) upon estimated waste concentrations.

The effect (upon concentration) of doubling (10 hours) and quadrupling (20 hours) the requested release time of 5 hours is illustrated in Figure 12 which demonstrates that no appreciable differences in actual waste concentration-relative to toxic concentrations are realized with increased release time. Thus, time-mortality-concentration relationships are virtually unchanged. Furthermore, it is essential to realize that regardless of the release time, the time required to reach LPC remains constant (i.e., 1 to 10 hours).

Summary:

Du Pont has described the toxicity of its Grasselli Plant's barged waste as a function of time through 96-hours of exposure; using EPA-approved methodology. The total time-mortality syndrome has been considered in light of an LPC derived from the 4-hour LC50 as well as estimated dispersion/dilution. These considerations are consistent with the Final Regulations and Criteria for Ocean Disposal and demonstrate that these wastes can be safely discharged into the marine environment under requested discharge conditions of 5 hours release time at a barge speed of 5 knots.

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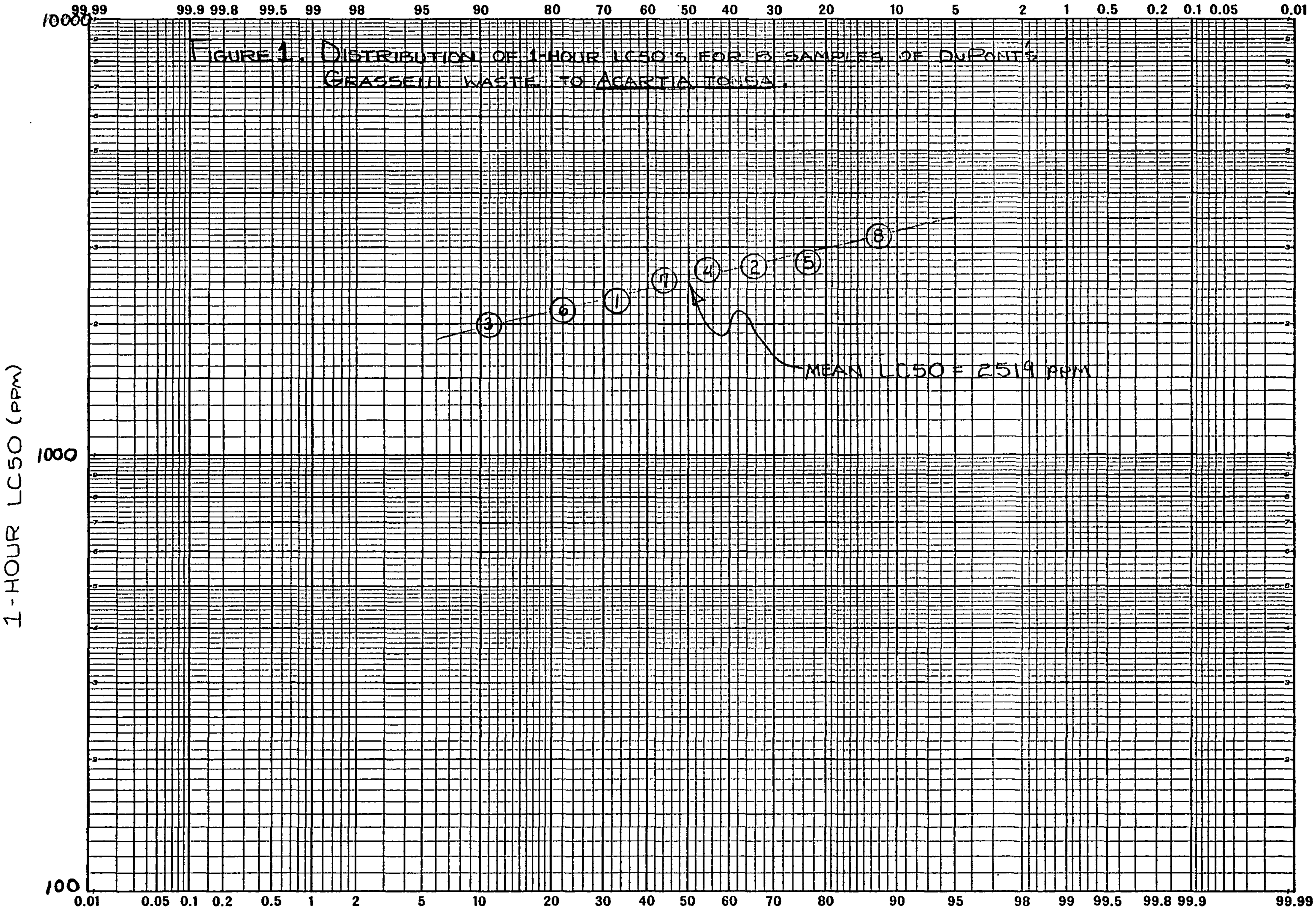
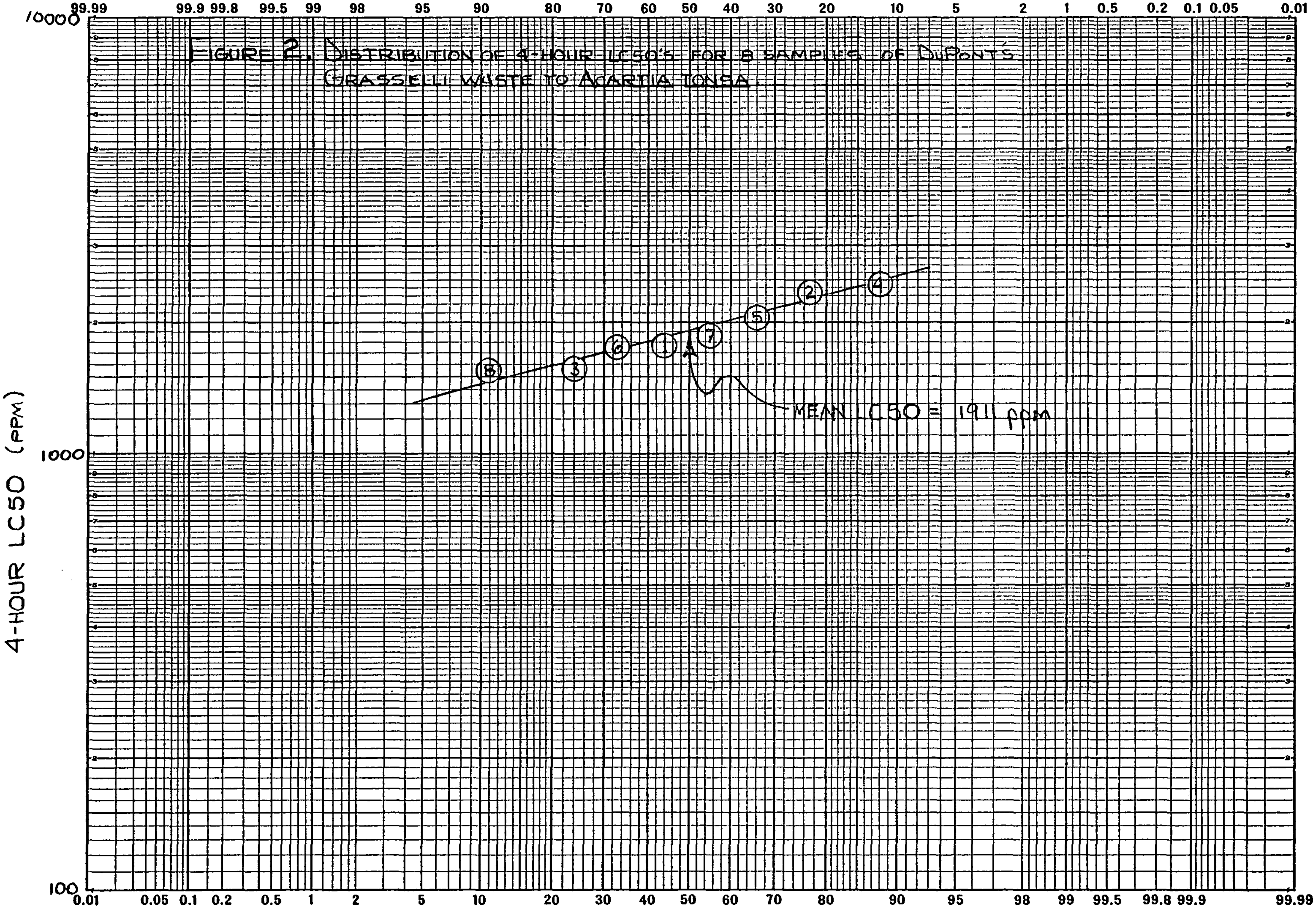



FIGURE 1. DISTRIBUTION OF 1-HOUR LC50'S FOR 8 SAMPLES OF DUPONT'S GRASSELLI WASTE TO ACARTIA TONSA.

FIGURE 2. DISTRIBUTION OF 4-HOUR LC50'S FOR 8 SAMPLES OF DUPONT'S GRASSELLI WASTE TO ACARTIA TONSA.



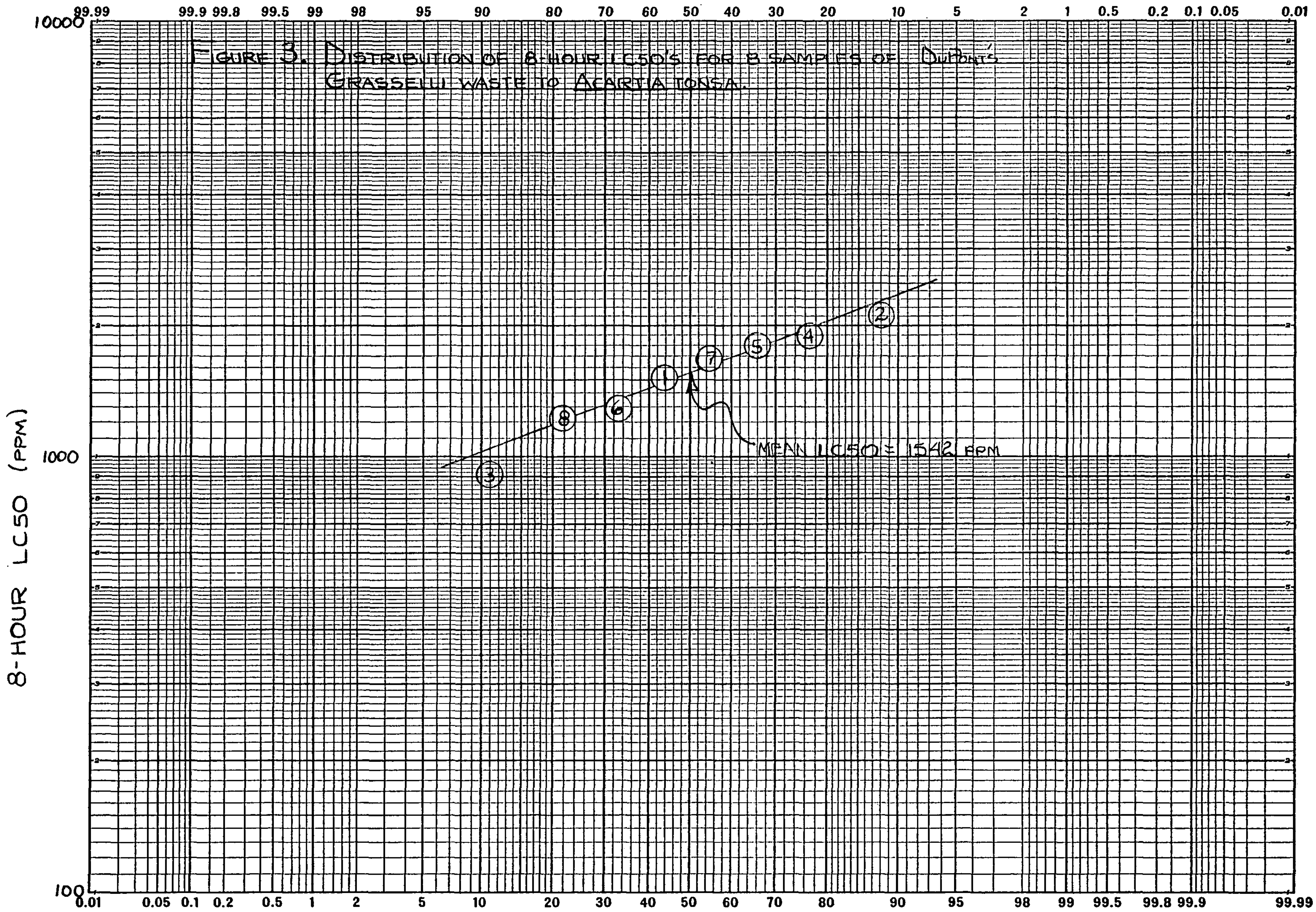



FIGURE 3. DISTRIBUTION OF 8-HOUR LC50'S FOR 8 SAMPLES OF DUPONT'S GRASSELLI WASTE TO ACARTIA TONSA.

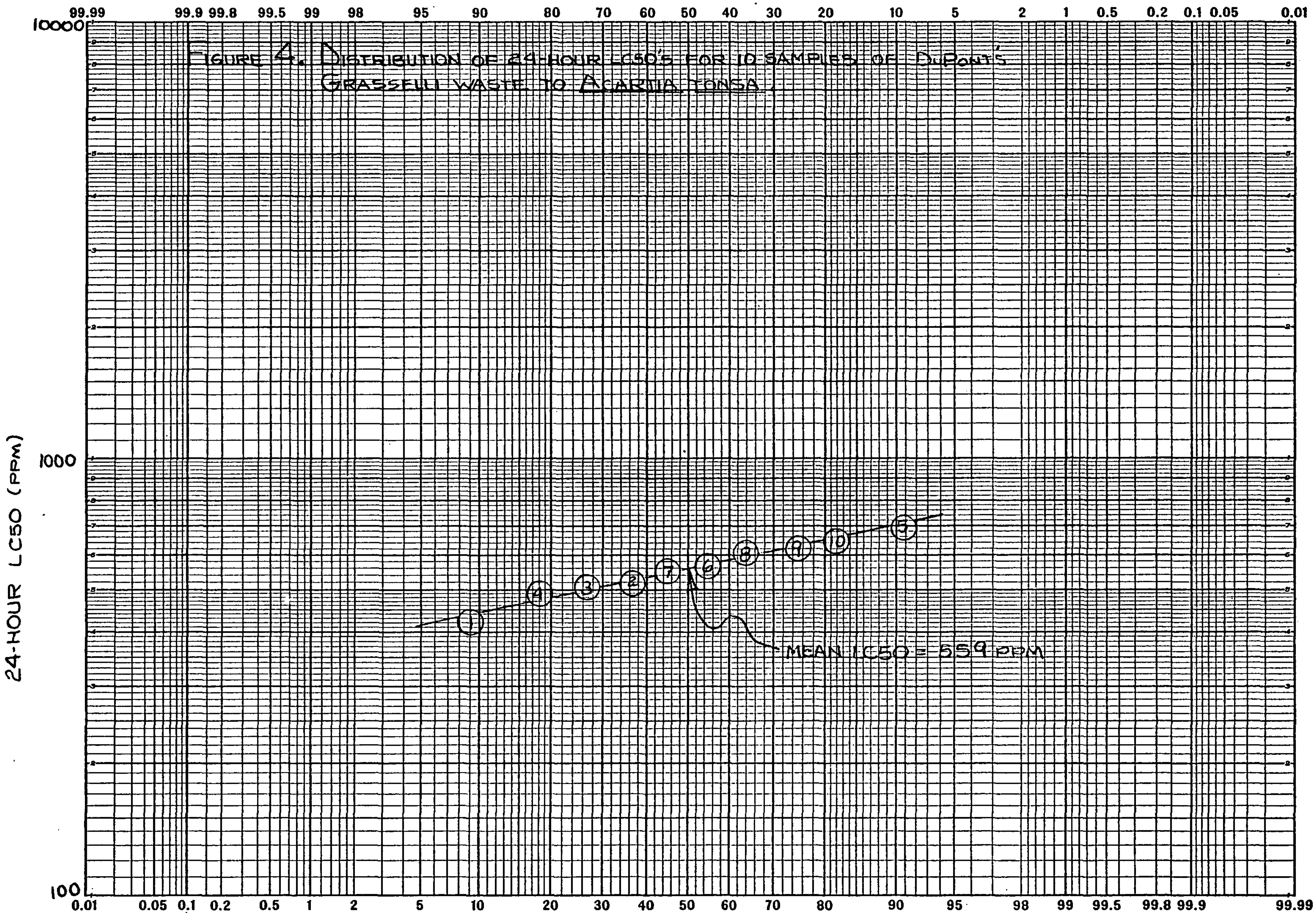
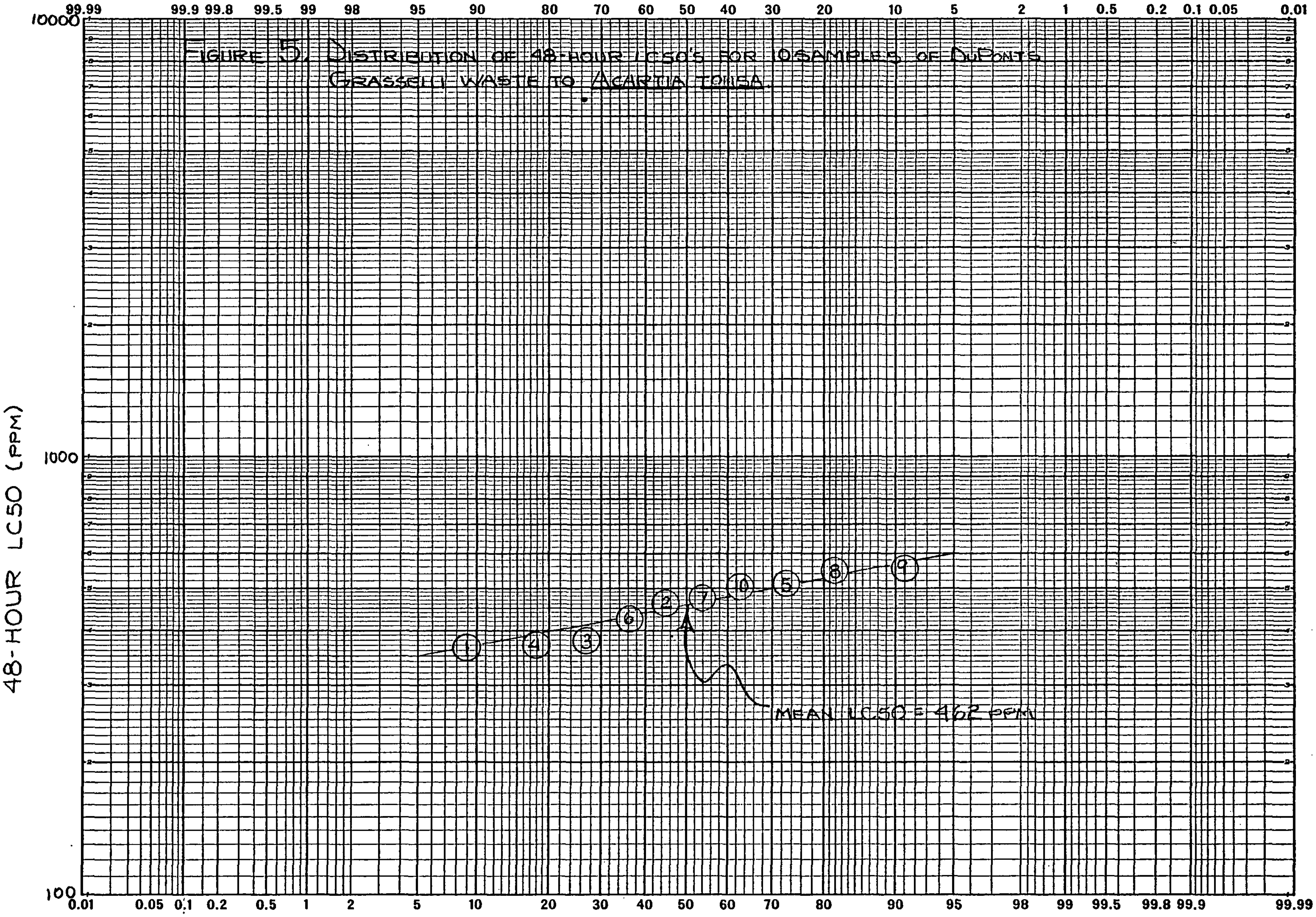



FIGURE 4. DISTRIBUTION OF 24-HOUR LC50'S FOR 10 SAMPLES OF DUPONT'S GRASSELLI WASTE TO ACARTIA TONSA.

NO. 3228. LOGARITHMIC PROBABILITY. DESIGNED BY HAZEN, WHIPPLE & FULLER. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS. PRINTED IN U.S.A.

FIGURE 5. DISTRIBUTION OF 48-HOUR LC50'S FOR 10 SAMPLES OF DUPONT'S GRASSELLI WASTE TO *ACARTIA TONSA*.



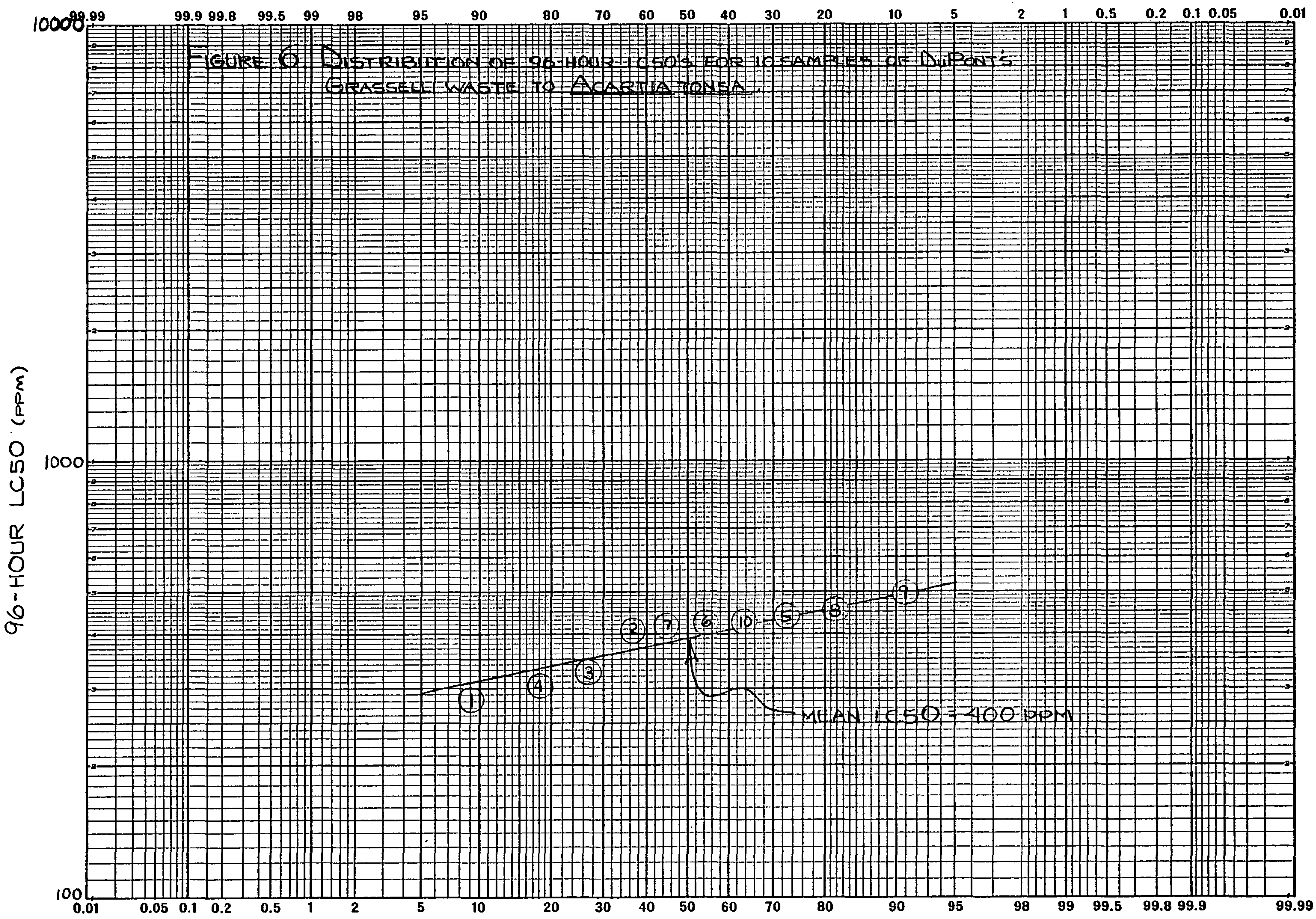



FIGURE 6. DISTRIBUTION OF 96-HOUR LC50'S FOR 10 SAMPLES OF DUPONT'S GRASSELLI WASTE TO *ACARTIA TONSA*.

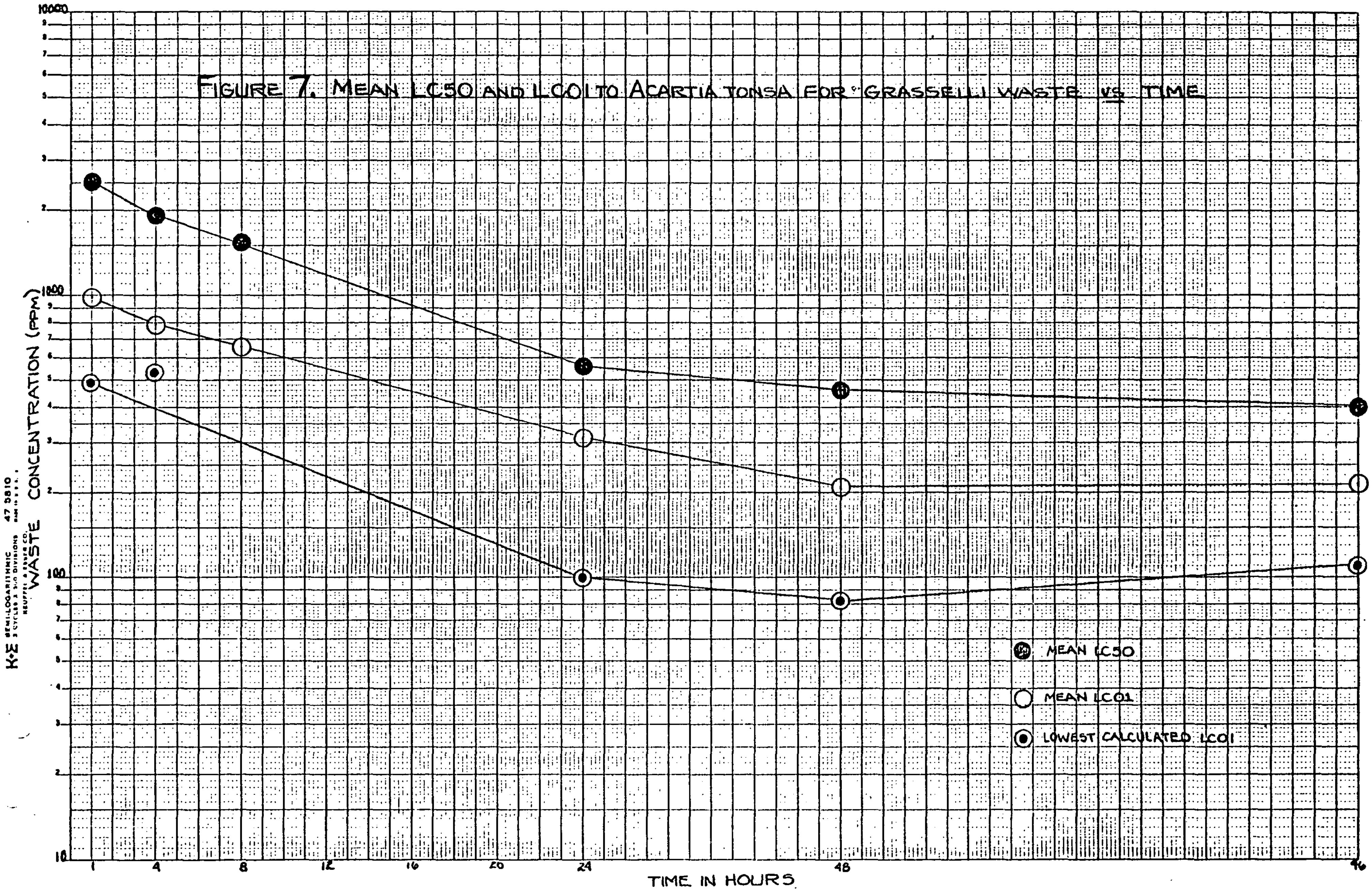
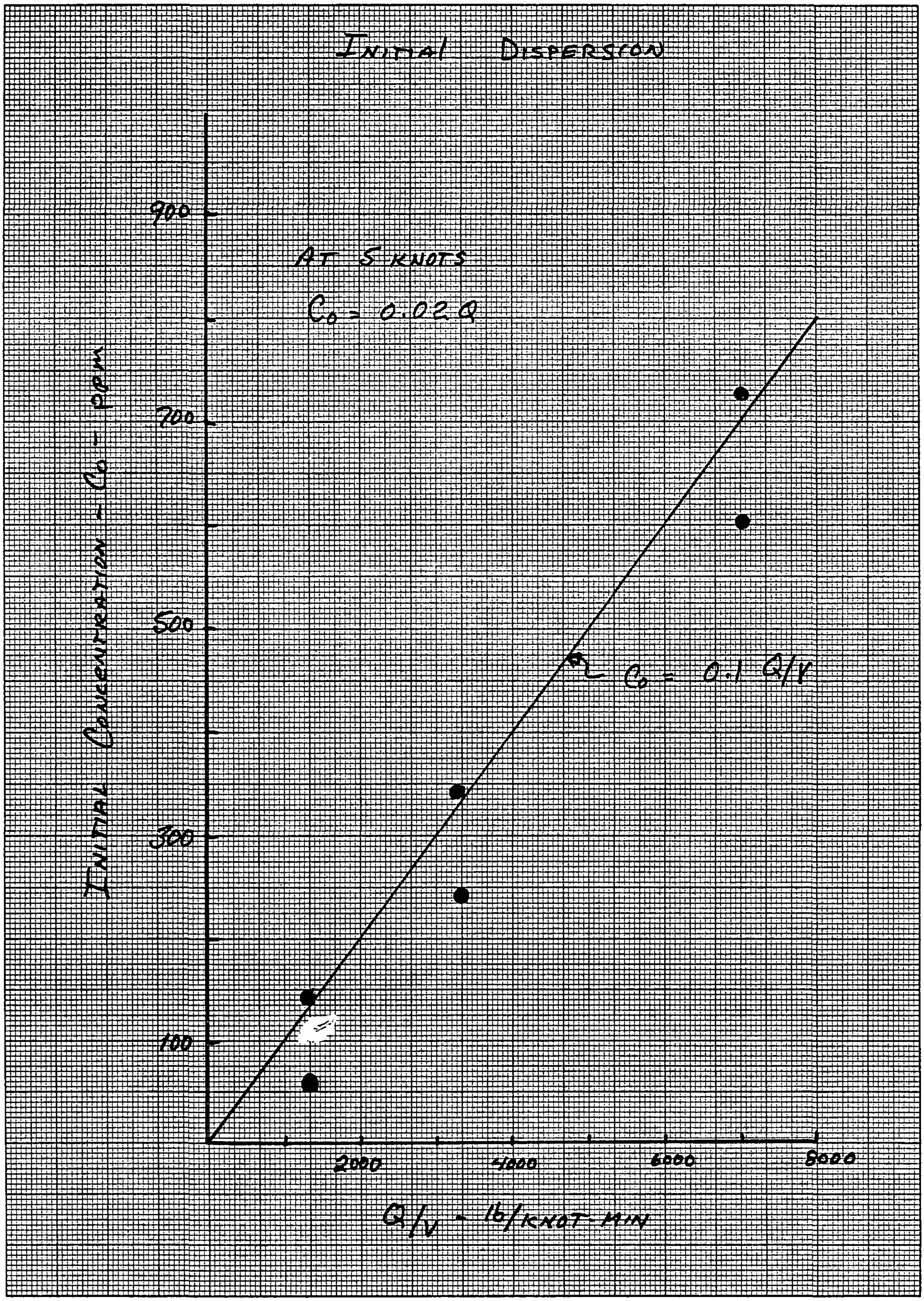


FIGURE 7. MEAN LC50 AND LC01 TO ACARTIA TONSA FOR GRASSELLI WASTE vs TIME
WASTE CONCENTRATION (PPM)
TIME IN HOURS
10000
1000
100
10
1
4
8
12
16
20
24
48
96
MEAN LC50
MEAN LC01
LOWEST CALCULATED LC01
K+E SEMI-LOGARITHMIC 47 5810
3 CYCLES X 140 DIVISIONS
KEUFFEL & ESSER CO.

FIGURE 8


INITIAL DISPERSION
AT 5 KNOTS
$C_o$ = 0.02 Q
$C_o$ = 0.1 Q/V
INITIAL CONCENTRATION - $C_o$ - PPM
900
700
500
300
100
2000
4000
6000
8000
Q/V - lb/KNOT-MIN

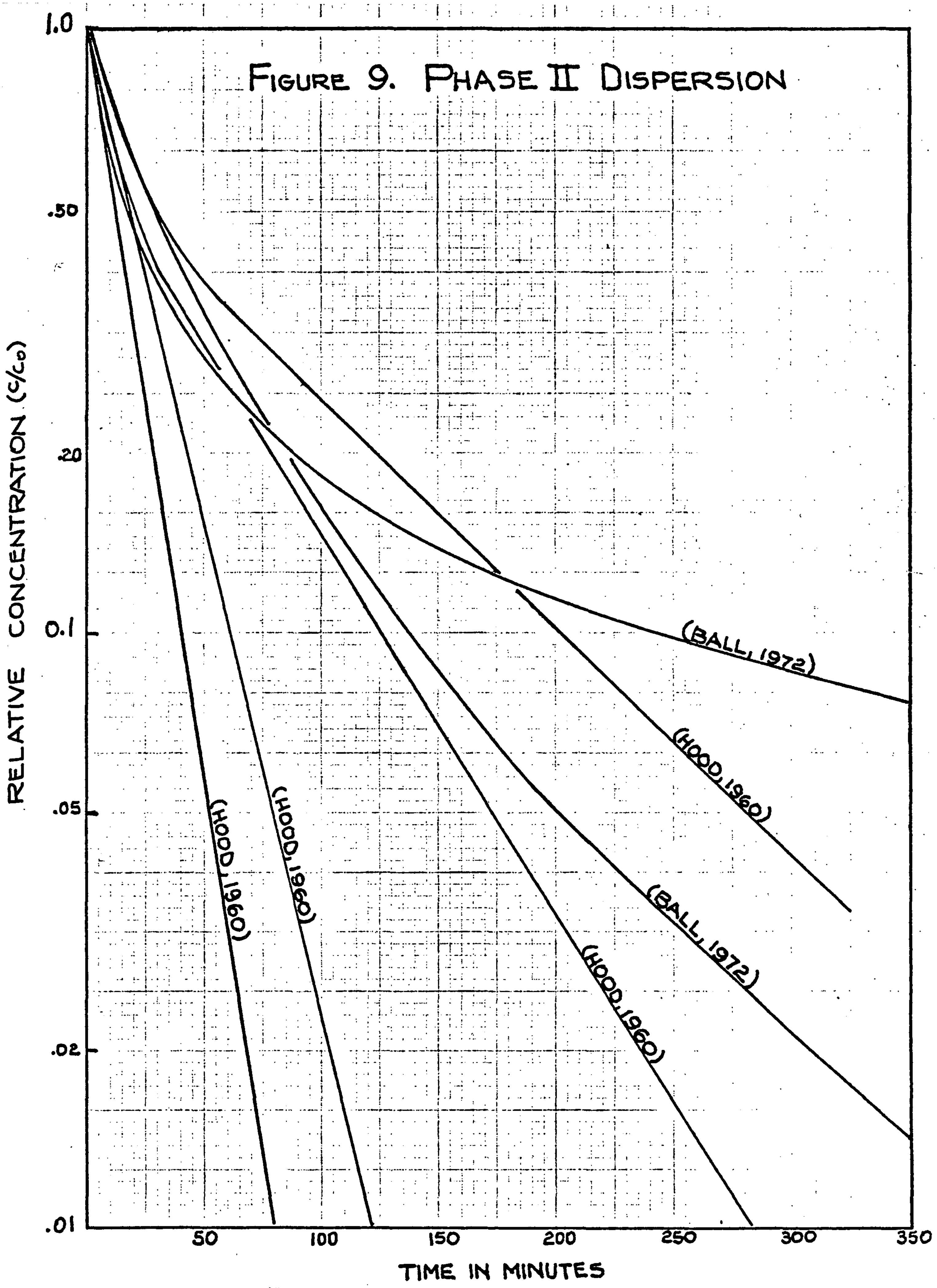


FIGURE 9. PHASE II DISPERSION
RELATIVE CONCENTRATION (C/C0)
1.0
.50
.20
0.1
.05
.02
.01
50
100
150
200
250
300
350
TIME IN MINUTES
(BALL, 1972)
(HOOD, 1960)
(BALL, 1972)
(HOOD, 1960)
(HOOD, 1960)
(HOOD 1960)

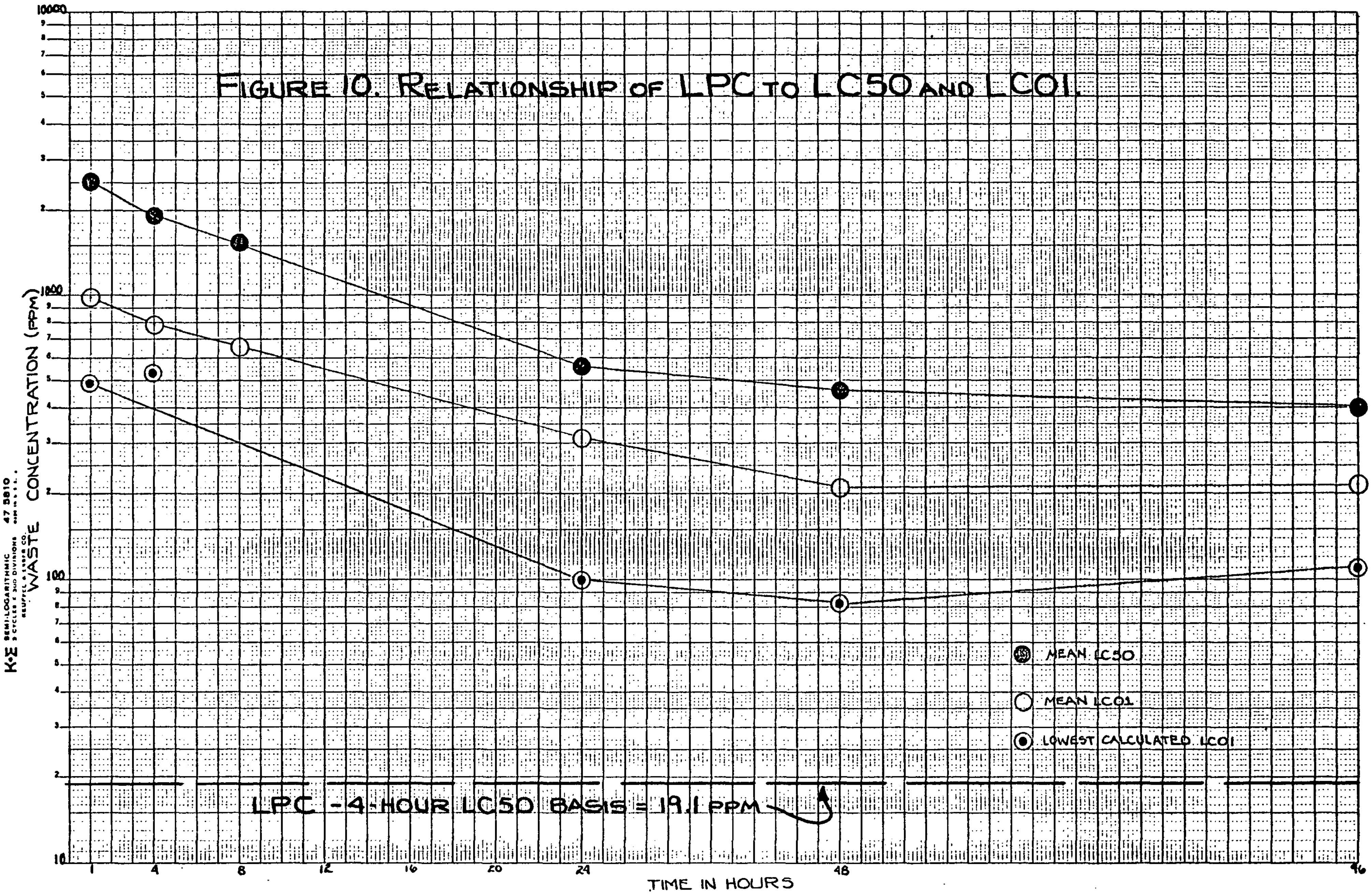


FIGURE 10. RELATIONSHIP OF LPC TO LC50 AND LC01.
WASTE CONCENTRATION (PPM)
TIME IN HOURS
10000
1000
100
10
1
4
8
12
16
20
24
48
96
MEAN LC50
MEAN LC01
LOWEST CALCULATED LC01
LPC - 4-HOUR LC50 BASIS = 19.1 PPM
K+E SEMI-LOGARITHMIC 47 5810
3 CYCLES X 200 DIVISIONS
KEUFFEL & ESSER CO.

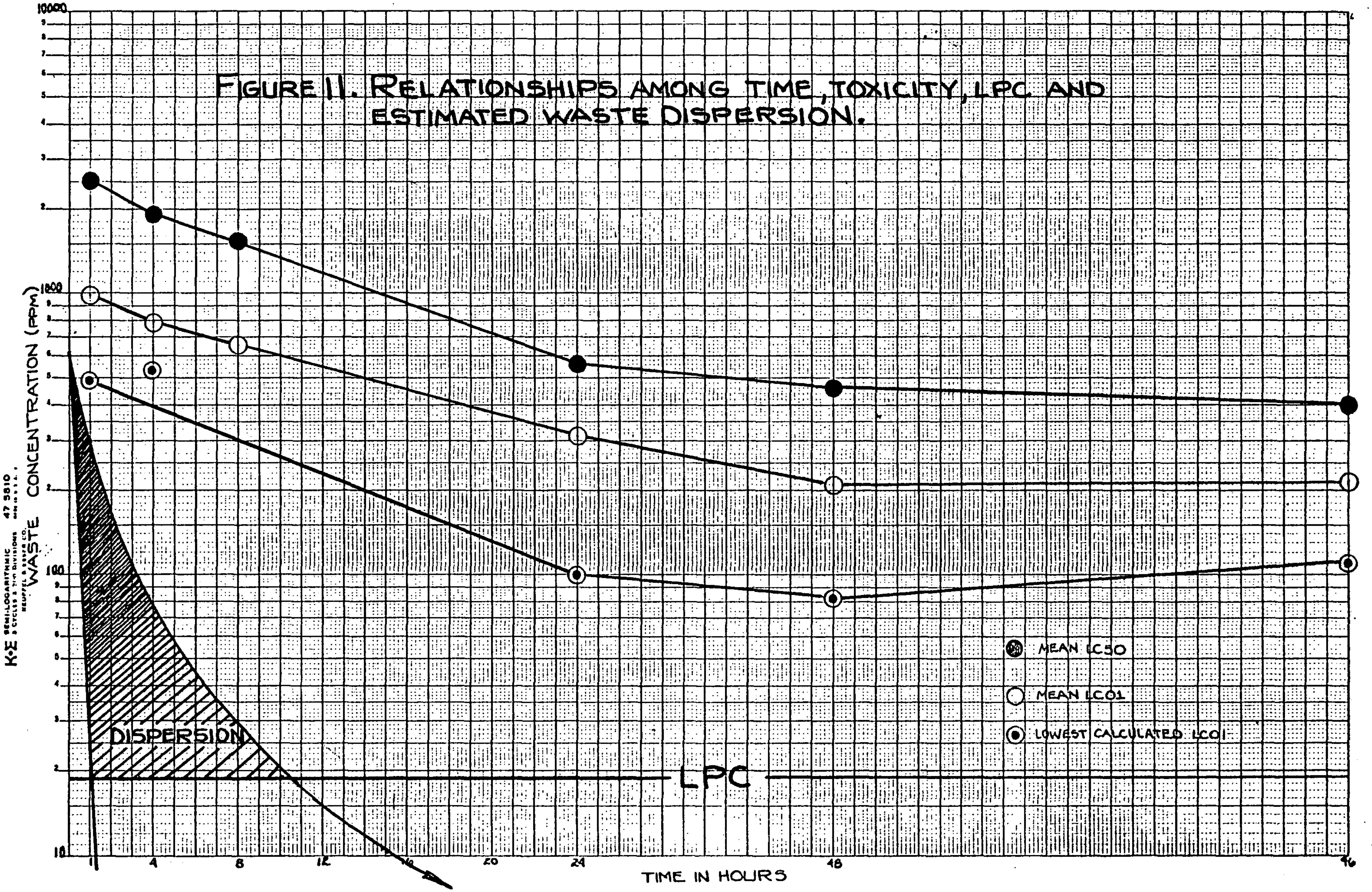



FIGURE 11. RELATIONSHIPS AMONG TIME, TOXICITY, LPC AND ESTIMATED WASTE DISPERSION.

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-1   4 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 1000.0000 | 3.0000 | 20. | 4. | .2000 | 4.1585 |
| 1500.0000 | 3.1761 | 20. | 7. | .3500 | 4.6151 |
| 2000.0000 | 3.3010 | 20. | 12. | .6000 | 5.2529 |
| 2500.0000 | 3.3979 | 20. | 11. | .5500 | 5.1254 |
| 3000.0000 | 3.4771 | 20. | 16. | .8000 | 5.8415 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |
| 4000.0000 | 3.6021 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 6 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .0925
TOTAL NUMBER OF CYCLES = 5

SUMMARY STATISTICS

AVG Y = 5.350447
AVG X = 3.328060
AVG T = 1.356333
NATURAL MORTALITY = .000002   SE = .000481
SLOPE = 4.482437   SE = .695539
T STATISTIC = SLOPE/SE = 6.444552
INTERCEPT = -9.567366
CHI SQUARED = 8.545459

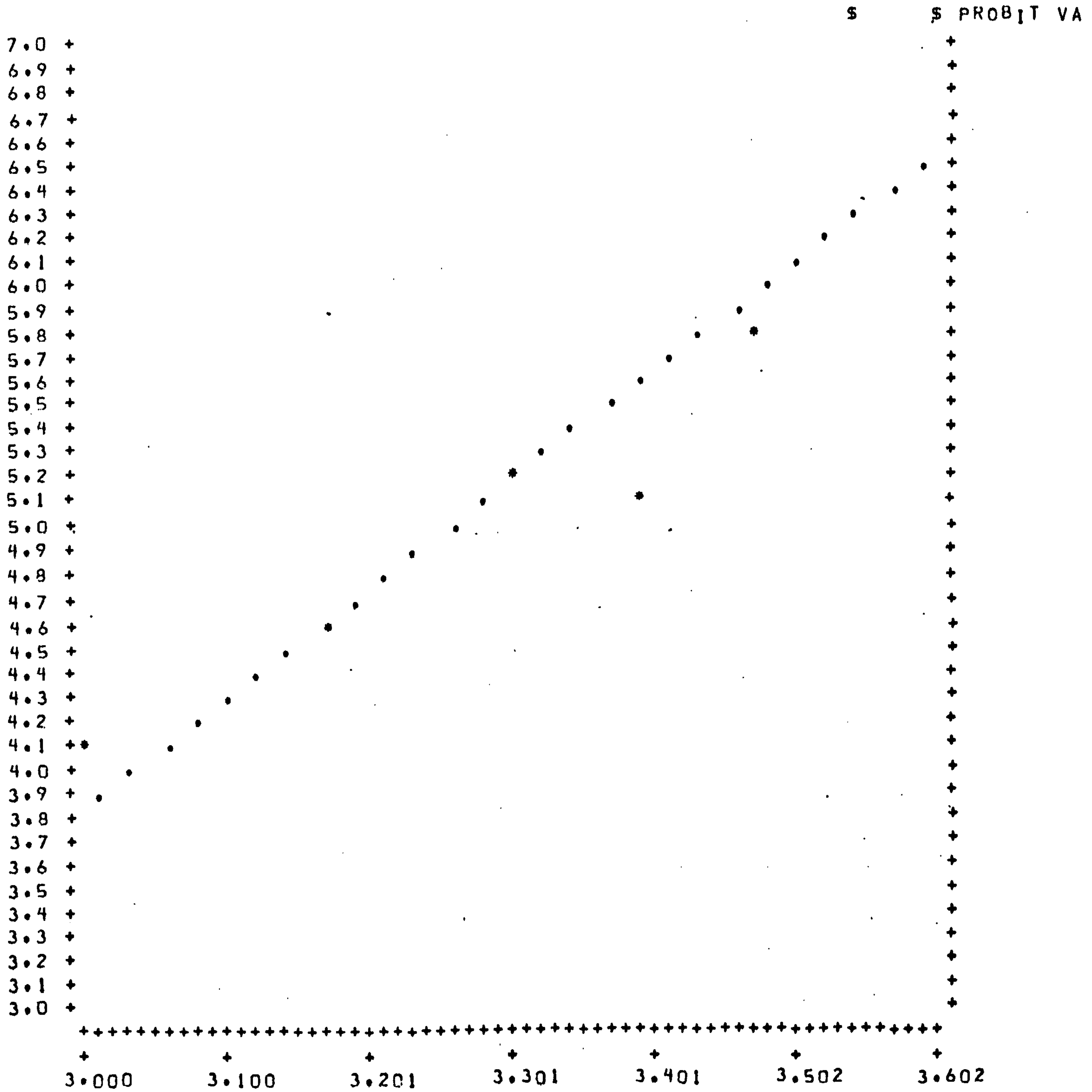
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 538.1401 | 289.5954 | 755.5568 |
| P = .05 | 763.6790 | 476.0382 | 994.1138 |
| P = .10 | 920.3660 | 619.3561 | 1152.8129 |
| P = .20 | 1153.7759 | 849.0410 | 1383.8923 |
| P = .50 | 1777.7738 | 1508.9690 | 2018.9909 |
| P = .80 | 2739.2487 | 2401.8135 | 3288.9631 |
| P = .90 | 3433.9374 | 2928.5051 | 4438.9895 |
| P = .95 | 4138.4910 | 3417.2953 | 5739.4297 |
| P = .99 | 5872.9670 | 4521.1603 | 9382.5438 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-1   4 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   4.4824, INTERCEPT=   -9.5674
NATURAL RESPONSE RATE=   .0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-1   8 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .(

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 1000.0000 | 3.0000 | 20. | 4. | .2000 | 4.1585 |
| 1500.0000 | 3.1761 | 20. | 8. | .4000 | 4.7471 |
| 2000.0000 | 3.3010 | 20. | 16. | .8000 | 5.8415 |
| 2500.0000 | 3.3979 | 20. | 18. | .9000 | 6.2817 |
| 3000.0000 | 3.4771 | 20. | 18. | .9000 | 6.2817 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |
| 4000.0000 | 3.6021 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 6 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .0882
TOTAL NUMBER OF CYCLES = 4

SUMMARY STATISTICS

AVG Y = 5.475922
AVG X = 3.265086
AVG T = 1.315386
NATURAL MORTALITY = .000000   SE = .000256
SLOPE = 5.547203   SE = .840577
T STATISTIC = SLOPE/SE = 6.599276
INTERCEPT = -12.636168
CHI SQUARED = 2.948767

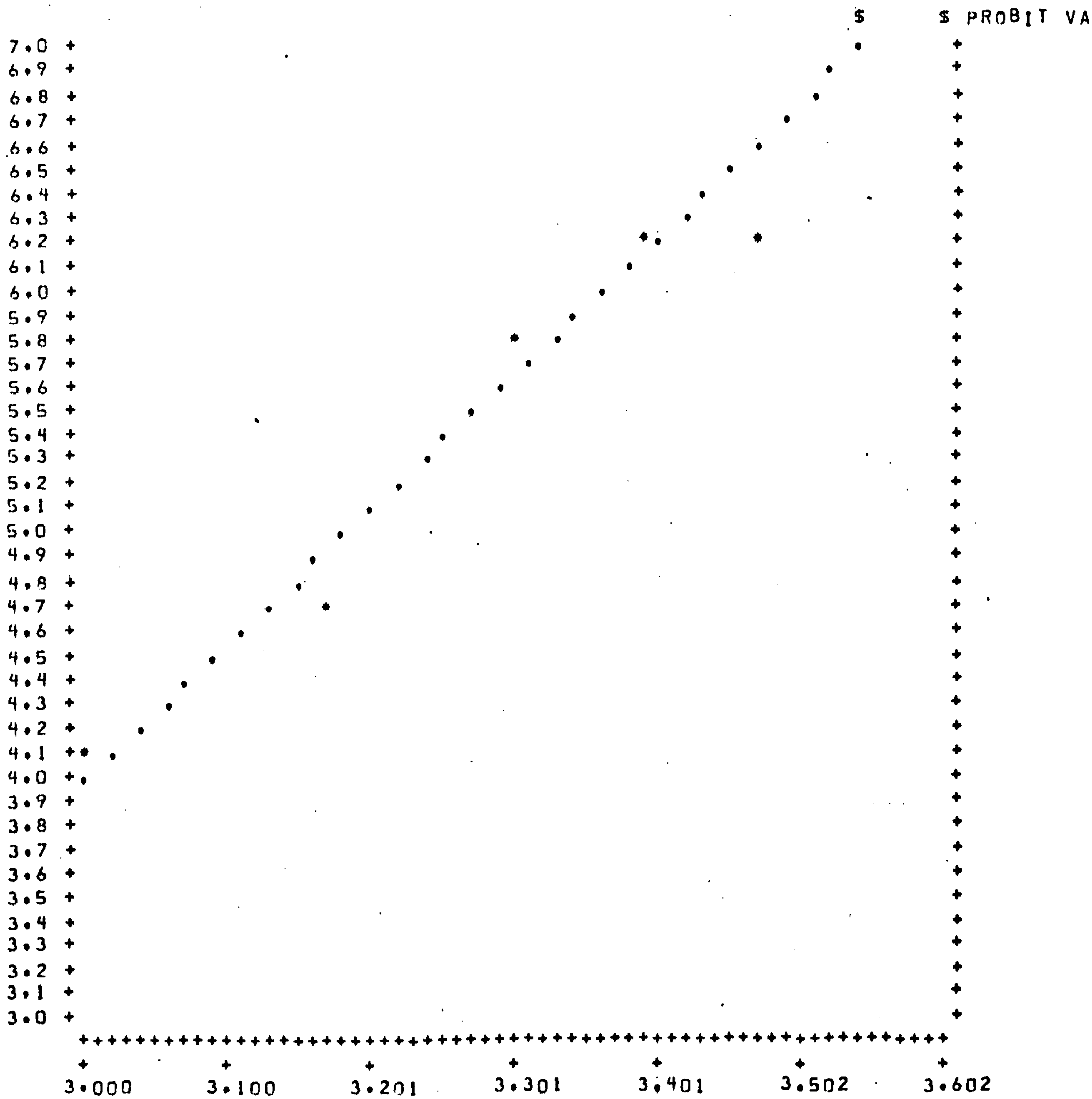
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 575.3416 | 345.1820 | 765.7036 |
| P = .05 | 763.4181 | 513.1688 | 957.8323 |
| P = .10 | 887.6770 | 632.9785 | 1080.9803 |
| P = .20 | 1065.5508 | 813.9034 | 1254.9304 |
| P = .50 | 1511.0900 | 1290.3026 | 1703.2898 |
| P = .80 | 2142.9221 | 1904.5810 | 2482.9505 |
| P = .90 | 2572.3239 | 2254.2955 | 3131.4287 |
| P = .95 | 2991.0116 | 2565.7729 | 3829.9408 |
| P = .99 | 3968.7596 | 3234.7726 | 5649.4667 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-1 8 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 5.5472, INTERCEPT= -12.6362,
NATURAL RESPONSE RATE= .0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-1 24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 1. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 200.0000 | 2.3010 | 20. | 0. | .0001 | 1.2809 |
| 250.0000 | 2.3979 | 20. | 0. | .0001 | 1.2809 |
| 300.0000 | 2.4771 | 20. | 2. | .0315 | 3.1408 |
| 350.0000 | 2.5441 | 20. | 2. | .0315 | 3.1408 |
| 400.0000 | 2.6021 | 20. | 8. | .3544 | 4.6268 |
| 450.0000 | 2.6532 | 20. | 15. | .7310 | 5.6154 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .3896
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 4.967285
AVG X = 2.621008
AVG T = 2.012092
NATURAL MORTALITY = .070697 SE = .028530
SLOPE = 21.001904 SE = 6.688589
T STATISTIC = SLOPE/SE = 3.139960
INTERCEPT = -50.078871
CHI SQUARED = .465868
B( 25) - B( 24) = -.0037003

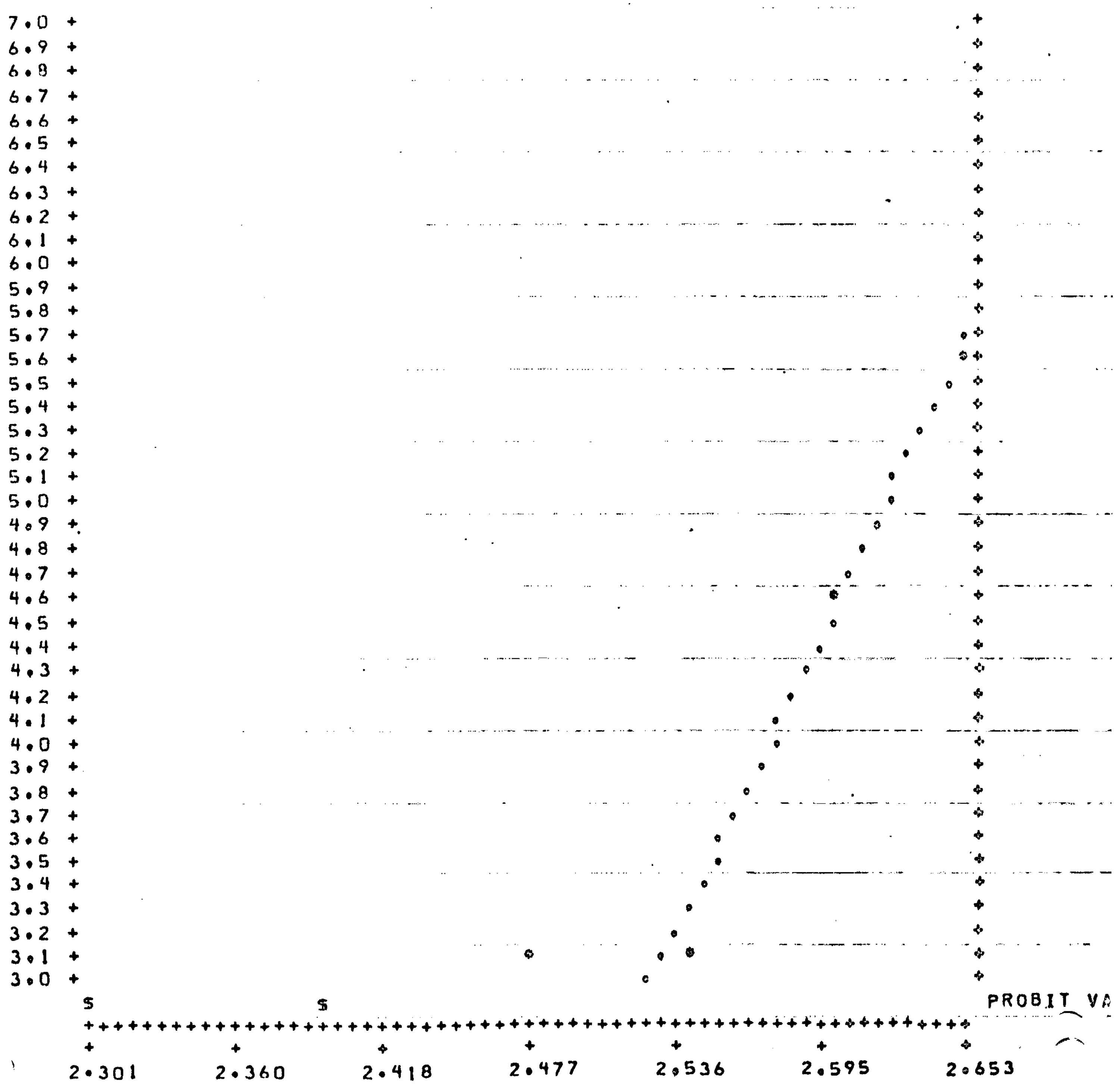
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 324.9371 | 210.3836 | 361.2935 |
| P = .05 | 350.1418 | 255.9397 | 379.3566 |
| P = .10 | 364.3699 | 283.8272 | 389.7751 |
| P = .20 | 382.3780 | 320.9332 | 403.7411 |
| P = .50 | 419.3392 | 393.6359 | 445.3803 |
| P = .80 | 459.8731 | 435.9862 | 544.0776 |
| P = .90 | 482.6013 | 451.7862 | 614.9648 |
| P = .95 | 502.2118 | 464.2598 | 681.8751 |
| P = .99 | 541.1674 | 487.5290 | 829.4283 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-1   24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 21.0019, INTERCEPT= -50.0784,
NATURAL RESPONSE RATE= .0707

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-1 48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 1. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 200.0000 | 2.3010 | 20. | 3. | .0523 | 3.3771 |
| 250.0000 | 2.3979 | 20. | 2. | .0001 | 1.2809 |
| 300.0000 | 2.4771 | 20. | 8. | .3311 | 4.5635 |
| 350.0000 | 2.5441 | 20. | 8. | .3311 | 4.5635 |
| 400.0000 | 2.6021 | 20. | 11. | .4983 | 4.9958 |
| 450.0000 | 2.6532 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 6

THERE IS AT LEAST ONE EXPECTED VALUE LESS THAN 5.

| DOSE | # RESPONSES | EXPECTED |
|---|---|---|
| 200.0000 | 3. | 2.0878 |
| 250.0000 | 2. | 2.6243 |
| 300.0000 | 8. | 5.1270 |
| 350.0000 | 8. | 9.7427 |
| 400.0000 | 11. | 14.3750 |
| 450.0000 | 20. | 17.4627 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 2.4213
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 2.7760
G = 1.2569
TOTAL NUMBER OF CYCLES = 9

SUMMARY STATISTICS

AVG Y = 5.132051
AVG X = 2.571294
AVG T = 1.682624
NATURAL MORTALITY = .103077 SE = .070447
SLOPE = 11.496858 SE = 4.643143
T STATISTIC = SLOPE/SE = 2.476094
INTERCEPT = -24.429797
CHI SQUARED = 9.685203 SIGNIF. AT .05

NONSIGNIFICANT REGRESSION

G GREATER THAN 1., CONFIDENCE LIMITS ARE NOT DEFINED

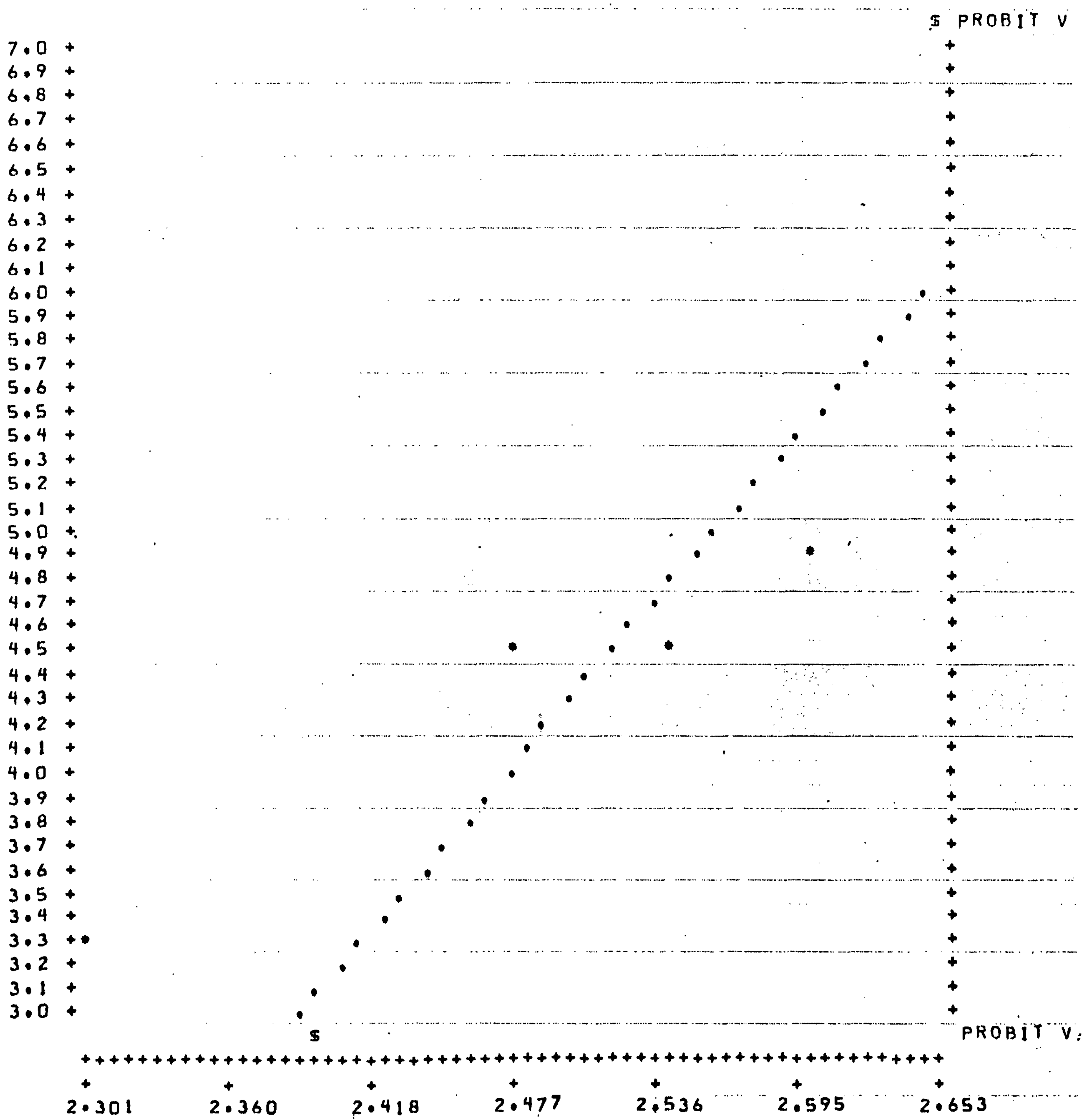
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 227.7560 | XXXXXXXXXXX | XXXXXXXXXXX |
| P = .05 | 261.0587 | XXXXXXXXXXX | XXXXXXXXXXX |
| P = .10 | 280.7618 | XXXXXXXXXXX | XXXXXXXXXXX |
| P = .20 | 306.6263 | XXXXXXXXXXX | XXXXXXXXXXX |
| P = .50 | 362.9209 | XXXXXXXXXXX | XXXXXXXXXXX |
| P = .80 | 429.5509 | XXXXXXXXXXX | XXXXXXXXXXX |
| P = .90 | 469.1221 | XXXXXXXXXXX | XXXXXXXXXXX |
| P = .95 | 504.5287 | XXXXXXXXXXX | XXXXXXXXXXX |
| P = .99 | 578.3014 | XXXXXXXXXXX | XXXXXXXXXXX |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-1   48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 11.4969, INTERCEPT= -24.4298,
NATURAL RESPONSE RATE= .1031

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-1   96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20.  # DEATHS = 1.  NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 200.0000 | 2.3010 | 20. | 7. | .2914 | 4.4510 |
| 250.0000 | 2.3979 | 20. | 6. | .2369 | 4.2838 |
| 300.0000 | 2.4771 | 20. | 13. | .6184 | 5.3009 |
| 350.0000 | 2.5441 | 20. | 12. | .5639 | 5.1606 |
| 400.0000 | 2.6021 | 20. | 20. | .9999 | 8.7191 |
| 450.0000 | 2.6532 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS  5  6

THERE IS AT LEAST ONE EXPECTED VALUE LESS THAN 5.

| DOSE | # RESPONSES | EXPECTED |
|---|---|---|
| 200.0000 | 7. | 4.0488 |
| 250.0000 | 6. | 8.2115 |
| 300.0000 | 13. | 12.6700 |
| 350.0000 | 12. | 15.9987 |
| 400.0000 | 20. | 18.0028 |
| 450.0000 | 20. | 19.0601 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 3.0516
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 2.7760
G = .9449
TOTAL NUMBER OF CYCLES = 22

SUMMARY STATISTICS

AVG Y = 5.352813
AVG X = 2.489683
AVG T = 1.326270
NATURAL MORTALITY = .082748   SE = .104995
SLOPE = 7.828596   SE = 2.741304
T STATISTIC = SLOPE/SE = 2.855792
INTERCEPT = -14.137914
CHI SQUARED = 12.206326   SIGNIF. AT .05

| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|

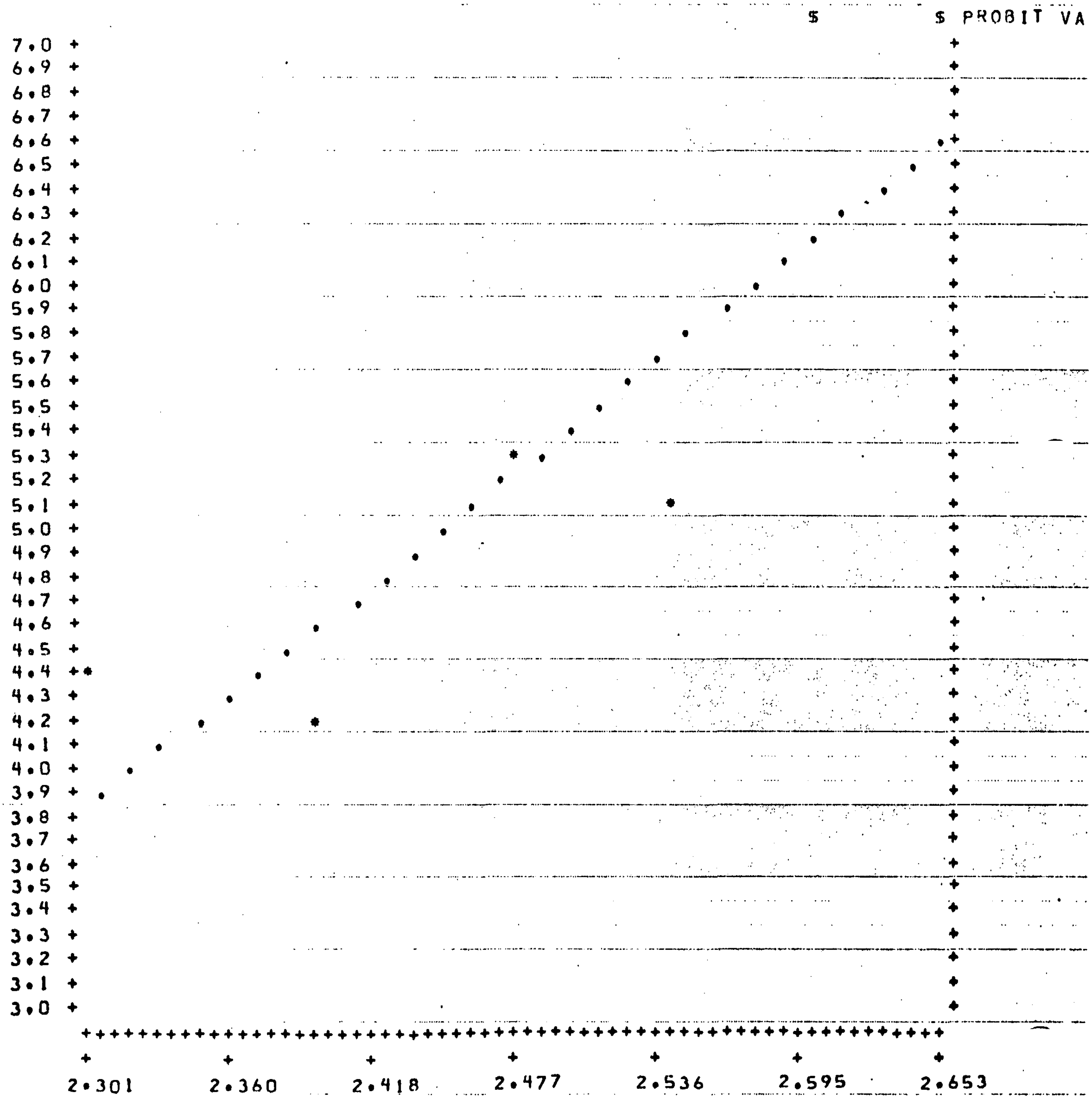
| | | | | |
|---|---|---|---|---|
| P = | .01 | 140.4307 | .0000 | 219.7223 |
| P = | .05 | 171.5939 | .0000 | 245.9944 |
| P = | .10 | 190.9452 | .0000 | 262.1750 |
| P = | .20 | 217.3266 | .0002 | 285.1211 |
| P = | .50 | 278.3660 | 1.2027 | 363.4600 |
| P = | .80 | 356.5493 | 255.0854 | 13677.8219 |
| P = | .90 | 405.8109 | 318.4718 | 1201418.9844 |
| P = | .95 | 451.5756 | 350.3689 | 52805880.0000 |
| P = | .99 | 551.7856 | 401.0415 | 66578643456.0000 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-1 96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 7.8286, INTERCEPT= -14.1379,
NATURAL RESPONSE RATE= .0827

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-2 1 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 0. | .0001 | 1.2809 |
| 1500.0000 | 3.1761 | 20. | 2. | .0580 | 3.4283 |
| 2000.0000 | 3.3010 | 20. | 2. | .0580 | 3.4283 |
| 2500.0000 | 3.3979 | 20. | 9. | .4244 | 4.8096 |
| 3000.0000 | 3.4771 | 20. | 12. | .5814 | 5.2050 |
| 4000.0000 | 3.6021 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .1792
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 5.068423
AVG X = 3.438975
AVG T = 1.983630
NATURAL MORTALITY = .045858 SE = .023210
SLOPE = 11.183365 SE = 2.415174
T STATISTIC = SLOPE/SE = 4.630459
INTERCEPT = -33.393632
CHI SQUARED = 4.277163
B( 25) - B( 24) = .0805151

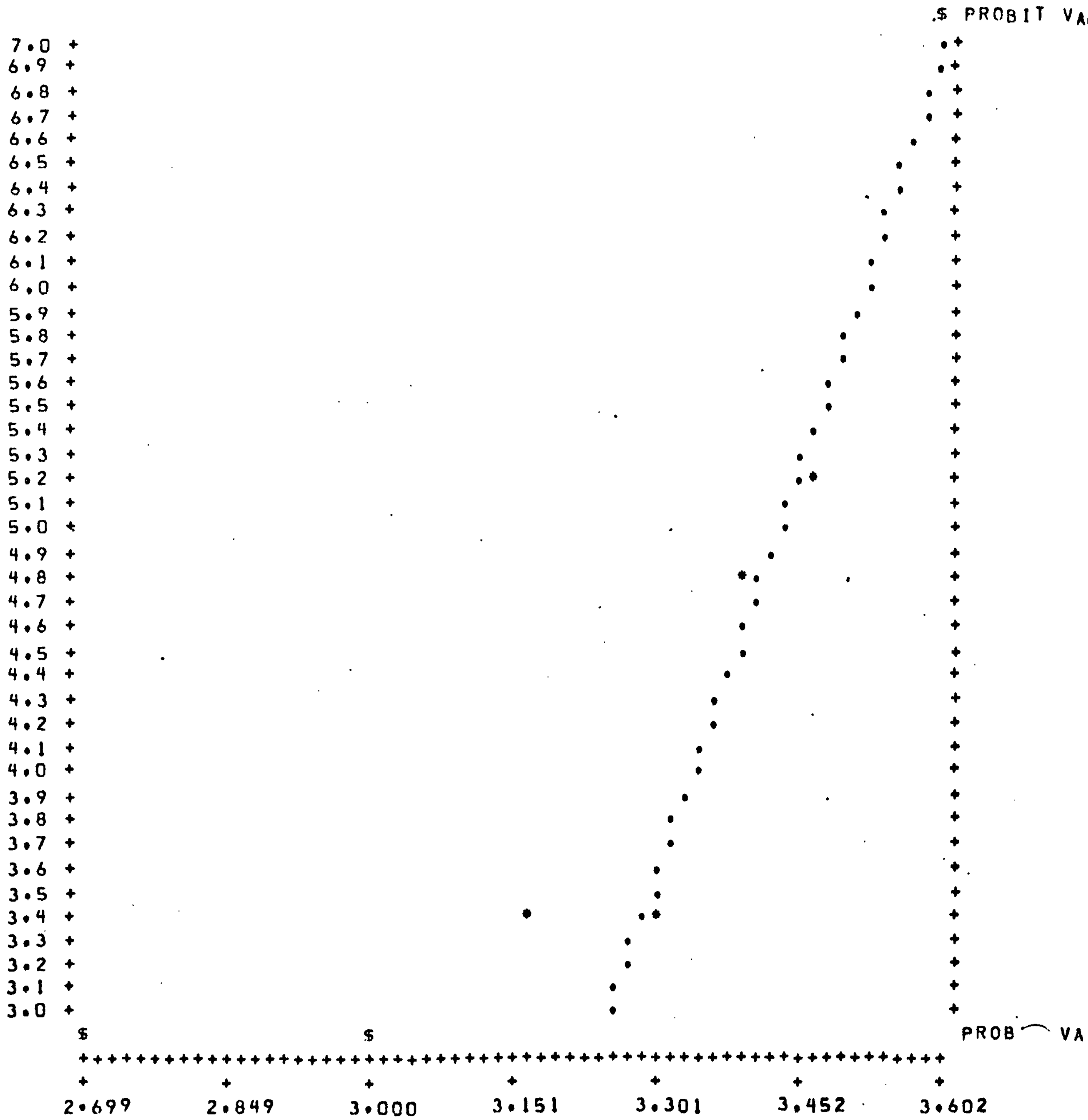
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 1679.1424 | 1144.5086 | 1977.8110 |
| P = .05 | 1932.0450 | 1452.4199 | 2193.6655 |
| P = .10 | 2082.1070 | 1646.3973 | 2322.1029 |
| P = .20 | 2279.5398 | 1910.1988 | 2495.7535 |
| P = .50 | 2710.8270 | 2470.4843 | 2943.4753 |
| P = .80 | 3223.7132 | 2965.8933 | 3739.8055 |
| P = .90 | 3529.3976 | 3197.7229 | 4325.4168 |
| P = .95 | 3803.5256 | 3389.3766 | 4896.6872 |
| P = .99 | 4376.3904 | 3763.7761 | 6206.6488 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-2 1 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 11.1834, INTERCEPT= -33.3936,
NATURAL RESPONSE RATE= .0459

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-2   4 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 0. | .0001 | 1.2809 |
| 1500.0000 | 3.1761 | 20. | 4. | .2000 | 4.1584 |
| 2000.0000 | 3.3010 | 20. | 6. | .3000 | 4.4759 |
| 2500.0000 | 3.3979 | 20. | 10. | .5000 | 4.9999 |
| 3000.0000 | 3.4771 | 20. | 14. | .7000 | 5.5240 |
| 4000.0000 | 3.6021 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .1005
TOTAL NUMBER OF CYCLES = 7

SUMMARY STATISTICS

AVG Y = 5.016270
AVG X = 3.369816
AVG T = 3.009834
NATURAL MORTALITY = .000052   SE = .001218
SLOPE = 6.350874   SE = 1.027218
T STATISTIC = SLOPE/SE = 6.182595
INTERCEPT = -16.385002
CHI SQUARED = 4.159465

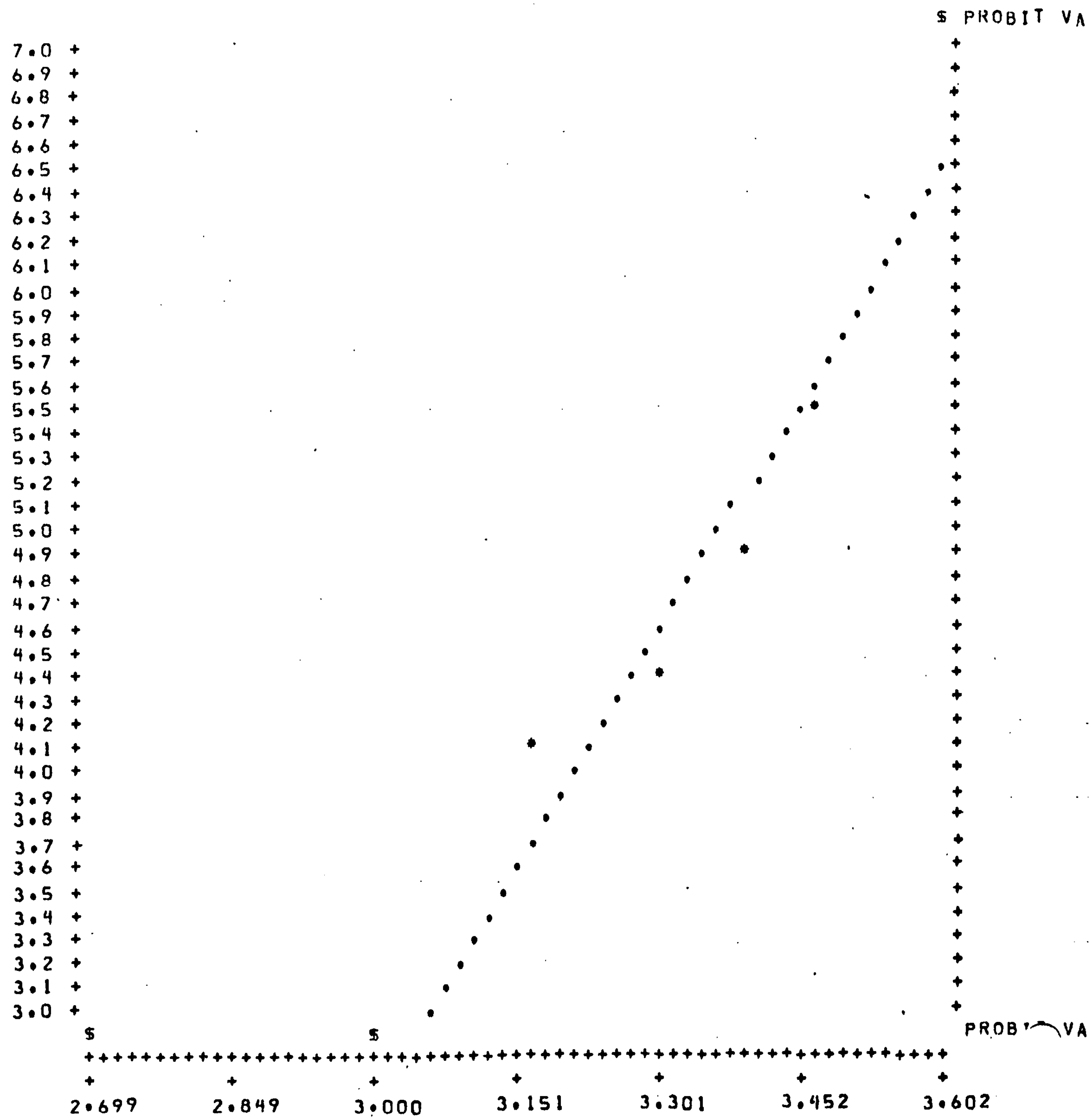
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 1002.2062 | 663.2120 | 1252.5668 |
| P = .05 | 1283.0672 | 945.7295 | 1521.4108 |
| P = .10 | 1463.7069 | 1139.9798 | 1691.6428 |
| P = .20 | 1716.8640 | 1422.7566 | 1932.5044 |
| P = .50 | 2329.4483 | 2092.0581 | 2590.1448 |
| P = .80 | 3160.6051 | 2812.8019 | 3796.6906 |
| P = .90 | 3707.2516 | 3215.1169 | 4735.7958 |
| P = .95 | 4229.1855 | 3575.7102 | 5707.1557 |
| P = .99 | 5414.3840 | 4344.1328 | 8136.5277 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-2 4 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 6.3509, INTERCEPT= -16.3850,
NATURAL RESPONSE RATE= .0001

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-2 8 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 0. | .0001 | 1.2809 |
| 1500.0000 | 3.1761 | 20. | 6. | .3000 | 4.4760 |
| 2000.0000 | 3.3010 | 20. | 6. | .3000 | 4.4760 |
| 2500.0000 | 3.3979 | 20. | 14. | .7000 | 5.5240 |
| 3000.0000 | 3.4771 | 20. | 16. | .8000 | 5.8414 |
| 4000.0000 | 3.6021 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .0944
TOTAL NUMBER OF CYCLES = 7

SUMMARY STATISTICS

AVG Y = 5.116717
AVG X = 3.341926
AVG T = 3.345420
NATURAL MORTALITY = .000021 SE = .000893
SLOPE = 6.443944 SE = 1.010299
T STATISTIC = SLOPE/SE = 6.378254
INTERCEPT = -16.418458
CHI SQUARED = 5.364687

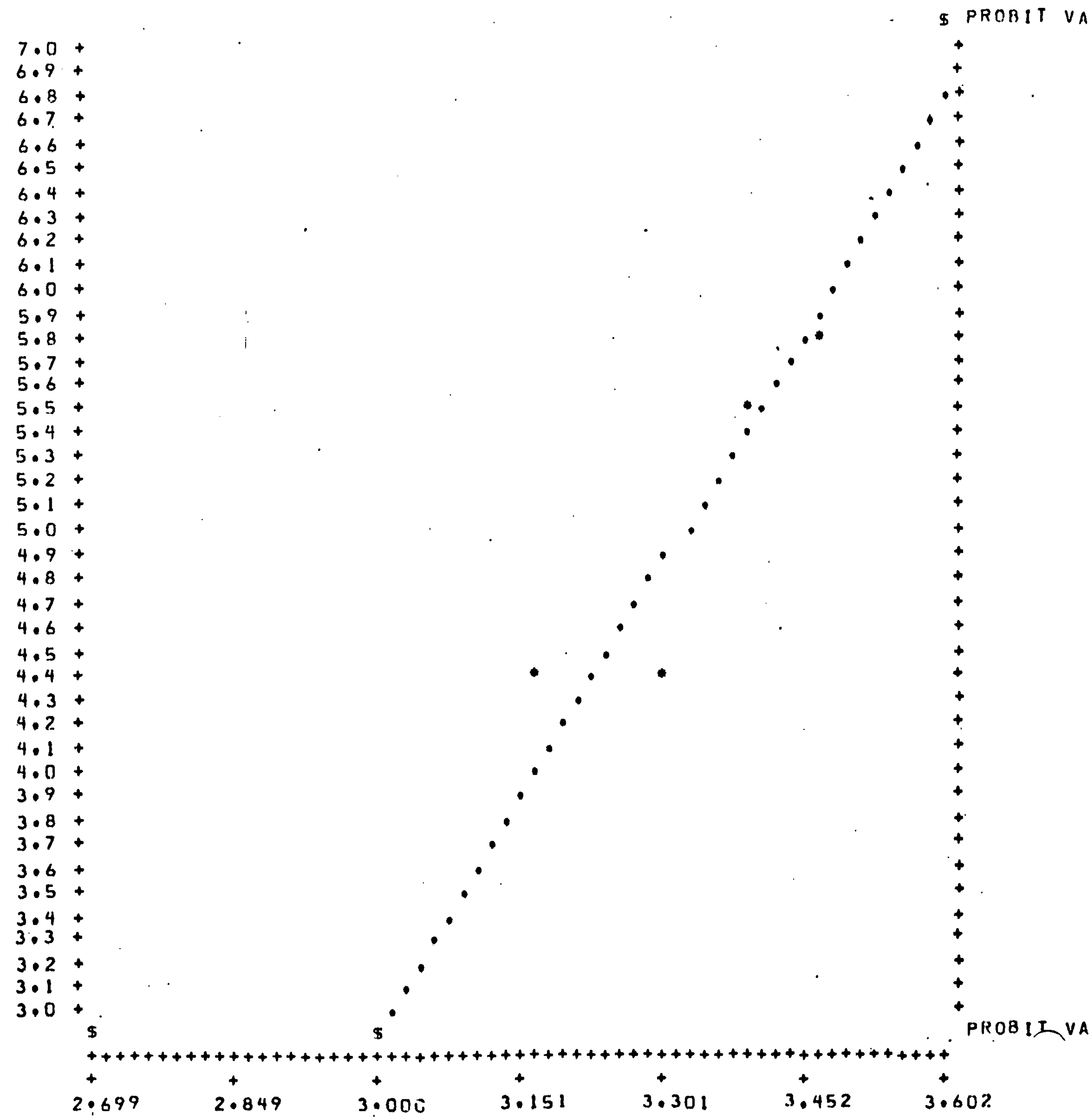
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 917.9227 | 611.7459 | 1148.0123 |
| P = .05 | 1170.9781 | 863.8072 | 1391.9997 |
| P = .10 | 1333.2982 | 1036.0831 | 1545.8817 |
| P = .20 | 1560.3012 | 1286.2682 | 1762.1457 |
| P = .50 | 2107.7141 | 1885.5561 | 2335.4909 |
| P = .80 | 2847.1801 | 2548.8395 | 3356.7516 |
| P = .90 | 3331.9317 | 2916.5003 | 4151.4730 |
| P = .95 | 3793.8014 | 3244.2104 | 4971.3014 |
| P = .99 | 4839.6870 | 3939.6920 | 7008.9857 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-2   8 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   6.4439, INTERCEPT= -16.4185,
NATURAL RESPONSE RATE=   .0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-2   24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 300.0000 | 2.4771 | 20. | 1. | .0338 | 3.1725 |
| 350.0000 | 2.5441 | 20. | 0. | .0001 | 1.2809 |
| 400.0000 | 2.6021 | 20. | 3. | .1355 | 3.8994 |
| 450.0000 | 2.6532 | 20. | 4. | .1864 | 4.1089 |
| 500.0000 | 2.6990 | 20. | 12. | .5932 | 5.2354 |
| 550.0000 | 2.7404 | 20. | 12. | .5932 | 5.2354 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 2

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .2574
TOTAL NUMBER OF CYCLES = 20

SUMMARY STATISTICS

| | | | |
|---|---|---|---|
| AVG Y = | 4.659512 | | |
| AVG X = | 2.677845 | | |
| AVG T = | 2.800446 | | |
| NATURAL MORTALITY = | .016726 | SE = | .021747 |
| SLOPE = | 11.806487 | SE = | 3.056385 |
| T STATISTIC = SLOPE/SE = | 3.862893 | | |
| INTERCEPT = | -26.956435 | | |
| CHI SQUARED = | 3.940106 | | |

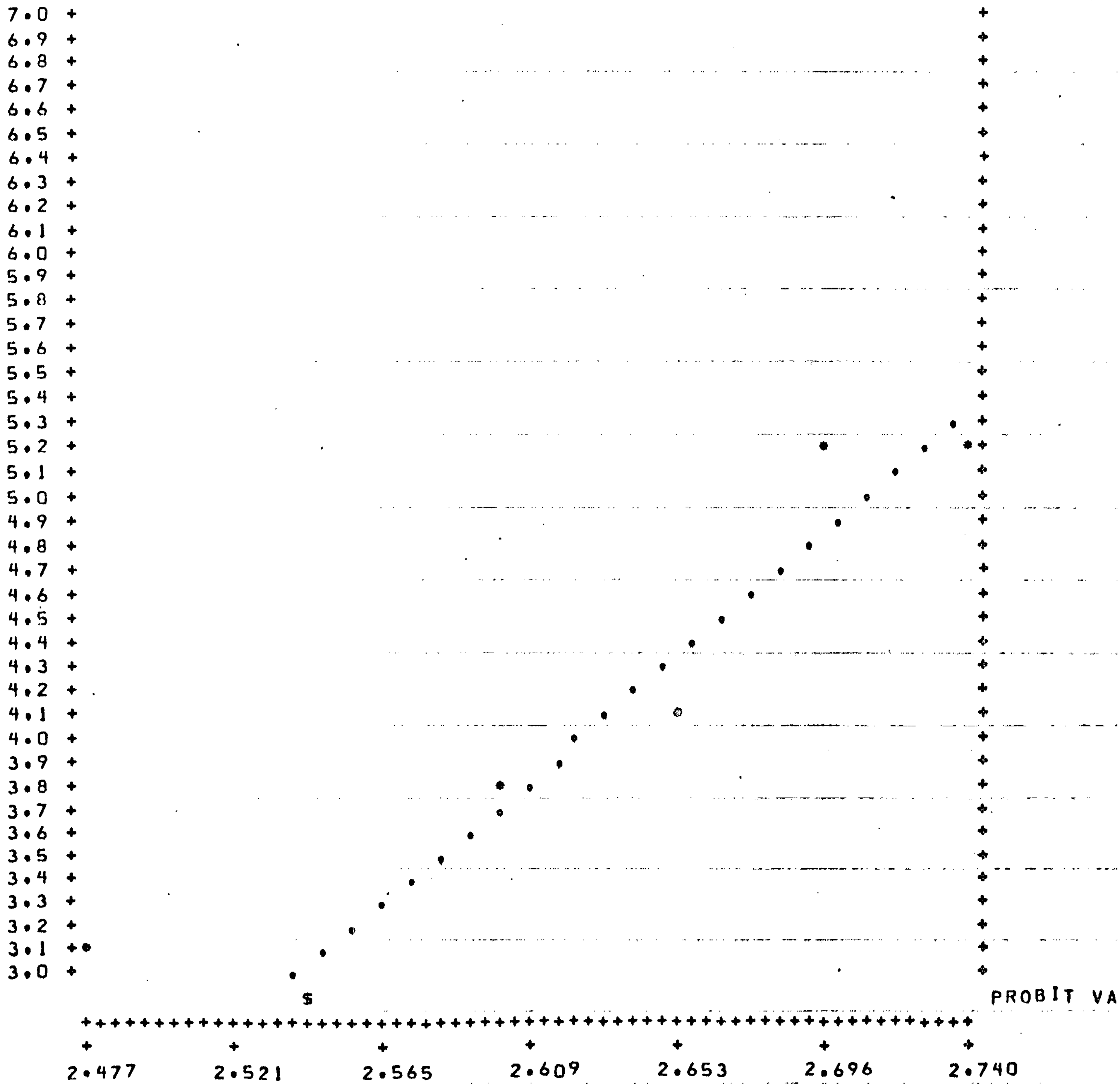
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 323.3318 | 210.6516 | 374.2645 |
| P = .05 | 369.2857 | 274.7129 | 410.4984 |
| P = .10 | 396.4001 | 315.8650 | 432.0844 |
| P = .20 | 431.9181 | 372.1854 | 462.0487 |
| P = .50 | 508.9606 | 477.8703 | 559.9261 |
| P = .80 | 599.7455 | 549.1160 | 758.1768 |
| P = .90 | 653.4836 | 583.9857 | 898.2751 |
| P = .95 | 701.4649 | 613.5120 | 1034.8274 |
| P = .99 | 801.1612 | 671.8364 | 1351.6830 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-2   24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 11.8065, INTERCEPT= -26.95
NATURAL RESPONSE RATE= .0167

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-2 48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 300.0000 | 2.4771 | 20. | 1. | .0241 | 3.0234 |
| 350.0000 | 2.5441 | 20. | 0. | .0001 | 1.2809 |
| 400.0000 | 2.6021 | 20. | 6. | .2809 | 4.4202 |
| 450.0000 | 2.6532 | 20. | 5. | .2295 | 4.2598 |
| 500.0000 | 2.6990 | 20. | 14. | .6918 | 5.5006 |
| 550.0000 | 2.7404 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 2 6

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .1568
TOTAL NUMBER OF CYCLES = 8

SUMMARY STATISTICS

AVG Y = 5.109424
AVG X = 2.669481
AVG T = 2.099241
NATURAL MORTALITY = .026657 SE = .023584
SLOPE = 18.105105 SE = 3.657314
T STATISTIC = SLOPE/SE = 4.950383
INTERCEPT = -43.221985
CHI SQUARED = 9.141503

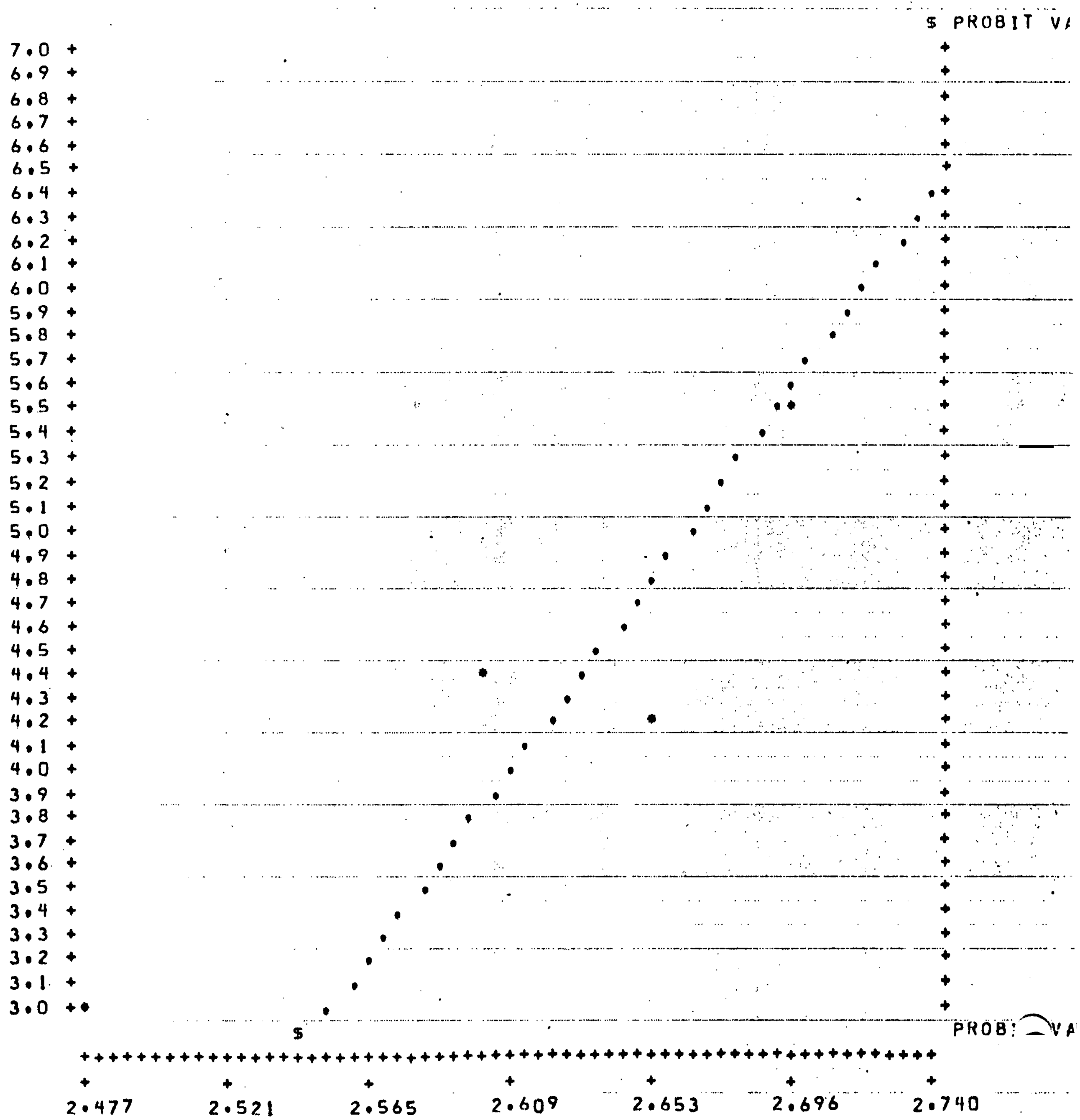
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 342.7348 | 275.8578 | 378.0459 |
| P = .05 | 373.7610 | 317.6152 | 403.2674 |
| P = .10 | 391.4354 | 342.1268 | 417.7345 |
| P = .20 | 413.9641 | 373.7832 | 436.6249 |
| P = .50 | 460.7303 | 436.8759 | 481.5279 |
| P = .80 | 512.7798 | 489.8049 | 553.6147 |
| P = .90 | 542.2923 | 513.4159 | 603.1178 |
| P = .95 | 567.9363 | 532.4561 | 648.9044 |
| P = .99 | 619.3489 | 568.5780 | 746.3441 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-2 48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 10.1051, INTERCEPT= -43.2220,
NATURAL RESPONSE RATE= .0267

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-2 96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 300.0000 | 2.4771 | 20. | 4. | .1833 | 4.0971 |
| 350.0000 | 2.5441 | 20. | 3. | .1322 | 3.8840 |
| 400.0000 | 2.6021 | 20. | 8. | .3875 | 4.7145 |
| 450.0000 | 2.6532 | 20. | 11. | .5406 | 5.1017 |
| 500.0000 | 2.6990 | 20. | 20. | .9999 | 8.7191 |
| 550.0000 | 2.7404 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 5 6

THERE IS AT LEAST ONE EXPECTED VALUE LESS THAN 5.

| DOSE | # RESPONSES | EXPECTED |
|---|---|---|
| 300.0000 | 4. | 1.5282 |
| 350.0000 | 3. | 4.6674 |
| 400.0000 | 8. | 9.7575 |
| 450.0000 | 11. | 14.5444 |
| 500.0000 | 20. | 17.6127 |
| 550.0000 | 20. | 19.1076 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 3.4252
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 2.7760
G = .7262
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 5.179752
AVG X = 2.622106
AVG T = 1.824209
NATURAL MORTALITY = .028619 SE = .055747
SLOPE = 13.099450 SE = 4.021239
T STATISTIC = SLOPE/SE = 3.257565
INTERCEPT = -29.183540
CHI SQUARED = 13.700885 SIGNIF. AT .05
B( 25) - B( 24) = .4179155

95% CONFIDENCE LIMITS

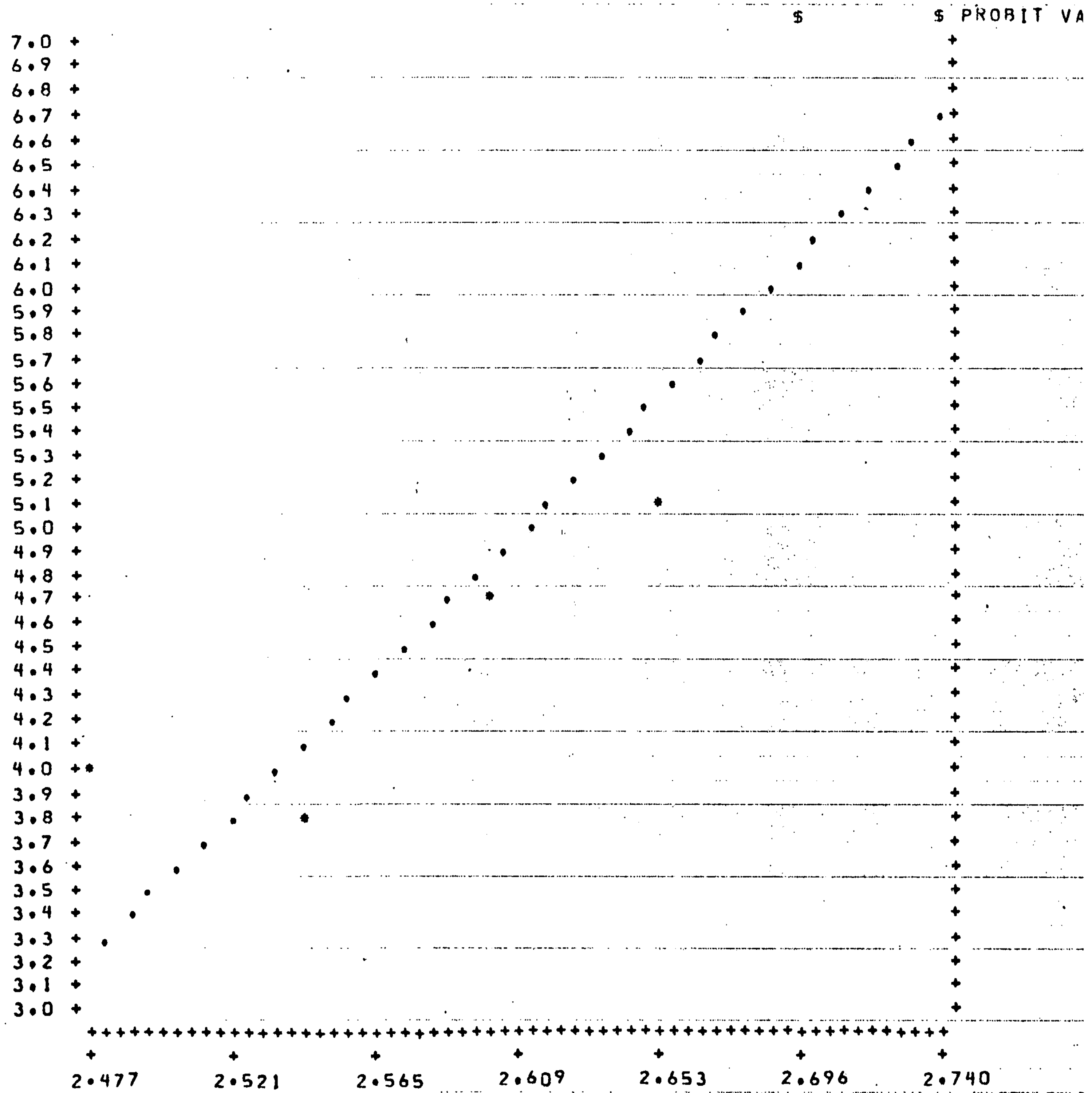
| POINT | DOSE | LOWER | UPPER |
|---|---|---|---|
| P = .01 | 270.3662 | 18.8184 | 342.2251 |
| P = .05 | 304.7683 | 41.9487 | 368.2437 |
| P = .10 | 324.8656 | 64.1315 | 384.0281 |
| P = .20 | 350.9886 | 106.6093 | 406.4336 |
| P = .50 | 406.9489 | 262.4626 | 486.4131 |
| P = .80 | 471.8315 | 407.7940 | 922.4013 |
| P = .90 | 509.7722 | 441.8144 | 1497.8600 |
| P = .95 | 543.3880 | 464.3978 | 2271.9668 |
| P = .99 | 612.5303 | 502.9058 | 5032.2706 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-2 96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 13.0994, INTERCEPT= -29.1835,
NATURAL RESPONSE RATE= .0286

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 1 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 0. | .0001 | 1.2809 |
| 1500.0000 | 3.1761 | 20. | 6. | .3000 | 4.4759 |
| 2000.0000 | 3.3010 | 20. | 8. | .4000 | 4.7470 |
| 2500.0000 | 3.3979 | 20. | 12. | .6000 | 5.2529 |
| 3000.0000 | 3.4771 | 20. | 20. | .9999 | 8.7191 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2 6 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .0906
TOTAL NUMBER OF CYCLES = 11

SUMMARY STATISTICS

AVG Y = 5.238328
AVG X = 3.332035
AVG T = 2.630454
NATURAL MORTALITY = .000062 SE = .001258
SLOPE = 7.637281 SE = 1.172751
T STATISTIC = SLOPE/SE = 6.512277
INTERCEPT = -20.209358
CHI SQUARED = 9.308674

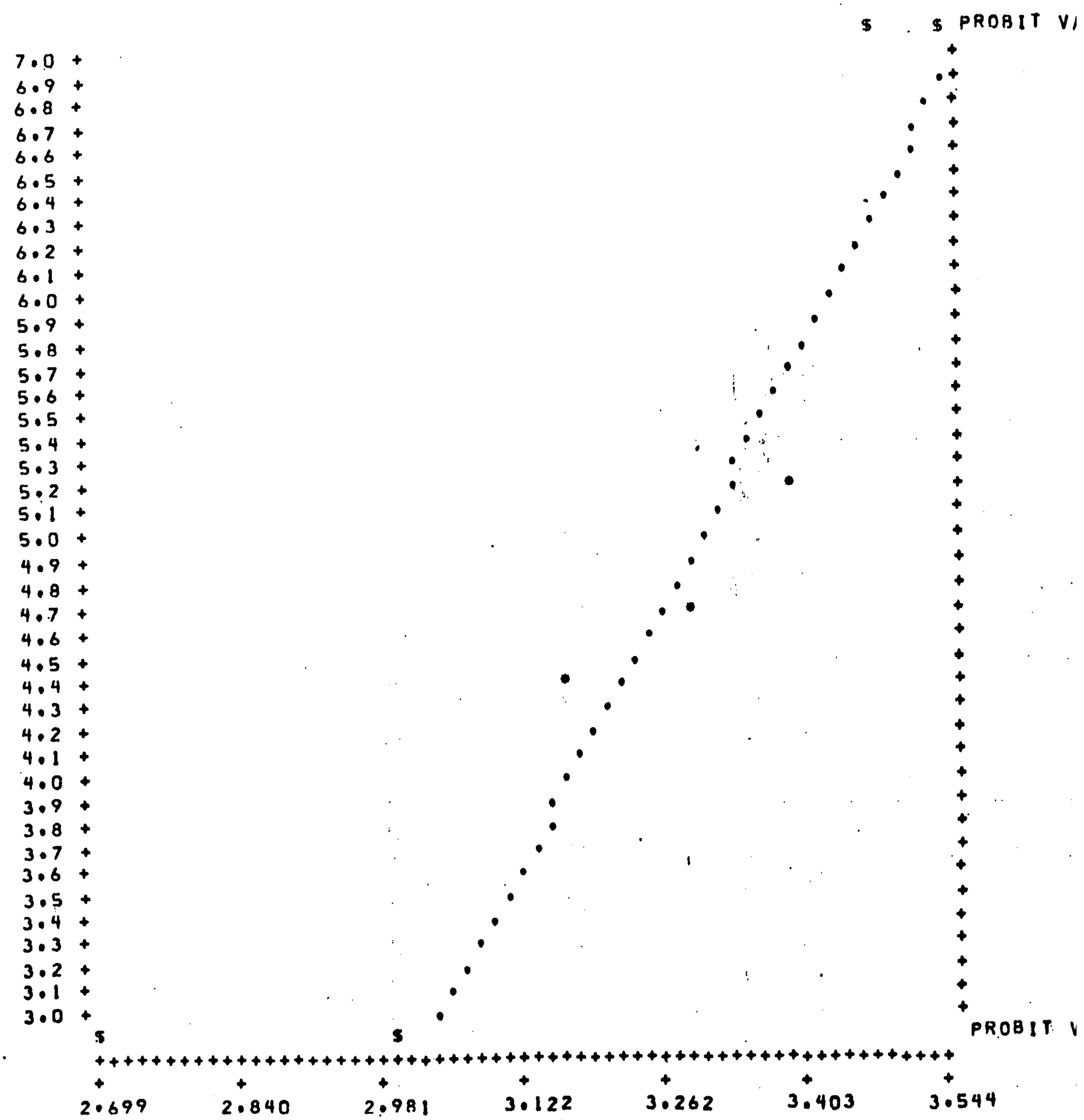
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 991.3587 | 698.7786 | 1205.6105 |
| P = .05 | 1217.4499 | 932.3780 | 1419.6091 |
| P = .10 | 1358.3772 | 1085.5693 | 1551.3798 |
| P = .20 | 1551.0738 | 1301.3557 | 1732.5303 |
| P = .50 | 1999.0736 | 1801.2231 | 2187.0276 |
| P = .80 | 2576.4698 | 2346.3982 | 2933.3568 |
| P = .90 | 2941.9628 | 2638.3171 | 3492.5351 |
| P = .95 | 3282.5128 | 2891.9677 | 4054.0513 |
| P = .99 | 4031.1287 | 3415.1084 | 5393.7672 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-3   1 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 7.6373, INTERCEPT= -20.2094,
NATURAL RESPONSE RATE= .0001

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 4 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .I

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0000 | .9095 |
| 1000.0000 | 3.0000 | 20. | 2. | .1000 | 3.7184 |
| 1500.0000 | 3.1761 | 20. | 12. | .6000 | 5.2530 |
| 2000.0000 | 3.3010 | 20. | 12. | .6000 | 5.2530 |
| 2500.0000 | 3.3979 | 20. | 16. | .8000 | 5.8415 |
| 3000.0000 | 3.4771 | 20. | 20. | .9999 | 8.7191 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 6 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .0857
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 5.354481
AVG X = 3.259072
AVG T = 2.893277
NATURAL MORTALITY = .000022 SE = .000000
SLOPE = 5.915191 SE = .883623
T STATISTIC = SLOPE/SE = 6.694246
INTERCEPT = -13.923680
CHI SQUARED = 6.325305
B( 25) - B( 24) = .0060771

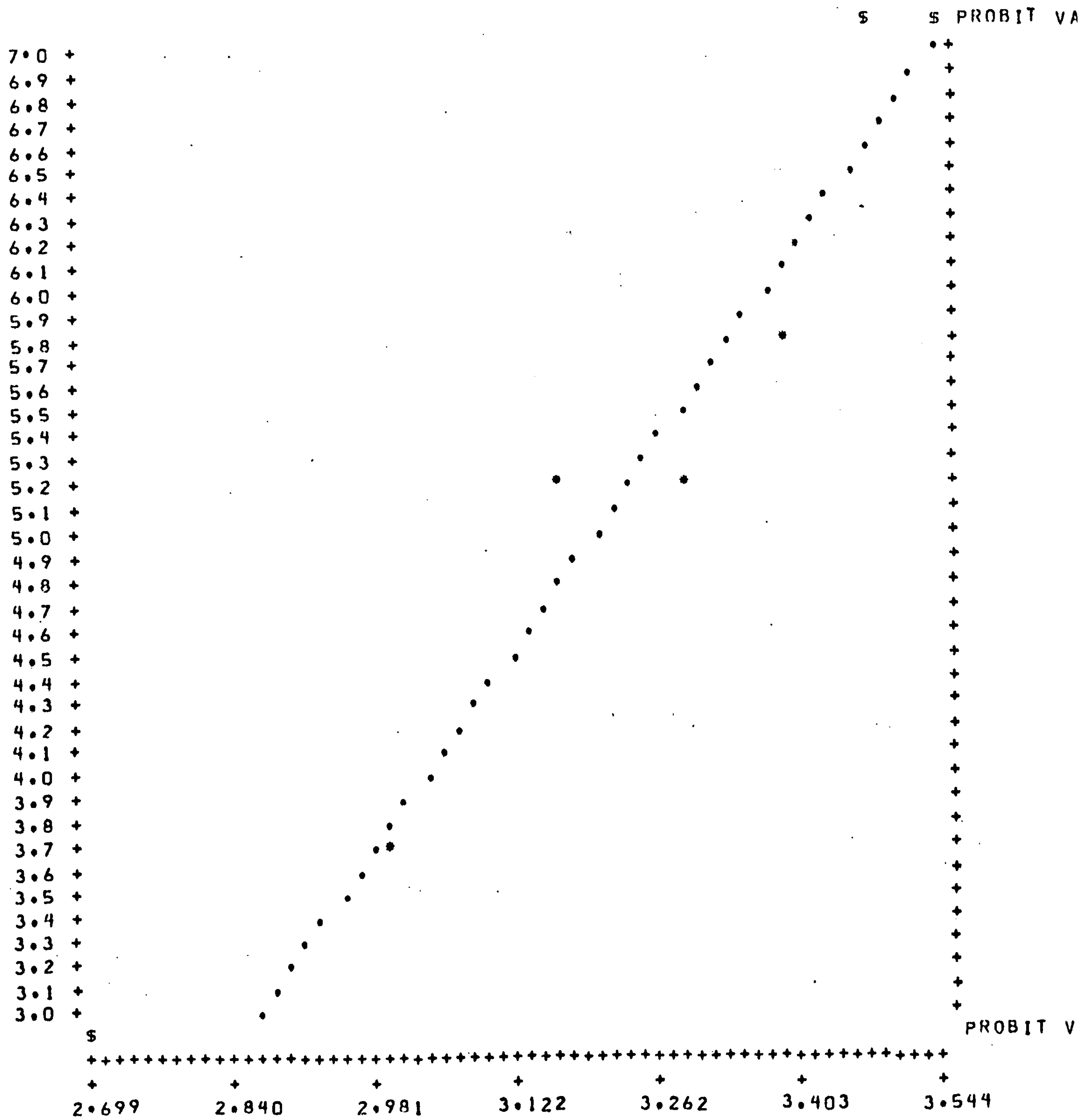
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 639.5740 | 407.0429 | 826.3892 |
| P = .05 | 833.8457 | 588.5928 | 1020.9437 |
| P = .10 | 960.5143 | 715.2222 | 1144.8001 |
| P = .20 | 1139.9573 | 902.7815 | 1319.1874 |
| P = .50 | 1581.8538 | 1377.6071 | 1770.1096 |
| P = .80 | 2195.0482 | 1957.8314 | 2550.2712 |
| P = .90 | 2605.1265 | 2285.4603 | 3177.6543 |
| P = .95 | 3000.8684 | 2577.5098 | 3839.1379 |
| P = .99 | 3912.3878 | 3201.6444 | 5521.4470 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-3   4 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 5.9152, INTERCEPT= -13.9237,
NATURAL RESPONSE RATE= .0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 8 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 8. | .4000 | 4.7471 |
| 1000.0000 | 3.0000 | 20. | 10. | .5000 | 5.0000 |
| 1500.0000 | 3.1761 | 20. | 12. | .6000 | 5.2529 |
| 2000.0000 | 3.3010 | 20. | 20. | .9999 | 8.7191 |
| 2500.0000 | 3.3979 | 20. | 20. | .9999 | 8.7191 |
| 3000.0000 | 3.4771 | 20. | 20. | .9999 | 8.7191 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 4 5 6 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 2.9137
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 2.5710
G = .5150
TOTAL NUMBER OF CYCLES = 7

SUMMARY STATISTICS

AVG Y = 5.656787
AVG X = 3.092627
AVG T = 1.063578
NATURAL MORTALITY = .000000 SE = .000042
SLOPE = 3.337525 SE = .931557
T STATISTIC = SLOPE/SE = 3.582740
INTERCEPT = -4.664934
CHI SQUARED = 14.568391 SIGNIF. AT .05

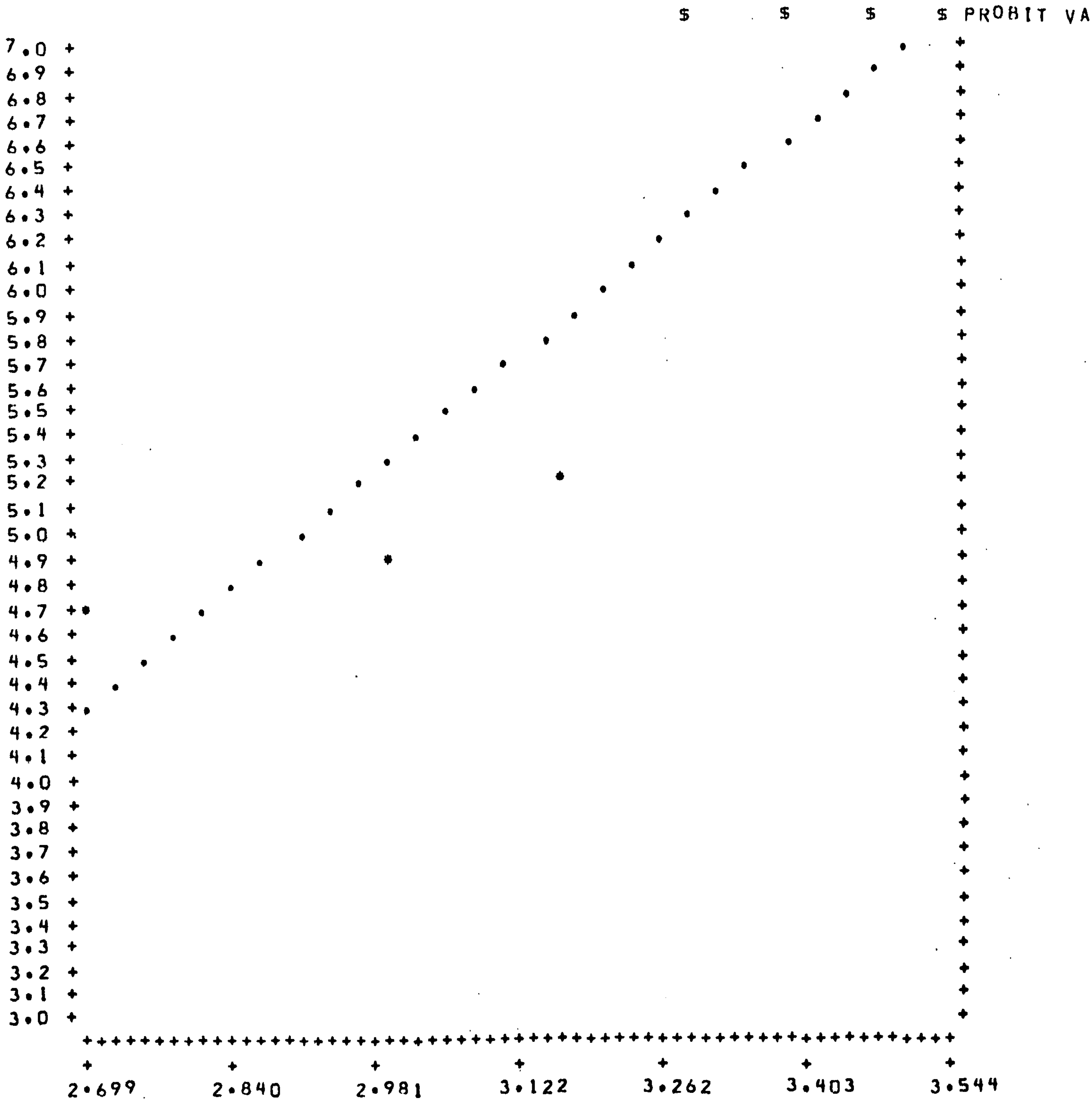
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 158.0611 | .7936 | 398.2664 |
| P = .05 | 252.9230 | 4.1168 | 533.4014 |
| P = .10 | 324.9687 | 9.8534 | 626.4280 |
| P = .20 | 440.2260 | 28.1081 | 767.7662 |
| P = .50 | 786.7533 | 193.9411 | 1219.4155 |
| P = .80 | 1406.0523 | 834.8155 | 3104.5051 |
| P = .90 | 1904.7401 | 1229.0417 | 7372.5507 |
| P = .95 | 2447.3090 | 1537.4088 | 16566.7288 |
| P = .99 | 3916.0848 | 2162.9733 | 81811.8242 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 8 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 3.3375, INTERCEPT= -4.6649,
NATURAL RESPONSE RATE= .0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = -.

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 200.0000 | 2.3010 | 20. | 0. | .0001 | 1.2809 |
| 250.0000 | 2.3979 | 20. | 2. | .1000 | 3.7183 |
| 300.0000 | 2.4771 | 20. | 1. | .0500 | 3.3548 |
| 350.0000 | 2.5441 | 20. | 5. | .2500 | 4.3258 |
| 400.0000 | 2.6021 | 20. | 4. | .2000 | 4.1585 |
| 450.0000 | 2.6532 | 20. | 9. | .4500 | 4.8746 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .3063
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 4.189020
AVG X = 2.553943
AVG T = 4.241139
NATURAL MORTALITY = -.000000 SE = .000000
SLOPE = 5.505771 SE = 1.554616
T STATISTIC = SLOPE/SE = 3.541563
INTERCEPT = -9.872408
CHI SQUARED = 3.692055
B( 25) - B( 24) = -.0031514

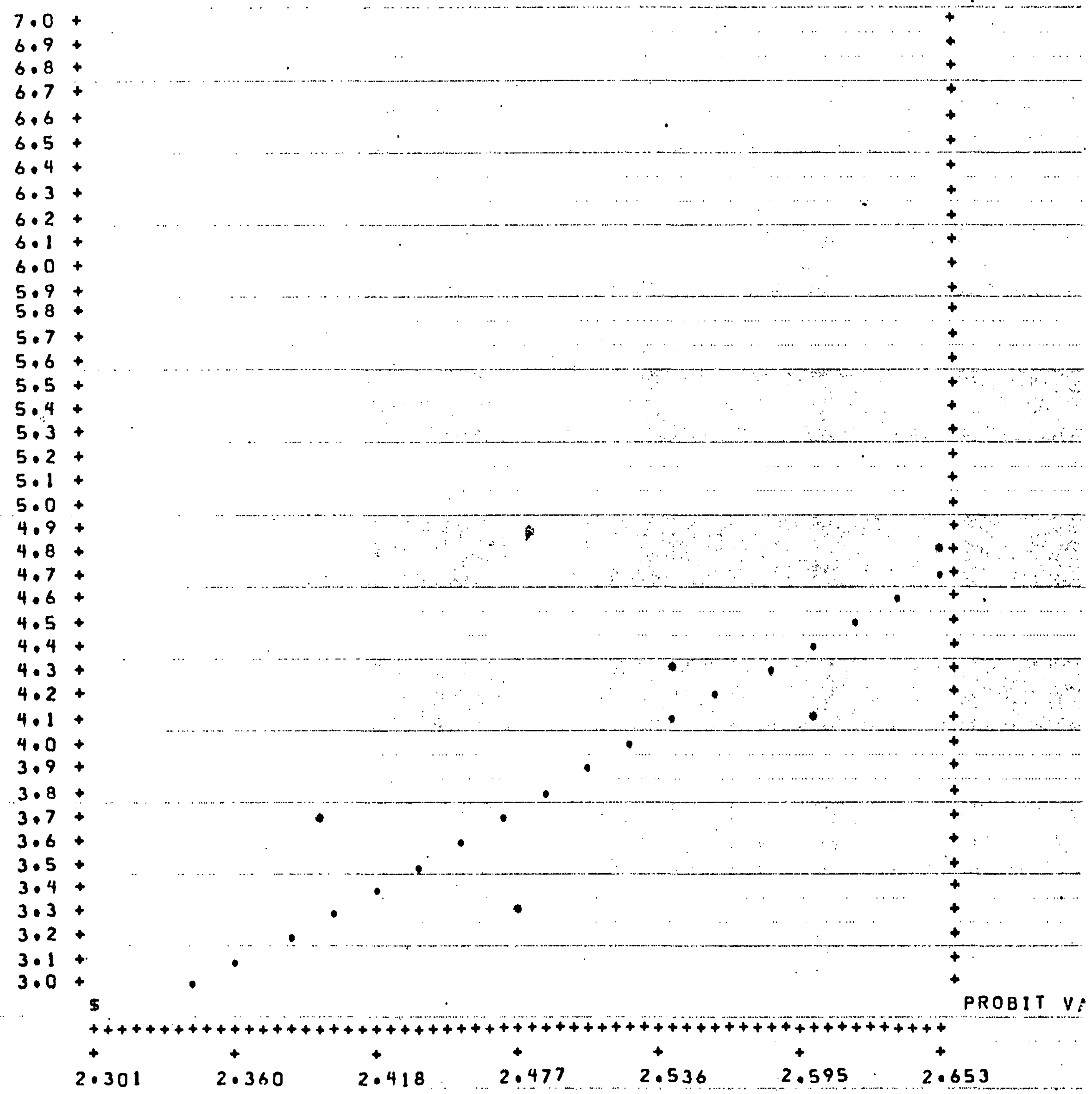
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 189.9850 | 84.9029 | 242.9340 |
| P = .05 | 252.6273 | 158.3349 | 296.2371 |
| P = .10 | 294.0800 | 217.8905 | 333.5913 |
| P = .20 | 353.4937 | 304.2895 | 406.0369 |
| P = .50 | 502.6197 | 429.7190 | 793.1580 |
| P = .80 | 714.6563 | 548.4613 | 1714.3121 |
| P = .90 | 859.0400 | 619.7803 | 2578.6812 |
| P = .95 | 999.9969 | 684.9235 | 3616.0150 |
| P = .99 | 1329.7186 | 825.0525 | 6826.4675 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 5.5058, INTERCEPT= -9.8724,
NATURAL RESPONSE RATE= -.0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 200.0000 | 2.3010 | 20. | 2. | .1000 | 3.7183 |
| 250.0000 | 2.3979 | 20. | 6. | .3000 | 4.4760 |
| 300.0000 | 2.4771 | 20. | 3. | .1500 | 3.9636 |
| 350.0000 | 2.5441 | 20. | 6. | .3000 | 4.4760 |
| 400.0000 | 2.6021 | 20. | 14. | .7000 | 5.5240 |
| 450.0000 | 2.6532 | 20. | 13. | .6500 | 5.3849 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .2096
TOTAL NUMBER OF CYCLES = 10

SUMMARY STATISTICS

AVG Y = 4.706753
AVG X = 2.518363
AVG T = 2.027917
NATURAL MORTALITY = .000000 SE = .000003
SLOPE = 4.853135 SE = 1.133481
T STATISTIC = SLOPE/SE = 4.281618
INTERCEPT = -7.515203
CHI SQUARED = 7.405735

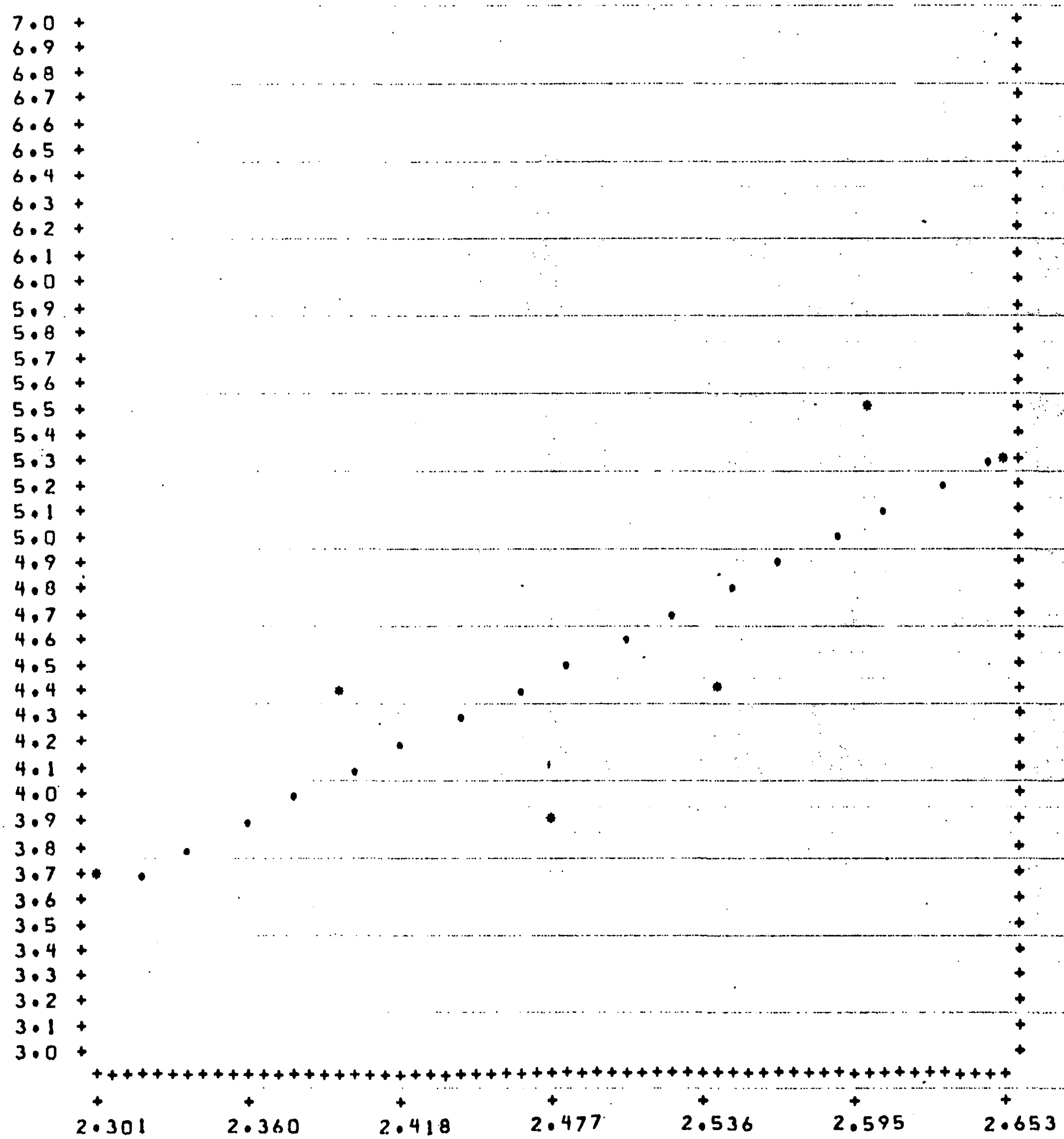
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 125.7325 | 54.8692 | 172.7627 |
| P = .05 | 173.7207 | 98.8935 | 217.2021 |
| P = .10 | 206.4004 | 134.9015 | 246.2771 |
| P = .20 | 254.3159 | 194.5700 | 289.5756 |
| P = .50 | 379.1291 | 337.6680 | 458.2709 |
| P = .80 | 565.1983 | 465.0736 | 913.8287 |
| P = .90 | 696.4082 | 540.3840 | 1333.7709 |
| P = .95 | 827.4136 | 610.3148 | 1826.5809 |
| P = .99 | 1143.2120 | 764.8818 | 3302.5648 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 4.8531, INTERCEPT= -7.5152,
NATURAL RESPONSE RATE= .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 1. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 200.0000 | 2.3010 | 20. | 4. | .0001 | 1.2809 |
| 250.0000 | 2.3979 | 20. | 8. | .2309 | 4.2643 |
| 300.0000 | 2.4771 | 20. | 5. | .0386 | 3.2326 |
| 350.0000 | 2.5441 | 20. | 12. | .4873 | 4.9681 |
| 400.0000 | 2.6021 | 20. | 17. | .8077 | 5.8694 |
| 450.0000 | 2.6532 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 6

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .3173
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 5.459048
AVG X = 2.572912
AVG T = 1.378785
NATURAL MORTALITY = .219872 SE = .051516
SLOPE = 20.743703 SE = 5.961683
T STATISTIC = SLOPE/SE = 3.479504
INTERCEPT = -47.912668
CHI SQUARED = 7.795070
B( 25) - B( 24) = -.0027611

NONSIGNIFICANT REGRESSION

| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 274.5599 | 180.1196 | 310.8251 |
| P = .05 | 296.1322 | 213.6293 | 327.0756 |
| P = .10 | 308.3184 | 233.8084 | 336.3231 |
| P = .20 | 323.7507 | 260.4922 | 348.3067 |
| P = .50 | 355.4529 | 317.1105 | 376.1858 |
| P = .80 | 390.2594 | 368.0377 | 426.1644 |
| P = .90 | 409.7931 | 386.6968 | 467.9923 |

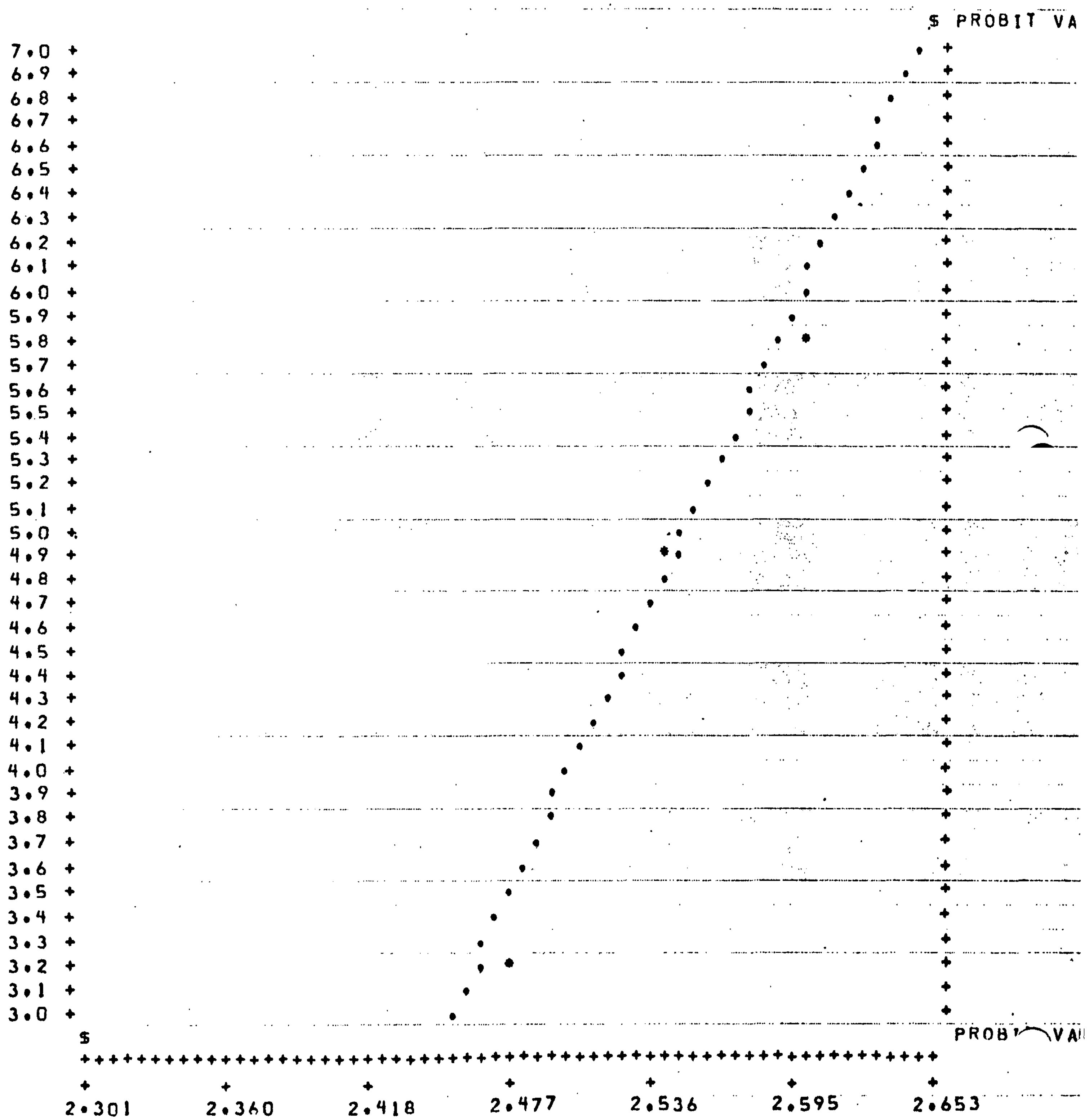
| | | | |
|---|---|---|---|
| P = .95 | 426.6565 | 399.8838 | 509.3112 |
| P = .99 | 460.1791 | 422.8216 | 601.1622 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-3 96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 20.7437, INTERCEPT= -47.9127,
NATURAL RESPONSE RATE= .2199

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-4 1 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = -.

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 0. | .0001 | 1.2809 |
| 1500.0000 | 3.1761 | 20. | 2. | .1000 | 3.7183 |
| 2000.0000 | 3.3010 | 20. | 8. | .4000 | 4.7471 |
| 2500.0000 | 3.3979 | 20. | 7. | .3500 | 4.6151 |
| 3000.0000 | 3.4771 | 20. | 10. | .5000 | 5.0000 |
| 4000.0000 | 3.6021 | 20. | 18. | .9000 | 6.2817 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .1178
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 4.829682
AVG X = 3.390526
AVG T = 4.297367
NATURAL MORTALITY = -.000000 SE = .000001
SLOPE = 5.289955 SE = .926397
T STATISTIC = SLOPE/SE = 5.710248
INTERCEPT = -13.106047
CHI SQUARED = 4.875936
B( 25) - B( 24) = -.0063013

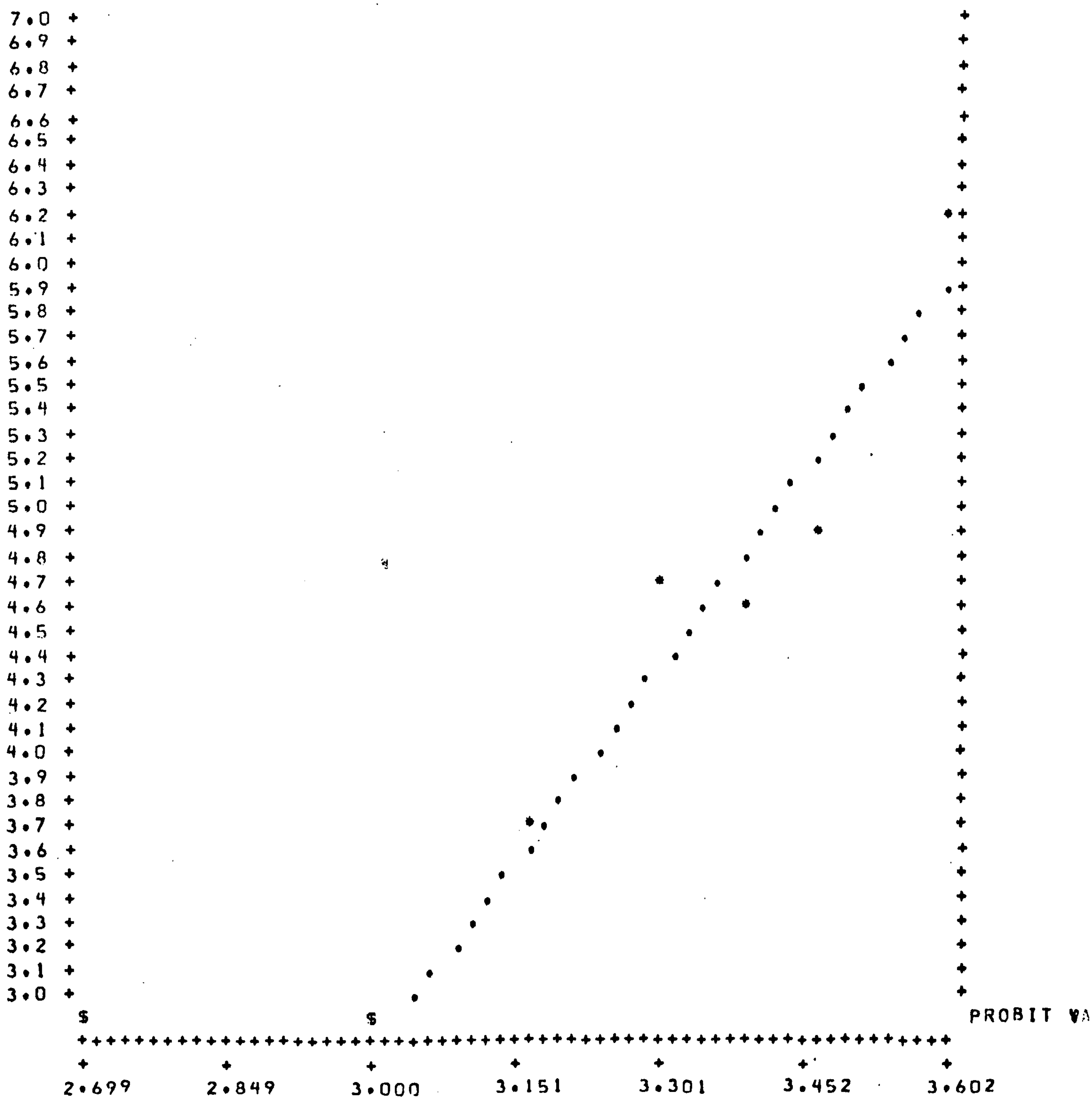
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 961.5328 | 576.8059 | 1247.4959 |
| P = .05 | 1293.5233 | 898.2716 | 1569.2298 |
| P = .10 | 1515.1359 | 1133.5862 | 1779.6640 |
| P = .20 | 1834.9661 | 1491.2155 | 2088.4374 |
| P = .50 | 2646.8056 | 2353.0215 | 3036.8111 |
| P = .80 | 3817.8250 | 3276.6645 | 5003.7267 |
| P = .90 | 4623.7309 | 3819.4273 | 6626.6905 |
| P = .95 | 5415.8900 | 4320.0911 | 8384.9464 |
| P = .99 | 7285.8457 | 5421.4550 | 13088.8878 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-4   1 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   5.2900, INTERCEPT= -13.1060,
NATURAL RESPONSE RATE=   -.0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-4 4 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 2. | .0529 | 3.3827 |
| 1500.0000 | 3.1761 | 20. | 2. | .0529 | 3.3827 |
| 2000.0000 | 3.3010 | 20. | 8. | .3686 | 4.6650 |
| 2500.0000 | 3.3979 | 20. | 9. | .4212 | 4.8017 |
| 3000.0000 | 3.4771 | 20. | 14. | .6843 | 5.4794 |
| 4000.0000 | 3.6021 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .1628
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 5.128573
AVG X = 3.404416
AVG T = 1.791223
NATURAL MORTALITY = .049687 SE = .028106
SLOPE = 7.386010 SE = 1.520326
T STATISTIC = SLOPE/SE = 4.858177
INTERCEPT = -20.016489
CHI SQUARED = 5.385145
B( 25) - B( 24) = .0000774

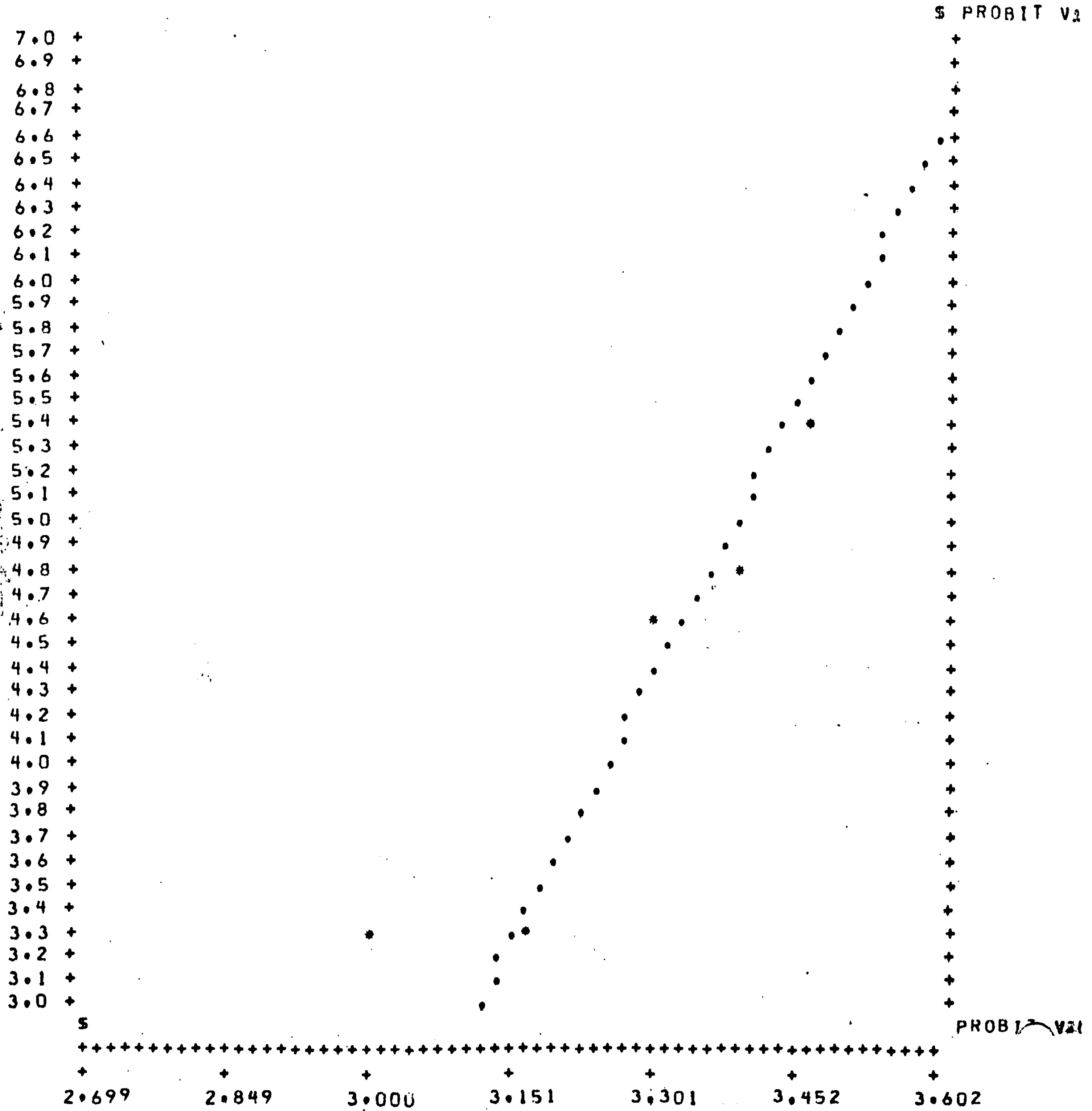
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 1180.4545 | 681.1731 | 1505.5131 |
| P = .05 | 1459.8383 | 967.0008 | 1761.5584 |
| P = .10 | 1634.9043 | 1163.4563 | 1918.9963 |
| P = .20 | 1875.2725 | 1450.3795 | 2136.2370 |
| P = .50 | 2437.8643 | 2141.2805 | 2708.0210 |
| P = .80 | 3169.2367 | 2839.6626 | 3821.6709 |
| P = .90 | 3635.1867 | 3184.4608 | 4729.2368 |
| P = .95 | 4071.1238 | 3479.3088 | 5673.2808 |
| P = .99 | 5034.6563 | 4081.7350 | 8032.7491 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-4    4 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 7.3860, INTERCEPT= -20.0165,
NATURAL RESPONSE RATE= .0497

7 LEVELS OF DOSE WERE ADMINISTERED.



J. P. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-4 8 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = -.

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 2. | .1000 | 3.7183 |
| 1500.0000 | 3.1761 | 20. | 7. | .3500 | 4.6151 |
| 2000.0000 | 3.3010 | 20. | 8. | .4000 | 4.7471 |
| 2500.0000 | 3.3979 | 20. | 14. | .7000 | 5.5240 |
| 3000.0000 | 3.4771 | 20. | 18. | .9000 | 6.2817 |
| 4000.0000 | 3.6021 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .0912
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 5.180862
AVG X = 3.309959
AVG T = 3.058541
NATURAL MORTALITY = -.000000 SE = .000000
SLOPE = 5.428868 SE = .836461
T STATISTIC = SLOPE/SE = 6.490285
INTERCEPT = -12.788469
CHI SQUARED = 3.836403
B( 25) - B( 24) = -.0029279

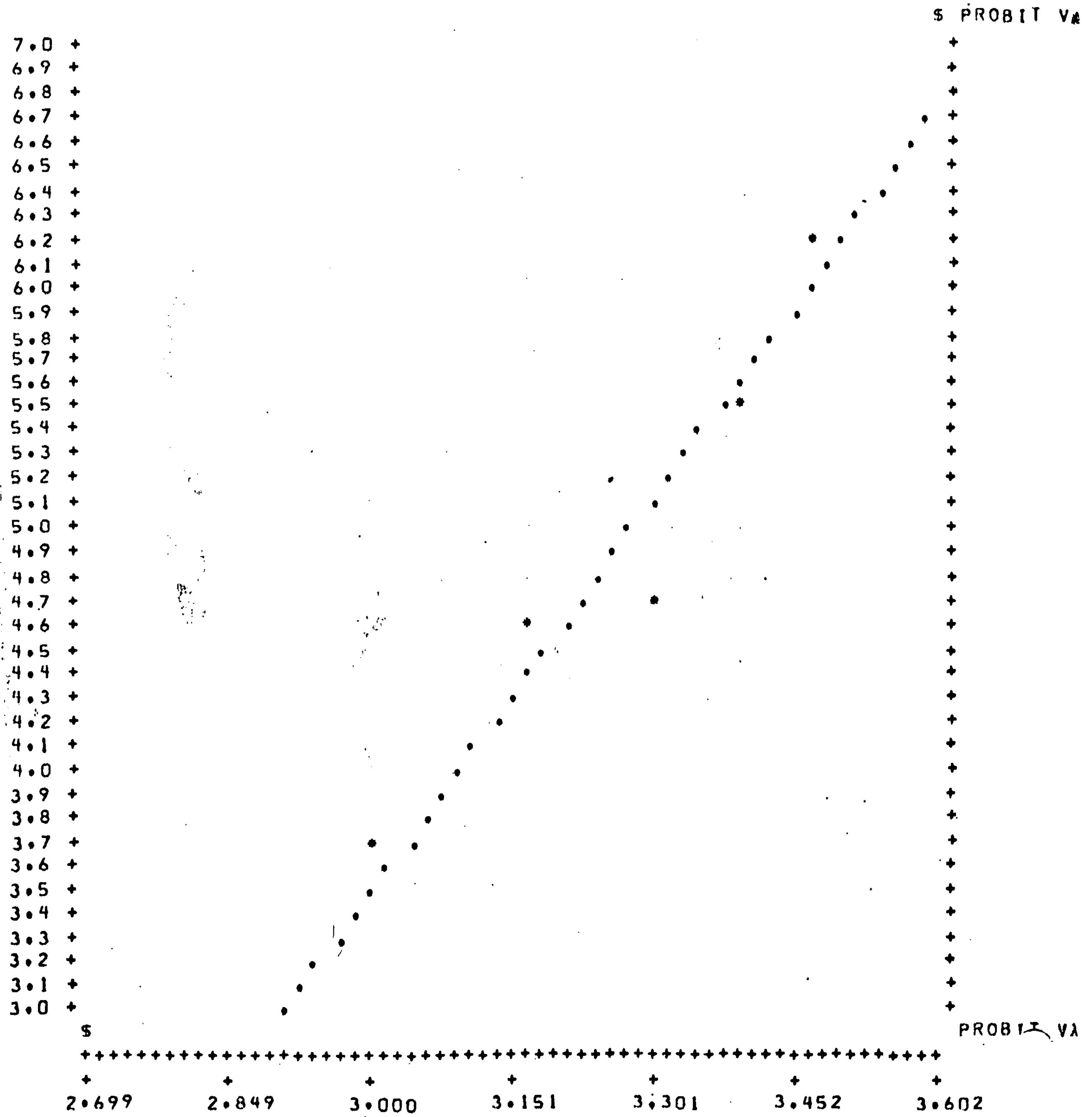
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 704.9180 | 436.1811 | 920.2875 |
| P = .05 | 941.1369 | 655.4179 | 1156.8871 |
| P = .10 | 1097.9255 | 812.5776 | 1309.8313 |
| P = .20 | 1323.1863 | 1049.9294 | 1528.5608 |
| P = .50 | 1890.7935 | 1658.9754 | 2122.0816 |
| P = .80 | 2701.8875 | 2386.5239 | 3235.9023 |
| P = .90 | 3256.2328 | 2803.9412 | 4152.9332 |
| P = .95 | 3798.7038 | 3183.7483 | 5134.0001 |
| P = .99 | 5071.6539 | 4012.8675 | 7694.1172 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-4    8 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=  5.4289, INTERCEPT= -12.7885,
NATURAL RESPONSE RATE=  -.0000

7 LEVELS OF DOSE WERE ADMINISTERED.

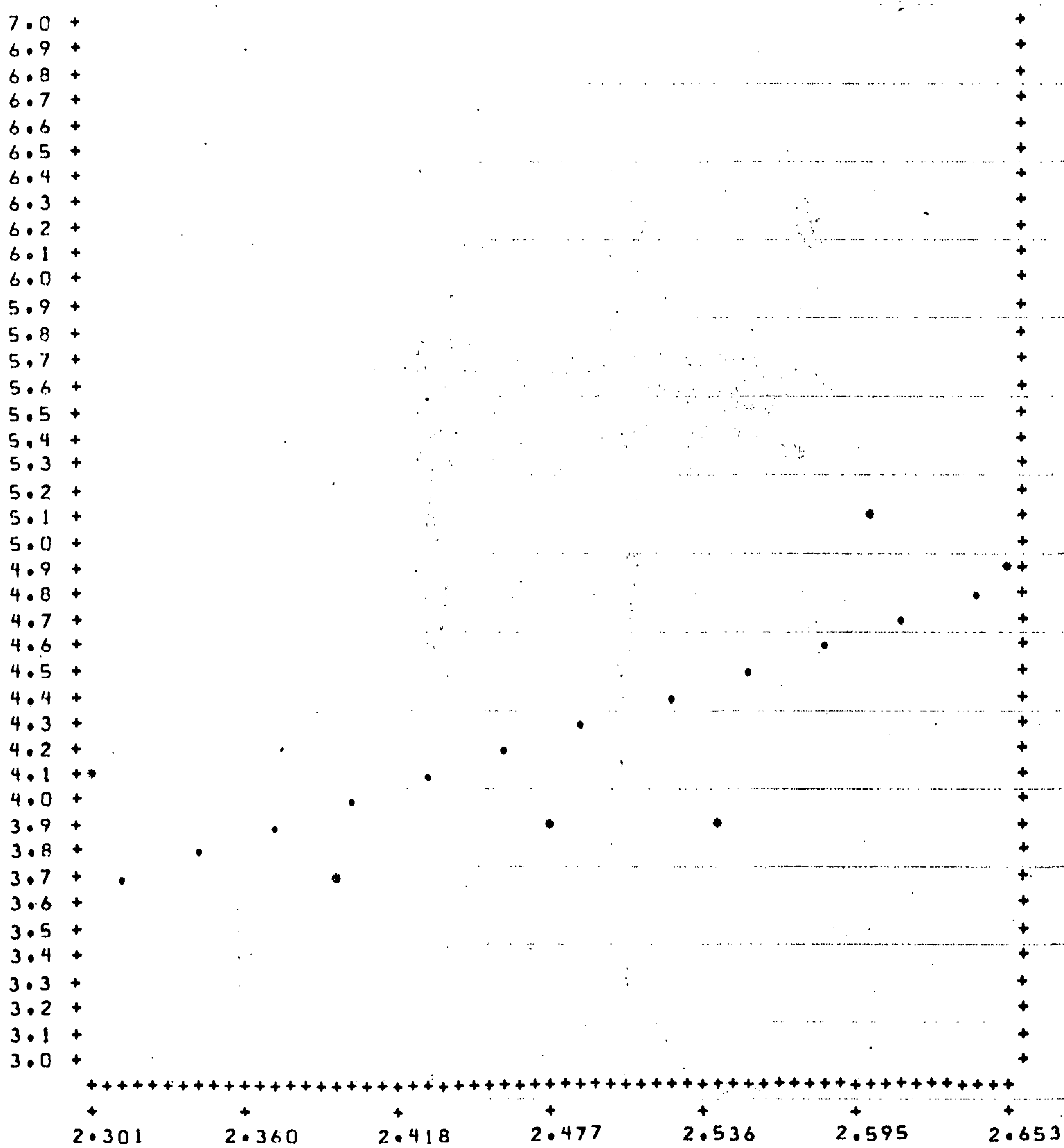


J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-4   24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   3.3972, INTERCEPT=  -4.1249,
NATURAL RESPONSE RATE=   .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-4 24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .C

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 200.0000 | 2.3010 | 20. | 4. | .2000 | 4.1585 |
| 250.0000 | 2.3979 | 20. | 2. | .1000 | 3.7183 |
| 300.0000 | 2.4771 | 20. | 3. | .1500 | 3.9636 |
| 350.0000 | 2.5441 | 20. | 3. | .1500 | 3.9636 |
| 400.0000 | 2.6021 | 20. | 11. | .5500 | 5.1254 |
| 450.0000 | 2.6532 | 20. | 10. | .5000 | 5.0000 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .4231
TOTAL NUMBER OF CYCLES = 7

SUMMARY STATISTICS

AVG Y = 4.435052
AVG X = 2.519737
AVG T = 2.407306
NATURAL MORTALITY = .000000 SE = .000228
SLOPE = 3.397178 SE = 1.127455
T STATISTIC = SLOPE/SE = 3.013139
INTERCEPT = -4.124944
CHI SQUARED = 8.893370

NONSIGNIFICANT REGRESSION

| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 100.2910 | 10.6789 | 163.4549 |
| P = .05 | 159.1622 | 39.5932 | 218.6289 |
| P = .10 | 203.6018 | 78.9963 | 257.3277 |
| P = .20 | 274.3475 | 176.1446 | 324.5377 |
| P = .50 | 485.3287 | 395.7718 | 1043.7183 |
| P = .80 | 858.5605 | 576.5906 | 5176.7134 |
| P = .90 | 1156.8849 | 694.4269 | 12087.4985 |
| P = .95 | 1479.8982 | 808.4117 | 24383.4761 |
| P = .99 | 2348.6055 | 1073.0477 | 91098.4521 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-4 .   48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 200.0000 | 2.3010 | 20. | 4. | .2000 | 4.1585 |
| 250.0000 | 2.3979 | 20. | 5. | .2500 | 4.3258 |
| 300.0000 | 2.4771 | 20. | 7. | .3500 | 4.6151 |
| 350.0000 | 2.5441 | 20. | 8. | .4000 | 4.7471 |
| 400.0000 | 2.6021 | 20. | 13. | .6500 | 5.3849 |
| 450.0000 | 2.6532 | 20. | 12. | .6000 | 5.2529 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .3227
TOTAL NUMBER OF CYCLES = 3

SUMMARY STATISTICS

AVG Y = 4.785117
AVG X = 2.507384
AVG T = 1.686163
NATURAL MORTALITY = .000000   SE = .000305
SLOPE = 3.592626   SE = 1.041222
T STATISTIC = SLOPE/SE = 3.450393
INTERCEPT = -4.222971
CHI SQUARED = 1.434065

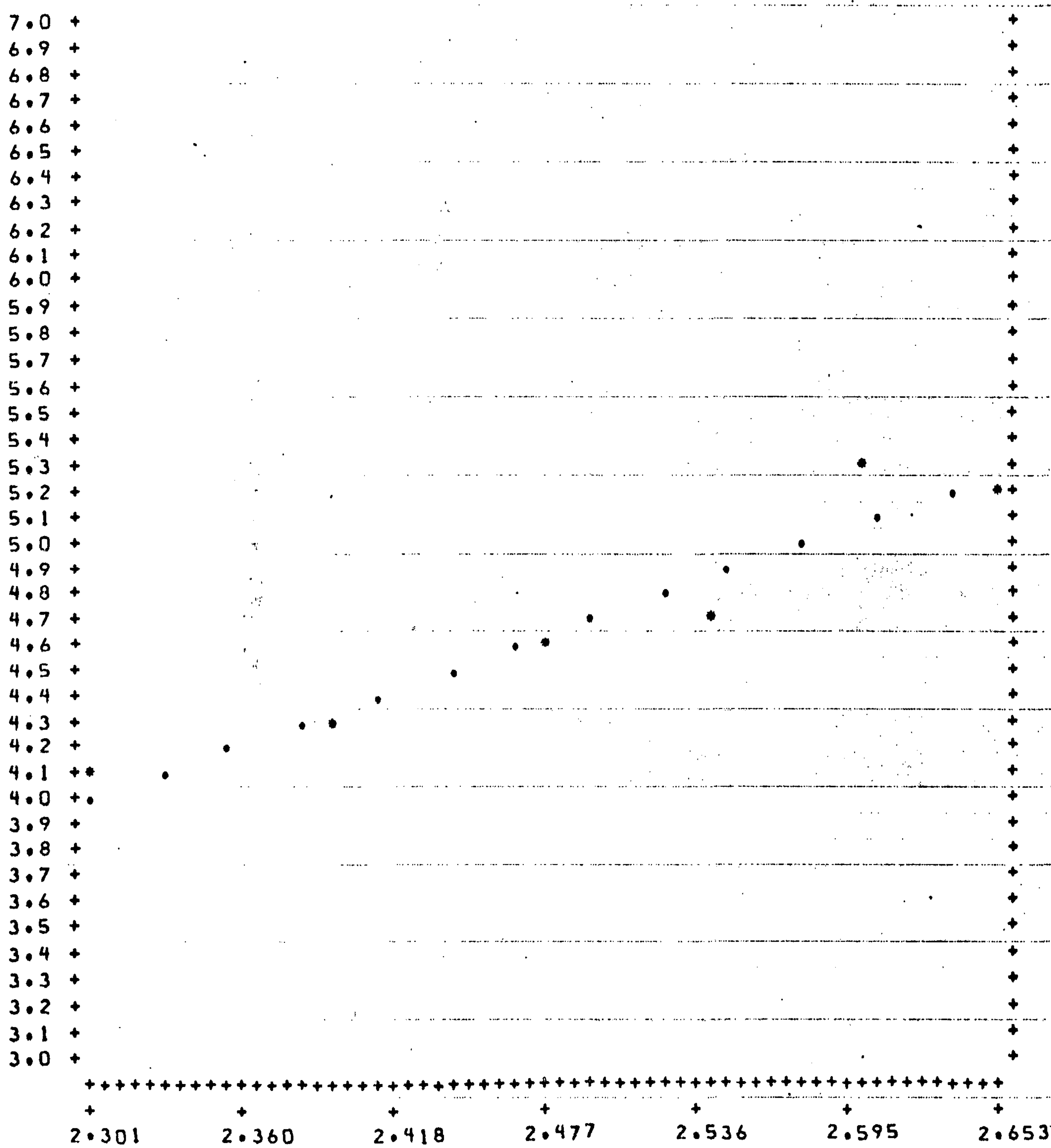
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 83.1140 | 13.8186 | 137.6894 |
| P = .05 | 128.6294 | 37.7238 | 183.1470 |
| P = .10 | 162.3544 | 64.2247 | 213.9505 |
| P = .20 | 215.2470 | 121.1914 | 260.7265 |
| P = .50 | 369.1431 | 317.6564 | 489.1260 |
| P = .80 | 633.0710 | 481.4188 | 1586.9988 |
| P = .90 | 839.3160 | 580.9867 | 3023.9521 |
| P = .95 | 1059.3740 | 676.6371 | 5163.9968 |
| P = .99 | 1639.5157 | 897.8688 | 14131.2307 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-4    48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=    3.5926, INTERCEPT=  -4.22
NATURAL RESPONSE RATE=     .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-4 96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 200.0000 | 2.3010 | 20. | 6. | .3000 | 4.4760 |
| 250.0000 | 2.3979 | 20. | 5. | .2500 | 4.3258 |
| 300.0000 | 2.4771 | 20. | 10. | .5000 | 5.0000 |
| 350.0000 | 2.5441 | 20. | 9. | .4500 | 4.8746 |
| 400.0000 | 2.6021 | 20. | 14. | .7000 | 5.5240 |
| 450.0000 | 2.6532 | 20. | 19. | .9500 | 6.6452 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .1822
TOTAL NUMBER OF CYCLES = 5

SUMMARY STATISTICS

AVG Y = 5.077084
AVG X = 2.496540
AVG T = 1.402291
NATURAL MORTALITY = .000000 SE = .000276
SLOPE = 4.898195 SE = 1.066673
T STATISTIC = SLOPE/SE = 4.592032
INTERCEPT = -7.151451
CHI SQUARED = 7.713995

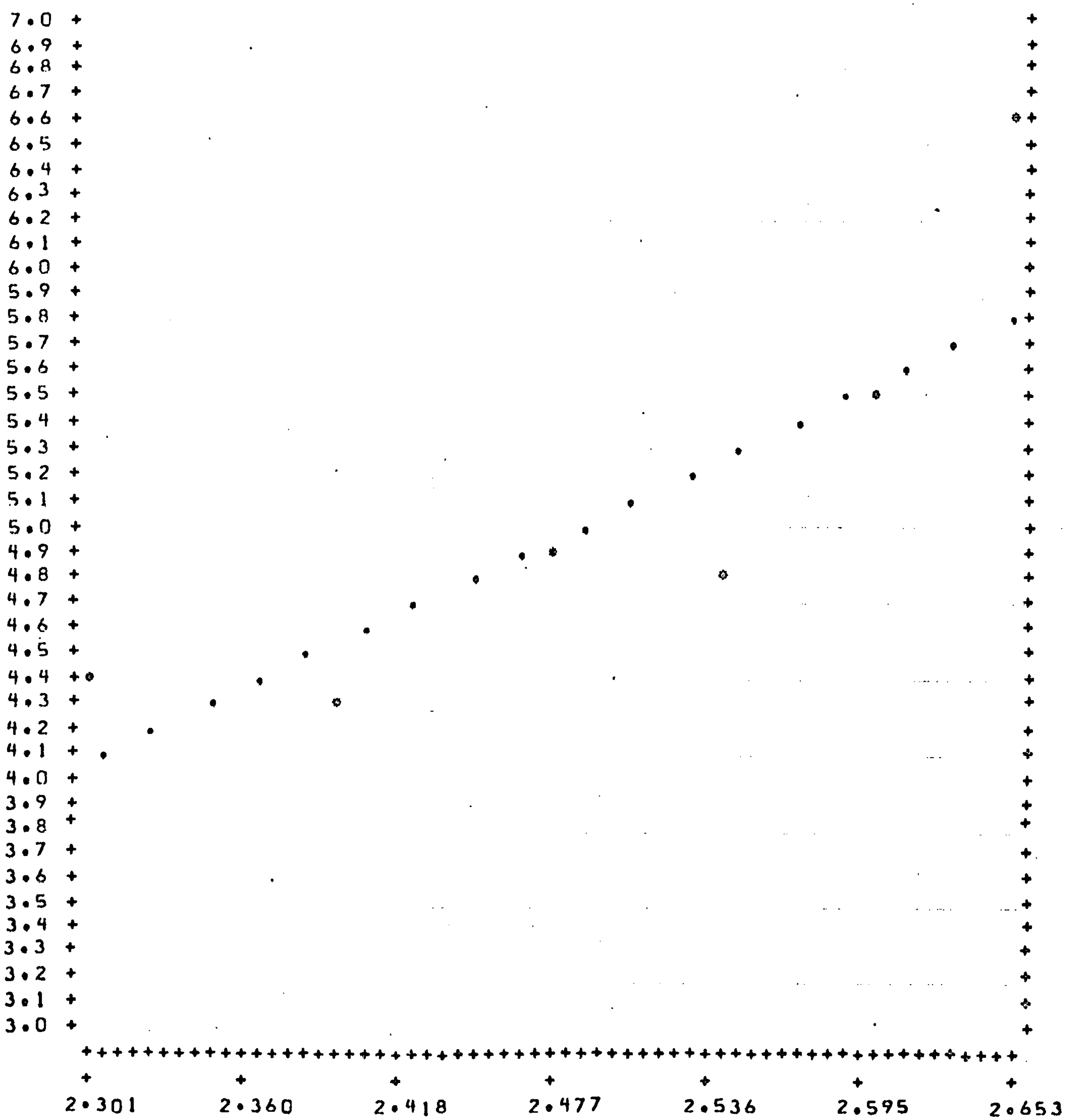
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 101.3612 | 43.1406 | 143.9632 |
| P = .05 | 139.6318 | 75.0678 | 181.0869 |
| P = .10 | 165.6359 | 100.6711 | 205.0318 |
| P = .20 | 203.6965 | 143.0488 | 239.2880 |
| P = .50 | 302.5533 | 264.7463 | 340.2217 |
| P = .80 | 449.3867 | 388.8153 | 609.5864 |
| P = .90 | 552.6488 | 455.0406 | 863.7893 |
| P = .95 | 655.5705 | 515.7115 | 1157.2744 |
| P = .99 | 903.0919 | 649.2224 | 2012.1167 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-4   96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   4.8982, INTERCEPT=  -7.1515,
NATURAL RESPONSE RATE=   .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-5 1 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 0. | .0001 | 1.2809 |
| 1500.0000 | 3.1761 | 20. | 0. | .0001 | 1.2809 |
| 2000.0000 | 3.3010 | 20. | 6. | .3000 | 4.4759 |
| 2500.0000 | 3.3979 | 20. | 9. | .4500 | 4.8746 |
| 3000.0000 | 3.4771 | 20. | 12. | .6000 | 5.2529 |
| 4000.0000 | 3.6021 | 20. | 14. | .7000 | 5.5240 |
| 5000.0000 | 3.6990 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2 3 8

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 8
DEGREES OF FREEDOM = 6
DEVIATE = 1.9600
G = .0834
TOTAL NUMBER OF CYCLES = 7

SUMMARY STATISTICS

AVG Y = 4.974712
AVG X = 3.434483
AVG T = 3.267531
NATURAL MORTALITY = .000036 SE = .000965
SLOPE = 6.070191 SE = .894604
T STATISTIC = SLOPE/SE = 6.785341
INTERCEPT = -15.873256
CHI SQUARED = 6.728146

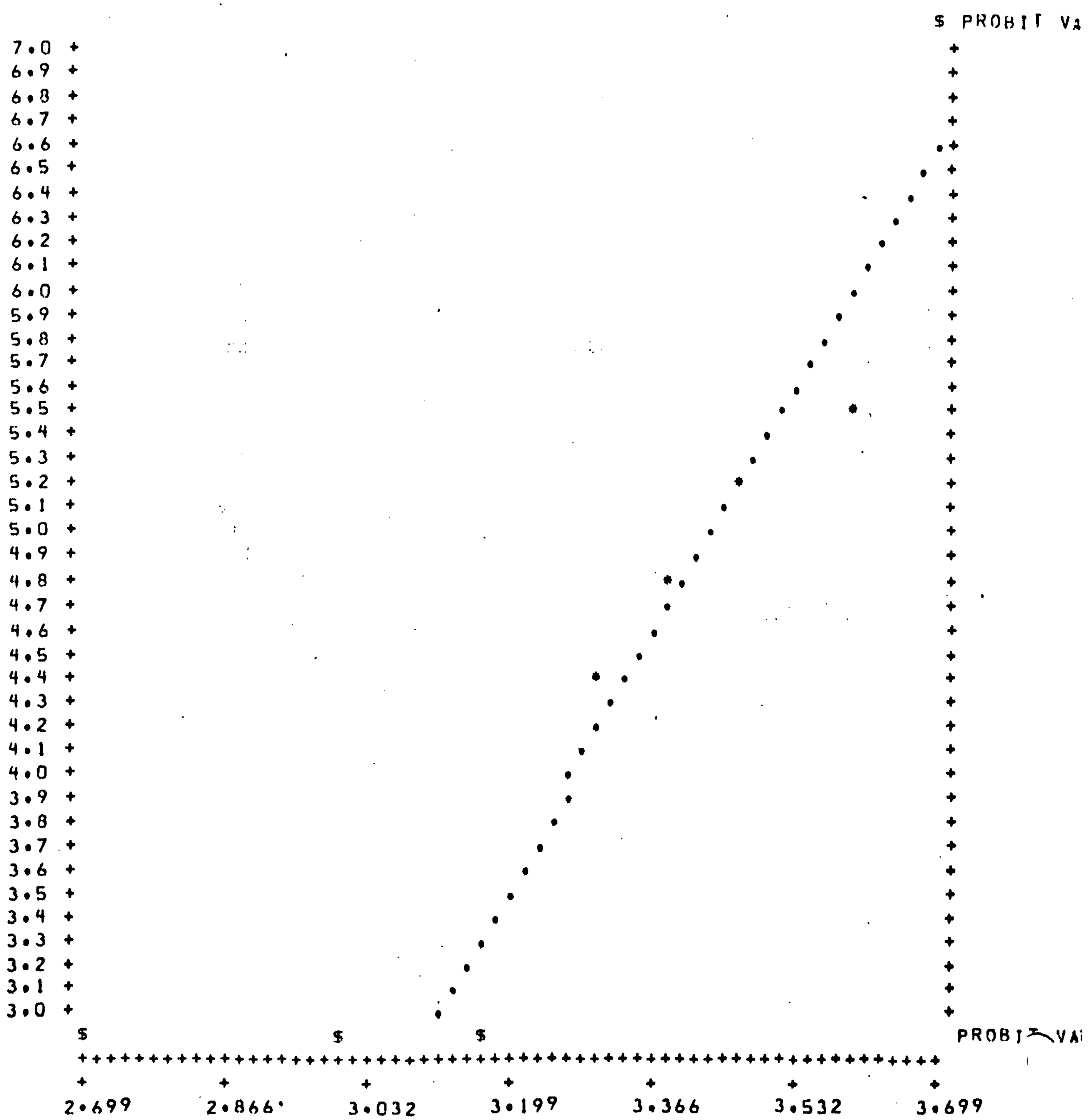
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 1136.0974 | 781.3811 | 1409.0520 |
| P = .05 | 1471.1911 | 1115.6112 | 1734.6904 |
| P = .10 | 1688.5695 | 1345.4032 | 1943.0274 |
| P = .20 | 1995.2820 | 1679.6531 | 2240.1645 |
| P = .50 | 2745.6744 | 2472.0735 | 3054.7140 |
| P = .80 | 3778.2765 | 3357.3855 | 4514.0160 |
| P = .90 | 4464.5646 | 3867.7854 | 5639.8834 |
| P = .95 | 5124.2342 | 4330.8447 | 6803.8754 |
| P = .99 | 6635.6334 | 5330.0377 | 9717.2532 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-5   1 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 6.0702, INTERCEPT= -15.8733,
NATURAL RESPONSE RATE= .0000

8 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-5 4 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 2. | .1000 | 3.7183 |
| 1500.0000 | 3.1761 | 20. | 2. | .1000 | 3.7183 |
| 2000.0000 | 3.3010 | 20. | 10. | .5000 | 5.0000 |
| 2500.0000 | 3.3979 | 20. | 15. | .7500 | 5.6742 |
| 3000.0000 | 3.4771 | 20. | 18. | .9000 | 6.2817 |
| 4000.0000 | 3.6021 | 20. | 18. | .9000 | 6.2817 |
| 5000.0000 | 3.6990 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 8

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 8
DEGREES OF FREEDOM = 6
DEVIATE = 1.9600
G = .0788
TOTAL NUMBER OF CYCLES = 10

SUMMARY STATISTICS

AVG Y = 5.202172
AVG X = 3.338781
AVG T = 3.247017
NATURAL MORTALITY = .000000 SE = .000009
SLOPE = 5.602317 SE = .802118
T STATISTIC = SLOPE/SE = 6.984406
INTERCEPT = -13.502734
CHI SQUARED = 5.888789

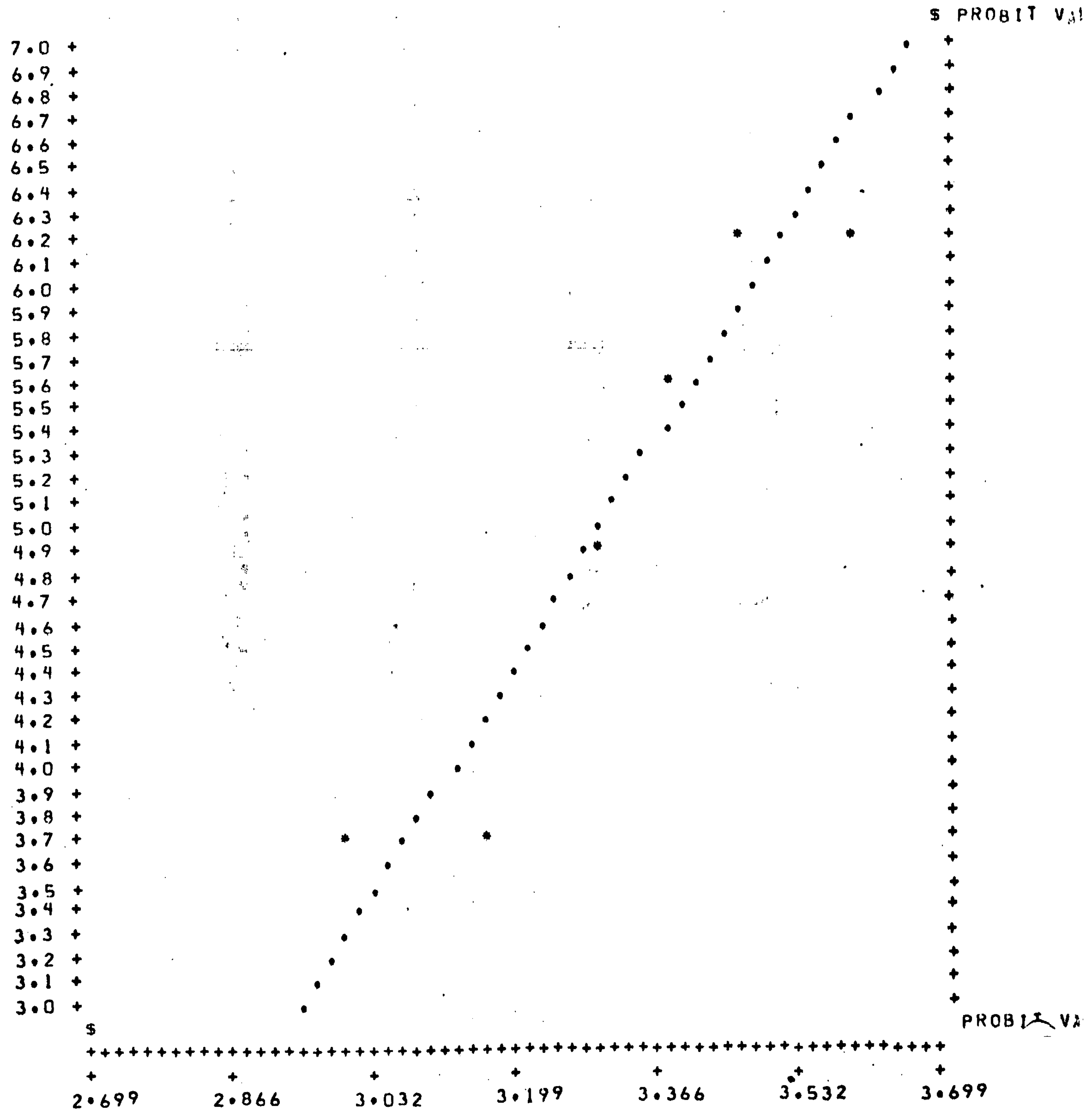
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 771.7100 | 504.3419 | 988.6043 |
| P = .05 | 1021.1332 | 739.4262 | 1238.5209 |
| P = .10 | 1185.5792 | 904.8866 | 1399.5459 |
| P = .20 | 1420.5924 | 1151.2784 | 1628.9435 |
| P = .50 | 2007.6735 | 1773.4518 | 2240.7693 |
| P = .80 | 2837.3743 | 2524.1419 | 3336.0508 |
| P = .90 | 3399.8170 | 2958.6427 | 4214.6268 |
| P = .95 | 3947.3321 | 3353.6278 | 5141.8552 |
| P = .99 | 5223.1434 | 4213.6041 | 7516.7747 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-5   4 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 5.6023, INTERCEPT= -13.5027,
NATURAL RESPONSE RATE= .0000

8 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-5    8 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20.  # DEATHS = 0.  NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0000 | .8764 |
| 1000.0000 | 3.0000 | 20. | 2. | .1000 | 3.7184 |
| 1500.0000 | 3.1761 | 20. | 4. | .2000 | 4.1586 |
| 2000.0000 | 3.3010 | 20. | 16. | .8000 | 5.8415 |
| 2500.0000 | 3.3979 | 20. | 18. | .9000 | 6.2817 |
| 3000.0000 | 3.4771 | 20. | 20. | .9999 | 8.7191 |
| 4000.0000 | 3.6021 | 20. | 18. | .9000 | 6.2817 |
| 5000.0000 | 3.6990 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 6 8

THERE IS AT LEAST ONE EXPECTED VALUE LESS THAN 5.

| DOSE | # RESPONSES | EXPECTED |
|---|---|---|
| 500.0000 | 0. | .0166 |
| 1000.0000 | 2. | 1.7257 |
| 1500.0000 | 4. | 7.5019 |
| 2000.0000 | 16. | 13.2809 |
| 2500.0000 | 18. | 16.8221 |
| 3000.0000 | 20. | 18.5823 |
| 4000.0000 | 18. | 19.7297 |
| 5000.0000 | 20. | 19.9467 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 2.9417
NUMBER OF POINTS = 8
DEGREES OF FREEDOM = 6
DEVIATE = 2.4470
G = .3794
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 5.302313
AVG X = 3.280653
AVG T = 3.112288
NATURAL MORTALITY = .000020   SE = .000000
SLOPE = 5.945162   SE = 1.496593
T STATISTIC = SLOPE/SE = 3.972465
INTERCEPT = -14.201824
CHI SQUARED = 17.649954  SIGNIF. AT .05

B( 25) - B( 24) = .0067957

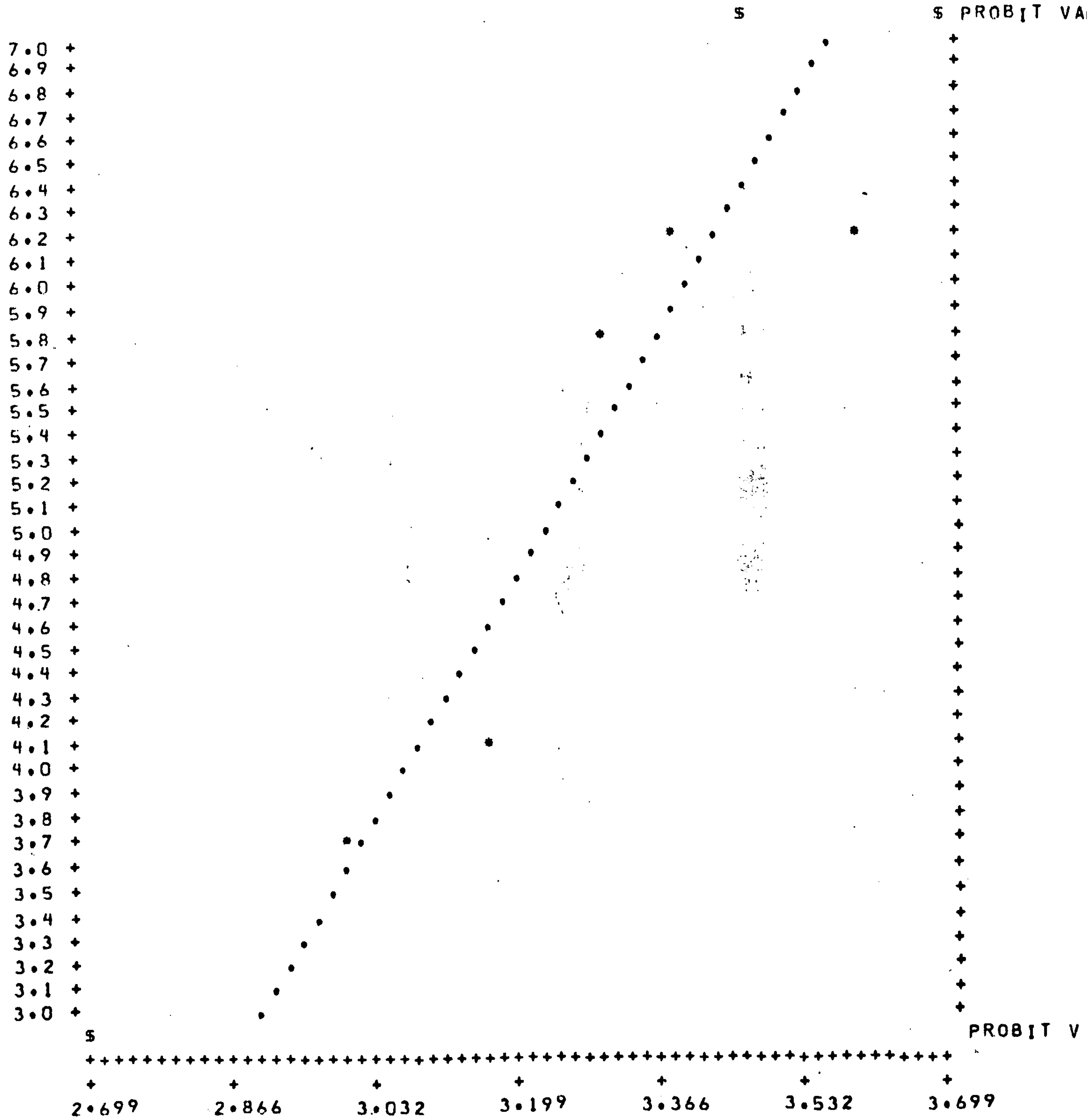
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 689.4938 | 129.0176 | 1061.4975 |
| P = .05 | 897.7276 | 252.8793 | 1267.7883 |
| P = .10 | 1033.3635 | 360.4360 | 1399.8436 |
| P = .20 | 1225.3576 | 549.1606 | 1591.2393 |
| P = .50 | 1697.5529 | 1146.1539 | 2179.8648 |
| P = .80 | 2351.7102 | 1855.8501 | 3849.1701 |
| P = .90 | 2788.6472 | 2173.0079 | 5693.4571 |
| P = .95 | 3209.9778 | 2428.2963 | 8018.3161 |
| P = .99 | 4179.4222 | 2931.3735 | 15549.1173 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-5    8 HR

'LOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

'HE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   5.9452, INTERCEPT= -14.2018,
JATURAL RESPONSE RATE=    .0000

8 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-5    24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL:  SAMPLE SIZE =  20.  # DEATHS =  0.  NATURAL MORTALITY =  .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 300.0000 | 2.4771 | 20. | 1. | .0500 | 3.3548 |
| 350.0000 | 2.5441 | 20. | 3. | .1500 | 3.9636 |
| 400.0000 | 2.6021 | 20. | 2. | .1000 | 3.7183 |
| 450.0000 | 2.6532 | 20. | 0. | .0001 | 1.2809 |
| 500.0000 | 2.6990 | 20. | 6. | .3000 | 4.4760 |
| 550.0000 | 2.7404 | 20. | 8. | .4000 | 4.7471 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS  4

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .5242
TOTAL NUMBER OF CYCLES = 9

SUMMARY STATISTICS

AVG Y = 4.085091
AVG X = 2.648247
AVG T = 3.798893
NATURAL MORTALITY = .000000    SE = .000060
SLOPE = 4.738658    SE = 1.750441
T STATISTIC = SLOPE/SE = 2.707122
INTERCEPT = -8.464048
CHI SQUARED = 7.027221

NONSIGNIFICANT REGRESSION

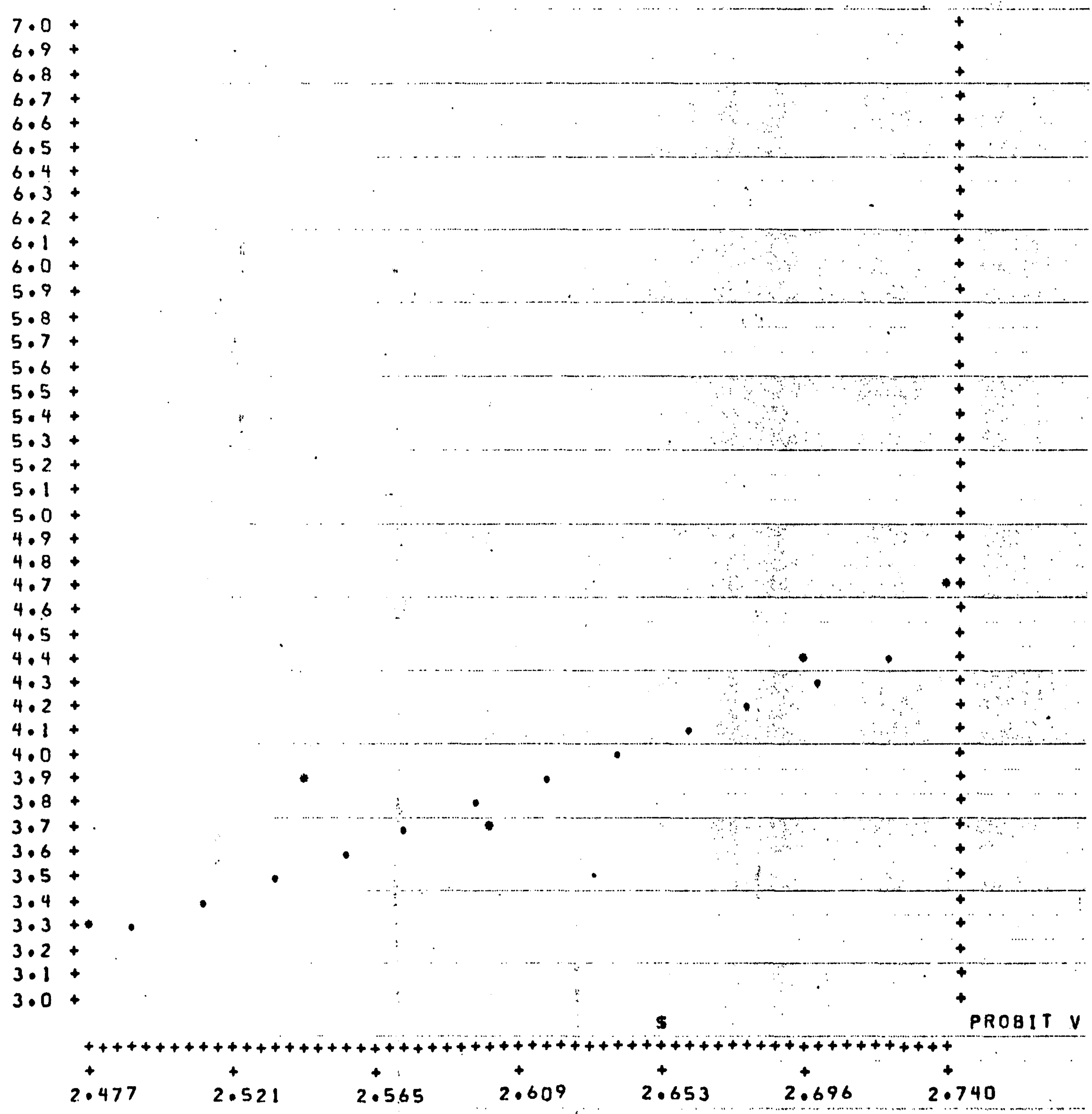
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 224.0790 | 36.4031 | 304.3534 |
| P = .05 | 312.0306 | 118.8890 | 374.8108 |
| P = .10 | 372.2755 | 218.9827 | 427.3763 |
| P = .20 | 461.0179 | 391.3849 | 587.3802 |
| P = .50 | 693.9382 | 560.0169 | 2290.1601 |
| P = .80 | 1044.5370 | 719.2715 | 9947.5845 |
| P = .90 | 1293.5318 | 816.6120 | 21522.7622 |
| P = .95 | 1543.2788 | 906.1608 | 40735.6577 |
| P = .99 | 2149.0197 | 1100.3476 | 134923.5879 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-5 24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 4.7387, INTERCEPT= -8.4640,
NATURAL RESPONSE RATE= .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-5 48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = -.

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 300.0000 | 2.4771 | 20. | 1. | .0500 | 3.3548 |
| 350.0000 | 2.5441 | 20. | 6. | .3000 | 4.4760 |
| 400.0000 | 2.6021 | 20. | 4. | .2000 | 4.1585 |
| 450.0000 | 2.6532 | 20. | 7. | .3500 | 4.6151 |
| 500.0000 | 2.6990 | 20. | 9. | .4500 | 4.8746 |
| 550.0000 | 2.7404 | 20. | 12. | .6000 | 5.2529 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .2710
TOTAL NUMBER OF CYCLES = 3

SUMMARY STATISTICS

AVG Y = 4.583683
AVG X = 2.636832
AVG T = 2.181445
NATURAL MORTALITY = -.000000 SE = .000379
SLOPE = 5.619625 SE = 1.492582
T STATISTIC = SLOPE/SE = 3.765036
INTERCEPT = -10.234314
CHI SQUARED = 3.346790

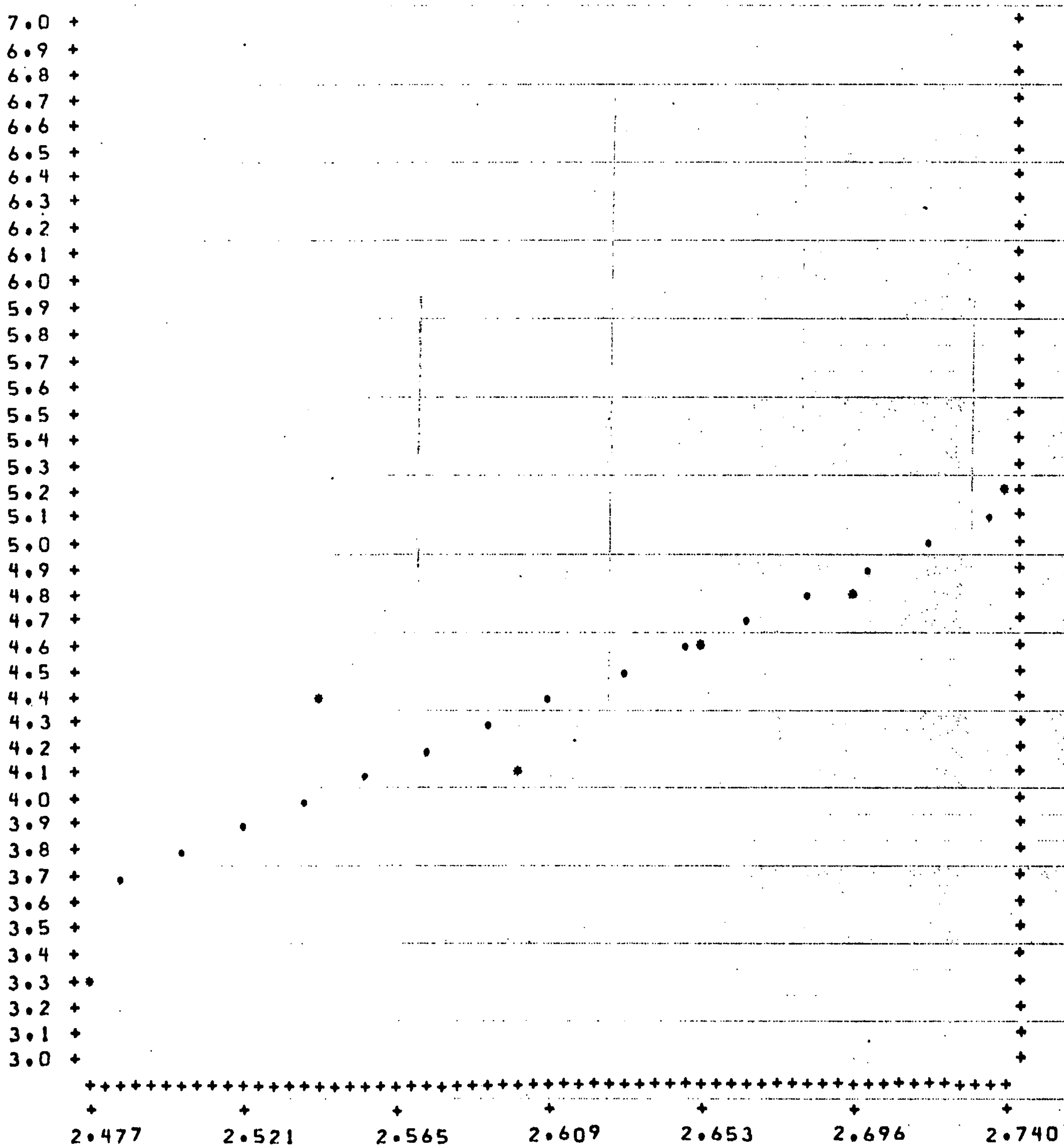
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 198.1313 | 83.6795 | 262.1727 |
| P = .05 | 261.9429 | 148.8439 | 317.0549 |
| P = .10 | 303.9871 | 201.5854 | 352.1835 |
| P = .20 | 364.0425 | 287.6047 | 404.7991 |
| P = .50 | 513.9407 | 462.4437 | 648.4028 |
| P = .80 | 725.5610 | 597.2285 | 1293.0982 |
| P = .90 | 868.9024 | 675.4853 | 1874.8374 |
| P = .95 | 1008.3688 | 746.7123 | 2551.4605 |
| P = .99 | 1333.1318 | 899.6972 | 4555.1695 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-5 48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 5.6196, INTERCEPT= -10.2343,
NATURAL RESPONSE RATE= -.0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-5 96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 300.0000 | 2.4771 | 20. | 3. | .1500 | 3.9636 |
| 350.0000 | 2.5441 | 20. | 6. | .3000 | 4.4760 |
| 400.0000 | 2.6021 | 20. | 5. | .2500 | 4.3258 |
| 450.0000 | 2.6532 | 20. | 10. | .5000 | 5.0000 |
| 500.0000 | 2.6990 | 20. | 14. | .7000 | 5.5240 |
| 550.0000 | 2.7404 | 20. | 17. | .8500 | 6.0364 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .1500
TOTAL NUMBER OF CYCLES = 7

SUMMARY STATISTICS

AVG Y = 4.930497
AVG X = 2.627557
AVG T = 1.719033
NATURAL MORTALITY = .000000 SE = .000077
SLOPE = 7.583950 SE = 1.498660
T STATISTIC = SLOPE/SE = 5.060489
INTERCEPT = -14.996763
CHI SQUARED = 3.185886

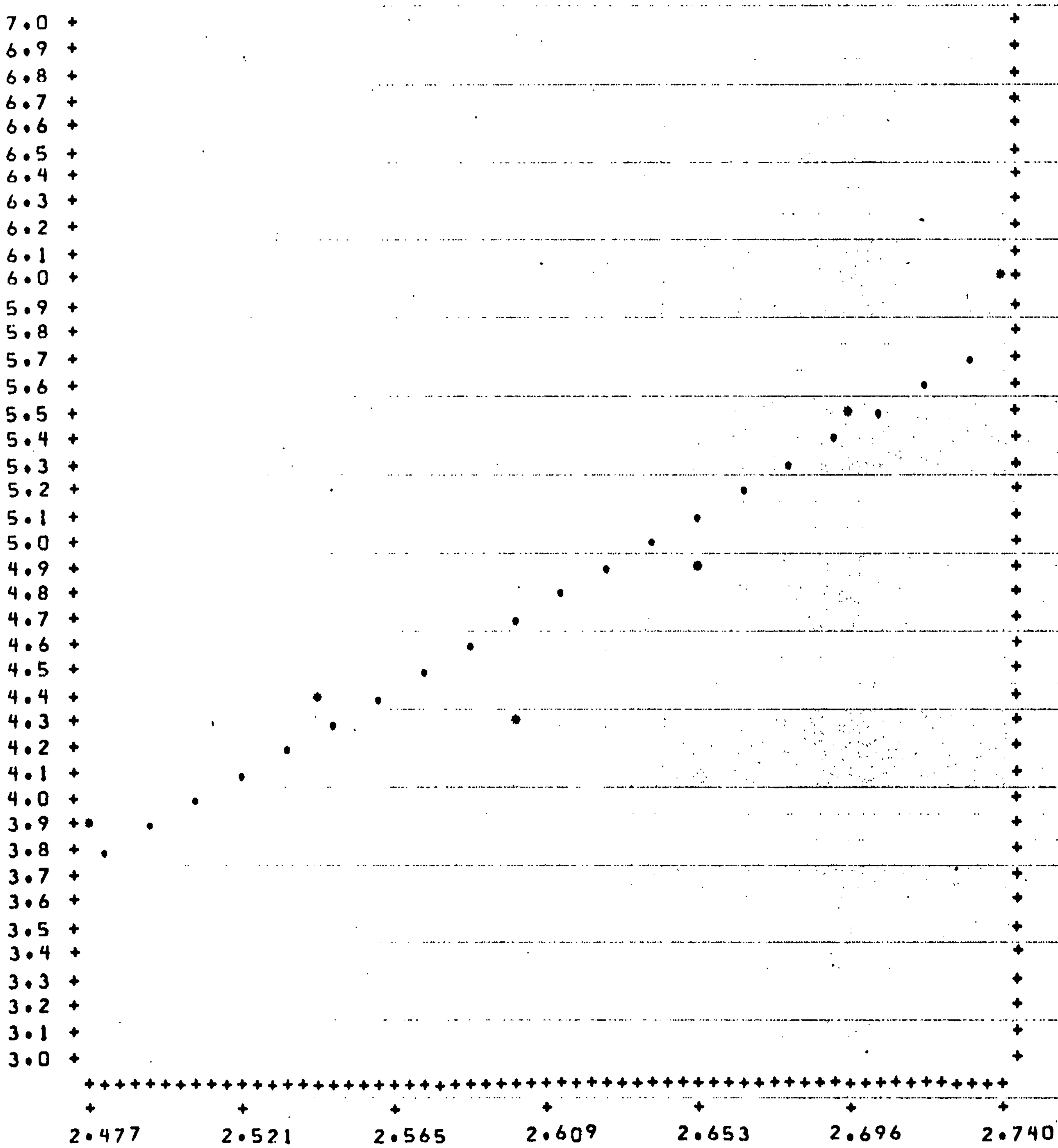
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 213.7871 | 137.2376 | 261.4887 |
| P = .05 | 262.9233 | 191.5663 | 304.8009 |
| P = .10 | 293.5843 | 228.4615 | 331.3132 |
| P = .20 | 335.5445 | 281.7037 | 367.9362 |
| P = .50 | 433.2328 | 401.1371 | 471.3946 |
| P = .80 | 559.3615 | 505.8594 | 681.9619 |
| P = .90 | 639.3075 | 560.8276 | 842.3134 |
| P = .95 | 713.8609 | 609.2339 | 1005.1609 |
| P = .99 | 877.9328 | 709.7744 | 1403.8111 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-5    96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=    7.5839, INTERCEPT= -14.9968,
NATURAL RESPONSE RATE=    .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-6 1 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 0. | .0001 | 1.2809 |
| 1500.0000 | 3.1761 | 20. | 2. | .1000 | 3.7180 |
| 2000.0000 | 3.3010 | 20. | 12. | .6000 | 5.2529 |
| 2500.0000 | 3.3979 | 20. | 11. | .5500 | 5.1253 |
| 3000.0000 | 3.4771 | 20. | 16. | .8000 | 5.8414 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .0943
TOTAL NUMBER OF CYCLES = 9

SUMMARY STATISTICS

AVG Y = 5.173838
AVG X = 3.353719
AVG T = 2.753739
NATURAL MORTALITY = .000048 SE = .001107
SLOPE = 7.369503 SE = 1.154875
T STATISTIC = SLOPE/SE = 6.381211
INTERCEPT = -19.541400
CHI SQUARED = 6.810274

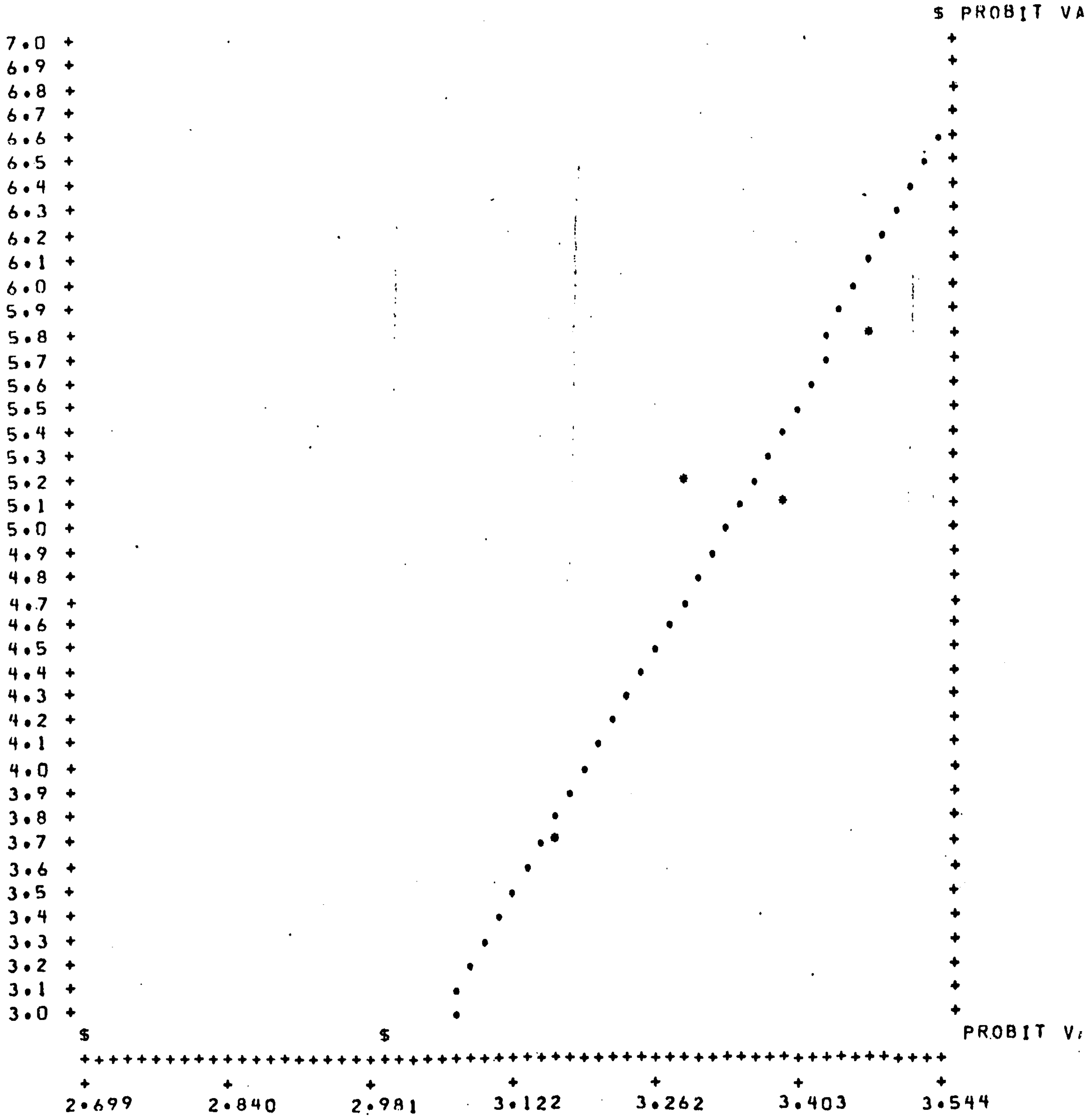
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 1033.8648 | 719.2914 | 1262.7684 |
| P = .05 | 1279.1630 | 972.5937 | 1494.4623 |
| P = .10 | 1432.9256 | 1140.3192 | 1637.7822 |
| P = .20 | 1644.1035 | 1378.1753 | 1835.8117 |
| P = .50 | 2138.5999 | 1930.9787 | 2341.7922 |
| P = .80 | 2781.8257 | 2526.1122 | 3199.3839 |
| P = .90 | 3191.7981 | 2845.8971 | 3847.2448 |
| P = .95 | 3575.4702 | 3125.6562 | 4500.8445 |
| P = .99 | 4423.7982 | 3706.7332 | 6073.3978 |

J. R. GIBSON  MR 2149  ACARTIA TONSA  SAMPLE 9923-6  1 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 7.3695, INTERCEPT= -19.5414,
NATURAL RESPONSE RATE= .0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON  MR 2149  ACARTIA TONSA  SAMPLE 9923-6  4 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = -.

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 0. | .0001 | 1.2809 |
| 1500.0000 | 3.1761 | 20. | 8. | .3999 | 4.7469 |
| 2000.0000 | 3.3010 | 20. | 16. | .8000 | 5.8414 |
| 2500.0000 | 3.3979 | 20. | 15. | .7500 | 5.6741 |
| 3000.0000 | 3.4771 | 20. | 18. | .9000 | 6.2817 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .0882
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 5.309288
AVG X = 3.287047
AVG T = 2.792943
NATURAL MORTALITY = -.000041  SE = .002077
SLOPE = 6.660354  SE = 1.009318
T STATISTIC = SLOPE/SE = 6.598868
INTERCEPT = -16.583148
CHI SQUARED = 6.178421
B( 25) - B( 24) = -.0249423

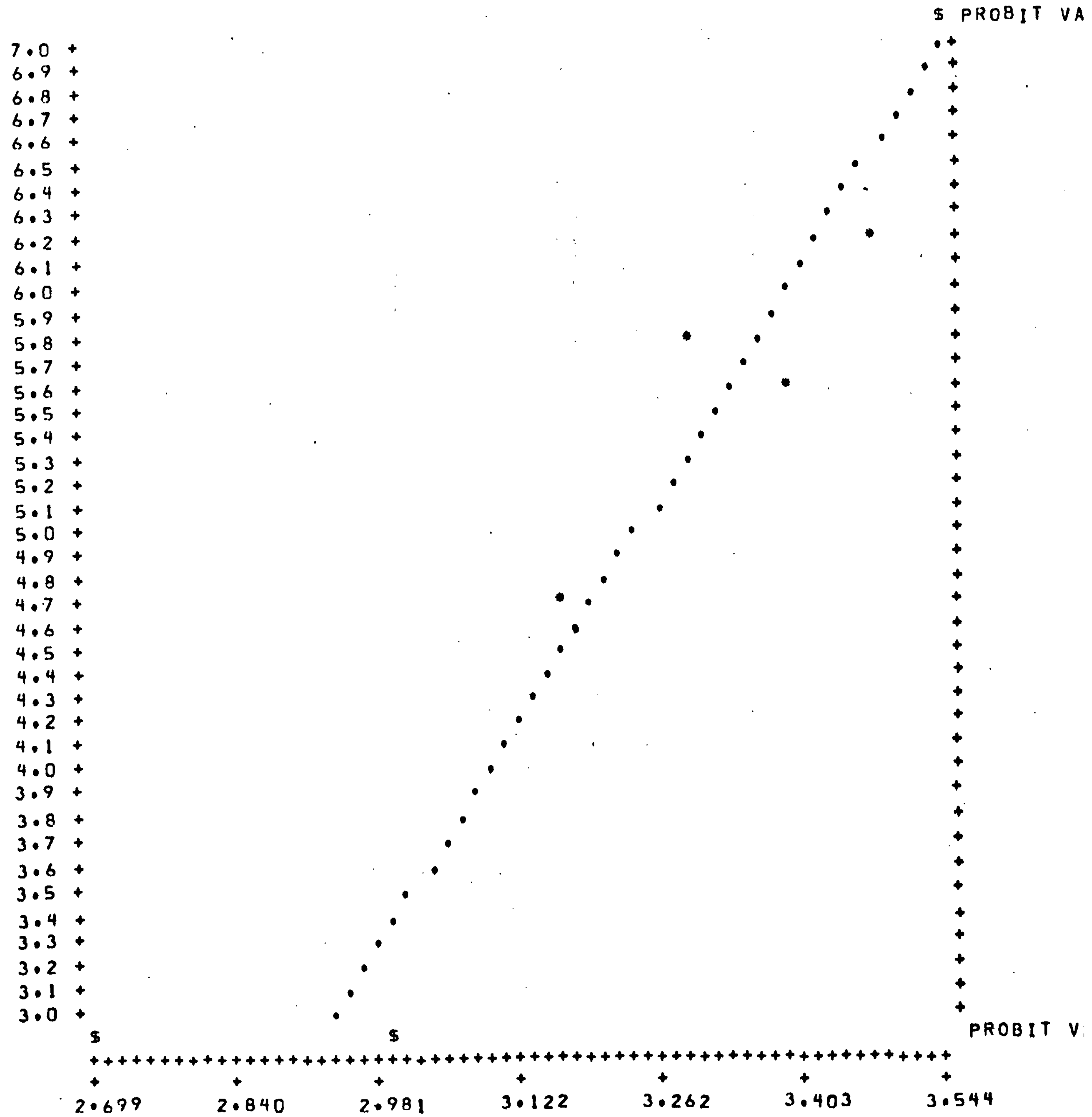
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 778.5109 | 519.7629 | 977.3466 |
| P = .05 | 985.3070 | 722.4137 | 1178.9069 |
| P = .10 | 1117.1673 | 859.5636 | 1305.0775 |
| P = .20 | 1300.7108 | 1057.8100 | 1480.5252 |
| P = .50 | 1739.9646 | 1539.0493 | 1926.3833 |
| P = .80 | 2327.5555 | 2096.8213 | 2676.7358 |
| P = .90 | 2709.9580 | 2403.2393 | 3260.4612 |
| P = .95 | 3072.6224 | 2672.6323 | 3861.7633 |
| P = .99 | 3888.8042 | 3237.7957 | 5344.2543 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-6   4 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   6.6604, INTERCEPT= -16.5831,
NATURAL RESPONSE RATE=   -.0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-6 8 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 4. | .2000 | 4.1585 |
| 1500.0000 | 3.1761 | 20. | 12. | .6000 | 5.2529 |
| 2000.0000 | 3.3010 | 20. | 20. | .9999 | 8.7191 |
| 2500.0000 | 3.3979 | 20. | 20. | .9999 | 8.7191 |
| 3000.0000 | 3.4771 | 20. | 20. | .9999 | 8.7191 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 4 5 6 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .1282
TOTAL NUMBER OF CYCLES = 8

SUMMARY STATISTICS

AVG Y = 5.285354
AVG X = 3.144049
AVG T = 4.606222
NATURAL MORTALITY = .000004 SE = .000640
SLOPE = 9.099302 SE = 1.662289
T STATISTIC = SLOPE/SE = 5.473959
INTERCEPT = -23.323273
CHI SQUARED = 2.722478

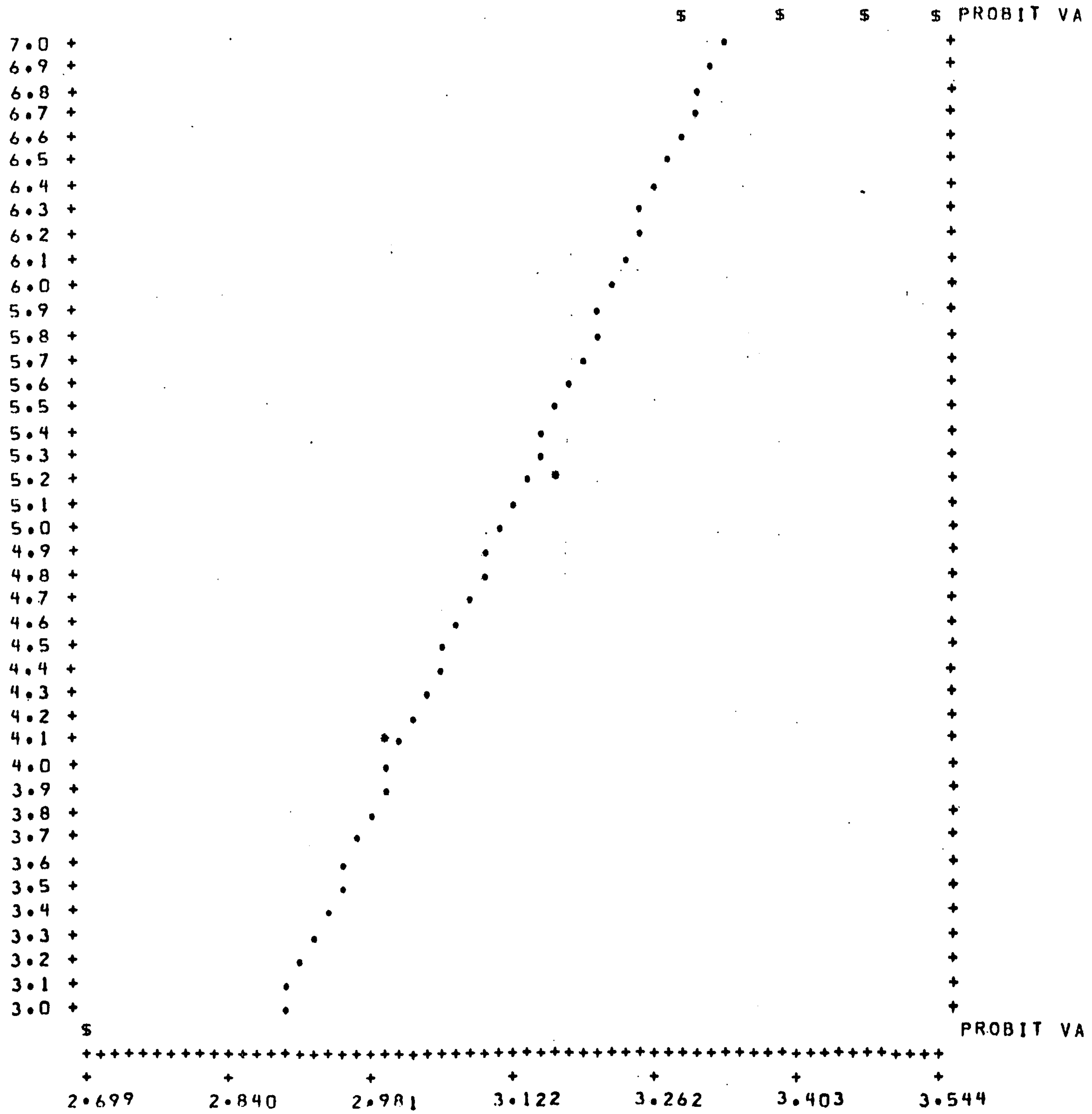
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 719.4977 | 487.7082 | 873.8975 |
| P = .05 | 854.8979 | 633.9438 | 998.5384 |
| P = .10 | 937.2175 | 727.7543 | 1074.0540 |
| P = .20 | 1047.6006 | 857.4598 | 1176.8745 |
| P = .50 | 1296.2428 | 1148.3259 | 1432.3969 |
| P = .80 | 1603.8989 | 1450.6472 | 1848.2099 |
| P = .90 | 1792.8022 | 1603.7994 | 2158.2219 |
| P = .95 | 1965.4340 | 1732.2577 | 2467.3398 |
| P = .99 | 2335.3036 | 1987.3402 | 3194.2148 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-6 8 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 9.0993, INTERCEPT= -23.3233,
NATURAL RESPONSE RATE= .0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-6 24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 300.0000 | 2.4771 | 20. | 1. | .0500 | 3.3548 |
| 350.0000 | 2.5441 | 20. | 0. | .0001 | 1.2809 |
| 400.0000 | 2.6021 | 20. | 2. | .1000 | 3.7183 |
| 450.0000 | 2.6532 | 20. | 8. | .4000 | 4.7471 |
| 500.0000 | 2.6990 | 20. | 6. | .3000 | 4.4760 |
| 550.0000 | 2.7404 | 20. | 9. | .4500 | 4.8746 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 2

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .2486
TOTAL NUMBER OF CYCLES = 6

SUMMARY STATISTICS

AVG Y = 4.321096
AVG X = 2.656907
AVG T = 3.518424
NATURAL MORTALITY = .000000 SE = .000248
SLOPE = 7.317760 SE = 1.861701
T STATISTIC = SLOPE/SE = 3.930684
INTERCEPT = -15.121505
CHI SQUARED = 5.435821

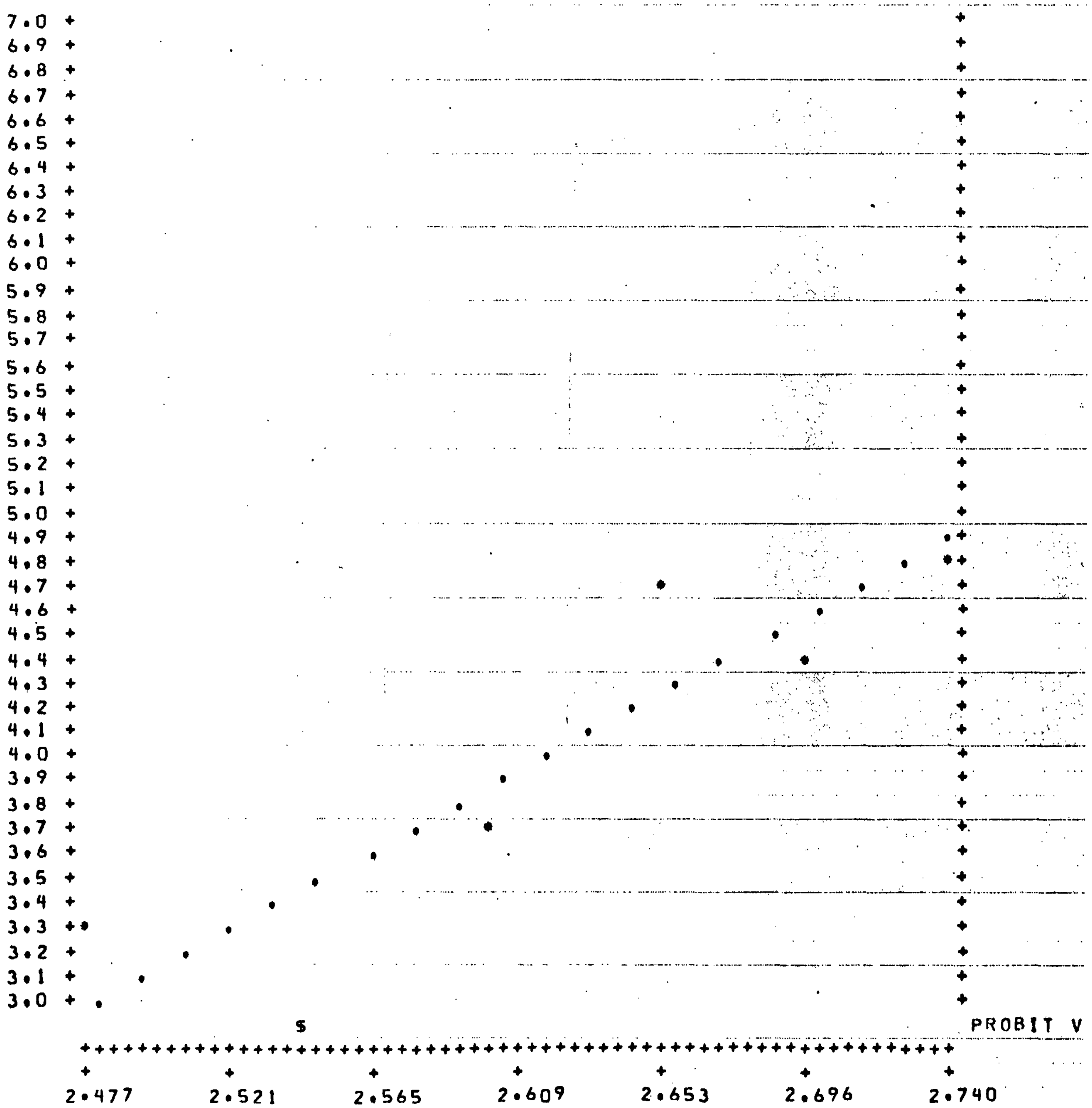
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 270.2608 | 159.1525 | 325.6516 |
| P = .05 | 334.8876 | 241.8922 | 379.1450 |
| P = .10 | 375.4442 | 300.4300 | 413.8425 |
| P = .20 | 431.1943 | 381.8167 | 470.7326 |
| P = .50 | 561.9283 | 507.3235 | 716.9317 |
| P = .80 | 732.2996 | 615.1857 | 1196.4381 |
| P = .90 | 841.0398 | 676.9408 | 1571.7980 |
| P = .95 | 942.8940 | 731.9172 | 1970.7727 |
| P = .99 | 1168.3656 | 846.3817 | 3015.7324 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-6 24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 7.3178, INTERCEPT= -15.1215,
NATURAL RESPONSE RATE= .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-6 48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 1. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 300.0000 | 2.4771 | 20. | 3. | .1076 | 3.7602 |
| 350.0000 | 2.5441 | 20. | 4. | .1601 | 4.0058 |
| 400.0000 | 2.6021 | 20. | 7. | .3175 | 4.5258 |
| 450.0000 | 2.6532 | 20. | 14. | .6850 | 5.4814 |
| 500.0000 | 2.6990 | 20. | 13. | .6325 | 5.3381 |
| 550.0000 | 2.7404 | 20. | 14. | .6850 | 5.4814 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .2261
TOTAL NUMBER OF CYCLES = 5

SUMMARY STATISTICS

AVG Y = 4.915166
AVG X = 2.638118
AVG T = 1.711835
NATURAL MORTALITY = .047559 SE = .046794
SLOPE = 7.455770 SE = 1.808693
T STATISTIC = SLOPE/SE = 4.122186
INTERCEPT = -14.754037
CHI SQUARED = 3.114439

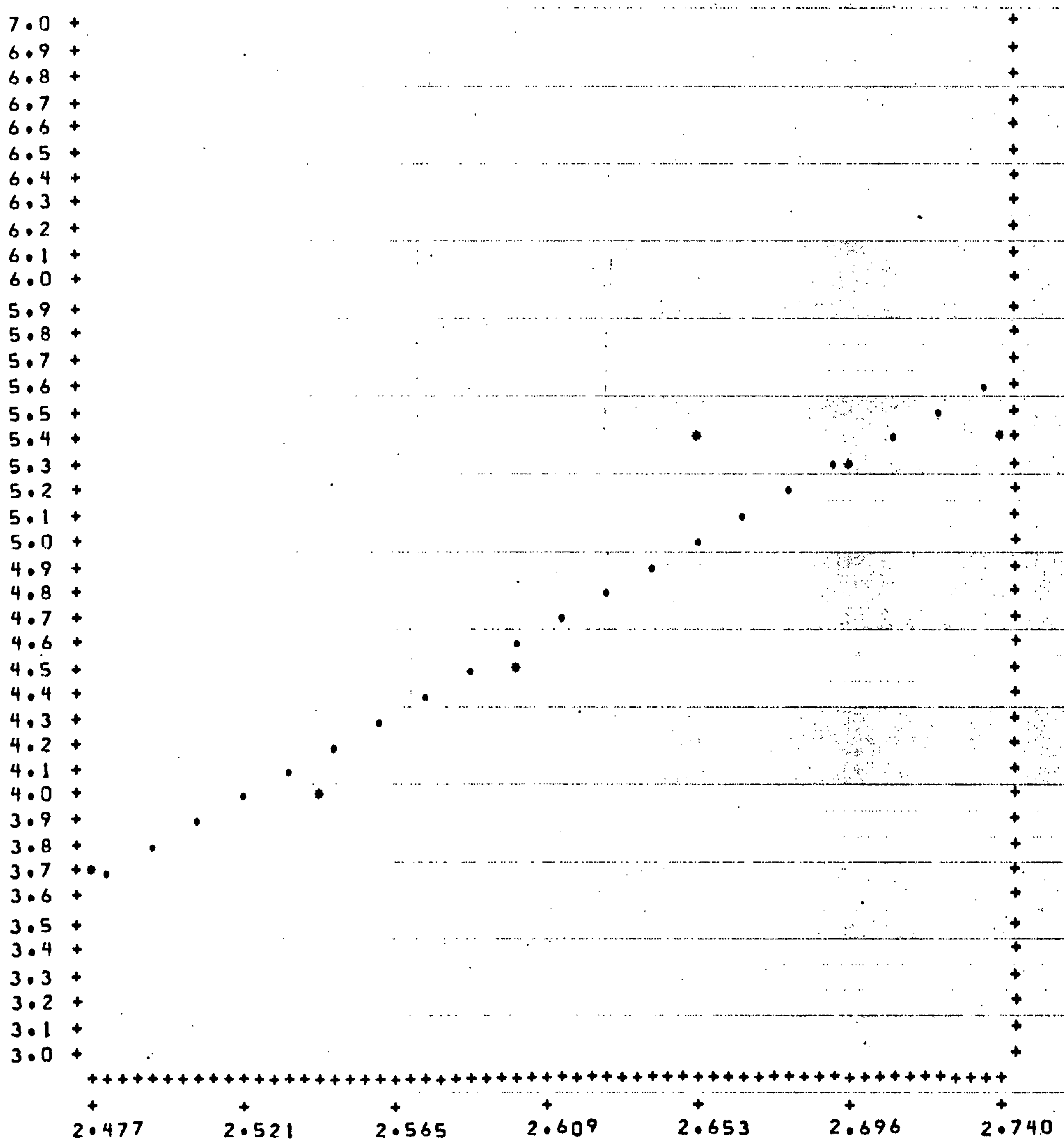
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 217.5119 | 110.6628 | 278.7918 |
| P = .05 | 268.4573 | 164.4997 | 323.0694 |
| P = .10 | 300.3327 | 202.8457 | 350.1210 |
| P = .20 | 344.0466 | 260.4081 | 387.4694 |
| P = .50 | 446.1658 | 399.5030 | 494.3995 |
| P = .80 | 578.5958 | 516.7765 | 748.1718 |
| P = .90 | 662.8114 | 572.6926 | 959.1589 |
| P = .95 | 741.5106 | 620.9556 | 1182.1556 |
| P = .99 | 915.1867 | 719.8782 | 1756.5298 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-6    48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 7.4558, INTERCEPT= -14.7540,
NATURAL RESPONSE RATE= .0476

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-6 96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 1. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 300.0000 | 2.4771 | 20. | 4. | .1154 | 3.8015 |
| 350.0000 | 2.5441 | 20. | 4. | .1154 | 3.8015 |
| 400.0000 | 2.6021 | 20. | 8. | .3365 | 4.5785 |
| 450.0000 | 2.6532 | 20. | 15. | .7236 | 5.5931 |
| 500.0000 | 2.6990 | 20. | 14. | .6683 | 5.4347 |
| 550.0000 | 2.7404 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 6

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .1965
TOTAL NUMBER OF CYCLES = 23

SUMMARY STATISTICS

AVG Y = 5.229132
AVG X = 2.645455
AVG T = 1.597838
NATURAL MORTALITY = .095658 SE = .055696
SLOPE = 12.610597 SE = 2.852032
T STATISTIC = SLOPE/SE = 4.421618
INTERCEPT = -28.131636
CHI SQUARED = 6.589073

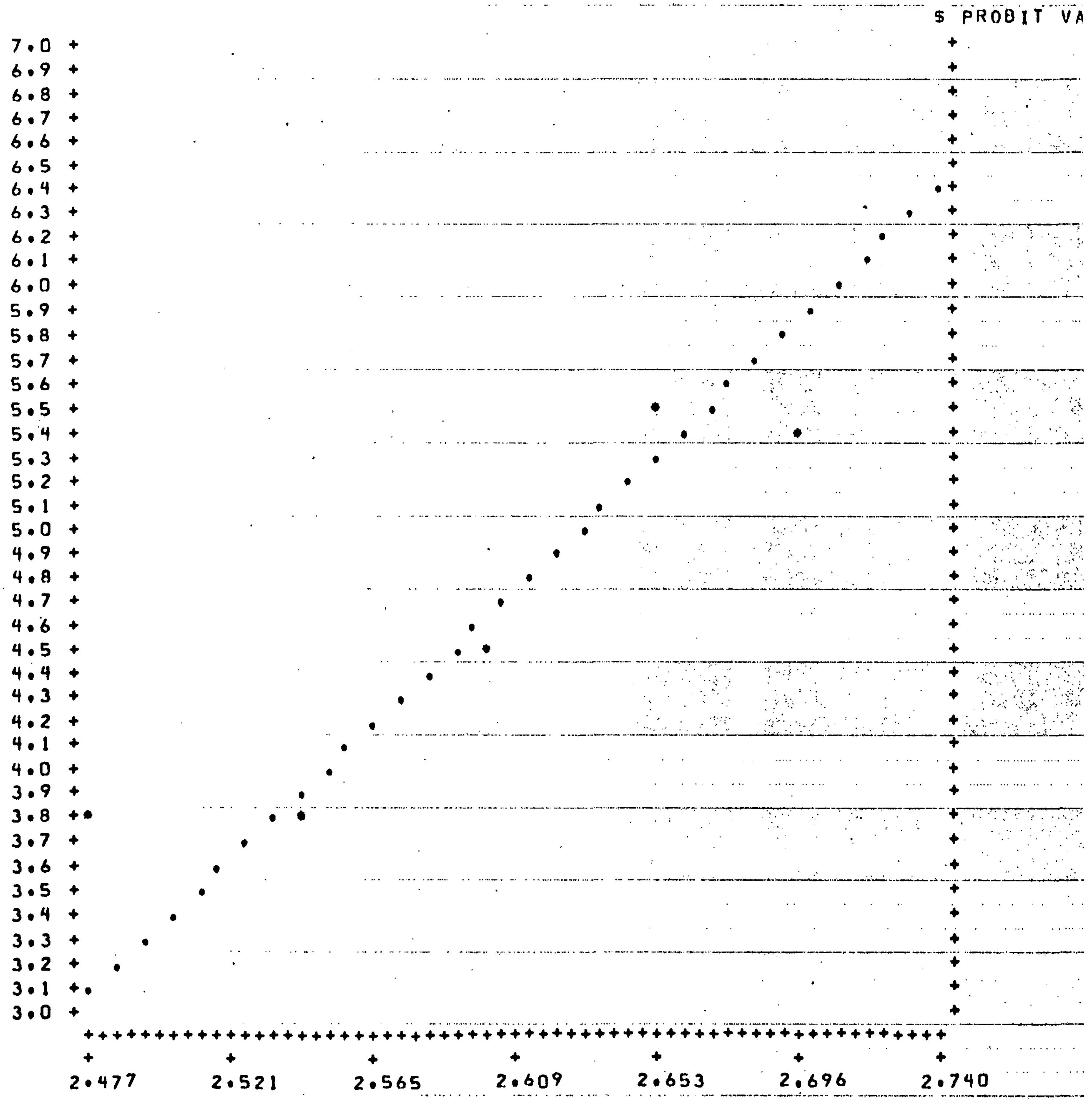
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 277.2129 | 183.7758 | 326.7029 |
| P = .05 | 313.9405 | 229.1344 | 357.1464 |
| P = .10 | 335.4721 | 257.5140 | 374.8386 |
| P = .20 | 363.5362 | 296.1752 | 398.0560 |
| P = .50 | 423.9213 | 381.7150 | 452.5242 |
| P = .80 | 494.3365 | 463.1855 | 546.9775 |
| P = .90 | 535.6906 | 497.4584 | 622.0357 |
| P = .95 | 572.4309 | 524.3783 | 696.0426 |
| P = .99 | 648.2716 | 575.3847 | 864.6048 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-6 96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 12.6106, INTERCEPT= -28.1316,
NATURAL RESPONSE RATE= .0957

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-7    1 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20.  # DEATHS = 0.  NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 1. | .0384 | 3.2301 |
| 1000.0000 | 3.0000 | 20. | 2. | .0890 | 3.6530 |
| 1500.0000 | 3.1761 | 20. | 4. | .1902 | 4.1231 |
| 2000.0000 | 3.3010 | 20. | 6. | .2915 | 4.4513 |
| 3000.0000 | 3.4771 | 20. | 16. | .7976 | 5.8328 |
| 3500.0000 | 3.5441 | 20. | 14. | .6963 | 5.5135 |
| 4000.0000 | 3.6021 | 20. | 13. | .6457 | 5.3734 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .1583
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 4.922639
AVG X = 3.376585
AVG T = 2.109094
NATURAL MORTALITY = .012123    SE = .021186
SLOPE = 3.289242    SE = .667655
T STATISTIC = SLOPE/SE = 4.926558
INTERCEPT = -6.183911
CHI SQUARED = 5.920975
B( 25) - B( 24) = .0018528

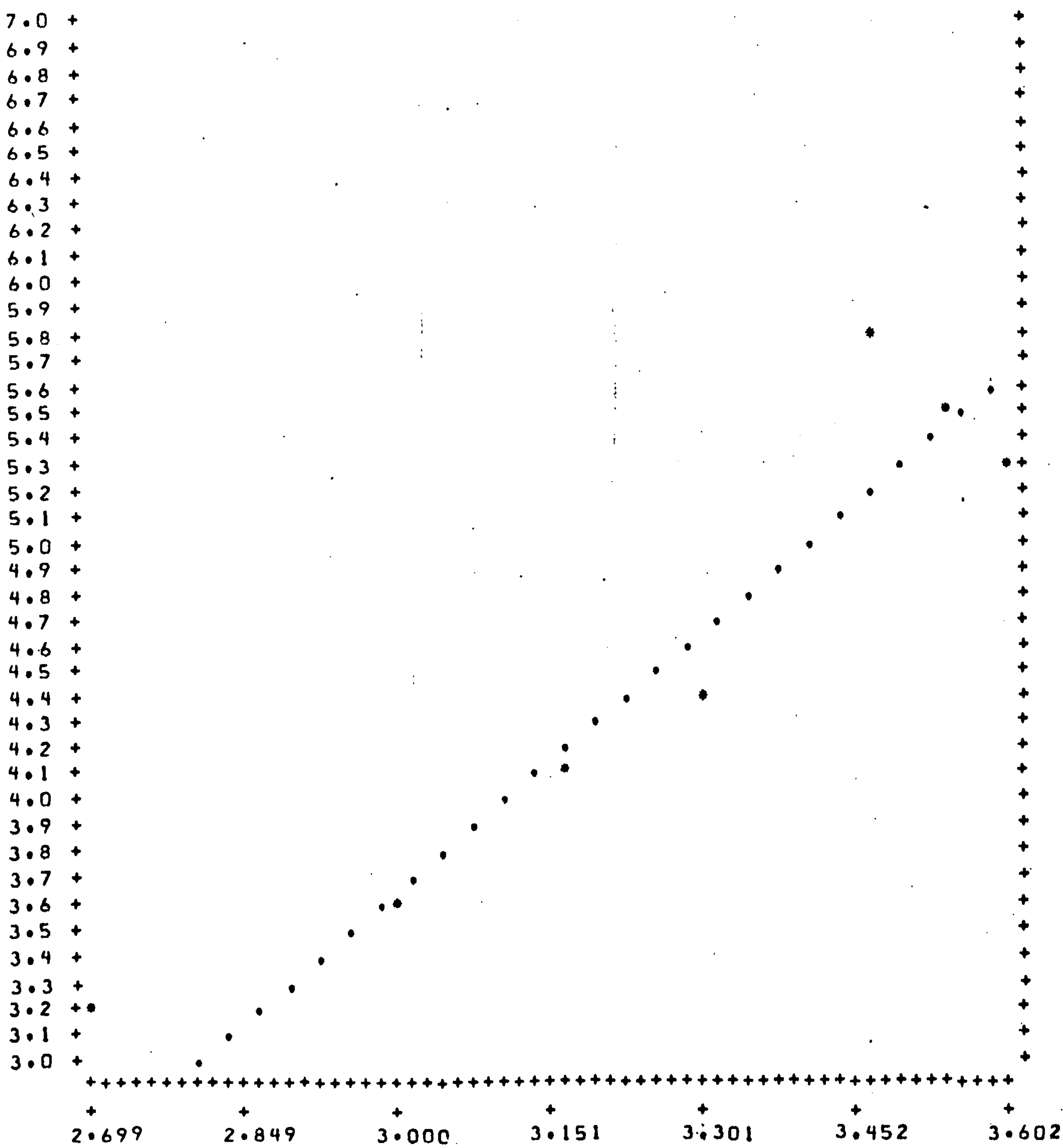
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 493.0642 | 163.5195 | 804.7006 |
| P = .05 | 794.4447 | 357.5257 | 1143.2127 |
| P = .10 | 1024.5064 | 540.4947 | 1383.8342 |
| P = .20 | 1394.0685 | 884.2456 | 1758.5315 |
| P = .50 | 2512.7458 | 2057.7315 | 3064.0110 |
| P = .80 | 4529.1105 | 3595.7770 | 7109.5477 |
| P = .90 | 6162.8611 | 4570.8964 | 11627.3580 |
| P = .95 | 7947.5516 | 5533.6418 | 17575.6897 |
| P = .99 | 12805.4114 | 7862.2858 | 38424.2227 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-7    1 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   3.2892, INTERCEPT=  -6.1839,
NATURAL RESPONSE RATE=   .0121

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-7   4 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 1. | .0243 | 3.0276 |
| 1000.0000 | 3.0000 | 20. | 2. | .0757 | 3.5648 |
| 1500.0000 | 3.1761 | 20. | 4. | .1784 | 4.0785 |
| 2000.0000 | 3.3010 | 20. | 14. | .6919 | 5.5008 |
| 3000.0000 | 3.4771 | 20. | 18. | .8973 | 6.2665 |
| 3500.0000 | 3.5441 | 20. | 18. | .8973 | 6.2665 |
| 4000.0000 | 3.6021 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .1017
TOTAL NUMBER OF CYCLES = 8

SUMMARY STATISTICS

AVG Y = 5.314131
AVG X = 3.322272
AVG T = 1.778980
NATURAL MORTALITY = .026337   SE = .024837
SLOPE = 6.015495   SE = .978770
T STATISTIC = SLOPE/SE = 6.145976
INTERCEPT = -14.670980
CHI SQUARED = 4.849266

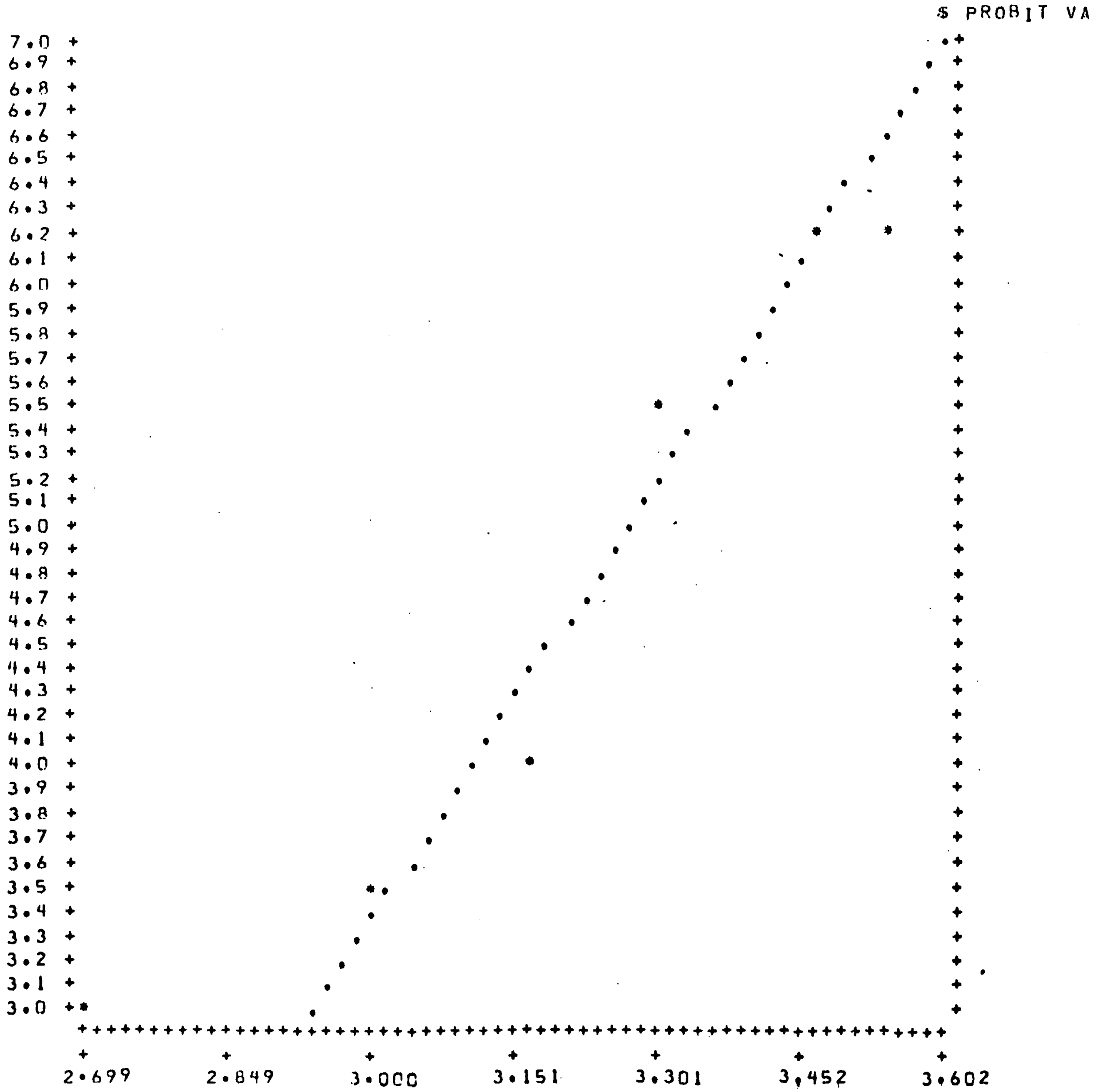
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 764.4224 | 459.5192 | 1005.1417 |
| P = .05 | 992.2189 | 669.2756 | 1233.4546 |
| P = .10 | 1140.2538 | 816.2653 | 1378.3520 |
| P = .20 | 1349.4164 | 1034.6993 | 1582.0802 |
| P = .50 | 1862.3071 | 1590.0048 | 2109.2792 |
| P = .80 | 2570.1392 | 2267.5299 | 3030.1862 |
| P = .90 | 3041.5928 | 2644.0905 | 3780.9177 |
| P = .95 | 3495.3857 | 2975.7895 | 4578.6207 |
| P = .99 | 4537.0049 | 3676.4669 | 6623.7430 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-7   4 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   6.0155, INTERCEPT= -14.6710,
NATURAL RESPONSE RATE=   .0263

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-7 8 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 1. | .0247 | 3.0340 |
| 1000.0000 | 3.0000 | 20. | 2. | .0760 | 3.5673 |
| 1500.0000 | 3.1761 | 20. | 6. | .2813 | 4.4215 |
| 2000.0000 | 3.3010 | 20. | 16. | .7947 | 5.8225 |
| 3000.0000 | 3.4771 | 20. | 18. | .8973 | 6.2667 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |
| 4000.0000 | 3.6021 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 6 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .1120
TOTAL NUMBER OF CYCLES = 8

SUMMARY STATISTICS

AVG Y = 5.287287
AVG X = 3.270461
AVG T = 1.825830
NATURAL MORTALITY = .025967 SE = .024712
SLOPE = 6.807632 SE = 1.162284
T STATISTIC = SLOPE/SE = 5.857117
INTERCEPT = -16.976813
CHI SQUARED = 4.455172

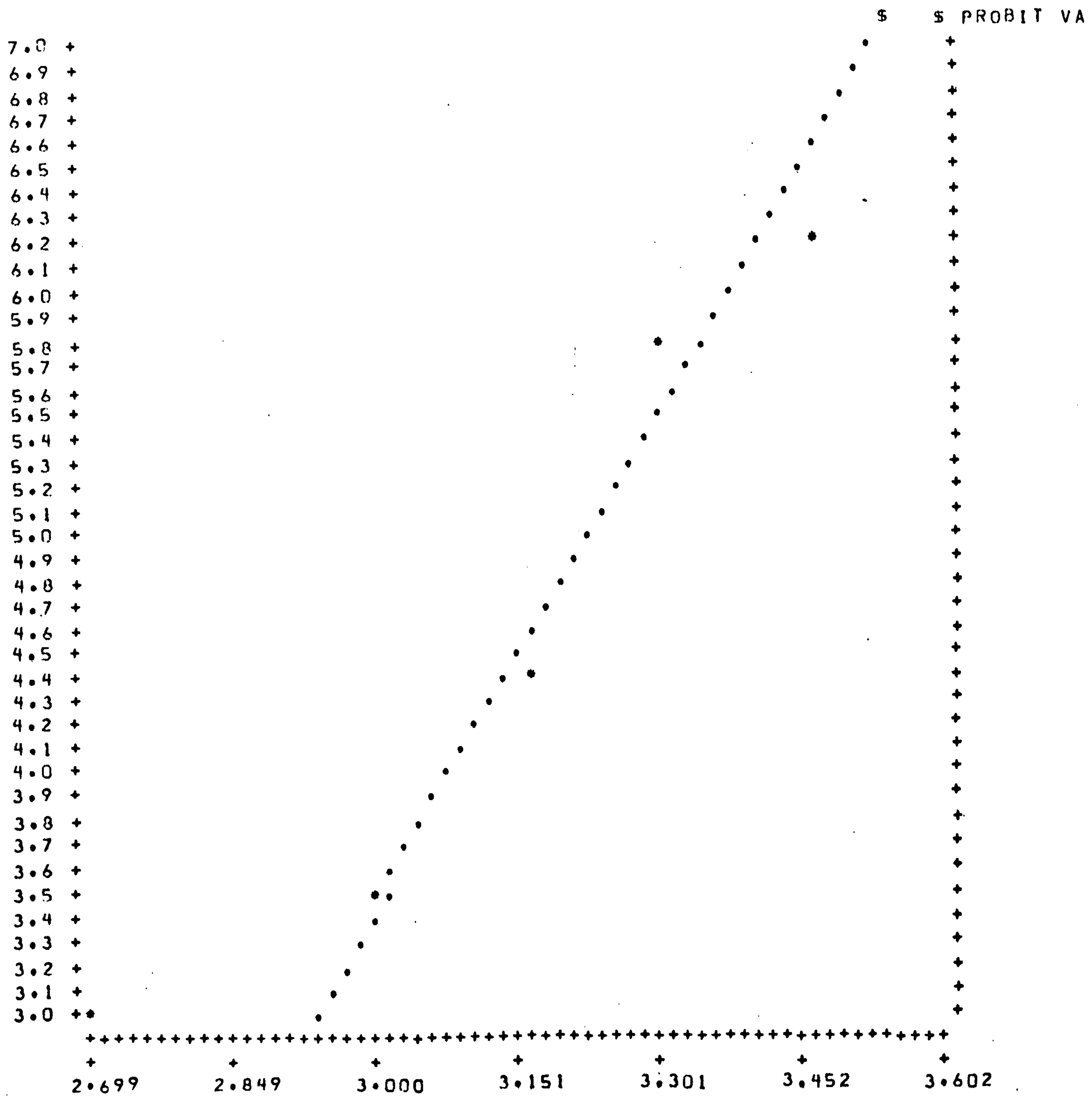
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 770.0896 | 477.3552 | 988.6358 |
| P = .05 | 969.6942 | 670.2272 | 1183.2785 |
| P = .10 | 1096.4818 | 801.5732 | 1304.8432 |
| P = .20 | 1272.4324 | 992.1990 | 1473.9072 |
| P = .50 | 1691.4559 | 1456.8828 | 1905.7905 |
| P = .80 | 2248.4675 | 1993.6638 | 2644.1047 |
| P = .90 | 2609.2757 | 2282.5611 | 3229.0567 |
| P = .95 | 2950.4381 | 2532.6287 | 3838.1230 |
| P = .99 | 3715.1814 | 3049.2726 | 5357.0438 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-7   8 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   6.8076, INTERCEPT= -16.9768,
NATURAL RESPONSE RATE=   .0260

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-7 24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = -.

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 0. | .0001 | 1.2809 |
| 400.0000 | 2.6021 | 20. | 4. | .2000 | 4.1585 |
| 450.0000 | 2.6532 | 20. | 3. | .1500 | 3.9636 |
| 500.0000 | 2.6990 | 20. | 6. | .3000 | 4.4760 |
| 550.0000 | 2.7404 | 20. | 10. | .5000 | 5.0000 |
| 600.0000 | 2.7782 | 20. | 13. | .6500 | 5.3849 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .1702
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 4.576179
AVG X = 2.696463
AVG T = 2.753682
NATURAL MORTALITY = -.000000 SE = .000000
SLOPE = 9.234921 SE = 1.943974
T STATISTIC = SLOPE/SE = 4.750538
INTERCEPT = -20.325442
CHI SQUARED = 3.664077
B( 25) - B( 24) = -.0024331

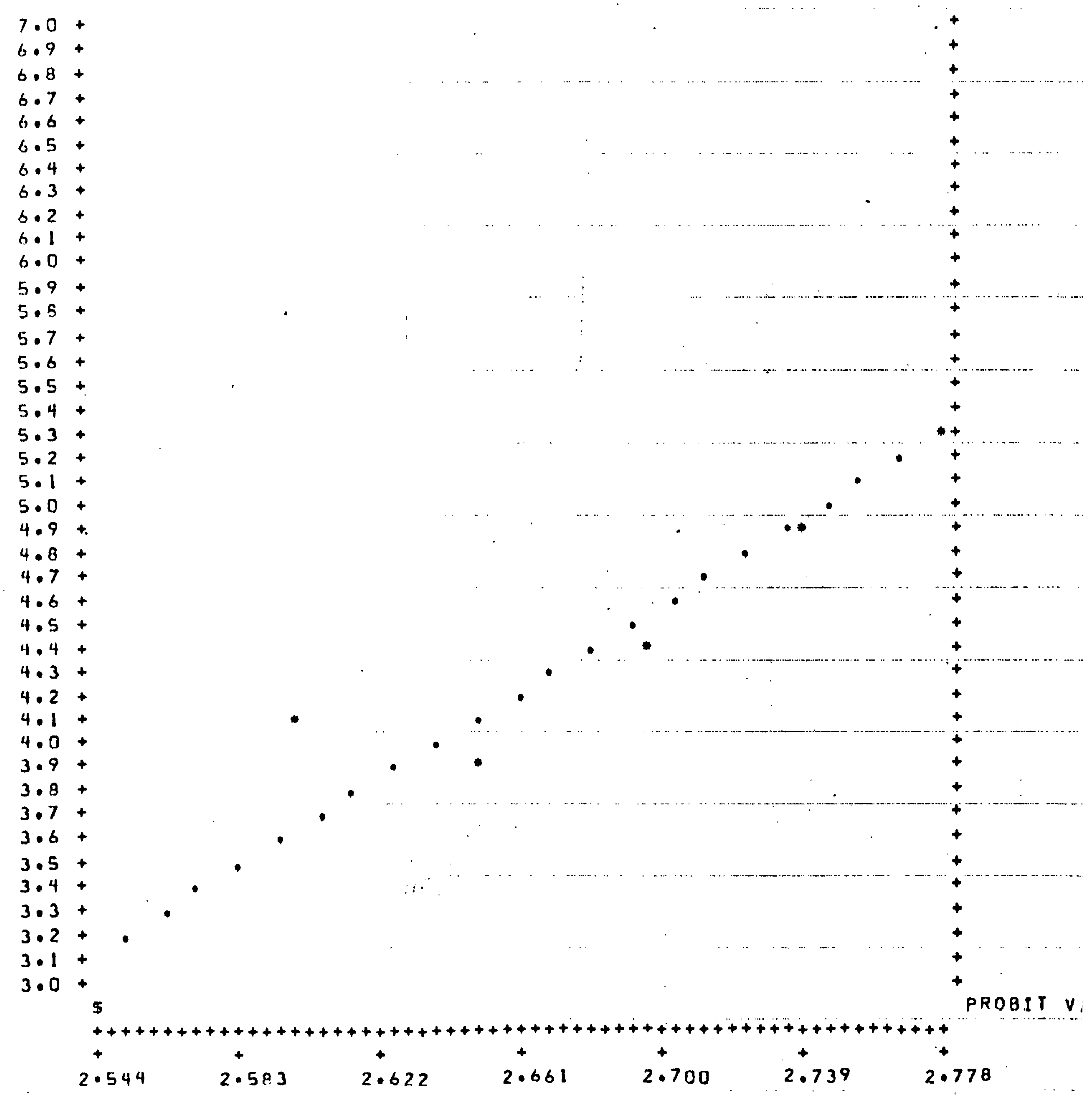
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 309.3524 | 219.3891 | 359.0602 |
| P = .05 | 366.6389 | 291.4018 | 407.1309 |
| P = .10 | 401.4009 | 338.0542 | 436.5766 |
| P = .20 | 447.9439 | 401.5760 | 478.7603 |
| P = .50 | 552.5301 | 516.8959 | 616.7919 |
| P = .80 | 681.5352 | 612.0820 | 863.7499 |
| P = .90 | 760.5602 | 663.9773 | 1037.2500 |
| P = .95 | 832.6708 | 709.3376 | 1207.8256 |
| P = .99 | 986.8667 | 801.8636 | 1609.1656 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-7 24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 9.2349, INTERCEPT= -20.3254,
NATURAL RESPONSE RATE= -.0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON  MR 2149  ACARTIA TONSA  SAMPLE 9923-7  48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 4. | .2000 | 4.1585 |
| 400.0000 | 2.6021 | 20. | 7. | .3500 | 4.6151 |
| 450.0000 | 2.6532 | 20. | 6. | .3000 | 4.4760 |
| 500.0000 | 2.6990 | 20. | 9. | .4500 | 4.8746 |
| 550.0000 | 2.7404 | 20. | 12. | .6000 | 5.2529 |
| 600.0000 | 2.7782 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 6

THERE IS AT LEAST ONE EXPECTED VALUE LESS THAN 5.

| DOSE | # RESPONSES | EXPECTED |
|---|---|---|
| 350.0000 | 4. | 2.7983 |
| 400.0000 | 7. | 5.4696 |
| 450.0000 | 6. | 8.5687 |
| 500.0000 | 9. | 11.5625 |
| 550.0000 | 12. | 14.0980 |
| 600.0000 | 20. | 16.0482 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 2.4652
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 2.7760
G = .7629
TOTAL NUMBER OF CYCLES = 10

SUMMARY STATISTICS

AVG Y = 4.985564
AVG X = 2.673327
AVG T = 1.593782
NATURAL MORTALITY = .000000  SE = .000024
SLOPE = 8.249049  SE = 2.595551
T STATISTIC = SLOPE/SE = 3.178150
INTERCEPT = -17.066841
CHI SQUARED = 9.860773  SIGNIF. AT .05

| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|

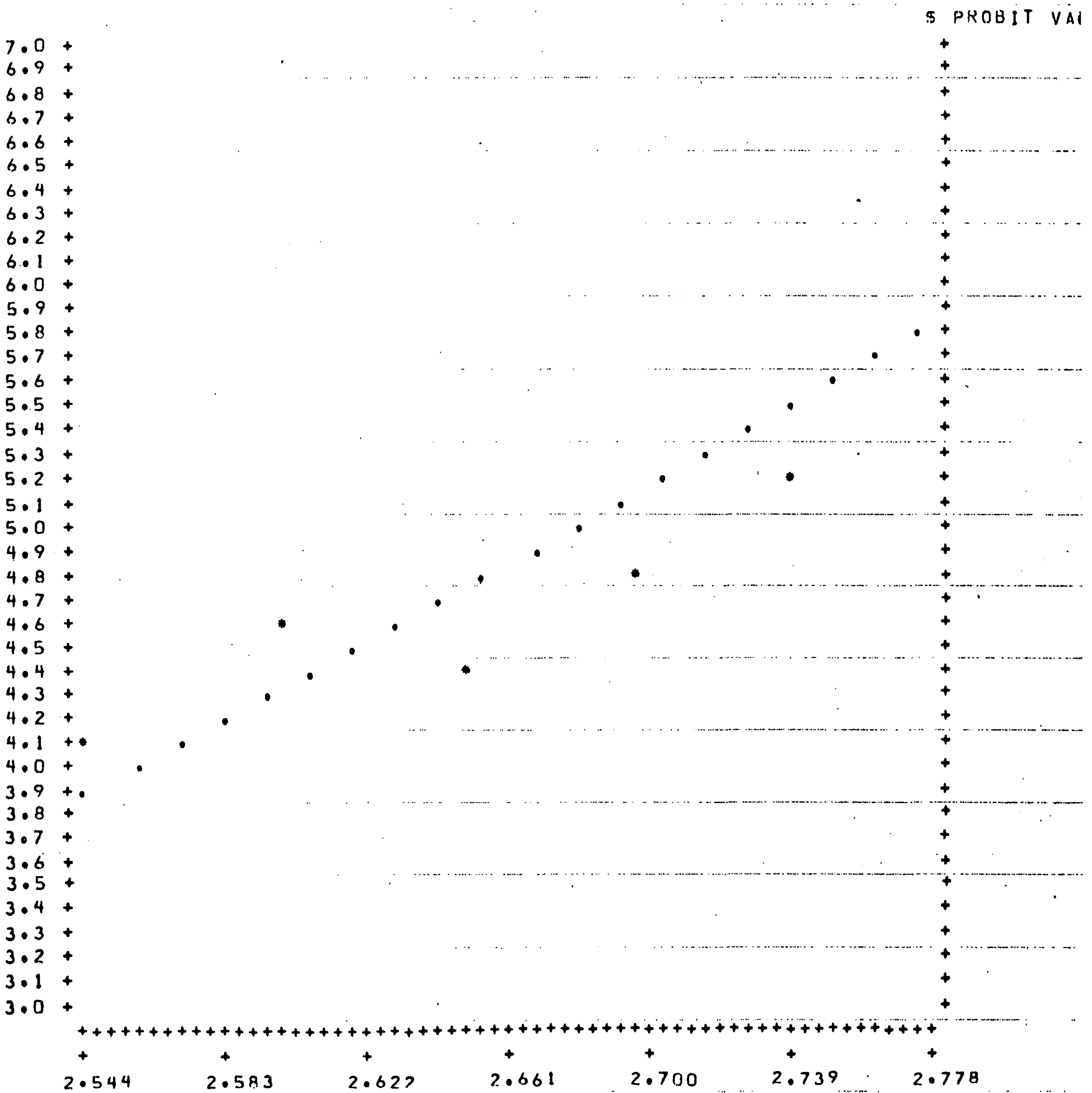
| | | | |
|---|---|---|---|
| P = .01 | 247.2115 | 2.8173 | 340.7032 |
| P = .05 | 299.0007 | 12.5625 | 380.2143 |
| P = .10 | 330.9128 | 27.7790 | 404.5307 |
| P = .20 | 374.1563 | 72.0050 | 439.8584 |
| P = .50 | 473.2351 | 352.1048 | 652.7485 |
| P = .80 | 598.5506 | 508.1090 | 3282.4873 |
| P = .90 | 676.7688 | 551.9625 | 8516.4418 |
| P = .95 | 748.9998 | 587.0872 | 18837.7192 |
| P = .99 | 905.9104 | 655.0157 | 84019.0732 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-7 48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 8.2490, INTERCEPT= -17.0668,
NATURAL RESPONSE RATE= .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-7 96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 7. | .3500 | 4.6151 |
| 400.0000 | 2.6021 | 20. | 8. | .4000 | 4.7471 |
| 450.0000 | 2.6532 | 20. | 12. | .6000 | 5.2529 |
| 500.0000 | 2.6990 | 20. | 11. | .5500 | 5.1254 |
| 550.0000 | 2.7404 | 20. | 17. | .8500 | 6.0364 |
| 600.0000 | 2.7782 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 6

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .1600
TOTAL NUMBER OF CYCLES = 8

SUMMARY STATISTICS

AVG Y = 5.296022
AVG X = 2.658029
AVG T = 1.184186
NATURAL MORTALITY = .000000 SE = .000003
SLOPE = 8.150023 SE = 1.663495
T STATISTIC = SLOPE/SE = 4.899336
INTERCEPT = -16.366979
CHI SQUARED = 6.706848

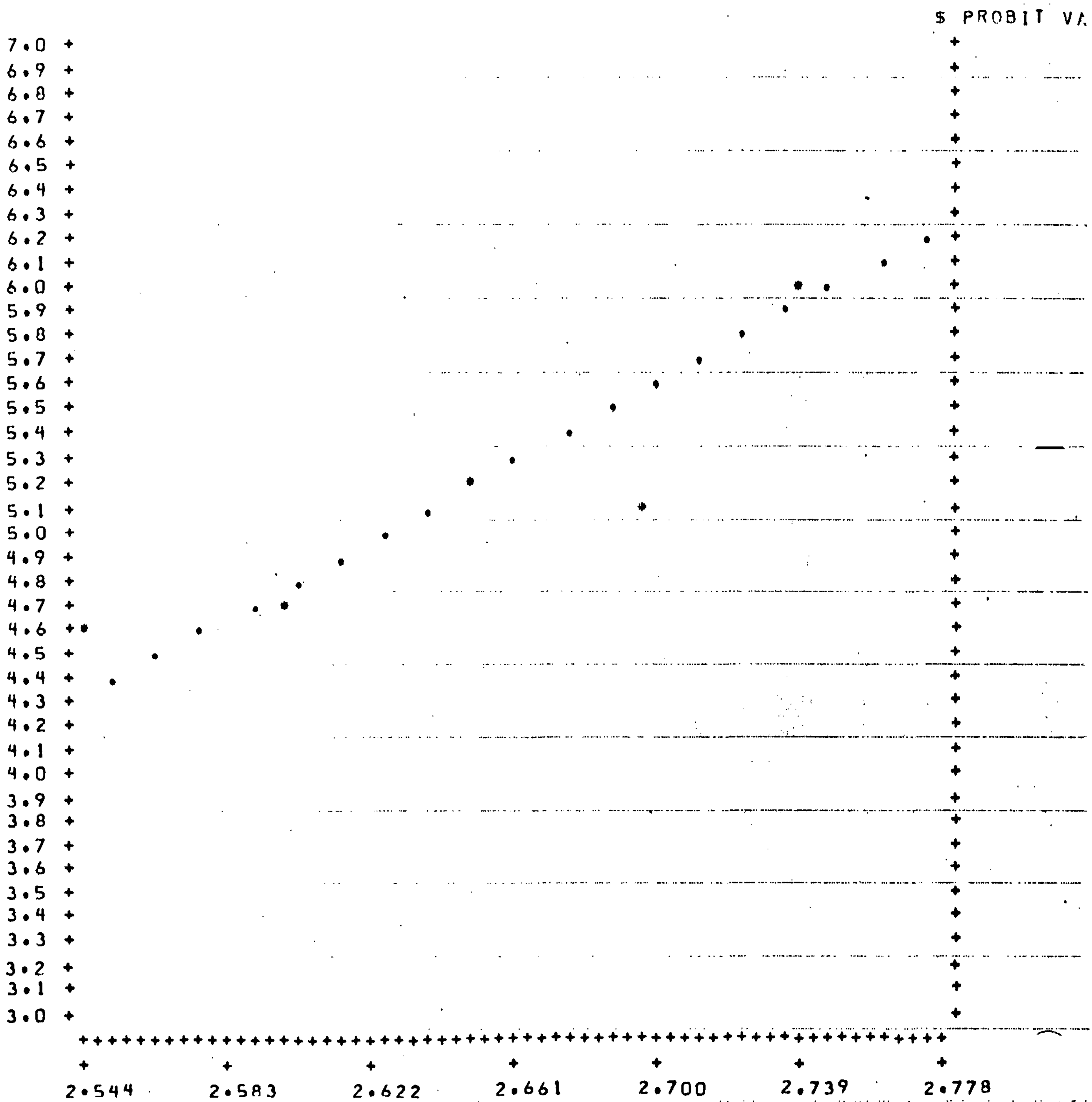
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 216.9067 | 131.2776 | 270.2351 |
| P = .05 | 262.9541 | 180.4483 | 310.9241 |
| P = .10 | 291.3779 | 213.6113 | 335.3692 |
| P = .20 | 329.9470 | 261.5721 | 368.2176 |
| P = .50 | 418.5118 | 377.9701 | 448.8660 |
| P = .80 | 530.8492 | 491.7938 | 607.6720 |
| P = .90 | 601.1166 | 543.9772 | 738.6182 |
| P = .95 | 666.0937 | 588.2797 | 872.0814 |
| P = .99 | 807.4998 | 678.3211 | 1196.1355 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-7    96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=    8.1500, INTERCEPT= -16.3670,
NATURAL RESPONSE RATE=    .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-8    1 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = -.

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0001 | 1.2809 |
| 1000.0000 | 3.0000 | 20. | 0. | .0001 | 1.2809 |
| 1500.0000 | 3.1761 | 20. | 2. | .0966 | 3.6988 |
| 2000.0000 | 3.3010 | 20. | 8. | .3978 | 4.7413 |
| 2500.0000 | 3.3979 | 20. | 10. | .4981 | 4.9953 |
| 3000.0000 | 3.4771 | 20. | 7. | .3476 | 4.6085 |
| 3500.0000 | 3.5441 | 20. | 10. | .4981 | 4.9953 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 2

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .2888
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 4.583934
AVG X = 3.376636
AVG T = 2.892154
NATURAL MORTALITY = -.001812    SE = .010983
SLOPE = 3.267009    SE = .895786
T STATISTIC = SLOPE/SE = 3.647088
INTERCEPT = -6.431485
CHI SQUARED = 6.482169
B( 25) - B( 24) = -.3760879

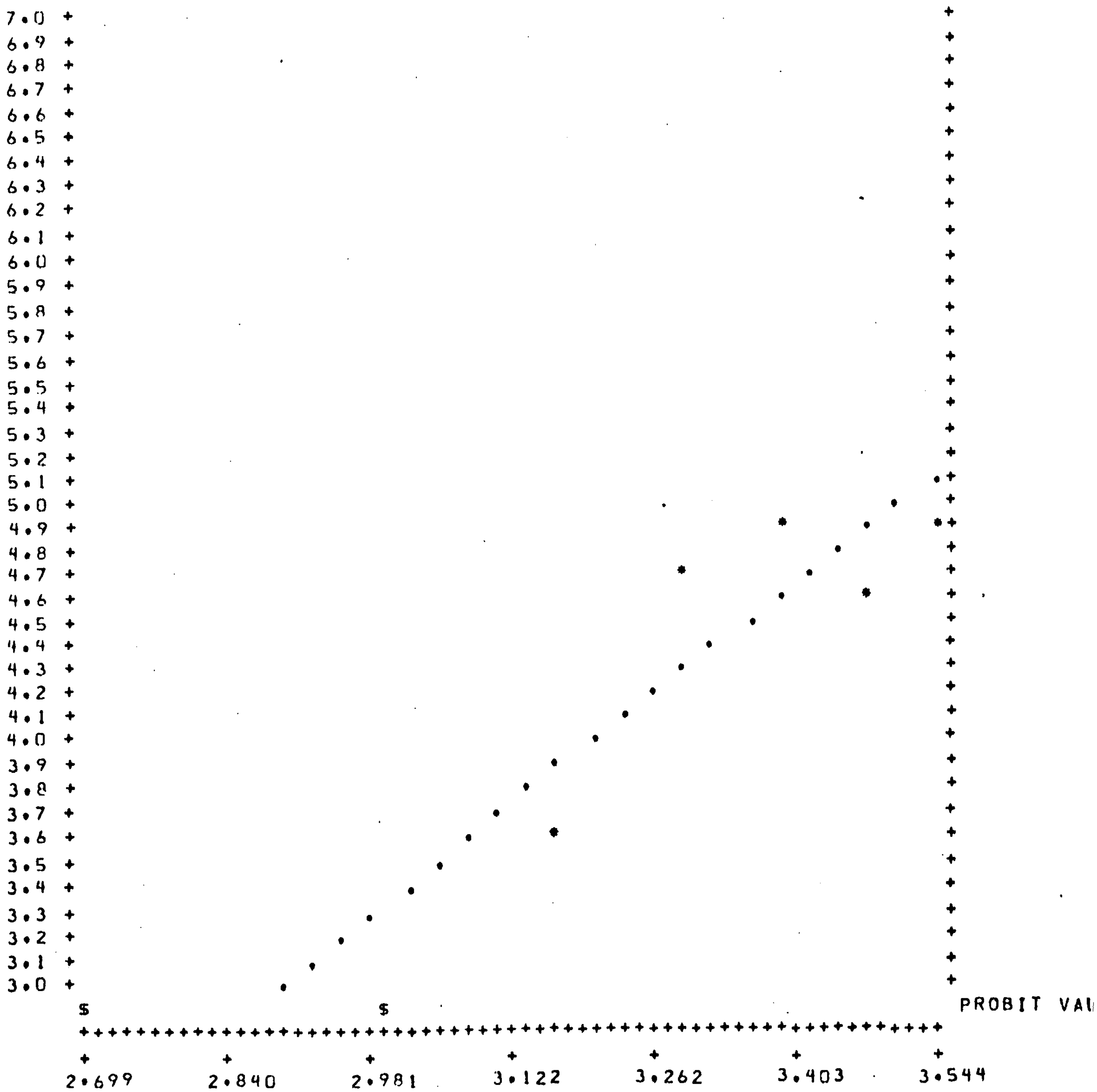
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 612.3631 | 120.1573 | 1015.6785 |
| P = .05 | 989.8719 | 335.3930 | 1404.4113 |
| P = .10 | 1278.7382 | 576.0463 | 1680.0249 |
| P = .20 | 1743.6583 | 1087.6996 | 2128.1956 |
| P = .50 | 3155.4911 | 2612.2086 | 4698.4318 |
| P = .80 | 5710.4802 | 4089.5135 | 15912.1737 |
| P = .90 | 7786.6804 | 5050.8288 | 30816.6763 |
| P = .95 | 10059.0033 | 5994.7802 | 53345.7705 |
| P = .99 | 16260.1622 | 8238.6698 | 149815.9961 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-8    1 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   3.2[illegible]70, INTERCEPT=   -6.4315,
NATURAL RESPONSE RATE=   -.0018

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-8 4 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 0. | .0000 | .5413 |
| 1000.0000 | 3.0000 | 20. | 2. | .1000 | 3.7183 |
| 1500.0000 | 3.1761 | 20. | 8. | .4000 | 4.7471 |
| 2000.0000 | 3.3010 | 20. | 19. | .9500 | 6.6452 |
| 2500.0000 | 3.3979 | 20. | 15. | .7500 | 5.6742 |
| 3000.0000 | 3.4771 | 20. | 20. | .9999 | 8.7191 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 1 6 7

THERE IS AT LEAST ONE EXPECTED VALUE LESS THAN 5.

| DOSE | # RESPONSES | EXPECTED |
|---|---|---|
| 500.0000 | 0. | .0109 |
| 1000.0000 | 2. | 2.0179 |
| 1500.0000 | 8. | 9.1145 |
| 2000.0000 | 19. | 15.2574 |
| 2500.0000 | 15. | 18.2517 |
| 3000.0000 | 20. | 19.4000 |
| 3500.0000 | 20. | 19.7987 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 2.3149
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 2.5710
G = .3505
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 5.359971
AVG X = 3.247323
AVG T = 3.329820
NATURAL MORTALITY = .000004 SE = .000000
SLOPE = 6.622214 SE = 1.524846
T STATISTIC = SLOPE/SE = 4.342874
INTERCEPT = -16.144522
CHI SQUARED = 11.574369 SIGNIF. AT .05
B( 25) - B( 24) = .0048053

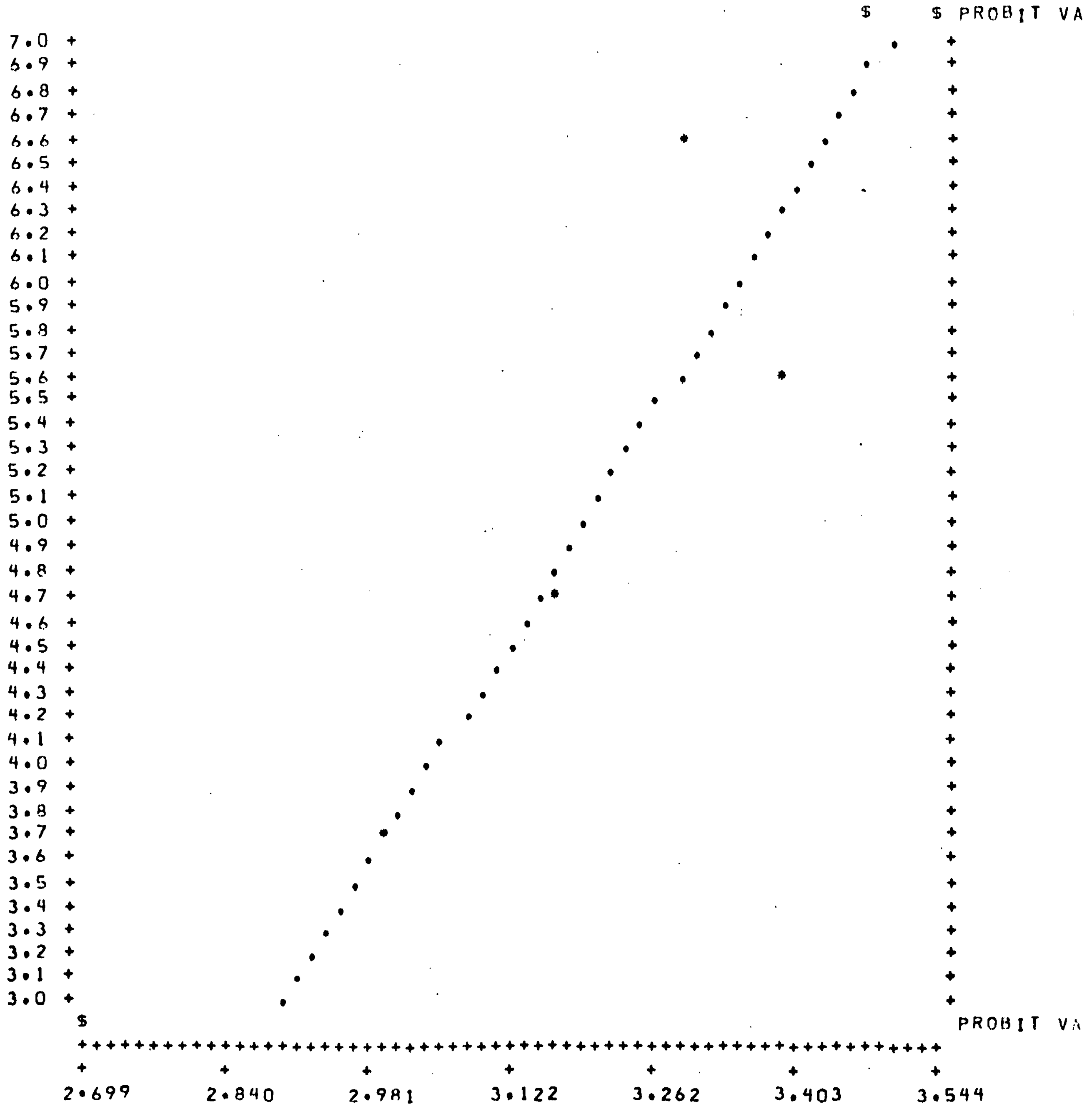
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 694.5143 | 172.1495 | 1022.6957 |
| P = .05 | 880.1918 | 303.8376 | 1201.8288 |
| P = .10 | 998.7072 | 409.8090 | 1314.7015 |
| P = .20 | 1163.8075 | 584.8640 | 1475.5073 |
| P = .50 | 1559.4397 | 1094.4438 | 1941.4373 |
| P = .80 | 2089.5654 | 1687.5726 | 3100.0935 |
| P = .90 | 2435.0004 | 1953.9416 | 4288.5797 |
| P = .95 | 2762.8658 | 2165.3777 | 5709.7307 |
| P = .99 | 3501.5142 | 2574.6752 | 9959.9902 |

J. R. GIBSON  MR 2149  ACARTIA TONSA  SAMPLE 9923-8  4 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 6.6222, INTERCEPT= -16.1445,
NATURAL RESPONSE RATE= .0000

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-8 8 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 500.0000 | 2.6990 | 20. | 1. | .0251 | 3.0408 |
| 1000.0000 | 3.0000 | 20. | 4. | .1790 | 4.0809 |
| 1500.0000 | 3.1761 | 20. | 16. | .7948 | 5.8228 |
| 2000.0000 | 3.3010 | 20. | 20. | .9999 | 8.7191 |
| 2500.0000 | 3.3979 | 20. | 20. | .9999 | 8.7191 |
| 3000.0000 | 3.4771 | 20. | 20. | .9999 | 8.7191 |
| 3500.0000 | 3.5441 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 4 5 6 7

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 1.0000
NUMBER OF POINTS = 7
DEGREES OF FREEDOM = 5
DEVIATE = 1.9600
G = .1693
TOTAL NUMBER OF CYCLES = 9

SUMMARY STATISTICS

AVG Y = 5.256570
AVG X = 3.113734
AVG T = 1.780920
NATURAL MORTALITY = .025572 SE = .024942
SLOPE = 10.790053 SE = 2.265214
T STATISTIC = SLOPE/SE = 4.763371
INTERCEPT = -28.340786
CHI SQUARED = 1.763603

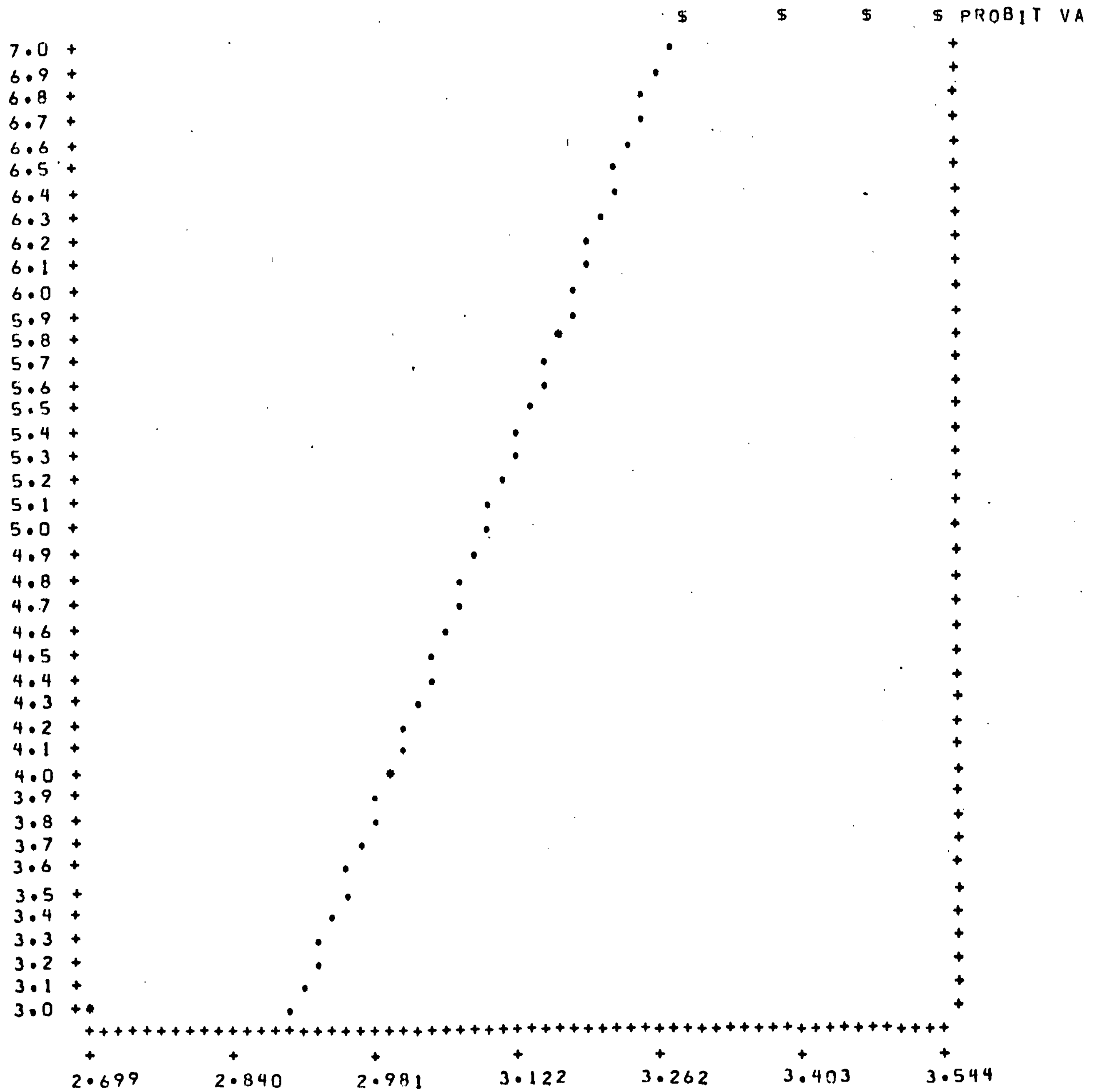
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 748.7879 | 496.6001 | 899.4605 |
| P = .05 | 865.9834 | 631.6322 | 1003.6189 |
| P = .10 | 935.7923 | 716.7176 | 1065.9823 |
| P = .20 | 1027.9162 | 832.5842 | 1150.4007 |
| P = .50 | 1230.1428 | 1084.8102 | 1360.5485 |
| P = .80 | 1472.1541 | 1332.4169 | 1706.9386 |
| P = .90 | 1617.0802 | 1451.1686 | 1964.8055 |
| P = .95 | 1747.4367 | 1547.9296 | 2219.9905 |
| P = .99 | 2020.9343 | 1734.3955 | 2811.8898 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-8    8 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=  10.7901, INTERCEPT= -28.3408,
NATURAL RESPONSE RATE=    .0256

7 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON  MR 2149  ACARTIA TONSA  SAMPLE 9923-8  24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = [illegible]

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 2. | .1000 | 3.7183 |
| 400.0000 | 2.6021 | 20. | 0. | .0001 | 1.2809 |
| 450.0000 | 2.6532 | 20. | 5. | .2500 | 4.3258 |
| 500.0000 | 2.6990 | 20. | 4. | .2000 | 4.1585 |
| 550.0000 | 2.7404 | 20. | 10. | .5000 | 5.0000 |
| 600.0000 | 2.7782 | 20. | 9. | .4500 | 4.8746 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 2

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .2720
TOTAL NUMBER OF CYCLES = 6

SUMMARY STATISTICS

AVG Y = 4.390182
AVG X = 2.693974
AVG T = 2.872650
NATURAL MORTALITY = .000000  SE = .000183
SLOPE = 6.951519  SE = 1.849854
T STATISTIC = SLOPE/SE = 3.757875
INTERCEPT = -14.337031
CHI SQUARED = 5.885684

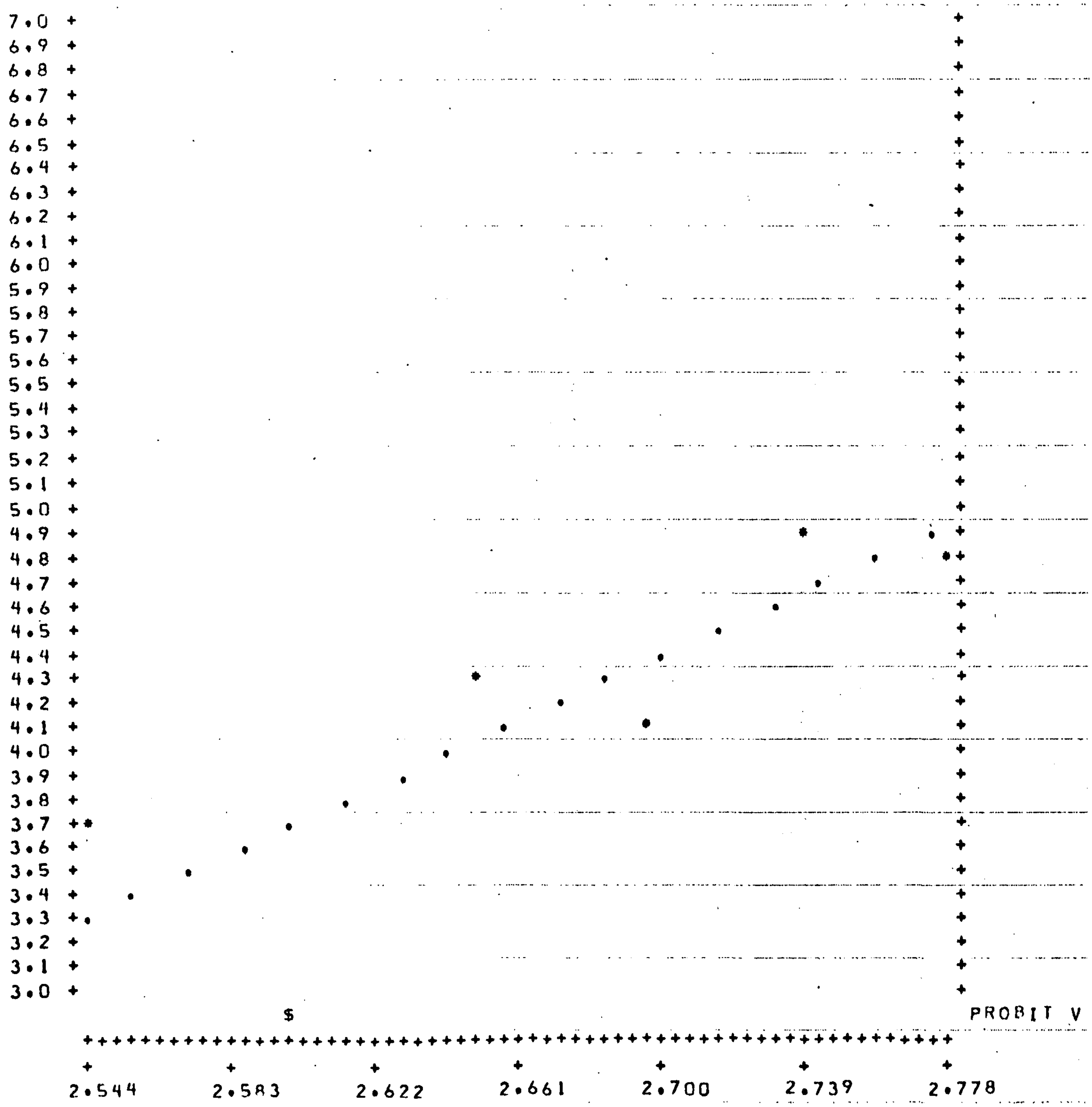
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 279.9318 | 148.7853 | 344.3472 |
| P = .05 | 350.8116 | 236.6819 | 402.4349 |
| P = .10 | 395.6726 | 301.5624 | 439.6101 |
| P = .20 | 457.7533 | 396.6613 | 498.7955 |
| P = .50 | 604.9208 | 546.9699 | 778.0320 |
| P = .80 | 799.4028 | 668.2823 | 1369.6812 |
| P = .90 | 924.8283 | 737.8521 | 1851.4317 |
| P = .95 | 1043.0932 | 799.9807 | 2376.7393 |
| P = .99 | 1307.2086 | 929.8921 | 3801.3045 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-8   24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   6.9515, INTERCEPT= -14.3370,
NATURAL RESPONSE RATE=   .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-8 48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 4. | .2000 | 4.1585 |
| 400.0000 | 2.6021 | 20. | 3. | .1500 | 3.9636 |
| 450.0000 | 2.6532 | 20. | 8. | .4000 | 4.7471 |
| 500.0000 | 2.6990 | 20. | 7. | .3500 | 4.6151 |
| 550.0000 | 2.7404 | 20. | 13. | .6500 | 5.3849 |
| 600.0000 | 2.7782 | 20. | 10. | .5000 | 5.0000 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENEITY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .3671
TOTAL NUMBER OF CYCLES = 3

SUMMARY STATISTICS

AVG Y = 4.697191
AVG X = 2.678199
AVG T = 1.809454
NATURAL MORTALITY = .000000 SE = .000086
SLOPE = 5.054686 SE = 1.562640
T STATISTIC = SLOPE/SE = 3.234710
INTERCEPT = -8.840266
CHI SQUARED = 4.221168

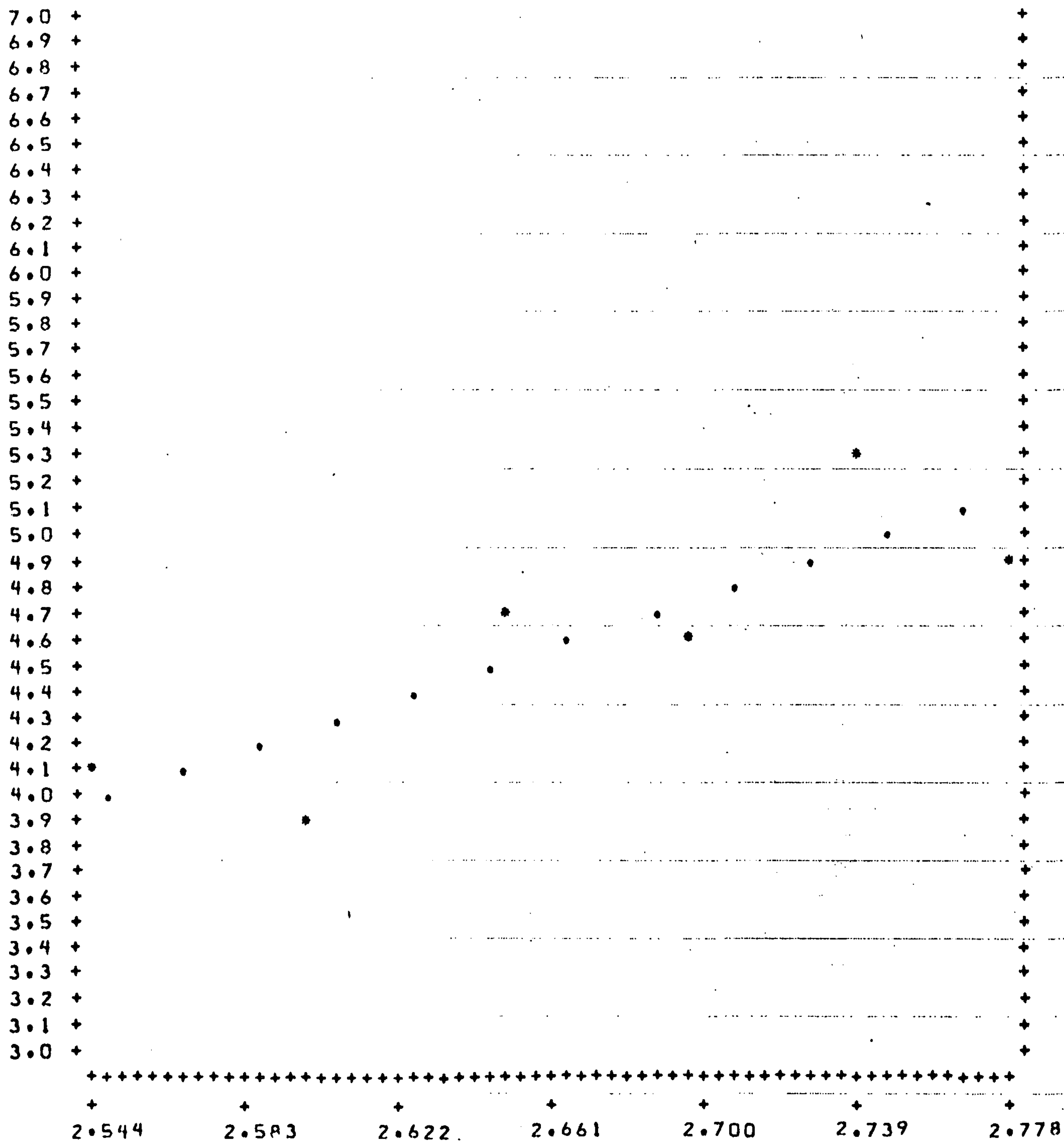
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 189.6179 | 45.4885 | 271.2485 |
| P = .05 | 258.6336 | 99.4893 | 330.7639 |
| P = .10 | 305.1820 | 150.5895 | 368.6741 |
| P = .20 | 372.9124 | 246.6682 | 424.0543 |
| P = .50 | 547.1492 | 490.8007 | 715.8395 |
| P = .80 | 802.7951 | 647.7620 | 1821.7621 |
| P = .90 | 980.9631 | 737.4436 | 3014.9193 |
| P = .95 | 1157.5148 | 819.4542 | 4577.4419 |
| P = .99 | 1578.8182 | 996.9049 | 10035.0469 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-8    48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=    5.0547, INTERCEPT=   -8.8403,
NATURAL RESPONSE RATE=     .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-8 96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 1. NATURAL MORTALITY = .

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 5. | .2113 | 4.1983 |
| 400.0000 | 2.6021 | 20. | 6. | .2639 | 4.3689 |
| 450.0000 | 2.6532 | 20. | 11. | .5268 | 5.0670 |
| 500.0000 | 2.6990 | 20. | 13. | .6319 | 5.3366 |
| 550.0000 | 2.7404 | 20. | 16. | .7897 | 5.8051 |
| 600.0000 | 2.7782 | 20. | 15. | .7371 | 5.6341 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .2256
TOTAL NUMBER OF CYCLES = 3

SUMMARY STATISTICS

AVG Y = 5.095573
AVG X = 2.672858
AVG T = 1.364201
NATURAL MORTALITY = .049048 SE = .048118
SLOPE = 7.282496 SE = 1.764882
T STATISTIC = SLOPE/SE = 4.126336
INTERCEPT = -14.369506
CHI SQUARED = 1.610430

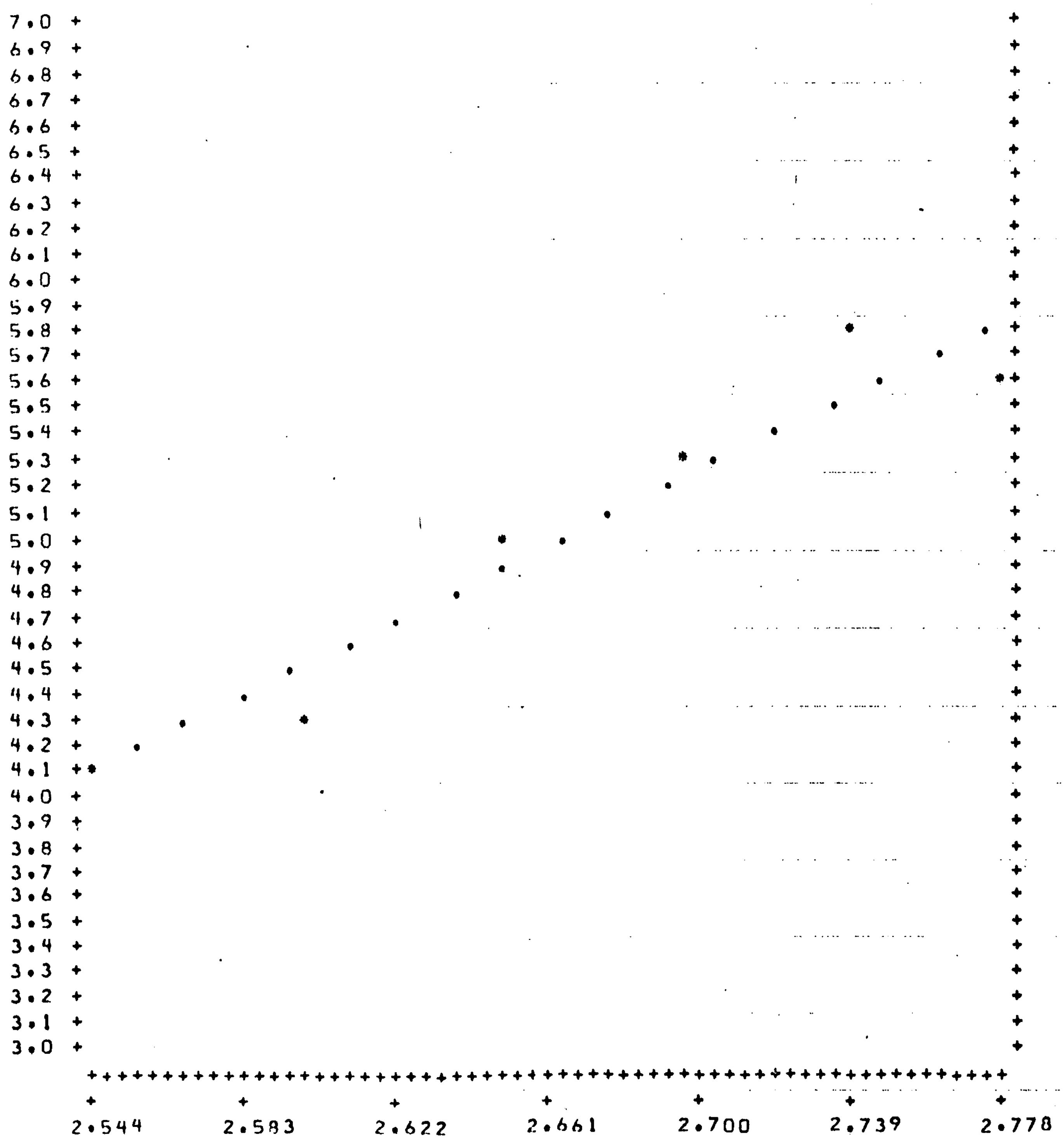
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 218.9259 | 106.1922 | 285.1754 |
| P = .05 | 271.5588 | 159.4534 | 331.3047 |
| P = .10 | 304.6146 | 197.7695 | 359.3731 |
| P = .20 | 350.0818 | 255.9600 | 397.7204 |
| P = .50 | 456.8086 | 404.2641 | 500.6755 |
| P = .80 | 596.0724 | 537.2787 | 749.0197 |
| P = .90 | 685.0431 | 597.6535 | 964.4692 |
| P = .95 | 768.4306 | 649.4506 | 1194.0851 |
| P = .99 | 953.1724 | 755.6286 | 1790.3170 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-8    96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   7.2825, INTERCEPT= -14.3695,
NATURAL RESPONSE RATE=    .0490

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-9 24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY = -.

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 1. | .0500 | 3.3548 |
| 400.0000 | 2.6021 | 20. | 0. | .0001 | 1.2809 |
| 450.0000 | 2.6532 | 20. | 6. | .3000 | 4.4760 |
| 500.0000 | 2.6990 | 20. | 5. | .2500 | 4.3258 |
| 550.0000 | 2.7404 | 20. | 8. | .4000 | 4.7471 |
| 600.0000 | 2.7782 | 20. | 8. | .4000 | 4.7471 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 2

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .2883
TOTAL NUMBER OF CYCLES = 25

SUMMARY STATISTICS

AVG Y = 4.337947
AVG X = 2.695549
AVG T = 3.059411
NATURAL MORTALITY = -.000000 SE = .000000
SLOPE = 6.895972 SE = 1.889286
T STATISTIC = SLOPE/SE = 3.650041
INTERCEPT = -14.250488
CHI SQUARED = 4.982816
B( 25) - B( 24) = -.0014179

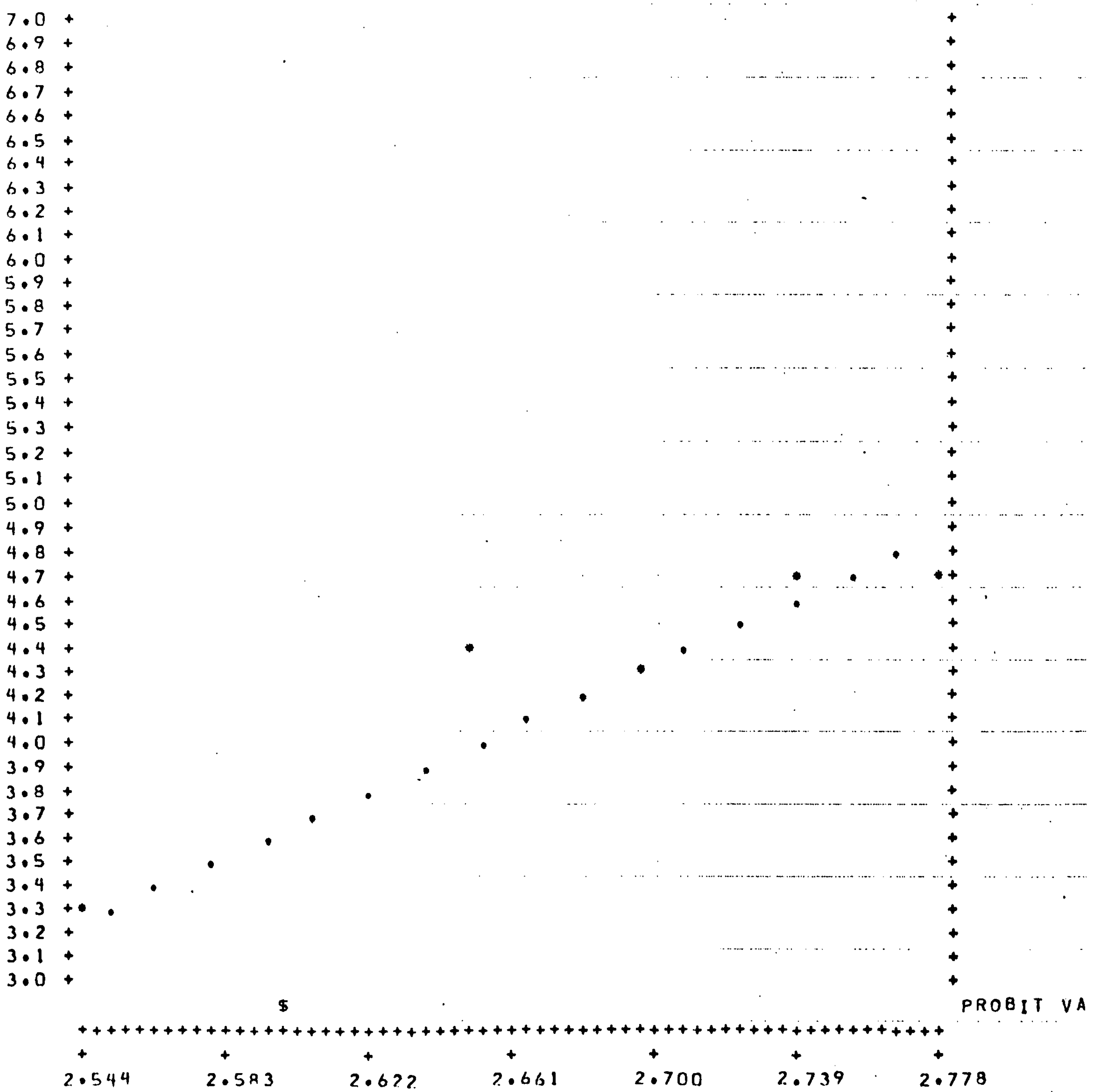
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 284.5858 | 147.5073 | 349.9803 |
| P = .05 | 357.2930 | 239.1333 | 409.1782 |
| P = .10 | 403.3736 | 307.5071 | 447.4613 |
| P = .20 | 467.2108 | 407.1213 | 510.7436 |
| P = .50 | 618.8069 | 556.0255 | 823.7868 |
| P = .80 | 819.5913 | 678.1635 | 1487.8458 |
| P = .90 | 949.2984 | 748.4981 | 2037.1256 |
| P = .95 | 1071.7306 | 811.3371 | 2642.8051 |
| P = .99 | 1345.5410 | 942.7451 | 4310.8974 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-9 24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 6.8960, INTERCEPT= -14.2505,
NATURAL RESPONSE RATE= -.0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-9 48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 1. NATURAL MORTALITY = .C

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 2. | .0567 | 3.4161 |
| 400.0000 | 2.6021 | 20. | 4. | .1615 | 4.0116 |
| 450.0000 | 2.6532 | 20. | 8. | .3711 | 4.6715 |
| 500.0000 | 2.6990 | 20. | 7. | .3187 | 4.5291 |
| 550.0000 | 2.7404 | 20. | 9. | .4235 | 4.8074 |
| 600.0000 | 2.7782 | 20. | 12. | .5807 | 5.2034 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .3978
TOTAL NUMBER OF CYCLES = 6

SUMMARY STATISTICS

AVG Y = 4.611302
AVG X = 2.692328
AVG T = 2.101522
NATURAL MORTALITY = .045952 SE = .046271
SLOPE = 6.379843 SE = 2.053012
T STATISTIC = SLOPE/SE = 3.107552
INTERCEPT = -12.565330
CHI SQUARED = 1.568268

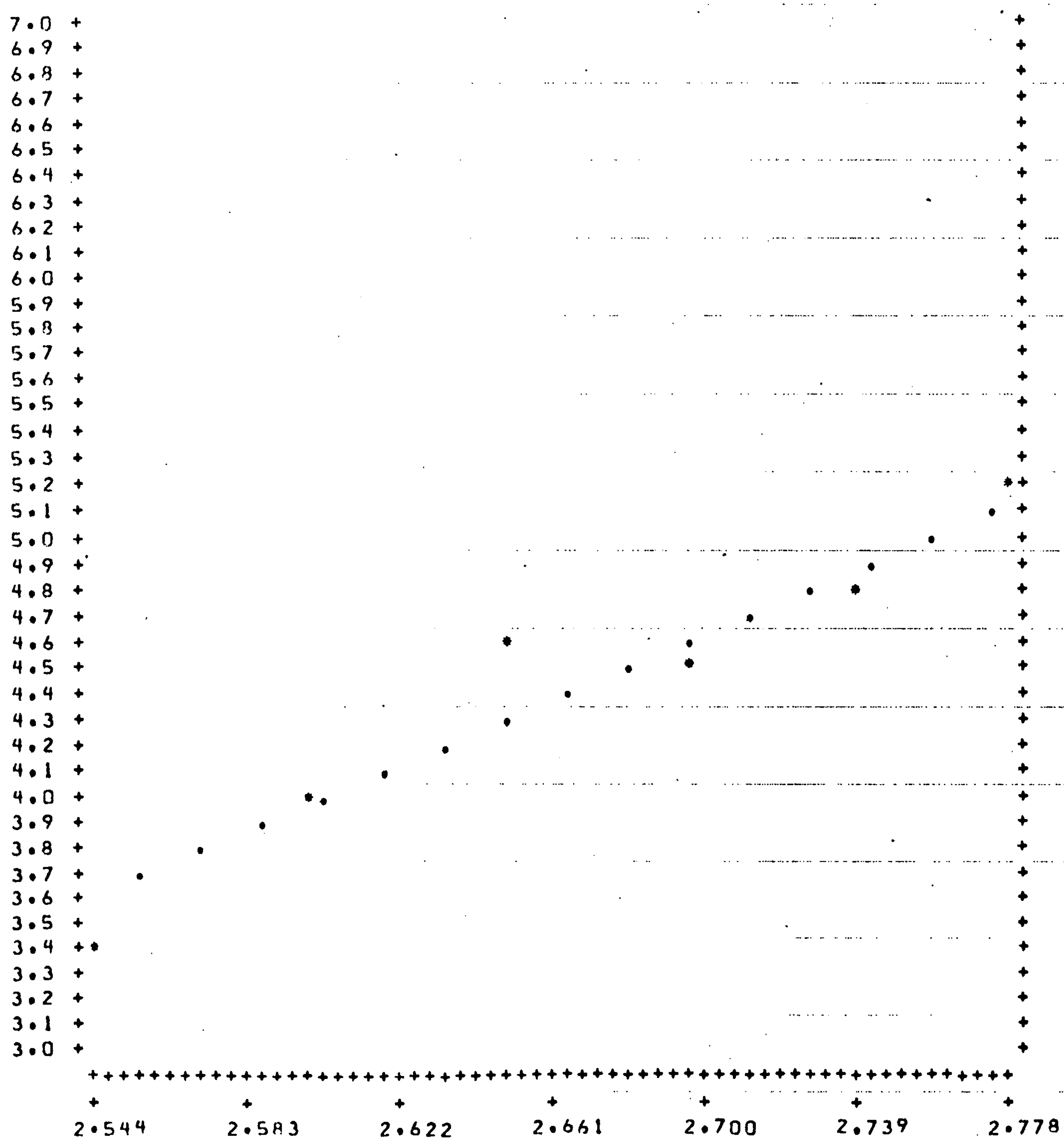
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 244.6930 | 67.8439 | 330.8498 |
| P = .05 | 312.9151 | 131.1400 | 387.3722 |
| P = .10 | 356.7562 | 185.7028 | 422.8354 |
| P = .20 | 418.1565 | 280.2056 | 474.8621 |
| P = .50 | 566.5709 | 503.7304 | 724.3775 |
| P = .80 | 767.6614 | 640.4446 | 1562.4285 |
| P = .90 | 899.7812 | 711.0206 | 2384.8118 |
| P = .95 | 1025.8454 | 773.2768 | 3389.4364 |
| P = .99 | 1311.8587 | 902.7649 | 6570.6753 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-9 48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 6.3798, INTERCEPT= -12.5653,
NATURAL RESPONSE RATE= .0460

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-9    96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL:  SAMPLE SIZE =  20.  # DEATHS =  1.  NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 3. | .1091 | 3.7684 |
| 400.0000 | 2.6021 | 20. | 6. | .2663 | 4.3763 |
| 450.0000 | 2.6532 | 20. | 12. | .5807 | 5.2034 |
| 500.0000 | 2.6990 | 20. | 9. | .4235 | 4.8075 |
| 550.0000 | 2.7404 | 20. | 13. | .6332 | 5.3398 |
| 600.0000 | 2.7782 | 20. | 14. | .6856 | 5.4829 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR =  1.0000
NUMBER OF POINTS =  6
DEGREES OF FREEDOM =  4
DEVIATE =  1.9600
G =  .2852
TOTAL NUMBER OF CYCLES =  5

SUMMARY STATISTICS

AVG Y =  4.915277
AVG X =  2.679321
AVG T =  1.555848
NATURAL MORTALITY =  .045924    SE =  .046620
SLOPE =  6.494441    SE =  1.769585
T STATISTIC = SLOPE/SE =  3.670036
INTERCEPT =  -12.485412
CHI SQUARED =  3.555260

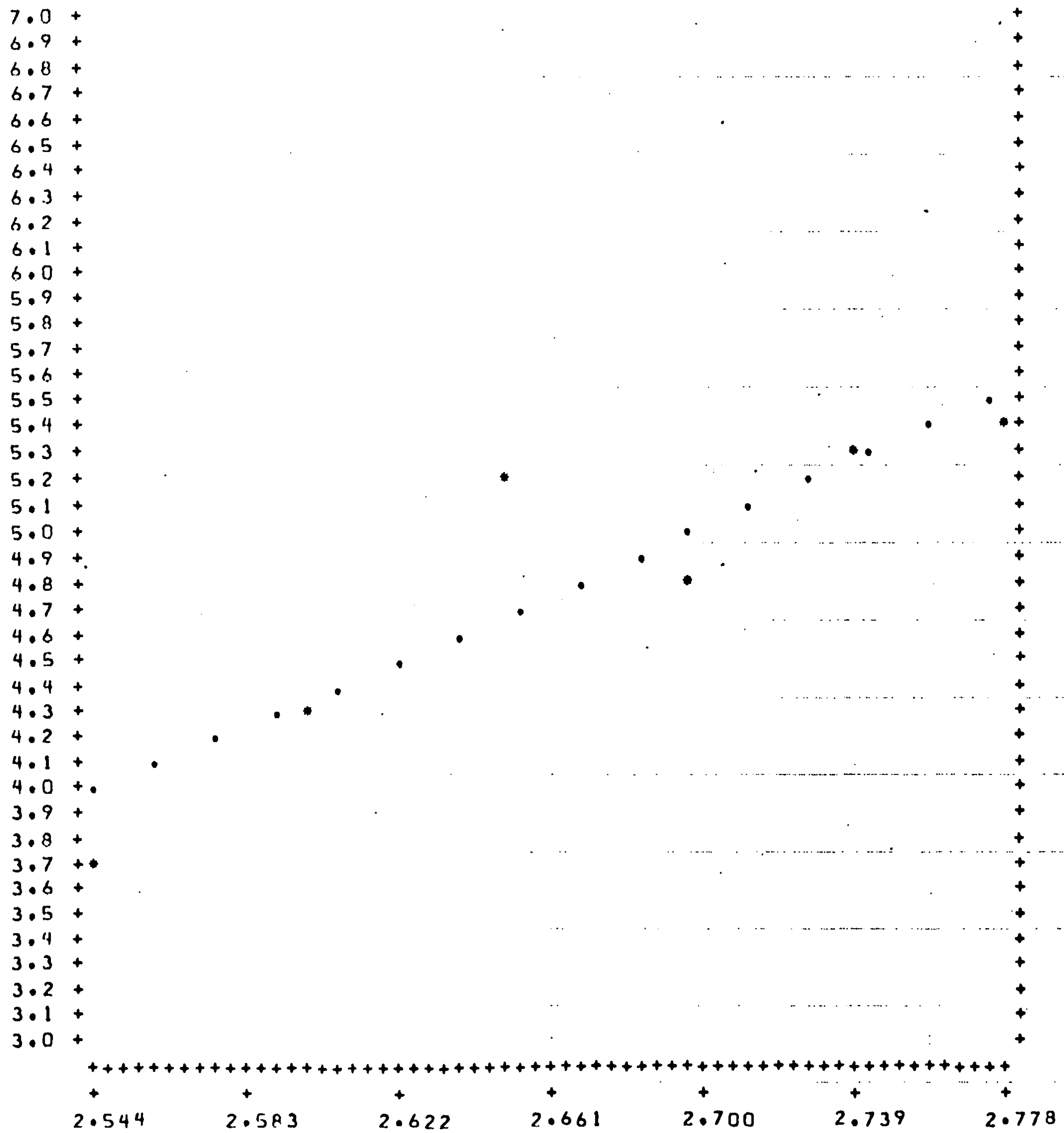
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 215.8575 | 83.2312 | 290.7028 |
| P = .05 | 274.8449 | 139.1212 | 341.9119 |
| P = .10 | 312.6279 | 182.6004 | 373.5327 |
| P = .20 | 365.4080 | 252.6825 | 417.6604 |
| P = .50 | 492.4541 | 436.9608 | 556.6059 |
| P = .80 | 663.6720 | 579.5560 | 967.1345 |
| P = .90 | 775.7178 | 647.8007 | 1338.7790 |
| P = .95 | 882.3561 | 707.6279 | 1757.3901 |
| P = .99 | 1123.4776 | 832.2010 | 2937.7641 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-9   96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=   6.4944, INTERCEPT= -12.4854,
NATURAL RESPONSE RATE=   .0459

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-10 24 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS : 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 1. | .0500 | 3.3548 |
| 400.0000 | 2.6021 | 20. | 0. | .0001 | 1.2809 |
| 450.0000 | 2.6532 | 20. | 3. | .1500 | 3.9636 |
| 500.0000 | 2.6990 | 20. | 4. | .2000 | 4.1585 |
| 550.0000 | 2.7404 | 20. | 8. | .4000 | 4.7471 |
| 600.0000 | 2.7782 | 20. | 7. | .3500 | 4.6151 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 2

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .3030
TOTAL NUMBER OF CYCLES = 7

SUMMARY STATISTICS

AVG Y = 4.219653
AVG X = 2.702318
AVG T = 3.751068
NATURAL MORTALITY = .000000 SE = .000054
SLOPE = 7.401013 SE = 2.078385
T STATISTIC = SLOPE/SE = 3.560944
INTERCEPT = -15.780241
CHI SQUARED = 3.066883

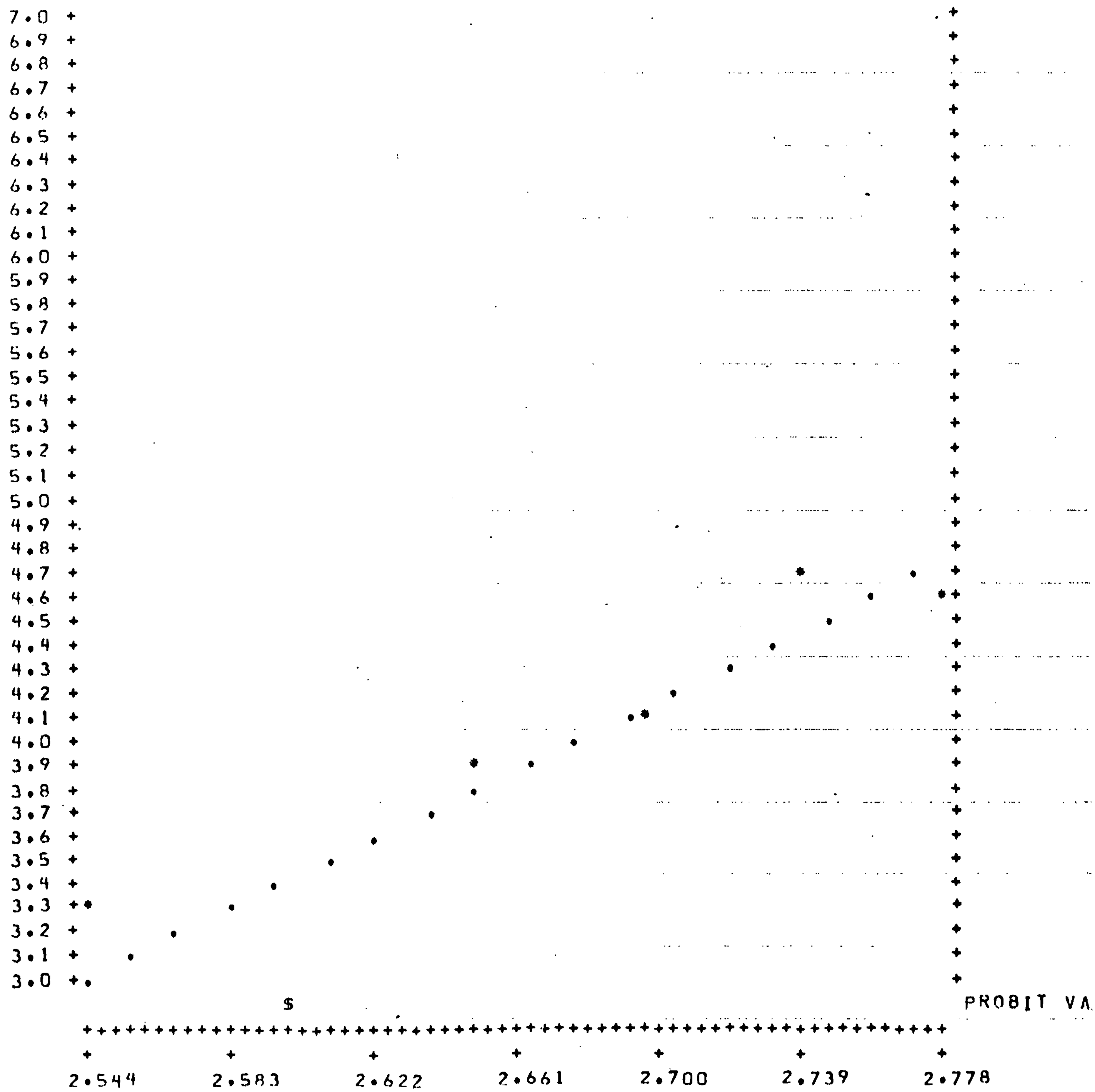
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 311.4830 | 170.4962 | 374.6090 |
| P = .05 | 385.0373 | 270.4983 | 433.8075 |
| P = .10 | 431.1125 | 343.0515 | 473.0952 |
| P = .20 | 494.3585 | 441.6985 | 544.2064 |
| P = .50 | 642.3270 | 574.1366 | 887.4633 |
| P = .80 | 834.5845 | 688.5772 | 1568.5170 |
| P = .90 | 957.0213 | 754.2061 | 2120.9643 |
| P = .95 | 1071.5427 | 812.4901 | 2723.0242 |
| P = .99 | 1324.5794 | 933.3371 | 4355.1191 |

J. R. GIBSON   MR 2149   ACARTIA TONSA   SAMPLE 9923-10   24 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 7.4010, INTERCEPT= -15.7802,
NATURAL RESPONSE RATE= .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-10 48 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 4. | .2000 | 4.1585 |
| 400.0000 | 2.6021 | 20. | 2. | .1000 | 3.7183 |
| 450.0000 | 2.6532 | 20. | 10. | .5000 | 5.0000 |
| 500.0000 | 2.6990 | 20. | 9. | .4500 | 4.8746 |
| 550.0000 | 2.7404 | 20. | 12. | .6000 | 5.2529 |
| 600.0000 | 2.7782 | 20. | 14. | .7000 | 5.5240 |

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .2193
TOTAL NUMBER OF CYCLES = 7

SUMMARY STATISTICS

AVG Y = 4.832714
AVG X = 2.677429
AVG T = 1.709583
NATURAL MORTALITY = .000000 SE = .000001
SLOPE = 6.703568 SE = 1.601706
T STATISTIC = SLOPE/SE = 4.185268
INTERCEPT = -13.115614
CHI SQUARED = 4.485715

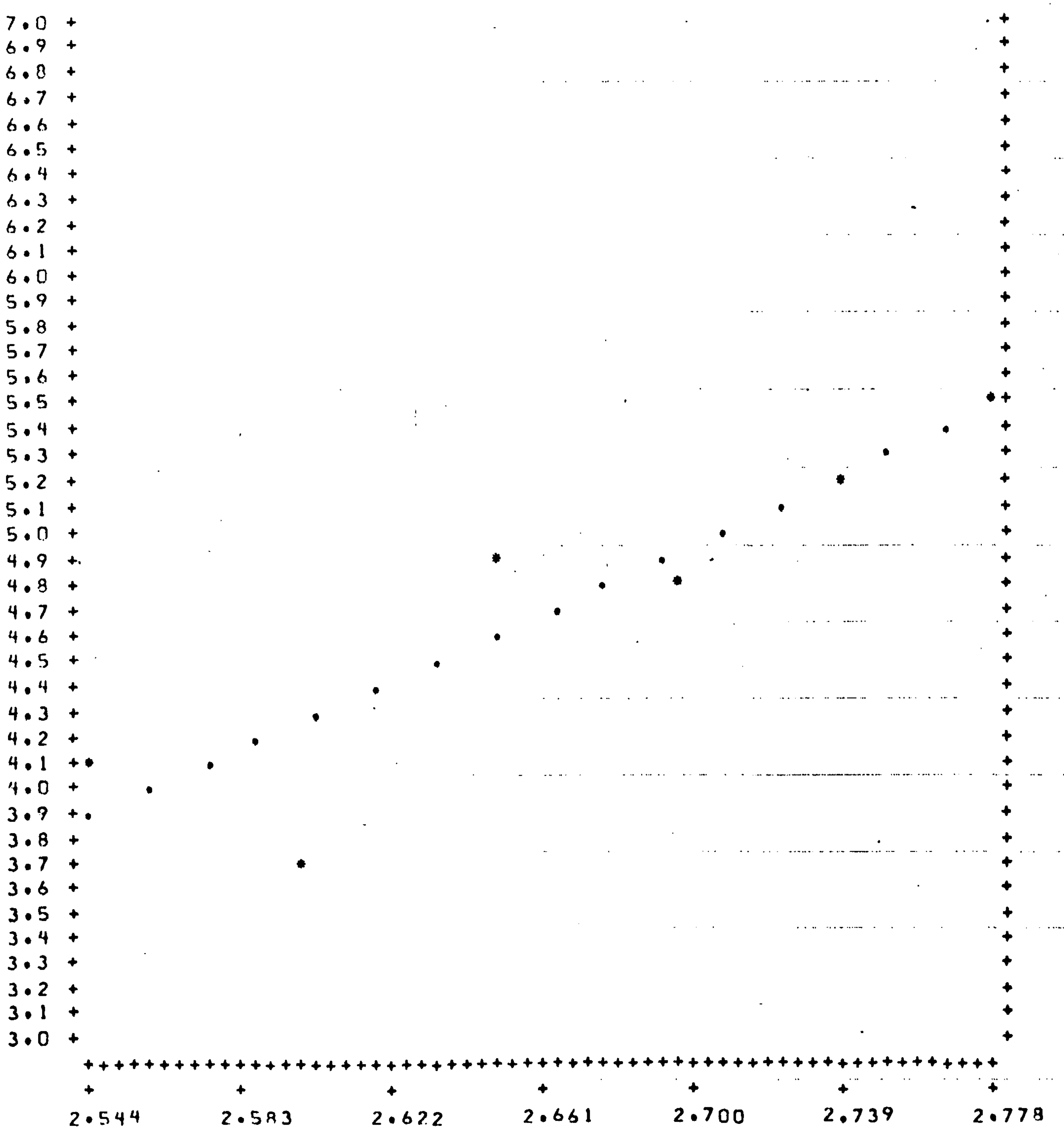
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 226.6520 | 116.8335 | 289.8662 |
| P = .05 | 286.4224 | 180.6827 | 341.3921 |
| P = .10 | 324.4905 | 227.5270 | 373.2301 |
| P = .20 | 377.4319 | 299.3197 | 417.8548 |
| P = .50 | 503.9457 | 464.0877 | 565.1817 |
| P = .80 | 672.8663 | 590.7810 | 931.0844 |
| P = .90 | 782.6462 | 658.5264 | 1230.2508 |
| P = .95 | 886.6668 | 718.8819 | 1551.4886 |
| P = .99 | 1120.4896 | 845.6572 | 2402.2432 |

J. R. GIBSON    MR 2149    ACARTIA TONSA    SAMPLE 9923-10    48 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE=    6.7036, INTERCEPT= -13.1156,
NATURAL RESPONSE RATE=     .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-10 96 HR

INPUT DOSE SCALE IS TRANSFORMED TO LOG(10).

INPUT DATA

CONTROL: SAMPLE SIZE = 20. # DEATHS = 0. NATURAL MORTALITY =

| DOSE | LOG DOSE | SAMPLE | # DEATHS | RATE(ADJ.) | PROBIT |
|---|---|---|---|---|---|
| 350.0000 | 2.5441 | 20. | 7. | .3500 | 4.6151 |
| 400.0000 | 2.6021 | 20. | 5. | .2500 | 4.3258 |
| 450.0000 | 2.6532 | 20. | 13. | .6500 | 5.3849 |
| 500.0000 | 2.6990 | 20. | 12. | .6000 | 5.2529 |
| 550.0000 | 2.7404 | 20. | 15. | .7500 | 5.6742 |
| 600.0000 | 2.7782 | 20. | 20. | .9999 | 8.7191 |

RESPONSE RATE = 0.0 OR 1.0 AT POINTS 6

CONSTANTS USED IN PROBIT CALCULATIONS

HETEROGENIETY FACTOR = 1.0000
NUMBER OF POINTS = 6
DEGREES OF FREEDOM = 4
DEVIATE = 1.9600
G = .1551
TOTAL NUMBER OF CYCLES = 13

SUMMARY STATISTICS

AVG Y = 5.238501
AVG X = 2.660788
AVG T = 1.250276
NATURAL MORTALITY = .000000 SE = .000000
SLOPE = 8.238772 SE = 1.655658
T STATISTIC = SLOPE/SE = 4.976132
INTERCEPT = -16.683127
CHI SQUARED = 8.239349

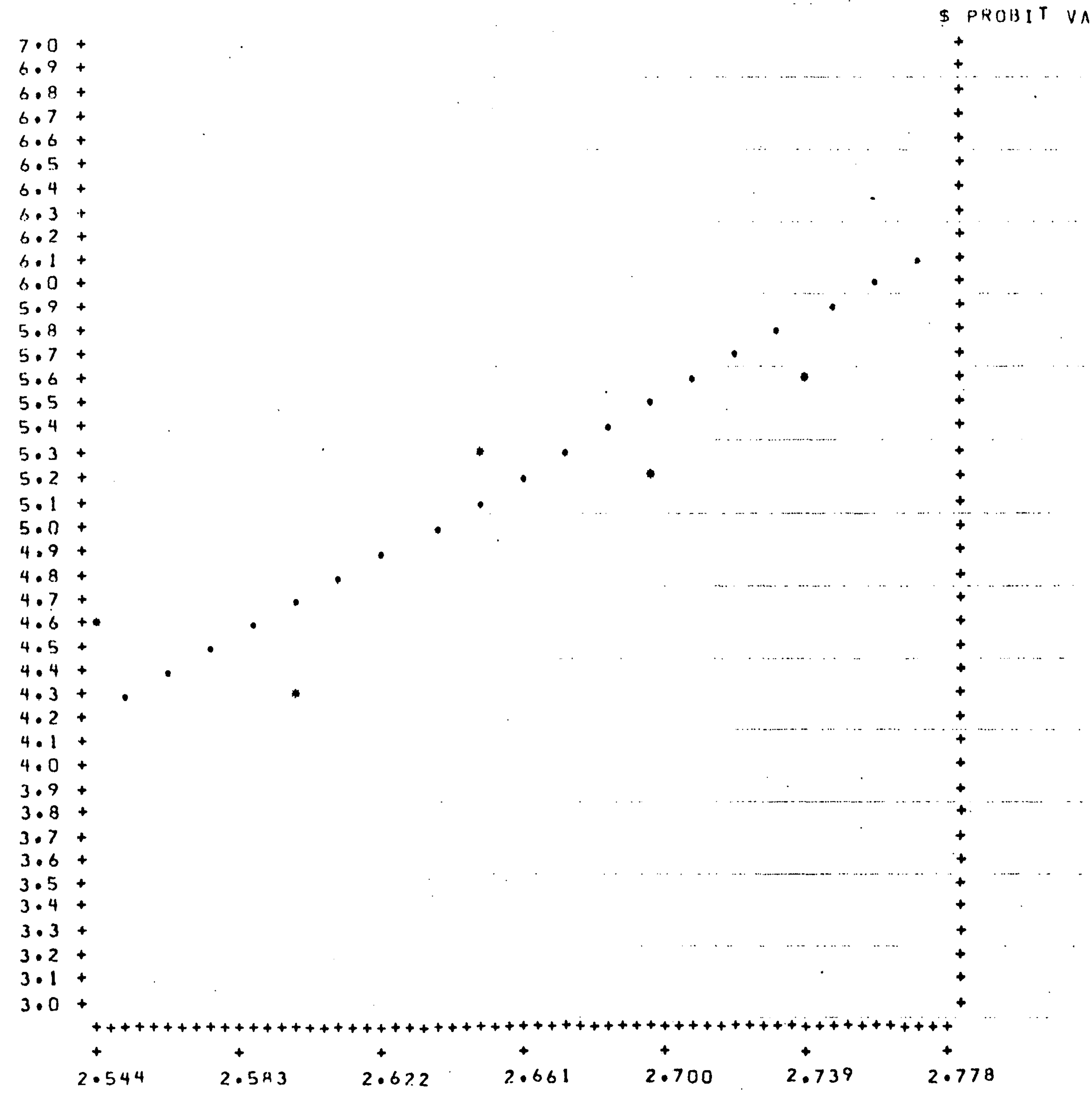
| POINT | DOSE | 95% CONFIDENCE LIMITS LOWER | UPPER |
|---|---|---|---|
| P = .01 | 223.6040 | 139.1887 | 276.0729 |
| P = .05 | 270.5117 | 190.0255 | 317.3976 |
| P = .10 | 299.4211 | 224.1195 | 342.2344 |
| P = .20 | 338.6012 | 273.1697 | 375.6615 |
| P = .50 | 428.3903 | 390.3141 | 458.8104 |
| P = .80 | 541.9894 | 501.6106 | 623.0160 |
| P = .90 | 612.9101 | 553.7408 | 755.0669 |
| P = .95 | 678.4114 | 598.2856 | 888.7321 |
| P = .99 | 820.7288 | 689.0102 | 1211.2719 |

J. R. GIBSON MR 2149 ACARTIA TONSA SAMPLE 9923-10 96 HR

PLOT OF THE MAXIMUM LIKELIHOOD ESTIMATE OF THE PROBIT REGRESSION LINE.

THE MAXIMUM LIKELIHOOD ESTIMATES WERE--SLOPE= 8.2388, INTERCEPT= -16.6831,
NATURAL RESPONSE RATE= .0000

6 LEVELS OF DOSE WERE ADMINISTERED.



# APPENDIX B

EN-1029

DU PONT

ESTABLISHED 1802

E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED

WILMINGTON, DELAWARE 19898

ENGINEERING DEPARTMENT

June 13, 1975

Mr. Richard T. Dewling, Director
Surveillance and Analysis Division
Environmental Protection Agency
Raritan Depot, Building 10
Edison, NJ 08817

Dear Mr. Dewling:

The report attached to R. D. Turner's letter of June 10, 1975, to you references two other Du Pont reports under the names, John Ball and D. W. Hood.

Attached herewith are copies of each. Similar copies were attached to material given to Mr. Paul Bermingham for the hearing record and to Dr. Paul Lefcourt in New York on June 12.

Very truly yours,

ENGINEERING SERVICE DIVISION

L. L. Falk

L. L. Falk

LLF:kmt

Atch.

*Note to BCC's: Copies also attached for these recipients.

ENGINEERING REPORT

ON

WASTE DISPERSION AT SEA

E. I. DU PONT DE NEMOURS & COMPANY (INC.)

July 31, 1973

## INTRODUCTION

Ocean dumping permits issued to E. I. du Pont de Nemours and Company (Du Pont) for plants at Beaumont, Texas, Houston, Texas, and Belle, West Virginia required that in situ waste dispersion studies be conducted. To this end, Du Pont contracted with Dr. John Ball, Civil Engineering Department, Texas A&M University (TAMU) to obtain waste dispersion data from barging operations in the Gulf of Mexico. This report presents results obtained at a 35,000 lb./minute discharge rate. A planned dispersion test at a 7,000 lb./minute discharge rate was postponed when barging operations were interrupted.

## RESULTS AND CONCLUSIONS

1. The mathematical model submitted to EPA (March, 1973) predicted an initial waste concentration (Phase I) of 750 ppm, for a discharge rate of 35,000 lb./minute at a speed of 5 knots. Initial concentrations found during the test ranged from 250 to 1200 ppm, averaging 610 ppm. These results appear to confirm Phase I of the model.

RESULTS AND CONCLUSIONS (CONTINUED)

2. Phase II dispersion occurred at a slower rate than predicted. The waste concentration in the wake of the barge was reduced to 40 ppm after 7 1/2 hours of dispersion. The study data is inconclusive regarding the validity of Phase II of the model.

3. The dispersion characteristics of wastes barged from Belle, West Virginia and Houston, Texas are expected to be similar to those of the Beaumont waste.

4. All dispersion data collected during the study are summarized in Table I.

STUDY PROCEDURE

Rhodamine WT dye was added to one compartment of the PATCO 100 barge when the barge was filled with Beaumont plant waste. The resultant waste-to-dye ratio was 2500:1. TAMU personnel and a Du Pont observer met the barge in the dump zone on May 15. The barge discharged waste at 35,000 lb./minute for 20 minutes while being towed at 5 knots. Waste was discharged twice from this compartment, and samples were taken at the center line of both wakes for 7 1/2 hours at depths from 3 feet to 33 feet.

STUDY PROCEDURE (CONTINUED)

Samples were transported to TAMU and read with two Turner Model 111 fluorometers. Calibration curves were prepared and used to convert fluorometer readings into dye concentrations which were converted into equivalent waste concentrations based on the 2500:1 waste-to-dye ratio. Appendix contains the calibration curves for both fluorometers.

DISCUSSION

Figure 1 shows the waste dispersion determined from the study and the calculated dispersion for Phase II of the mathematical model presented in "Engineering Report on Deep Sea Disposal of Wastes" which was attached as Exhibit III to our application (3/23/73) for Ocean Dumping Permit 730-D002.

The Phase I portion of the model is corroborated by the study data for initial mixing. The results show some variability as might be expected in the turbulent mixing zone immediately behind the barge. Five samples taken just under the surface of the water behind the barge showed a waste concentration range of 1200 - 250 ppm. The average concentration of these samples was 610 ppm, which compares very closely to the model prediction of 750 ppm for a 5 knot barge speed and 35,000 lb./minute discharge rate.

DISCUSSION (CONTINUED)

The original study data shows variability in waste dispersion among the four wakes. The current study data is compared with the original study data in Figure 2. All four wakes in that study showed logarithmic decay, and the preponderance of the data forms the basis for the rapid dispersion predicted by the model. However, Wake 3 exhibited a much slower dispersion rate than did the other three wakes. The decrease in waste concentration is of the same order of magnitude as the waste concentration decrease in this study.

Overall dispersion (following the initial mix) was slower than expected. Dispersion appears to have been second-order or logarithmic in nature. The initial dispersion rate closely approximated that of the model. However, this rate was not maintained and declined steadily.

The study data cannot be regarded as conclusive, since the amount of data taken was limited by difficulties encountered during the study. The choppy seas incapacitated most of the sampling party. Neither fluorometer on board the boat operated, necessitating discreet sampling instead of the planned continuous record. The second wake was discharged four miles from the first wake, and planned monitoring of both wakes at the same time was not possible. Because of these difficulties, Table 1 shows that only five profiles were taken during the 7 1/2 hour monitoring period from both wakes.

DISCUSSION (CONTINUED)

Figure 3 shows that the waste concentration varies considerably with depth, time and wake monitored. The 5-minute profile from the first wake drops off sharply below the 3-foot depth. Although the boat captain was instructed to keep the boat at the center line of the visible plume on the water's surface, the boat may have drifted toward the edge or the plume may have been dispersed diagonally instead of vertically. Because of profile variability of waste concentration in the wakes, a conservative approach to interpreting the data was used, and the high concentration, indicated by a box in Table 1, was plotted in Figure 1 as the data point. No Bathothermograph data were available at the time of the study; however, the thermocline was reportedly well below the 33 feet depth.

The Civil Engineering Department of TAMU was contracted through the Texas A&M Research Foundation to monitor waste discharge at 7,000 lb./minute discharge rate. However, this study has not been completed due to the interruption of the Beaumont barging schedule. This interruption was caused by difficulties with the constituent limits in the barging permit, and restrictions encountered pursuant to obtaining an amended barging permit.

DISCUSSION (CONTINUED)

The barge dispersion study was done for Beaumont plant waste discharge. The dispersion characteristics of the La Porte and Belle plant wastes should be very similar to those for Beaumont since the density of the wastes from these three plants are nearly the same. TAMU has indicated that the dispersion characteristics for the three plant wastes should be similar in a letter to the Beaumont Plant (Appendix B).

WCG/fs
Attachments

TABLE 1

WASTE CONCENTRATION BEHIND BARGE

CONCENTRATION (mg/1) OF WASTE

| Time After Discharge (Minutes) | Wake No. | Depth 3' | 9' | 15' | 21' | 27' | 33' |
|---|---|---|---|---|---|---|---|
| < 5 | 1* | 610 | - | - | - | - | - |
| < 5 | 2 | 560 | 580 | 650 | 740 | 215 | 95 |
| 5 | 1 | 600 | 160 | 200 | 110 | 40 | - |
| 75 | 1 | 60 | 60 | 80 | 110 | 160 | 130 |
| 90 | 2 | 125 | 130 | 140 | 120 | 30 | 10 |
| 195 | 2 | 40 | - | - | - | - | - |
| 450 | 1 | 25 | 35 | 35 | 40 | 40 | 40 |

* Average of 5 results with range 250-1200 mg/l

Comparison of Study Waste Dispersion with Phase II of Model

@ 35,000 #/min and 5 knots

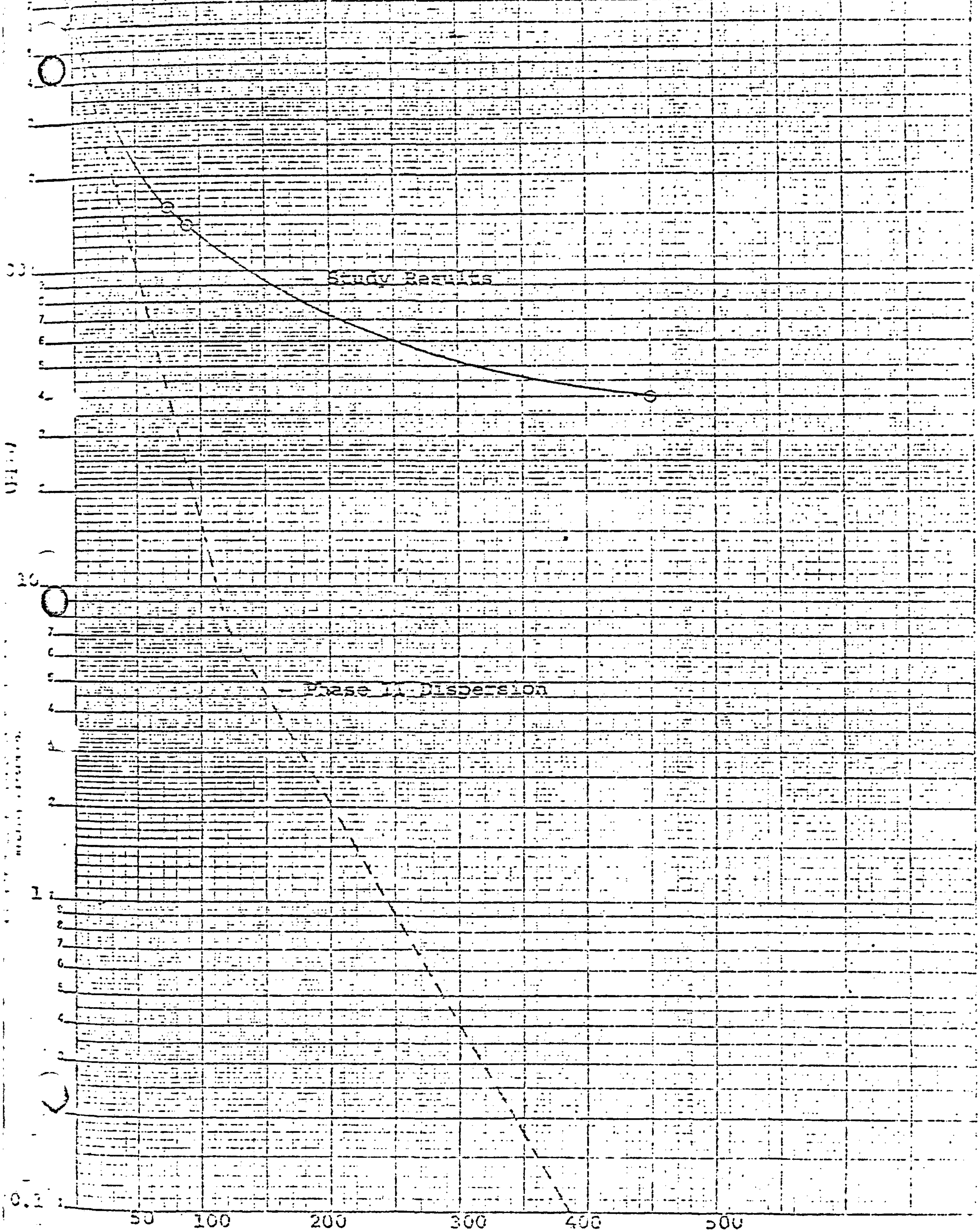


Figure 7

Comparison of Study Waste Dispersion with Hood Report Waves I - IV Dispersion

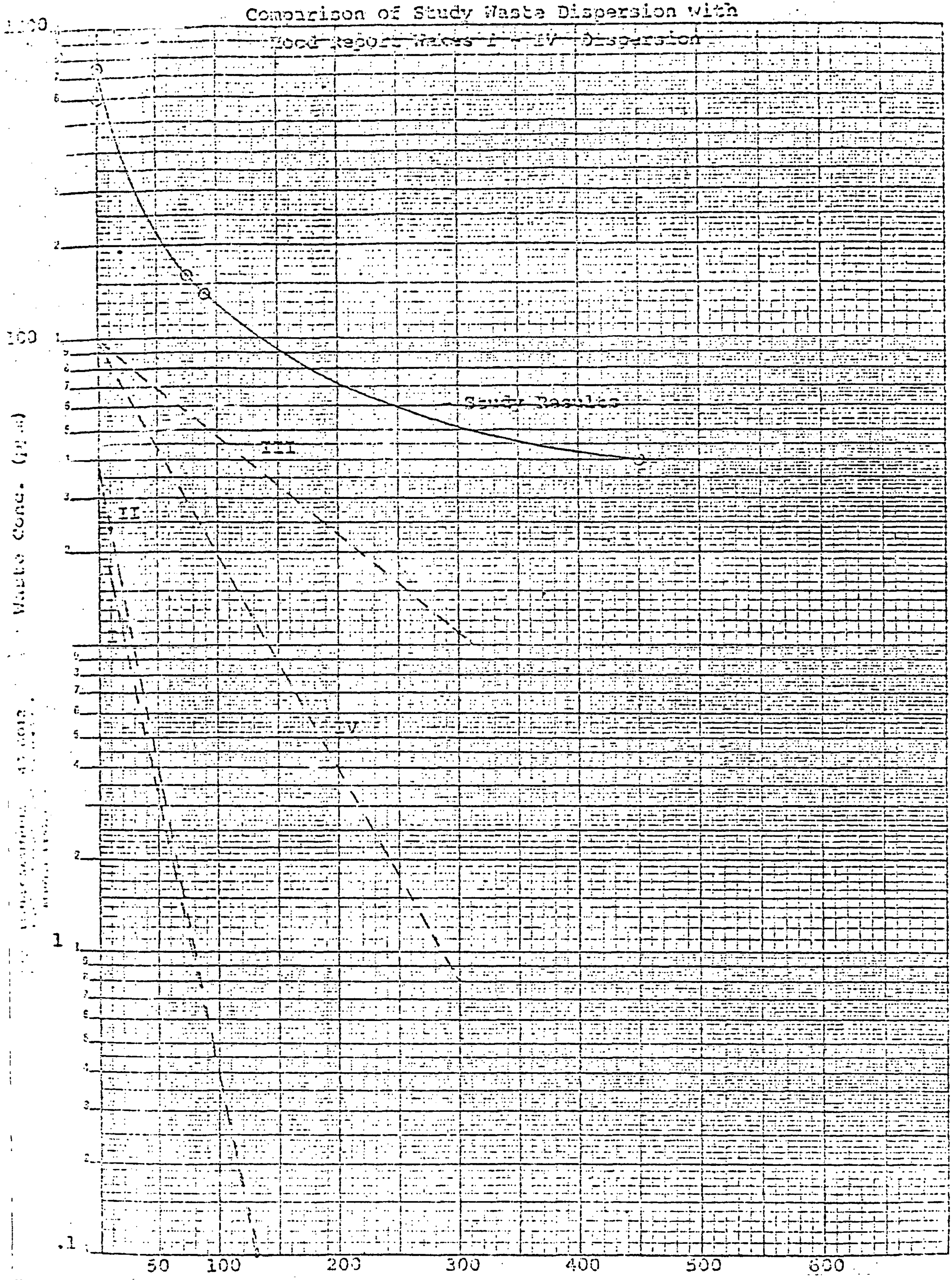
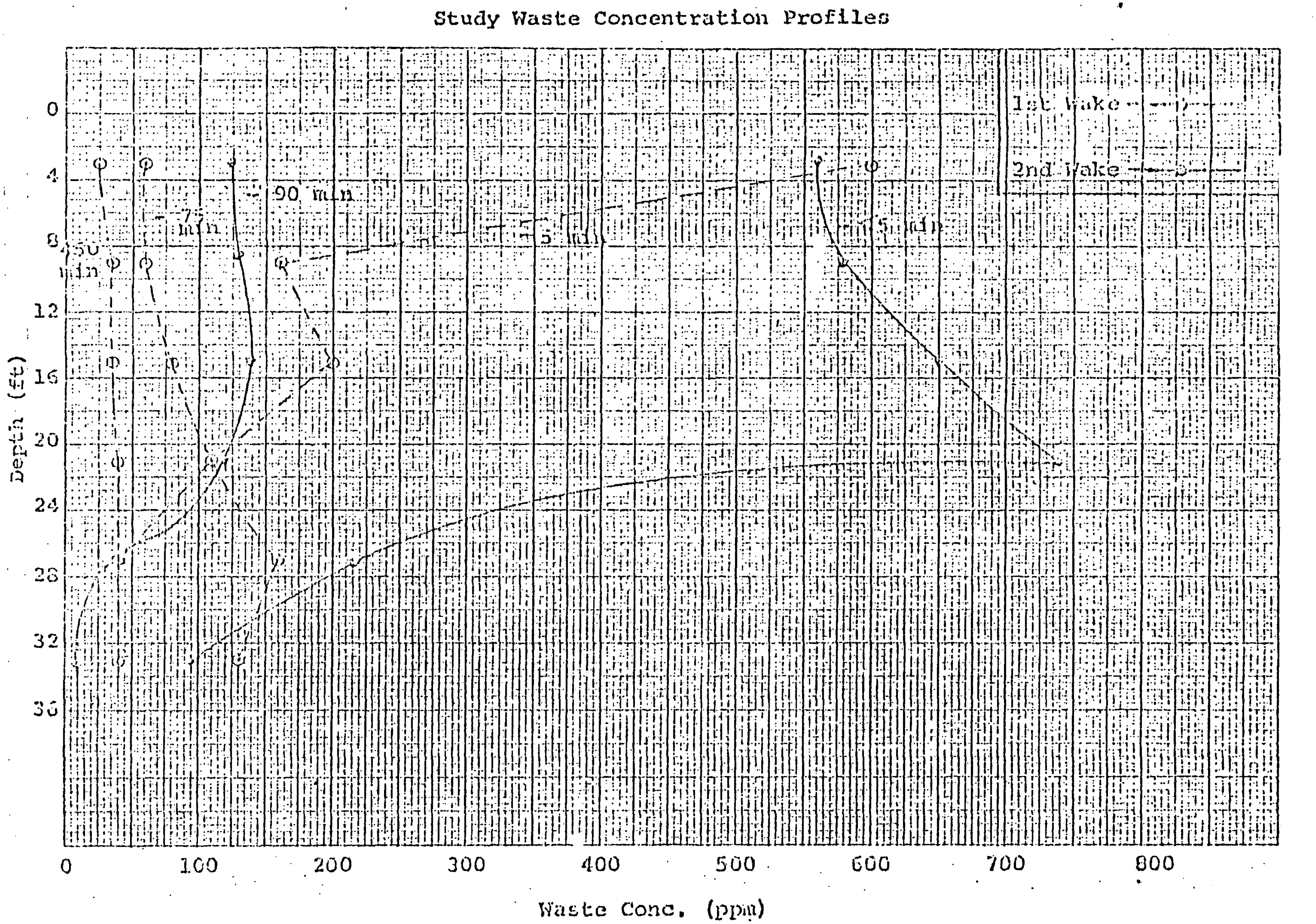
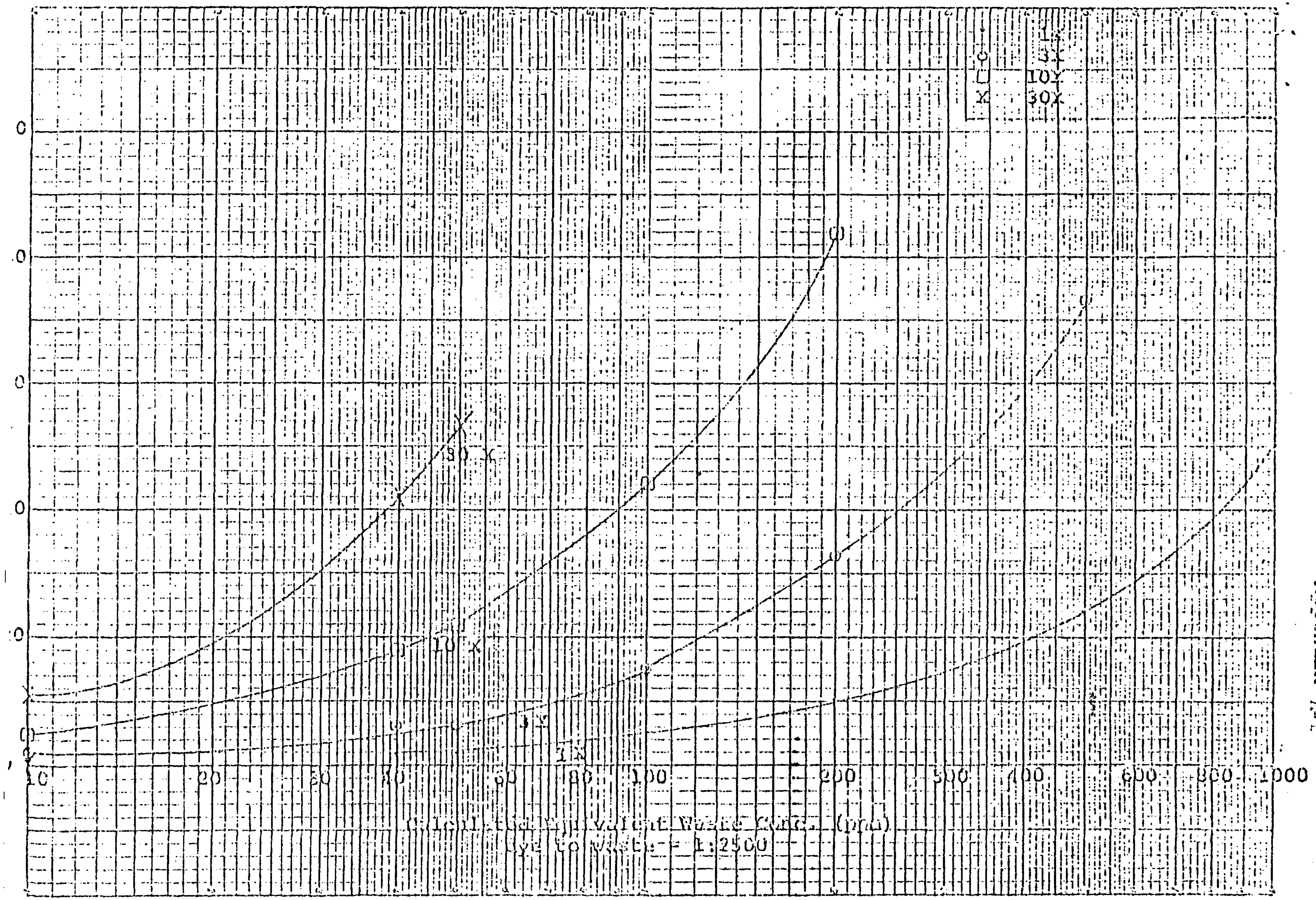


Fig 3

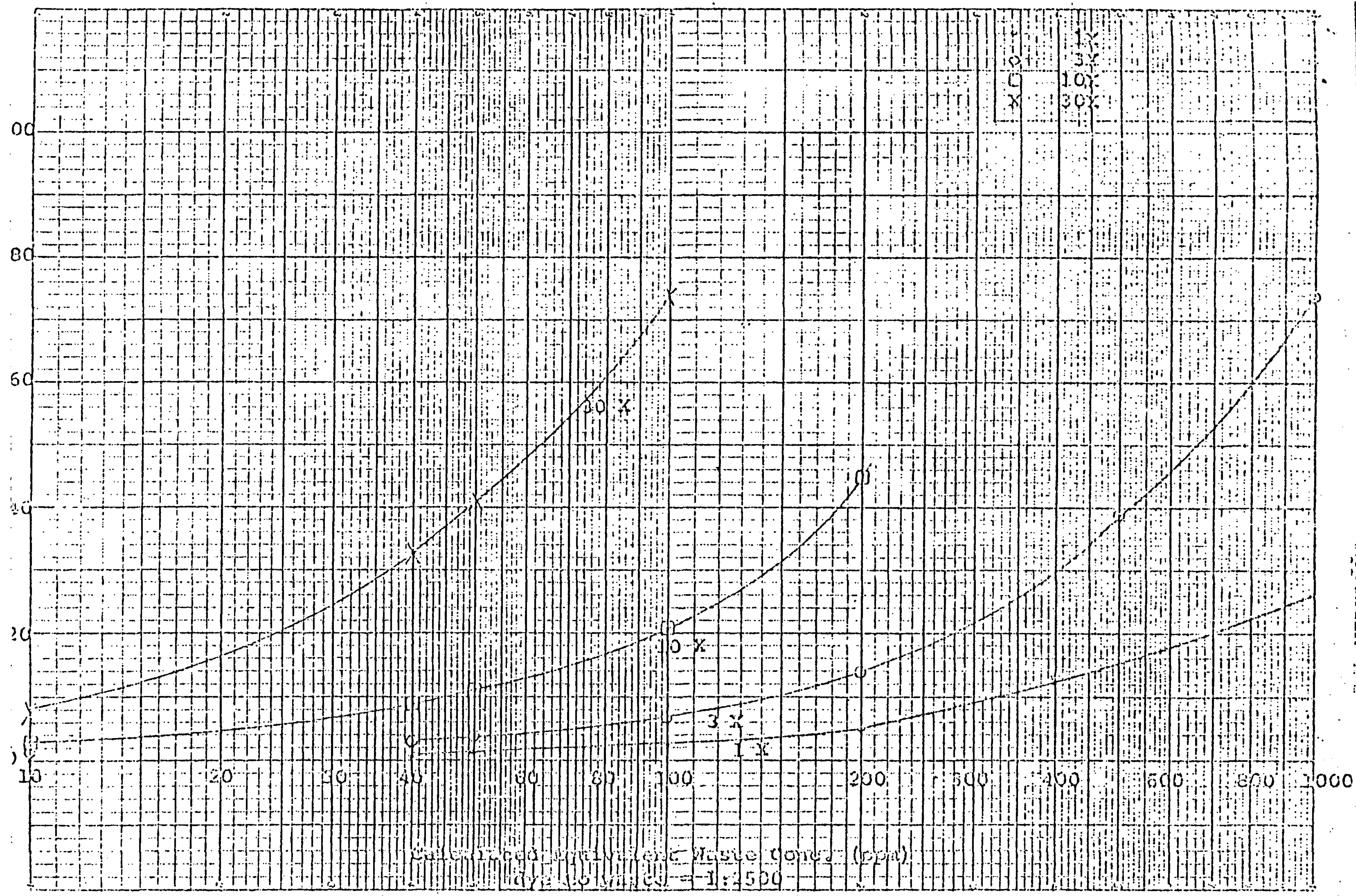


Study Waste Concentration Profiles
1st Wake
2nd Wake
90 min
75 min
150 min
5 min
5 min
0
4
8
12
16
20
24
28
32
36
Depth (ft)
0
100
200
300
400
500
600
700
800
Waste Conc. (ppm)

Flu· ·ometer #1 Calibration Cu· ·e



Fluorometer #2 Calibration Curve



TEXAS A&M UNIVERSITY
CIVIL ENGINEERING DEPARTMENT
COLLEGE STATION TEXAS 77843

ENVIRONMENTAL ENGINEERING AND ENVIRONMENTAL SCIENCE DIVISION

July 20, 1973

Mr. David Hoene
The DuPont Corporation
ICD - Technical
P. O. Box 3269
Beaumont, Texas

Dear Mr. Hoene:

This letter is in answer to a question submitted by Mr. Dick Schwer with regard to diffusion characteristics of DuPont wastes.

Our preliminary assessment of the diffusion characteristics of DuPont wastes from LaPorte and Beaumont, Texas, and Belle, West Virginia, indicates that these waste materials would have similar diffusion characteristics when discharged from barges into the Gulf of Mexico waters. This evaluation is based upon waste characteristics and initial laboratory results.

We hope this information will serve your needs.

Sincerely,

Roy W. Hann, Jr., Ph.D., P.E.
Professor and Head

cc: Mr. Dick Schwer

RWH:bj

# EXHIBIT II
# ENGINEERING REPORT
# ON
# DEEP SEA DISPOSAL OF WASTES
# E. I. DU PONT DE NEMOURS & COMPANY (INC.)

E. I. du Pont de Nemours & Company (Inc.) has applied for permits to transport and dump materials in the Gulf of Mexico. This report presents additional data on these activities.

## Background

Du Pont first began its ocean dumping program in 1961. At that time, there was little information available on the nature of the dispersion of wastes discharged from a moving barge. In order to provide assurance that the dumping program could be conducted without adverse environmental effects, Du Pont contracted with Prof. D. W. Hood, Department of Oceanography and Meteorology, Texas A & M Research Foundation for assistance in the development of information which would adequately predict waste dispersion behind a moving barge. A report describing this study is attached, Appendix A.

## Study Summary

The dispersion study utilized the 2000 net ton barge, "H.L. Jacobs", traveling at speeds of 2 and 5 knots. Material was discharged at a rate of 6700 lb/minute. At a barge speed of 5 knots, a nearly instantaneous 6633-fold dilution occurred. This initial mix was followed by a slower, logarithmic decay in waste concentration. Decay rates appeared to be influenced somewhat by turbulence from the barge wake, since decay rates at 2 knots were slower than at 5 knots. The data collected have been used to construct a model describing dispersion behind a barge.

## The Model

The mathematical model constructed from the above study considers dispersion to occur in two distinct phases:

Phase I - Initial Mixing
Phase II - Logarithmic Decay

<u>Phase I</u> describes the initial mixing which occurs immediately behind the barge. This mixing is nearly instantaneous (less than 3 minutes). During the study, a 6633-fold dilution occurred when the barge was traveling at a speed of 5 knots and discharging at a rate of 6700 lb/minute. The model considers this mix to be a linear function of both barge speed and discharge rate. The size of the barge is recognized as an important variable. However, the manner in which barge size influences the initial mix cannot be accurately predicted. Since the "H.L. Jacobs" is the smallest barge proposed for use, this factor has not been included in the model. Larger barges can be expected to render the model more conservative. The initial mix is described by the equation:

$$C_o = (150)\left(\frac{5}{x}\right)\left(\frac{y}{6700}\right), \text{ where}$$

$C_o$ = the concentration after the initial mix (ppm),
$x$ = barge speed (knots), and
$y$ = discharge rate (lb/min)

<u>Phase II</u> occurs during the period following the initial mix. Monitoring of waste concentration at speeds of 2 and 5 knots indicated a first-order decay in concentration. The model assumes this decay to be independent of barge speed. Phase II dispersion is defined by the equation:

$$t = 60 \log C_o/C_1, \text{ where}$$

$C_o$ = the concentration after the initial mix,
$C_1$ = waste concentration at time t,
$t$ = time after initial mix, minutes

The above equation is applied at barge speed of 5 knots and greater for times up to 2 hours.

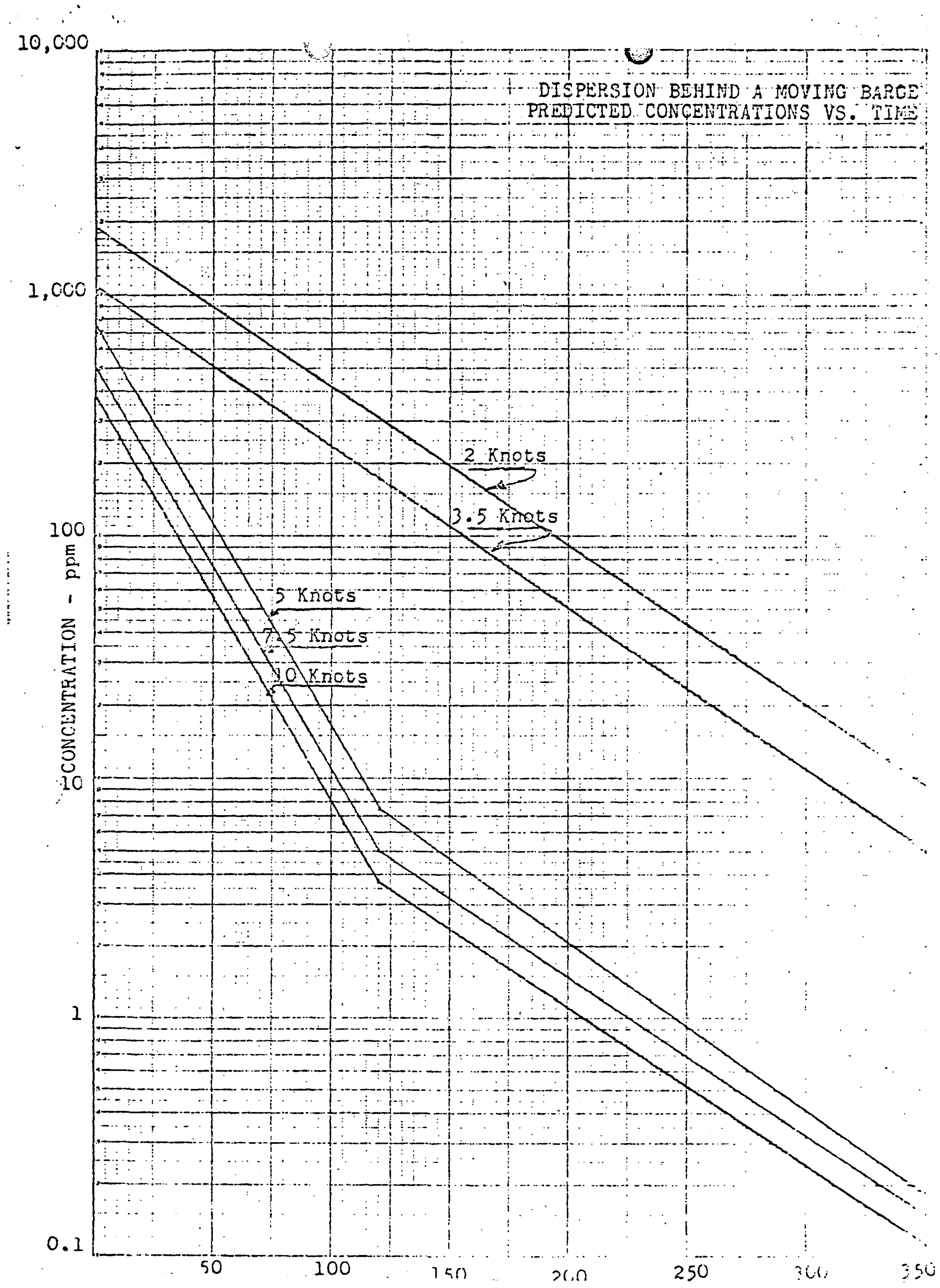
For barge speeds below 5 knots or times beyond 2 hours, the equation:

$$t = 152 \log C_o/C_1$$

is employed.

<u>Application of Model</u>

Du Pont's waste barging in the Gulf of Mexico normally employs the PATCO 100 barge. This barge is a 4800 ton barge which discharges at a rate of 35,000 lb/minute. Alternate barges employ lower discharge rates and would yield more conservative results. The barge is towed at speeds of 5 to 10 knots, except when heavy seas require a speed reduction. Figure 1 shows the predicted concentrations of waste with time for varying barge speeds.


DISPERSION BEHIND A MOVING BARGE
PREDICTED CONCENTRATIONS VS. TIME
CONCENTRATION - ppm
10,000
1,000
100
10
1
0.1
50
100
150
200
250
300
350
2 Knots
3.5 Knots
5 Knots
7.5 Knots
10 Knots

REPORT

from

DEPARTMENT OF OCEANOGRAPHY & METEOROLOGY
in Cooperation with
TEXAS A & M RESEARCH FOUNDATION

to

E. I. DUPONT DE NEMOURS AND COMPANY
of
Wilmington, Delaware

on

# RESULTS OF THE SURVEY ON DEEP SEA DISPOSAL OF CAPROLACTAM WASTES FROM THE BEAUMONT, TEXAS PLANT

Prepared by
Donald W. Hood

30 August 1961

## INTRODUCTION

Early in 1960 work was conducted by the author as a consultant to Industrial Waste Disposal Corporation to evaluate the caprolactam waste stream of the Beaumont works for deep sea disposal. In laboratory studies it was determined that the waste material inhibited respiration of brine shrimp (*Artemia salina*) at a concentration of 20 ppm. Effective toxicity levels to photosynthesis of the plants, *Platymonas* sp., *Nitzschia closterium*, and *Prophyridium cruentum*, were found to be between 115 and 235 ppm and lethal levels of three species of fish were all over 100 ppm. Based on these data, coupled with data on mixing rates of similar materials at sea, it was computed that sea disposal would be feasible for this material if conducted under conditions favorable to dispersal.

Based on this information a program of sea disposal was undertaken by the Beaumont Works in water of greater depth than 400 fathoms in a region due south of Sabine Pass. On the first operation, the Texas A & M Research Foundation under this contract was engaged to observe the dispersal rates of the waste at sea in an effort to reveal the feasibility of disposal of this material at sea and to establish the conditions that would bring about the most economical and sound operation

The specific objectives outlined in the proposal submitted 30 March 1961 was to observe the physical behavior of the waste in sea water; to determine the diffusion rate of the waste by measuring dispersion of

Rhodamine B which had previously been added to the waste in the disposal vessel; and, preparation of a report covering the above work.

It is the purpose of this report to present the details of this survey and to evaluate the technical aspects of the sea disposal operation conducted. Pictures obtained during the survey are presented in the Appendix.

Abbreviated Log of Survey

Monday, 5 June:

0900 - left College Station with equipment and four technical workers, headed for Galveston.

1330 - arrived Galveston and boarded the "Thelma J" at Grossos Dock and set up sampling gear and prepared necessary accessories.

1710 - departed Galveston to make rendezvous with barge which sailed from Beaumont, 4 June.

1810 - passed the sea buoy and encountered a fairly choppy sea with four to six foot swells and a 10-12 knot southeast breeze.

Tuesday, 6 June:

0300 - contacted the barge about 80 miles south of Sabine Pass. The tug and barge were proceeding at 5 knots.

0940 - arrived at 400 fathoms depth. Location: 27°27'N., 23°45'W., and began discharging the waste. The wake of the barge was labelled a brilliant red and measurement of the concentration of Rhodamine B in the wake was initiated.

0945 - moving behind the barge at a constant distance of 250 feet while monitoring the Rhodamine concentration in the wake.

0953 - dropped back to 600 feet behind the barge.

1003 - dropped back to 1200 feet behind the barge.

1009 - dropped back to 2400 feet behind the barge.

1021 - dropped back to 3600 feet behind the barge.

1036 - dropped back to 4800 feet behind the barge.

1047 - dropped back to 6000 feet behind the barge.

1145 - placed floating buoys in wake at about 1200 feet and began vertical crossings of wake. Continued crossing this wake at approximately three minute intervals.

1244 - barge laid down a second wake at approximately 200 yards from the first and the survey vessel monitored both wakes.

1411 - the barge passed again at a reduced speed of 2 knots and approximately 400 yards from the second wake and this wake was also monitored.

1447 - the fourth wake was laid down with the barge moving at 2 knots 300 yards from the third wake. At this time monitoring of the first two wakes was discontined and attention was paid to wakes 3 and 4. Sampling these wakes continued until 1907.

1907 - at this time the monitoring of the wakes laid down by the barge was discontinued and we departed the disposal area for Galveston, Texas.

Wednesday, 7 June:
0700 - Docked at 'Grossos' in Galveston.
0900 - Cleared the Thelma J and headed to College Station.

## General Information Concerning the Survey

The disposal vessel was a 9,000 barrel barge equipped with radio control valves and diesel pump system which was towed at 1200 feet behind a sea-going tug. The speed of the barge, which was established while running between fixed points, was estimated at five knots. The barge contained [illegible] barrels of caprolactam wastes and the density of the material was 8.5 pounds per gallon, giving a total weight in the barge of 3,111,500 pounds. To the entire barge contents 250 pounds of Rhodamine B as a 20% acetic acid solution was added as a tracer. The concentration of the dye in the waste was calculated to be 79.6 ppm or 1 part in 12,270 parts of waste.

Survey Vessel: The survey vessel used was the Thelma J. which is owned and operated by Mr. Falgout of Galveston, Texas. The vessel was 100 feet long with twin screws driven by two six hundred horse power GMC diesel engines. A picture of the vessel is shown in Figure 1 of the appendix.

Equipment: For this survey the measurements of Rhodamine B in the wake of the ship were made by means of two Turner Model 111 automatic recording fluorescent meters to which continuous streams of water were pumped from approximately six and twenty feet, respectively. The pumps used were Deming 3/4 inch gear pumps powered by 1/2 horsepower, 110 volt AC motors. From these pumps a small portion of the total flow was diverted to pass through the absorption cells of the fluorescent meters and the rest was by-passed overboard. The meters were standardized with weighed portions of solid Rhodamine B in the laboratory before use and again upon return from the survey to ascertain that the calibration curves had not shifted. These curves are presented in Figures 1 and 2 for Meters A and B, respectively. Also, some of the waste material obtained from the barge which contained the Rhodamine B tracer was analyzed upon returning to the laboratory. These values checked within reason to that estimated for the barge content.

Personnel

Ken Mack, Technical Supervisor of the E. I. Dupont de Nemours and Company's Beaumont Works.

Harold L. Jacobs, Senior waste disposal consultant with the E. I. Dupont de Nemours and Company of Wilmington, Delaware.

Rudy Marek, Chemist, Texas Game and Fish Commission, Seabrook, Texas.

W. C. Schilling, Chief of Industrial Waste, Division of Water and Pollution Control, State Health Department, Austin, Texas.

Scientific Party:

D. W. Hood, party chief.

Thomas W. Duke, Biological Oceanographer.

John E. Noakes, Chemical Oceanographer.

W. D. Kirwan, Physical Oceanographer.

Dean Letzring, Technical Observer.

Ship's Crew:

E. A. Theriout, Captain.

Bill Boddecker, Deck hand.

T. G. Moore, Cook.

Summary of Data Obtained on Laboratory Studies of Toxicity of Caprolactam Wastes to Marine Organisms *

| Common Name | Organism | Type Experiment | $TL_m$ Values (ppm) | Time (hrs) |
|---|---|---|---|---|
| Fundulus | *Fundulus similis* | Lethality | 550 | 96 |
| Gulf Silversides | *Menidia beryllina* | Lethality | 108 | 96 |
| Grass Shrimp | *Palaemonetes pugio* | Lethality | 830 | 48 |
| Brine Shrimp | *Artemia salina* | Inhibition of Respiration | 20 | 24 |
| Phytoplankton | *Platymonas sp.* | Inhibition of Photosynthesis | 235 | 24 |
| Phytoplankton | *Nitzschia closterium* | Inhibition of Photosynthesis | 145 | 24 |
| Phytoplankton | *Porphyridium cruentum* | Inhibition of Photosynthesis | 115 | 24 |

For the purpose of studying the dispersal at sea, it seems advisable to take the lowest concentration which shows effect on metabolism for computation purposes. Reasonable adjustments in operation procedure could then be recommended for practical reasons without necessarily causing a hazardous operation. A value of 20 ppm was chosen as a level of dispersal which would be considered safe from all aspects.

## Results and Discussion

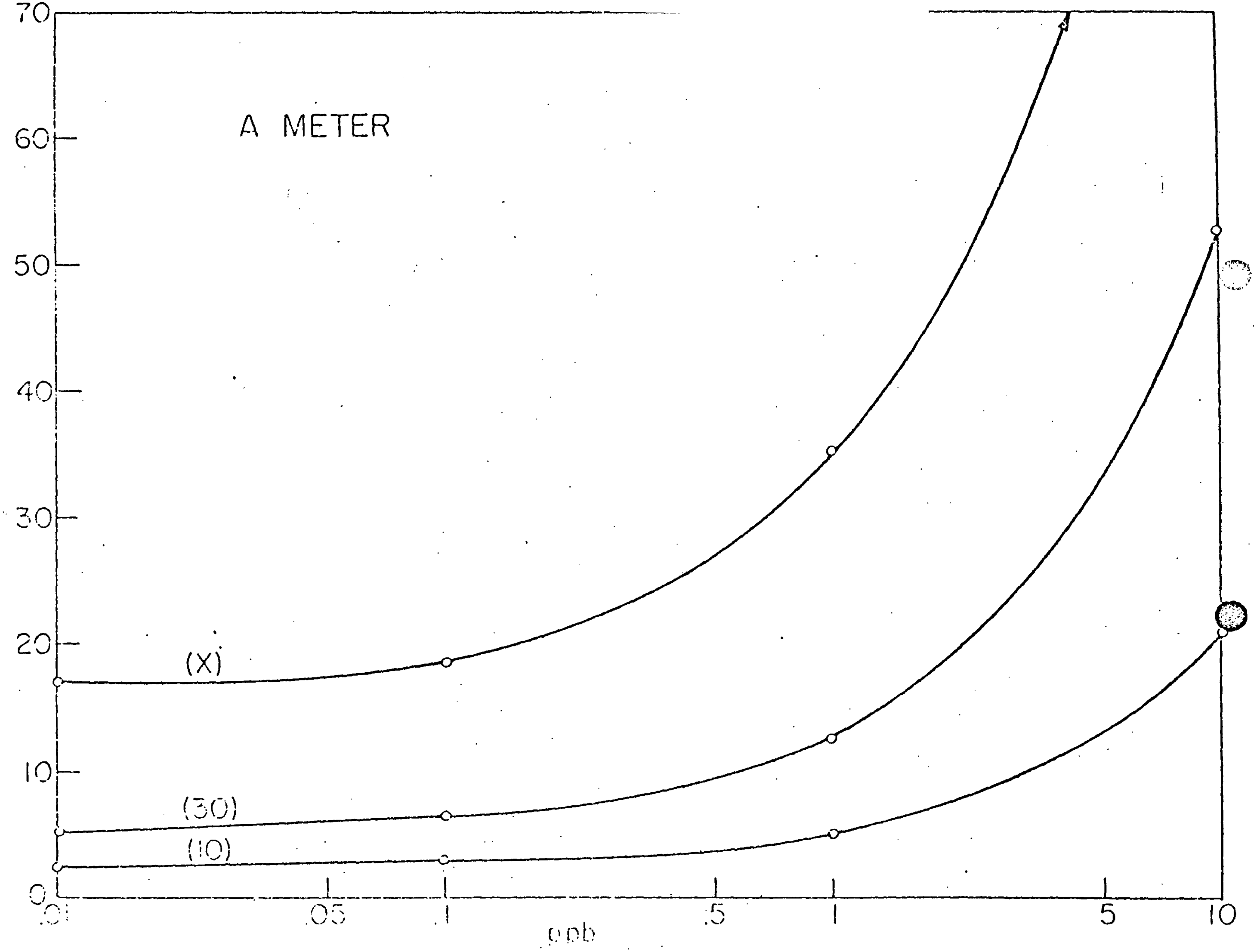
The results obtained during this survey are shown in Figures 3 through 7. The curves were fitted to the data by the least squares method employing the formula

$$M = \frac{\Sigma x^2 - (\Sigma x)^2}{N\,(\Sigma x\,y) - (\Sigma x)(\Sigma y)}$$

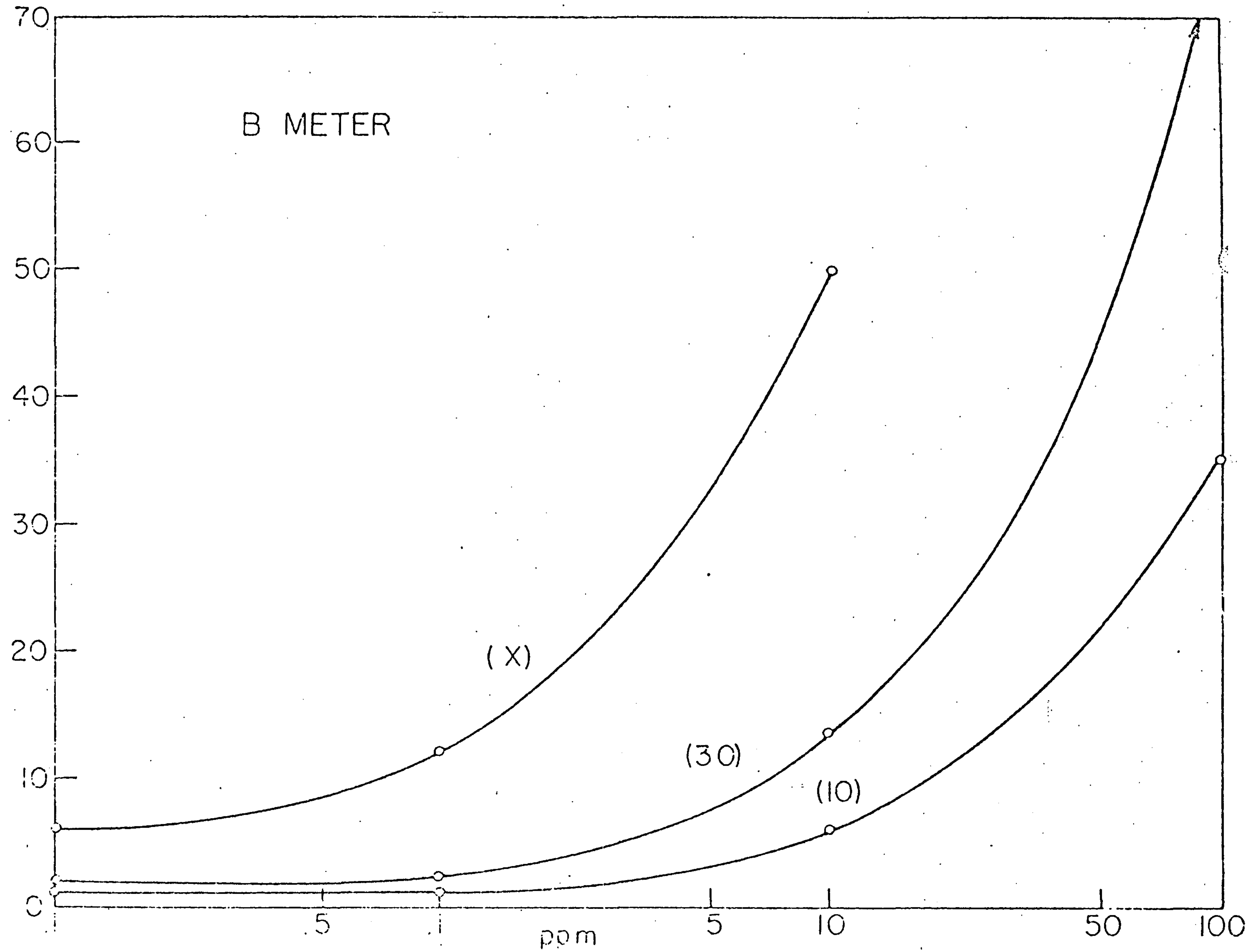
* Complete report to E. I. DuPont de Nemours and Company, 21 March 1960.

FIGURES 1 and 2

Standardization Curves for Rhodamine B using Turner Model 111 Continuous Recording Fluorescent Meters.



A METER
70
60
50
40
30
20
10
0
(X)
(30)
(10)
.01
.05
.1
.5
1
5
10
ppb



B METER
70
60
50
40
30
20
10
0
(X)
(30)
(10)
.5
1
5
10
50
100
ppm

## FIGURE 3

Log of Concentration of Rhodamine B in Wake I against feet from Barge.

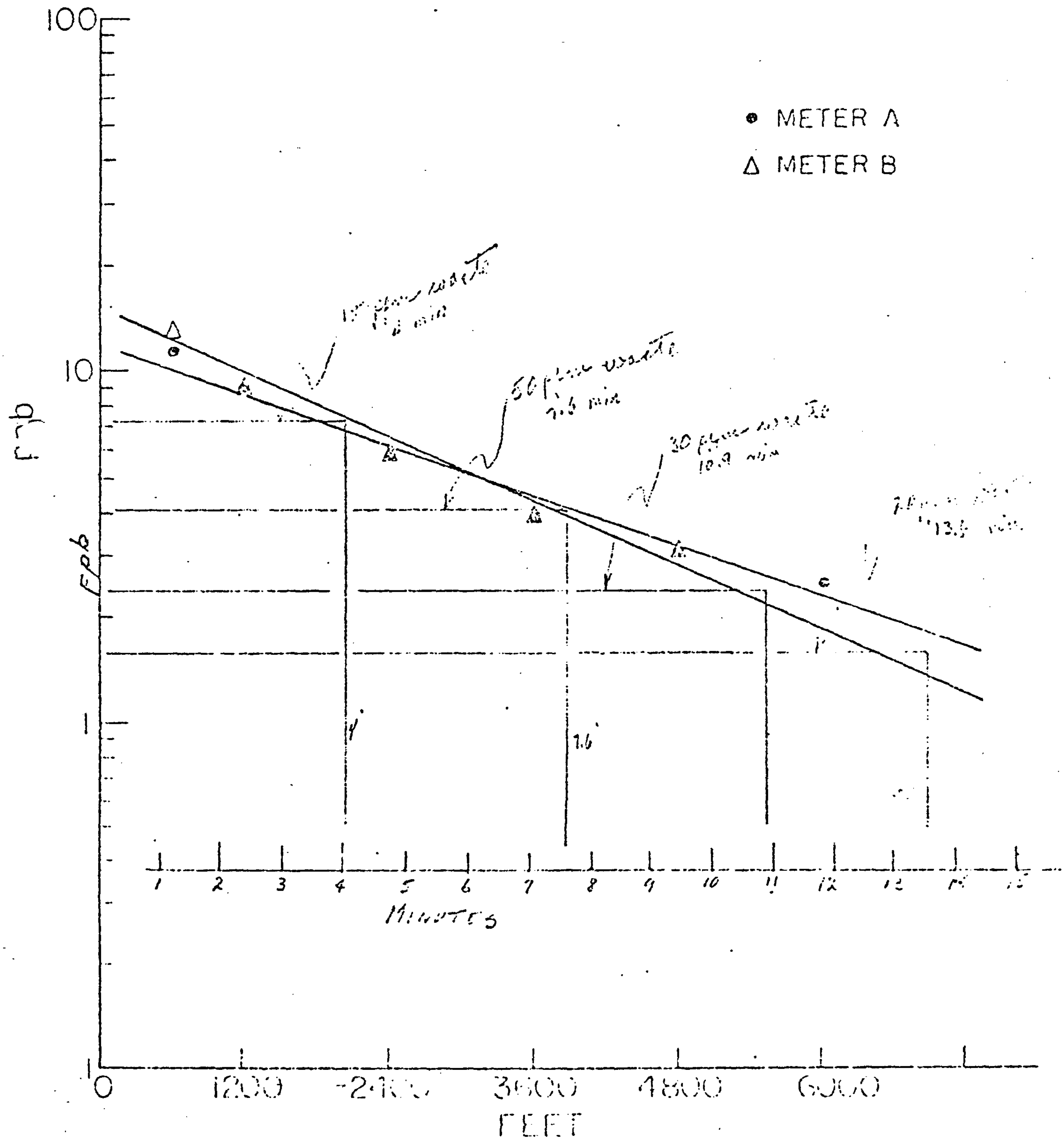
<u>Prediction Equation:</u>

$$d = 8300 \log \frac{C_o}{C_1}$$

where d is distance in feet; $C_o$ is concentration at $d = 0$; and, $C_1$ is desired concentration.

<u>Pumping Conditions:</u>

| | |
|---|---|
| Speed of tug and barge | 500 ft/minute (5 knots) |
| Total Dispersal Time | 470 minutes |
| Total Waste Pumped | 3, 141, 500 lbs |
| Pumping Rate | 0.4 lb/cm ([illegible] lbs/minute) |
| Concentration of Dye | 79.6 ppm |
| Ratio of Waste to Dye | 12, 270 |



100
10
1
METER A
METER B
0
1200
2400
3600
4800
6000
FEET
Minutes


FIGURE 3.

Figure 3 was obtained by monitoring the wake of the barge for several minutes while following at a fixed distance. Each point plotted represents an average concentration of 15-25 individual readings from the continuous record of concentration in the wake. As a result of analysis of these data, a prediction equation was derived as follows:

$$d = 8300 \log \frac{C_o}{C_1}$$

This equation applies to dispersion rates at distances relatively close behind the barge since the maximum distance examined was 6000 feet. At the 5 knot tug speed this represents a maximum of 12 minutes after pumping. If we assume that the dilution due to pumping from the barge as being represented by that dilution occurring between that of dye in the waste in the barge and that observed in the wake at 250 feet, the dilution due to pumping would be:

$$\text{Pumping dilution} = \frac{\text{Dye concentration in Barge}}{\text{Dye concentration at 250 feet}}$$

$$\frac{79.6 \times 10^{-3}\ g/kg}{12 \times 10^{-6}\ g/kg^{*}} = 6633 \text{ fold}$$

The concentration of the waste at 250 feet would then be 147 ppm (ratio of dye to waste, 12,272). Using the prediction equation, this concentration would be reduced to the target value of 20 ppm in about 14 minutes.

$$d = 8300 \log \frac{147}{20} = 8300 \times 0.87 = 7220 \text{ feet}$$

---

* Value taken from Figure 3

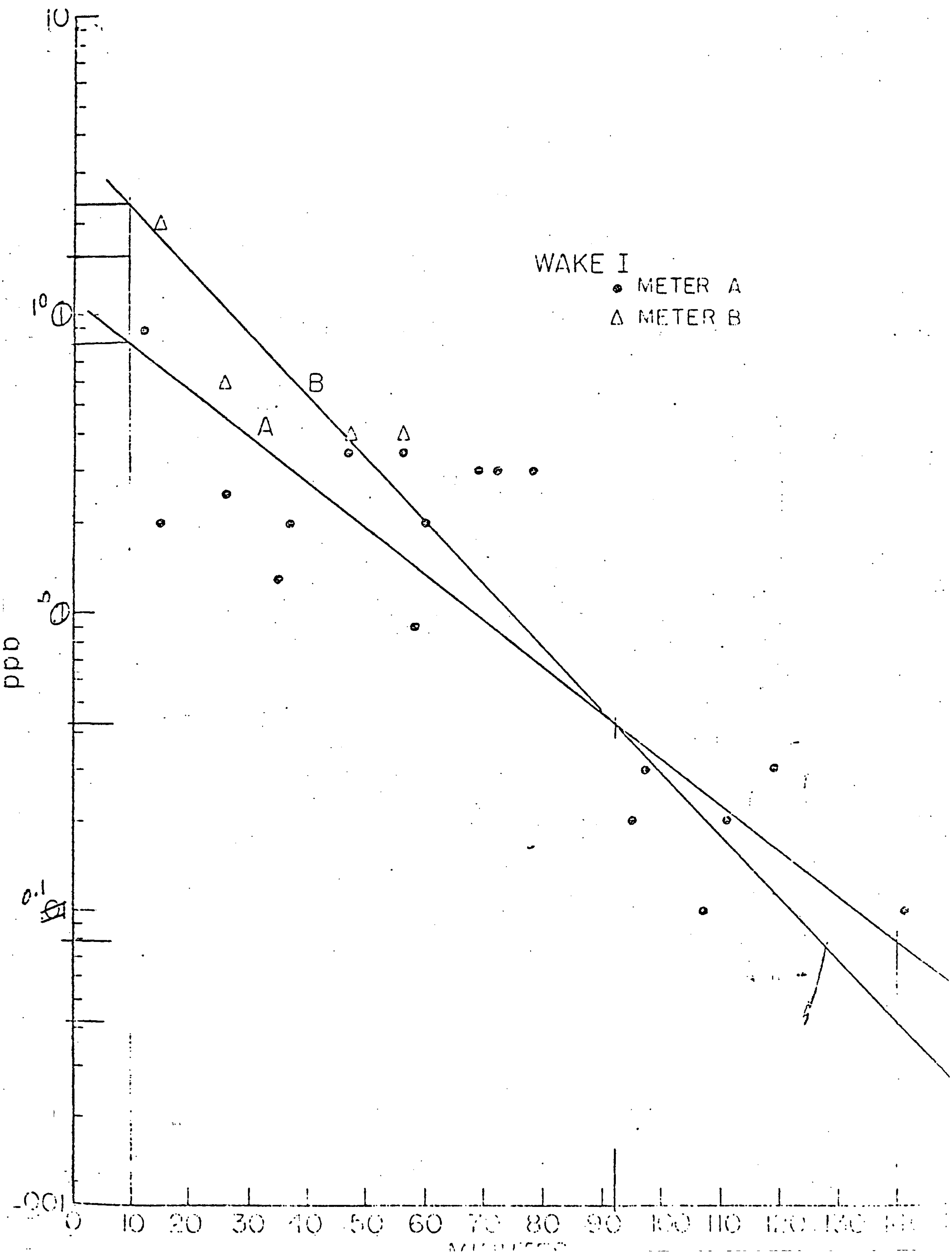

WAKE I
METER A
Δ METER B
A
B
ppb
10
$10^0$
0.1
.001
0
10
20
30
40
50
60
70
80
90
100
110

FIGURE 6

Log of Concentration of Rhodamine B in Wake III against time in Minutes from Dumping.

Prediction Equations:

$$t = 495 \log \frac{C_o}{C} \quad \text{at 6 foot depth (Meter A)}$$

$$t = 225 \log \frac{C_o}{C} \quad \text{at 15 foot depth (Meter B)}$$

Pumping Conditions:

Speed of tug and barge estimated at 2 knots, 200 feet/minute.

Boat was moving against current of ca. 1 knot.

Other pumping conditions were the same as those listed under Figure 3.

FIGURE 5

Log of Concentration of Rhodamine B in Wake II against time in Minutes from Dumping.

Prediction Equations:

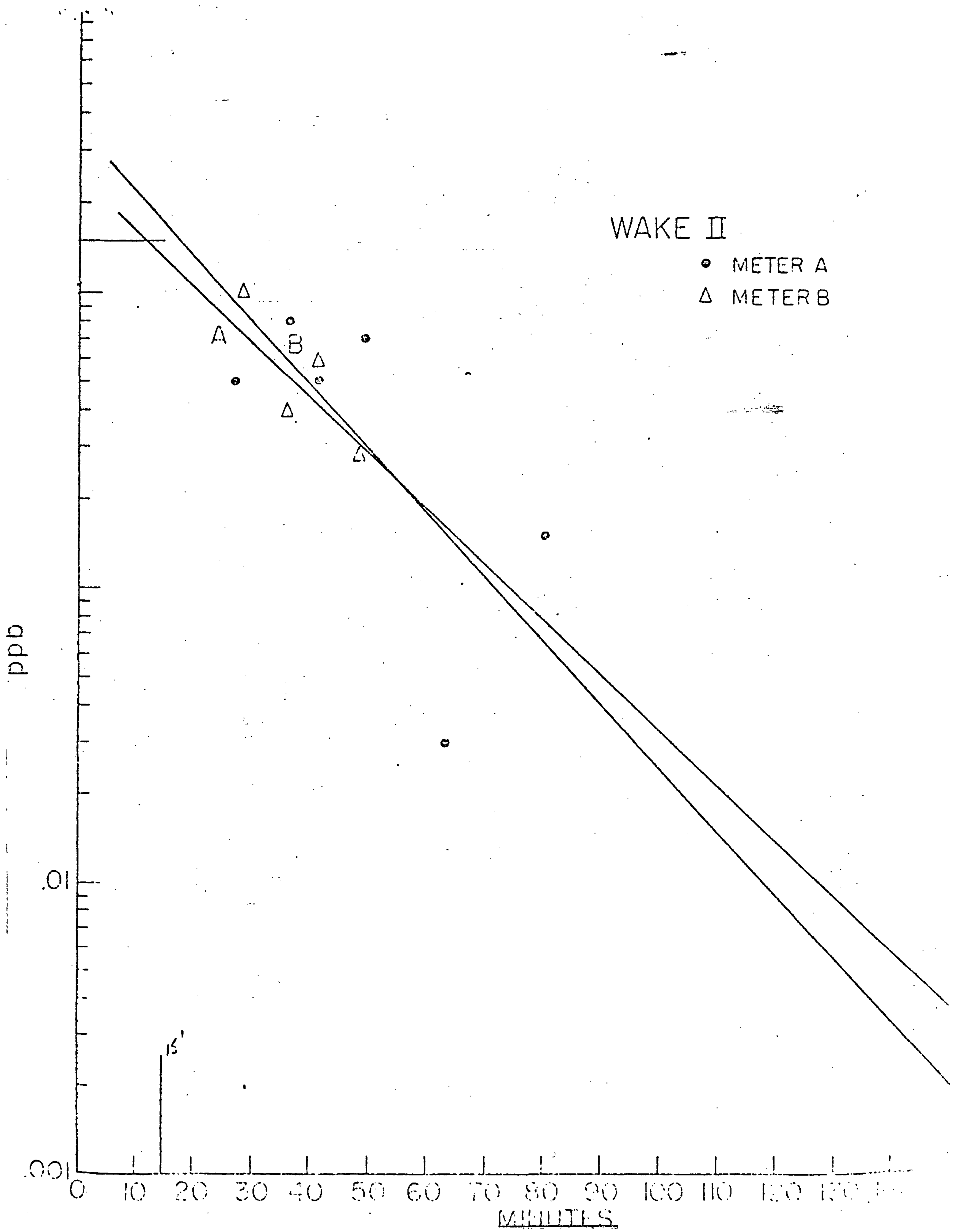
$$t = 57 \log \frac{C_o}{C_1} \text{ at 6 foot depth (Meter A)}$$

$$t = 46 \log \frac{C_o}{C_1} \text{ at 15 foot depth (Meter B)}$$

where $C_o$ is concentration at initial time and $C_1$ is concentration desired.

Pumping Conditions:

Same as those shown in Figure 3.



WAKE II
METER A
METER B
ppb
.01
.001
MINUTES
0
10
20
30
40
50
60
70
80
90
100
110
A
B
15'

FIGURE 7

Log of Concentration of Rhodamine B in Wake IV against time in Minutes from Dumping.

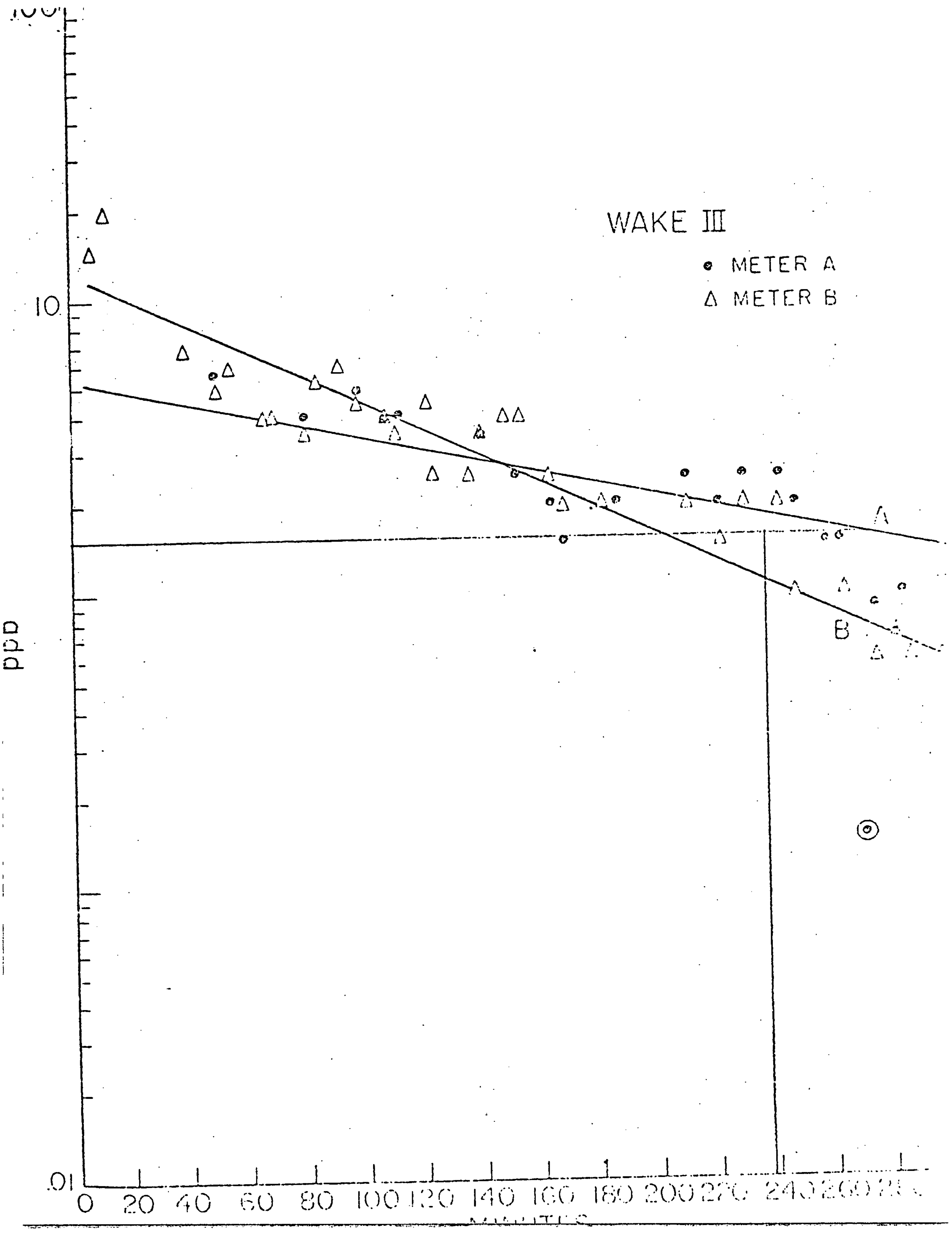
Prediction Equations:

$$t = 131 \log \frac{C_o}{C_1} \text{ at 6 foot depth (Meter A)}$$

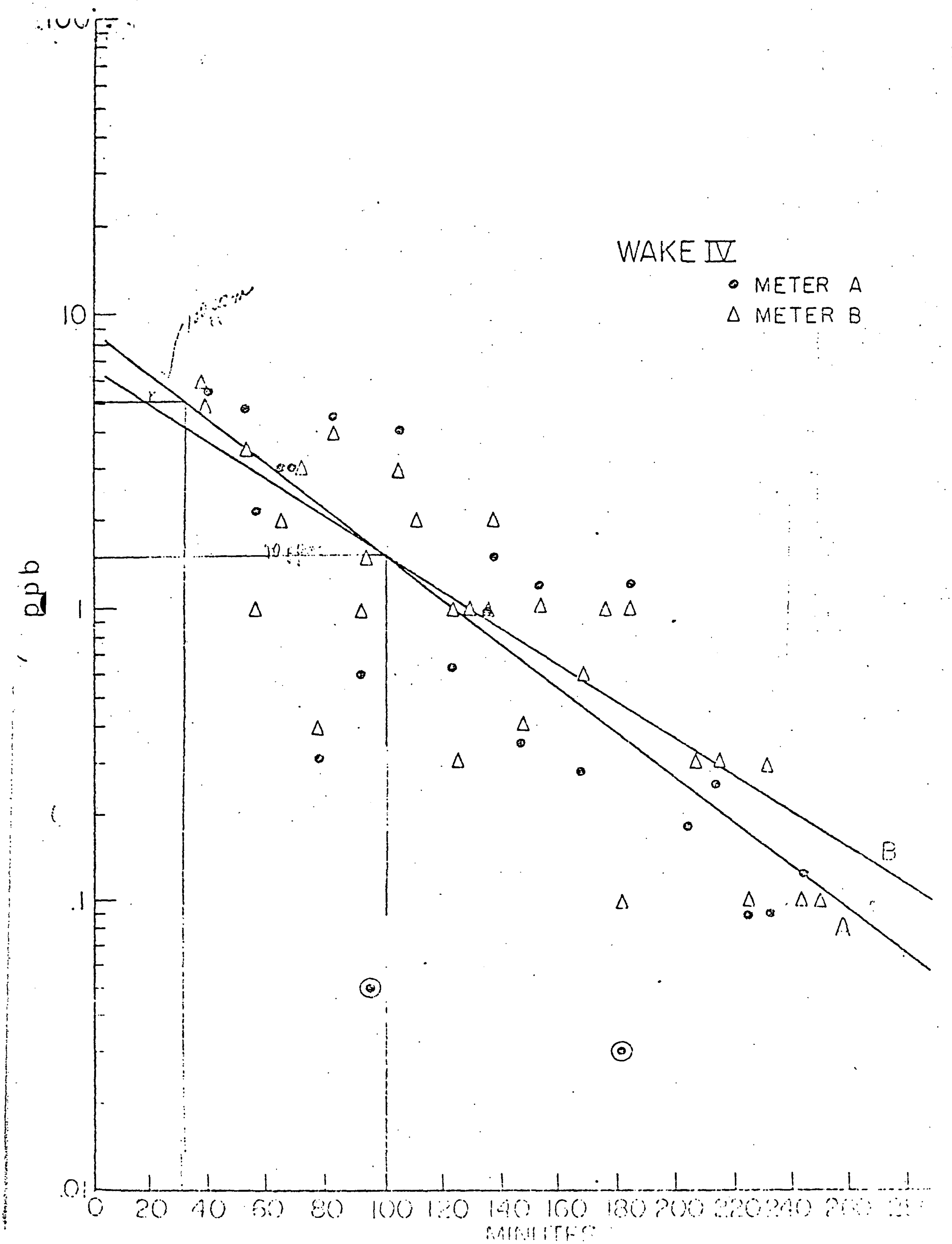
$$t = 152 \log \frac{C_o}{C_1} \text{ at 15 foot depth (Meter B)}$$

Pumping Conditions:

Same conditions as those shown in Figure 6, but boat was steaming with the current of ca. 1 knot.



WAKE III
METER A
METER B
B
ppb
100
10
.01
0
20
40
60
80
100
120
140
160
180
200
220
240
260


WAKE IV
METER A
METER B
ppb
10
1
.1
.01
0
20
40
60
80
100
120
140
160
180
200
220
240
B
A

wakes 3 and 4 and the second, and most likely, that on wake 3, steaming was into the current, whereas wake 4 it was with the current The current was about one knot in a northeast direction.

The rate of dispersal in wake 3 was followed carefully for a period of 300 minutes. This wake was much heavier than the others and the rate of dispersion much slower. At the end of the experiment, the wake had widened to about 1000 feet and the concentration of dye at the 6 foot level was 1.5 ppb and at 15 feet was 0.15 ppb after 300 minutes from pumping time. In this wake, based on graphical solution, the time required to reach 20 ppm at 6 feet depth was about 260 minutes or 4.3 hours and at 15 feet was 200 minutes or 3.3 hours from time of dumping. From the prediction equations the time becomes 7.2 hours and 3.3 hours for 6 and 15 feet, respectively.

Wake 4 showed faster dispersion than wake 3, although the pumping rate was supposedly the same. In this wake the time required to reach the 20 ppm level was 85 minutes (1.25 hours) at both the 6 and 15 feet levels as determined by the graphical method. By the prediction equations, the time would be 129 and 111 minutes for 6 and 15 foot depths, respectively. If t = 0 at 1200 in feet is chosen then the time required would be 110 and 95 minutes for the same depths.

## Conclusions

It is concluded from the observations made on this survey and those previously made in the laboratory study on the toxicity to marine organisms that the disposal of caprolactam wastes under controlled operating conditions in the deep sea will cause very little or no sustained damage and/or influence on the biological community. This statement is made on the requisite that the barge is towed at a minimum speed of 5 knots with a pumping rate of less than 7,000 pounds per minute be maintained and that the disposal is carried out in waters greater than 400 fathoms. Modifications of these operating procedures such as to permit disposal in shallow water seems feasible, but further study of a more detailed nature will be necessary to resolve some points in question concerning shallow water disposal.

It is apparent that the ship's speed is very critical in dispersal of waste at sea and it is therefore extremely important to keep the tug on maximum power while disposing of the waste so as to induce into the wake a maximum mixing energy and also to pump a minimum amount of waste per unit distance as is possible. The study completed and reported here indicates that to those organisms tested, the waste will be dispersed to levels ineffective to metabolism of these organisms after a period of 10-15 minutes providing the above rates of pumping and ship's speed are maintained. Data also obtained indicate that faster pumping rates per unit distance which is caused by slower ship's speed can prolong this time of toxic level in the sea up to several hours. This emphasizes the importance of operational procedure in sea disposal and it is strongly urged that maximum ship speed and minimum pumping rate for unit distance be emphasized.

The prediction equations that have been derived in this report are useful in predicting the dispersal rate occurring in sea water from an established or semi-established wake that is for situations in which the natural turbulent motion of the sea is the dominate factor contributing to dispersion. In operations of this type, however, the major mixing occurs during pumping of the waste into the wake (6600 fold dilution in this case) and the data collected did not permit evaluation of these effects. To do so would require data for multiple pumping rates at constant speed of the tug as well as constant pumping rates at different tug speeds. When the prediction equations are used, however, it is thought that they would always be on the safe side and for that reason they were used here in computing the time required to reach the desired concentration of 20 ppm.

# EXHIBIT III

## ENVIRONMENTAL DATA ON MATERIAL FOR DISPOSAL

**Source:** Oceanonics, Inc., Texas A & M College

| Organism | Disposal Material ppm by Volume |
|---|---|
| Top Water Minnows (Fundulus Simulus) | |
| 48 hr TLm[1] | 600[3] |
| Brine Shrimp (artemia salina) | |
| 24 hr TLm | 800[4] |
| 48 hr TLm | 200[4] |
| Dinoflagellate (gymnodinium breve) | |
| 24 hr value[2] | 1000[5] |
| 48 hr value | 100[5] |
| Phytoplankton (platymonas subcordiforms) | |
| 48 hr value | 30[6] |

**Source:** U. S. Environmental Protection Agency

Composite of samples taken during barge loading operations on April 26, 1972 (Joint Waste Source Survey of the Galveston Bay and Tributaries, Field Report on E. I. du Pont de Nemours and Company, September, 1972).

| | |
|---|---|
| Croaker (Micropagor Undulatus) | |
| 24 hr TLm | 1100 |
| 48 hr TLm | 1000 |

NOTES:

1. TLm - Median Tolerance Limit
2. Value of maximum concentration which caused less than 50% reduction of cells.
3. Process "C" - Rubber Chemicals and Fungicides
4. Process "B" - "Lannate" Methyl Insecticide
5. Process "B" - "Lannate" Methyl Insecticide
6. Process "C" - Rubber Chemicals and Fungicides

# EXHIBIT IV

## MAMMAL DATA - MATERIAL FOR DISPOSAL

## DU PONT HASKELL LABORATORY FOR TOXICOLOGY AND INDUSTRIAL MEDICINE

| Type of Test* | Results |
|---|---|
| Acute Oral | >25,000 mg/kg**, Not a Class B poison. |
| Eye Irritation | No ocular effects in rabbit eyes. |
| Inhalation Test | Not a Class B poison. |
| Skin Irritation | Not a skin irritant. |

*Animals tested: acute oral - male rats, eye irritation - albino rabbit, skin - albino guinea pigs, inhalation - male rats

**These were the highest concentrations tested. Class B poison is defined in Department of Transportation Regulations, Tariff No. 19, 11/29/68, page 108, section 173.343

# EXHIBIT V

## PROCESS DESCRIPTIONS

## Supplement to Section 7

### A - Uracil Herbicides

Two similar products are manufactured in this area on a campaign basis, using the same batch process equipment. Either secondary-butyl or tertiary-butyl amine are reacted with methylacetoacetate. An intermediate sodium salt is then formed by reaction with sodium methylate. This intermediate is halogenated to form the product which is then separated from organic and inorganic by-products by filtration and drying. The dried product is blended with formulating inerts and packaged for sale.

A small stream from the initial reaction step is combined with aqueous materials from the filtration and drying step for disposal at sea. Also included is spent caustic from an off-gas scrubber used to prevent air pollution.

### B - Lannate® Methomyl Insecticide

Methomyl is produced in a batch process. Caustic potash, methyl-mercaptan, and nitroethane are reacted in a series of steps to form an intermediate salt. This salt is neutralized (forming stoichiometric quantities of by-product potassium chloride) and steam stripped to remove organic by-products. The intermediate is extracted from the purified aqueous potassium chloride solution using recycled methylene chloride solvent and is converted to methomyl by reaction with methyl isocyanate. Methomyl is then solvent-exchanged into water, crystallized, centrifuged, and dried. The dry product is blended with formulating ingredients and packaged for sale.

Waste material is separated from the process in the intermediate purification steps (steam stripping and extraction). Smaller aqueous streams originate in the initial reaction step and final solvent exchange. A small purge stream from the centrifuging step is also included in the barged materials.

### C - Rubber Chemicals and Fungicides

Three chemically related products are manufactured on a campaign basis in the same process equipment. The sodium salt of the intermediate dimethyl or diethyl dithiocarbamic acid is prepared by reaction of carbon disulfide with dimethyl or diethyl amine and sodium hydroxide in aqueous solution. The products (thiuram mono and disulfides) are then formed by oxidation of the intermediate with either chlorine or phosgene. The products are recovered by filtration and drying, mixed with formulating ingredients and packaged for sale.

® Registered Du Pont Trademark

The barged material is an aqueous purge of by-product inorganic salts and organics from the filtration step. Although this water stream is recycled, the salt build-up necessitates a purge.

D - Formaldehyde

Methanol is catalytically oxidized in the presence of air. The resulting formaldehyde is absorbed in water for sale. This product stream is treated in an ion exchange column to remove by-product formic acid. A small dilute aqueous stream is generated in this final purification step and is disposed of at sea.

# APPENDIX C

**DRAFT**

777 291
EF Wilkes
6 June 75

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10007

MARINE PROTECTION, RESEARCH, AND
SANCTUARIES ACT (OCEAN DUMPING) PERMIT

PERMIT NO. AND TYPE: NJ006 - Special

EFFECTIVE DATE:

EXPIRATION DATE: 3 years

REAPPLICATION DATE:

APPLICANT: R.D. Turner, Plant Manager
E.I. DuPont de Nemours
Grasselli Plant
Linden, N.J. 07036

WASTE GENERATOR(S): E.I. DuPont De Nemours & Co., Inc.
Wilmington, Delaware 19898

WASTE GENERATED AT: E.I. DuPont de Nemours & Co., Inc.
Grasselli Plant
Linden, N.J. 07036

PORT OF DEPARTURE: E.I. DuPont de Nemours
Grasselli Plant
Linden, N.J. 07036

WASTE TRANSPORTER(S): Scandinavian Transport Service Company, Inc.
500 Fifth Avenue
New York, NY 10036

and any person owning or operating a towing vessel employed for the purpose authorized herein.

This permit authorizes the transportation and dumping into ocean waters of certain material pursuant to the Marine Protection, Research, and Sanctuaries Act of 1972, 33 U.S.C. 1401-1444, (hereinafter referred to as "the Act"), regulations promulgated thereunder, and the terms and conditions set forth below.

General Conditions:

1. All transportation and dumping authorized herein shall at all times be undertaken in a manner consistent with the terms and conditions of this permit. The applicant, waste generator(s) and waste transporter(s) designated above shall be the permittees liable for compliance with such terms and conditions. The liability of each is set forth in the Special Conditions. Compliance by any permittee with one or more but less than all of the conditions with which such permittee must comply will not constitute a ground or grounds of defense in any proceeding against that permittee for violation of the provisions of this permit.

2. Any person who violates any provision of the Act, the Final Regulations issued thereunder, or any term or condition of this permit shall be liable for a civil penalty of not more than $50,000 for each violation. Additionally, any knowing violation of the Act, Final Regulations, or permit may result in a criminal action being brought with penalties of not more than $50,000 or one year in prison, or both.

3. a. Transportation to, and dumping at any location other than that authorized by this permit shall constitute a violation of the Act and of the terms and conditions of this permit.

b. Transportation and dumping of any material not identified in or significantly in excess of that identified in the application for this permit, unless specifically authorized by a written modification hereto, shall constitute a violation of the Act and of the terms and conditions of this permit.

4. Nothing contained herein shall be deemed to authorize, in any way, the transportation from the United States for the purpose of dumping into the ocean waters, into the territorial sea, or into the contiguous zone, of the following material:

a. High-level radioactive wastes.

b. Materials, in whatever form, produced for radiological, chemical or biological warfare.

c. Persistent synthetic or natural materials which may float or remain in suspension in the ocean.

5. The applicant may not apply for, nor any permittee simultaneously hold, a permit from another EPA Regional Office for any of the material to which this permit is applicable, nor may the applicant or any permittee transfer material from one EPA Region to another if a permit for the transportation or dumping of such material has been denied by one EPA Region.

6. After notice and opportunity for a hearing, this permit may be modified or revoked, in whole or in part, during its term for cause including, but not limited to, the following:

a. Violation of any term or condition of the permit;

b. Misrepresentation, inaccuracy, or failure by the applicant to disclose all relevant facts in the permit application;

c. A change in any condition or material fact upon which this permit is based that requires either a temporary or permanent reduction or elimination of the authorized transportation or dumping including, but not limited to, changes in conditions at the designated dump site, and newly discovered scientific data relative to the granting of this permit.

d. Failure to keep records, to engage in monitoring activities, or to notify appropriate officials in a timely manner of transportation and dumping activities as specified in any condition of this permit.

7. This permit shall be subject to suspension by the Regional Administrator or his delegate if he determines that the permitted dumping has resulted, or is resulting, in imminent and substantial harm to human health or welfare or the marine environment. Such suspension shall be effective subject only to the provisions of 40 C.F.R. 223.2(c).

8. The authority conferred by this permit may, at the discretion of the Regional Administrator or his delegate, be transferred to a waste transporter other than that (those) named herein, provided that a request for such a transfer be made, in writing, by the applicant at least 30 days prior to the requested transfer date.

9. If material which is regulated by this permit is discharged due to an emergency to safeguard life at sea in locations or in a manner not in accordance with the terms of this permit, one of the permittees shall make a full report, in accordance with the provisions of 18 U.S.C. 1001, within 10 days to the Regional Administrator detailing the conditions of this emergency and the actions taken.

10. Unless otherwise provided for herein, all terms used in this permit shall have the meanings assigned to them by the Act or the Final Regulations issued thereunder.

11. The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of rights, nor any infringement of Federal, State or local laws or regulations, nor does it obviate the necessity of obtaining State or local assent required by applicable law for the activity authorized.

12. This permit does not authorize or approve the construction of any onshore physical structures or facilities or, except as authorized by this permit, the undertaking of any work in any navigable water.

13. Each permittee shall at all times maintain in good working order and operate as efficiently as possible all facilities, including vessels, used by such permittee in achieving compliance with the terms and conditions of this permit.

14. This permit, or a true copy thereof, shall be placed in a conspicuous place on the vessel which will be used for the transportation and dumping authorized by this permit. If the dumping vessel is an unmanned barge, the permit or true copy of the permit shall be transferred to the towing vessel or an additional true copy shall be available onboard the towing vessel.

15. In accordance with 33 U.S.C. 445, every scow or boat engaged in the transportation of municipal sludge or industrial wastes shall have its name or number and owner's name painted in letters and numbers at least fourteen inches high on both sides of the scow or boat. These names and numbers shall be kept distinctly legible at all times, and no scow or boat not so marked shall be used to transport or dump any such material.

16. The permittee(s) shall provide telephone notification of sailing to Captain-of-the-Port, (COTP) New York at 212-264-8753 during working hours (8:00 AM to 4:30 PM Monday through Friday) and to 212-264-8770 during non-working hours, weekends, and holidays not later than twenty-four (24) hours prior to the estimated time of departure. The permittee(s) shall confirm the exact time of departure within thirty (30) minutes of the actual departure time, and immediately notify the COTP upon any changes in the estimated time of departure greater than one hour. Within two (2) hours after receipt of the initial notification the transporter will be advised as to whether or not a Coast Guard shiprider will be assigned to the voyage.

17. Surveillance will at times be accomplished by a Coast Guard shiprider who will be on board the towing vessel for the entire voyage. His quarters and subsistence while on board shall be provided by and shall be at the expense of the permittee(s). He shall be treated courteously and afforded free and immediate access to all navigational capabilities on the vessel which can provide information on position, course, speed, depth of water, bearings, etc. The notification procedures which will permit the timely assignment of a shiprider are specified in General Condition 16. The following information shall be provided in the notification of sailing:

a. Name of the towing vessel and barge or tank vessel

b. Name of the transporter

c. Description of the vessel's contents including volume

d. Place of departure

e. Location of the dump site

f. The time of departure

g. Estimated time of arrival at the dump site

h. Estimated time of return to port.

18. The permittee(s) shall maintain and submit Coast Guard Form CCGD 3-278, Monthly Transportation and Dumping Log, to COTP, USCG, c/o New York Station, Governors Island, New York, N. Y. 10004. Permittee(s) shall enter on this form under the column entitled "Dump Site" the latitude and longitude at which the actual dumping occurred. These forms are to be mailed to the Coast Guard during the first week of the succeeding month for which they were prepared. If additional forms are required, they may be obtained by forwarding a written request to Commander (mep), Third Coast Guard District, Governors Island, New York, N. Y. 10004. Copies of these logs will be forwarded on a quarterly basis to: U. S. Environmental Protection Agency, Surveillance and Analysis Division, Edison, N. J. 08817, Attn: Marine Protection Program.

NJ006

Special Conditions:

1. This permit shall expire at midnight on ______________________.
This permit is nonrenewable. Application for a new permit must be submitted to EPA at least 150 days prior to expiration of this permit.

2. During the term of this permit, the type and quantity of material permitted for transportation for the purpose of ocean dumping shall be in accordance with the following:

85 MILLION GALLONS/YEAR OF WATER SOLUTION OF INORGANIC SALT, CONTAINING LESS THAN 2% SOLUBLE ORGANICS. WASTE GENERATED BY ANISOLE AND DMHA PRODUCTION.

3. Disposal Site - Transportation for the purpose of ocean dumping shall terminate at, and waste dumping shall be confined to, the area described below:

Latitude: 38°40' TO 39°0'N 40 MILES (4 TIMES)

Longitude: 72°0' TO 72°30'W ~25 MILES (6 TIMES)

4. Method of Disposal -(a) The permittee Spentonbush Trans shall use only the following vessel(s)/barge(s) for transportation and dumping of wastes authorized under this permit:

SPARKLING WATERS, FRANCIS S. BUSHEY, A.H. DUMONT, GEORGE WHITLOCK II, SUSAN FRANK

(b) Waste is to be discharged at a uniform rate over a distance of at least 150 nautical miles within the disposal site designated in Special Condition No. 3. Vessel/barge traverses shall be at least 0.5 nautical mile apart. If two or more vessels/barges are discharging simultaneously, or if any two or more vessel/barge trips are to occur within one hour of each other, a distance of at least 0.5 nautical mile is to be maintained between discharges.

(c) If the waste cannot be uniformly discharged as required above, the permittee Spentonbush Trans shall, within 30 days of issuance of this permit, provide to EPA in writing, detailed technical information, certified by a naval architect or marine engineer, as to why this condition cannot be met. A time period of not more than one year from the date of issuance of this permit will be allowed for the installation of equipment or systems necessary to meet the uniform discharge requirement. WITH RESPECT TO USE OF THE M/V F.S. BUSHEY, M/V A.H. DUMONT, M/V GEORGE WHITLOCK II, VESSELS WHICH ARE USED PRIMARILY FOR THE TRANSPORTATION OF PETROLEUM PRODUCTS, THE PERMITTEE SHALL PROVIDE APPROPRIATE DOCUMENTATION THAT THE VESSEL HAS BEEN CLEANED PRIOR TO EACH USE FOR TRANSPORTATION OF WASTES FOR ULTIMATE OCEAN DISPOSAL.

NJ 006

5. Analysis of Authorized Wastes - (a) Analyses shall be conducted monthly on a representative sample of a vessel/barge load for the following parameters:

Bioassay (mg/l) using the organisms *Artemia salina*, *Skeletonema costatum*, *Acartia tonsa* or *Acartia clausii*, *Menidia menidia*, and/or any substitute organism designated to be more appropriate by EPA, Region II.

Mercury (mg/kg), liquid and solid phase

Cadmium (mg/kg), liquid and solid phase

Specific gravity at 20°C

Oil and grease (mg/l), using liquid-liquid extraction with trichlorotrifluoroethane.

Petroleum hydrocarbon (mg/l), using tentative IR procedure

pH

Analyses shall be conducted monthly on a representative sample of a barge/vessel load for the following parameters:

Lead (µg/l)
Zinc (µg/l)
Nickel (µg/l)
TOC (mg/l)
Total solids (mg/l)
Phenol (µg/l)
DMHA (mg/l)

Copper (µg/l)
Chromium (µg/l)
TKN (mg/l)
COD (mg/l)
Suspended solids (mg/l)
Anisole (mg/l)

(b) Analytical data will be submitted to EPA, Region II, on a monthly basis, with the first report due no later than 30 days following the initial discharge.

(c) All analyses will be conducted according to one of the following:

(1) Specific analytical procedures distributed by EPA, Region II;

(2) Approved test procedures contained in "Guidelines Establishing Test Procedures for Analysis of Pollutants," 40 C.F.R. 136; or

(3) Test procedures selected by the permittee and approved by EPA, Region II.

(d) Within 20 days of effective date, the name and address of the designated laboratory and a description of all analytical test procedures being used shall be provided to the EPA, Region II.

(e) Any laboratory employed for purposes of performing the analyses specified in Special Condition No. 5(a) shall maintain a viable analytical quality control program. This program will include:

(1) Use of EPA approved analytical test procedures as listed in Special Condition No. 5(c).

(2) Use of the sample preservation techniques and the holding time specified in the analytical method employed or in EPA manual entitled "Methods for Chemical Analysis of Water and Wastes."

(3) Routine use and documentation of intra-laboratory quality control practices as recommended in the EPA manual "Handbook for Analytical Quality Control in Water and Wastewater Laboratories." These practices will include use and documentation of internal quality control samples.

(f) The laboratory facilities, data, records, and quality control records are subject to periodic inspection by EPA, Region II personnel.

(g) EPA may require analysis of quality control samples by any laboratory employed for purposes of compliance with Special Condition 5(a) Upon request, permittee(s) shall provide EPA with the analytical results from such samples.

6. Monitoring – Permittee(s) may be required, during the term of this permit, to conduct or participate in a monitoring program of the impact of the permitted waste disposal on the marine environment at the designated disposal site, pursuant to 40 C.F.R. 223.1(f) (Supp. 1973).

7. See attached sheet.

8. Reports and Correspondence – All reports, required by Special Condition No. 5 and General Condition No. 18 shall be submitted to the following address:

U.S. Environmental Protection Agency, Region II
Surveillance and Analysis Division
Edison, New Jersey 08817
Attn: Marine Protection Program

All other material required by this permit to be submitted to EPA, and related correspondence, shall be sent, in duplicate to:

U.S. Environmental Protection Agency, Region II
Enforcement and Regional Counsel Division
26 Federal Plaza
New York, New York 10007
Attn: Status of Compliance Branch

7. Implementation Plan, Schedule, or Alternative - In accordance with 40 C.F.R. 227.4 (Supp. 1973) the permittee DuPont shall submit on or before October 31, 1975 a final plan to implement the most environmentally acceptable alternative to its current practice of ocean dumping of its waste, based upon the evaluation of alternatives contained in its previously required engineering report. The implementation plan shall set forth a schedule of deadlines, in accordance with the regional goal to completely phase out ocean dumping by 1981. The permittee shall submit quarterly progress reports on this implementation plan beginning January 15, 1976, and may be required to submit additional detailed engineering reports on studies of ocean dumping alternatives.

9. Liability - (a) The permittees DU PONT & SPENTONBUSH TRANS. shall be jointly and severally liable for compliance with Special Conditions 2, 5(a)-(g), and 6 as well as all applicable General Conditions.

(b) The permittee(s) SPENTONBUSH TRANS. shall be solely liable for compliance with Special Conditions 4(a) and (c).

(c) Any person owning or operating a towing vessel employed for purposes of the activities authorized by this permit shall be, for purposes of each discharge, a joint permittee herein who shall be jointly and severally liable together with the permittee(s) SPENTONBUSH TRANS for compliance with Special Conditions 3 and 4(b) and all applicable General Conditions.

(d) The permittee DU PONT shall be solely liable for compliance with Special Condition No. 7.

D

APPENDIX D

STATEMENT OF LLOYD L. FALK
ON BEHALF OF
E. I. DU PONT DE NEMOURS AND COMPANY
AT THE PUBLIC HEARING OF THE
ENVIRONMENTAL PROTECTION AGENCY
ON OCEAN DISPOSAL PERMITS
NEW YORK, NY, JUNE 12, 1975

My name is Lloyd L. Falk. I am a Principal Consultant in the Engineering Department of the Du Pont Company, Wilmington, Delaware.

The October 15, 1973, Final Regulations and Criteria under PL 92-532, require the use of bioassays on appropriate sensitive marine organisms in establishing permissible concentrations of wastes during ocean disposal operations. Region II has specified the appropriate sensitive marine organisms to be tested are the zooplankton *Acartia tonsa*, the phytoplankton *Skeletonema costatum*, and the finfish *Menidia menidia*.

Du Pont has tested all three organisms, using EPA-approved methodology and submitted data to Region II in May, 1975. The zooplankton, *Acartia tonsa*, exhibited the greatest sensitivity to our waste. Thus, we have calculated the safe release time based on the bioassay data for that organism.

We have submitted to Region II a report detailing our calculations of the release time based on the *Acartia* data. We request that that report be made a part of the record of this hearing.

in 1960 and in 1973. Those studies showed that the initial concentration in the immediate wake of the barge is directly proportional to the waste release rate and inversely proportional to the barge speed. Furthermore, subsequent to initial dispersion, a further 1:10 dilution occurs in 0.5 to 3.5 hours. Then, typically, another 1:10 dilution occurs by the 6th to 8th hour after release.

In our analysis, we combined the 4-hour $LC_{50}$ and $LC_{01}$ data with the dispersion data. While our report details the calculations, I shall summarize the results as follows:

1. At all times, the waste concentrations behind the barge will be less than mean 4-hour $LC_{01}$.

2. The waste concentration will be less than 0.01 of the mean $LC_{50}$ within 1 to 10 hours after discharge at the centerline of the dispersing waste plume.

3. By using a 5-hour dispersion time at a 5-knot barge speed, the waste concentration in the mixing zone permitted in Section 227.73 is less than 0.01 of the mean 4-hour $LC_{50}$ after 4 hours.

One final point. Our analysis shows that extending the dispersion time beyond 5 to, say, 10 or 20 hours does not significantly add to the relative differences in the time-mortality-concentration relationships. Put another way, 5 hours will allow meeting the requirement of Section 227.71. Additional

# APPENDIX E

TO: H. R. BLANKENSHIP - ICD - WILM. (3 pages)
FROM: H. W. MCDOWELL - ICD - GRASSELLI PLANT

File 12 day hearing

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 8 1975

OFFICE OF
RESEARCH AND DEVELOPMENT

Subject: Response to 2-SA Request on Ocean Dumping - E.I. Dupont Company

From: Acting Director Ecological Effects Division

To: Richard T. Dewling, Director S&A Division, Region II

This memo responds to your letter dated June 13, 1975, requesting our comments on the alternative proposal submitted by the E.I. DuPont Co. of Linden, New Jersey.

With respect to your question (1) we have checked with Al Wastler and confirmed, that in accordance with the current regulations and criteria, the Regional Administrator has the discretion to specify the kinds of biological testing required for his Region. Therefore the Region could accept a four hour bioassay test if it felt the test was adequate.

not only 1

Skipping to your question (3) dealing with the possibility of applying the DuPont concept to other cases of industrial waste disposal, it is our opinion that if it is determined that the concept has validity, then it may be applied to other waste disposals providing those wastes are totally liquid and miscible with water. However such determinations would have to be done on a case-by-case basis.

Question 2 asks if Region II, from a technical standpoint, should concur with the DuPont recommended approach. In our opinion, we feel that based on the information provided, the DuPont recommendation should be rejected. We have arrived at this conclusion for the following reasons.

The use of a bioassay test to simulate toxicological reactions to marine ecosystems can, at best, only provide a rough estimate of ecosystem impact. For this reason every effort has been made to provide test procedures that use sensitive marine organisms. The procedures selected for use by a Region must be a compromise between sensitivity of toxicological response, facility of performance, ecological significance of the test species, and the financial cost of running the tests.

ORD in recommending the use of *Acartia tonsa*, *Skeletonema costatum*, and *Menidia menidia*, has made a scientific judgment that essentially states that using these organisms, performing the bioassay tests under standard conditions, and interpreting the results according to the ocean disposal criteria, will provide adequate protection to the marine environment from dumping operations.

FROM: H. W. McDOWELL - ICD - GRASSELLI PLANT

Clearly there is nothing sacred about a 96 hour static acute toxicity bioassay test. ORD could have specified tests dealing with such sub-lethal effects as:

1. Physiology, e.g., the effects on osmoregulation, effect on temperature tolerance, effects on metabolic rate, respiratory quotients, digestion, etc.

2. Sensory physiology, e.g., interference with chemoreception.

3. Behavior, e.g., locomotor performance, chemotactic responses, modification of learned responses, schooling.

4. Growth, reproduction and development, e.g. fecundity, fertilization rates, hatching success, larval development, larval behavior, abnormalities and growth rates.

The above sub-lethal effects are not observed in the ORD recommended acute toxicity tests. It is our best scientific judgment that specifying 96 hours for the Acartia bioassay in conjunction with the 0.01 application factor to obtain the LPC, protection is provided to eliminate sub-lethal effects. It is important to note that so-called sub-lethal effects can be just as damaging to a functioning ecosystem as the most obvious lethal effects.

The issue of "scientific judgment" is also at stake here. Any particular judgment can only be vindicated by accruing a great amount of research information. It certainly would not be practical to mount a full research expedition for every ocean dumping permit application. Therefore, we must rely on the "judgment" of our experienced research scientists to provide the technical guidance for the program.

I recognize that DuPont scientists may take exception to our judgments with judgments of their own. In that case they will have to perform a well balanced and comprehensive research program to prove their case. In our opinion the information provided to date is insufficient to prove the adequacy of their recommended alternative. Some of our specific objections to DuPont's proposal are as follows:

It is unclear from the appended DuPont technical material if a four hour bioassay accounts for latency or delayed mortality effects or morbidity. Thus, the observation of no observed mortality in a four hour test may be meaningless particularly when the concentration is roughly four times the value of that obtained after the mortality curve stabilizes at about 24 hours.

Much importance is assigned to Hydroscience's model work and its implication for predicting concentrations at particular time periods. While the material Hydroscience's Mr. Mancini presented (at the Pensacola hearing) suggests 10 hours rather than 4 to be the time break this is somewhat an incidental relationship. No precision or accuracy concerns are expressed related to the model, it's specific applicability, its variability with changing hydrological or meteorlogical conditions etc.

It is common knowledge in toxicological research that slight changes in concentration can produce non-linear effects. However, it is of greater ecological concern to note that the measurable endpoint in the suggested test estimates death of a portion of the population. Such laboratory tests do not speak to possible field effects upon growth, reproduction or metabolism. Prudence would seem to dictate conservative approaches using accepted procedures.

Andrew J. McErlean, Ph.D.

F

# APPENDIX F

E. I. du Pont de Nemours & Company
Incorporated

Grasselli Plant
Linden, New Jersey 07036

Industrial Chemicals Department

July 30, 1975

Mr. P. J. Bermingham, Hearing Officer
EPA Region II
26 Federal Plaza
New York, N.Y. 10007

Ocean Dumping Permit No. NJ006
E. I. du Pont de Nemours & Co.
Grasselli Plant
Linden, New Jersey

Dear Mr. Bermingham:

In his letter of July 23, 1975, Mr. R. E. Austin of our Legal Department requested that the hearing record on our application for a Special Permit be extended. The purpose was to submit to you comments relative to Dr. A. J. McErlean's July 8, 1975 memorandum to Richard T. Dewling regarding that permit.

Accordingly, we submit the attached comments. We will discuss these matters more fully with you and other appropriate EPA officials at our meeting in Edison, New Jersey on August 6, 1975, at 10:00 a.m.

Very truly yours,

R. D. Turner
Plant Manager

RDT/rik
attachment

CC: R. T. Dewling, Director
Surveillance & Analysis Div.
EPA Region II
Edison, N.J.

T. A. Wastler, Chief
Marine Protection Branch
AW 448
U.S. EPA
Washington, D.C. 20460

Dr. A. J. McErlean
ATTN: Dr. Paul Lefcourt
Ecosystem Branch
Ecological Effects Division
Waterside Mall (RD 684)
Washington, D.C. 20460

Dr. Jan Prager
EPA
National Marine Water
Quality Laboratory
South Ferry Road
Narraganset, R.I. 02882

E. I. DU PONT DE NEMOURS AND COMPANY

COMMENTS ON

EPA MEMORANDUM OF JULY 8, 1975

TO

R. T. DEWLING
DIRECTOR,
SURVEILLANCE AND ANALYSIS DIVISION,
REGION II

FROM

A. J. MC ERLEAN, PhD
ACTING DIRECTOR, ECOLOGY EFFECTS DIVISION,
OFFICE OF RESEARCH AND DEVELOPMENT

BY

L. L. FALK, PhD
PRINCIPAL CONSULTANT,
WATER RESOURCES AND POLLUTION,
ENGINEERING DEPARTMENT (DU PONT)

J. R. GIBSON, PhD
CHIEF, AQUATIC TOXICOLOGY,
HASKELL LABORATORY FOR INDUSTRIAL
MEDICINE AND TOXICOLOGY
CENTRAL RESEARCH & DEVELOPMENT DEPARTMENT (DU PONT)

On June 10, 1975, Du Pont (R. D. Turner) submitted to Mr. Richard T. Dewling, Director, Surveillance and Analysis Division, Region II, a "Report on Release Conditions Based on Testing of Appropriate Sensitive Marine Organisms". The report was in support of Du Pont's Grasselli (Linden) NJ Plant's application for a Special Permit under PL 92-532. Copies of two other reports referenced in the above report were supplied to Mr. Dewling on June 13 by L. L. Falk (Du Pont). At the June 12 hearing in New York, Falk summarized the report and conclusions.

The results of bioassay tests on those appropriate sensitive marine organisms specified by EPA, coupled with evaluation of expected dispersion, indicate that a 5-hour dispersion time (at a barge speed of 5 knots) would meet the limiting permissible concentration as defined by 40 CFR 227.71. Since the Grasselli wastewaters meet the limitations on trace contaminants, Du Pont believes it has demonstrated that a Special Permit specifying no more than a 5-hour dispersal time could be issued and so recommends.

In his memorandum of July 8, 1975 to R. T. Dewling, Dr. A. J. McErlean, Acting Director of EPA's Ecological Effects Division (EED), indicated that Du Pont's recommendation should be rejected. The memorandum essentially presents three arguments to support the recommended rejection of our proposal.

The first deals with the inability of an acute bioassay to deal with sublethal effects. The second is the need for providing a margin of protection by requiring that LPC be based on a 96-hour rather than a 4-hour acute bioassay test, with the associated 0.01 application factor. The third is the inability to predict dispersion precisely and accurately.

In regard to the first point, the memorandum points out that EPA's Office of Research and Development might have specified studies on a variety of enumerated sublethal effects. The memorandum indicates that sublethal effects can be eliminated by, in EPA's "best scientific judgment", applying a 0.01 application factor to the 96-hour acute bioassays.

For situations where wastewaters mix with receiving waters, the consensus of scientific judgment is that time-toxicity exposure relationships be considered in arriving at acceptable practices. Du Pont has done this, not believing that a decision based on only one selected time duration (96 hours) for a bioassay test is the "Best" for protecting against sublethal effects. Du Pont concurs with the EED memorandum that "there is nothing sacred about a 96-hour static acute toxicity bioassay test". It was, in fact, precisely for that reason that Du Pont examined the time-responses vs time-dilution expectations rather than be limited to what is clearly not "sacred".

The second point raised by EED dealt with the additional protection of a 96-hour vs a 4-hour test. Obviously, the longer test would be the safer if the only consideration was mere use of application factors. Du Pont has neither requested nor proposed that Region II accept a 4-hour test as the basis for calculating the LPC. Rather, Du Pont proposed that an LPC based on a 4-hour test to Acartia tonsa is appropriate for providing a high level of protection to the marine environment.

Thus the entire spectrum of time-response data developed during the 96-hour bioassay tests should be used in evaluating permissible wastewater levels. That spectrum of data ought to be, and indeed was, linked to the wastewater concentrations expected in the continually diluting plume behind the moving barge. Clearly, EED did not even address itself to the validity of these concepts. Rather, the Division only narrowly considered the use of an application factor applied to a 96-hour test.

EED's third point related to the imprecision of wastewater dispersion predictions. Du Pont recognized this in its proposal by showing an envelope of expected dispersion patterns in Figure 11 of the June 10 report to Dewling. Du Pont then compared the least favorable pattern with LC50, LC01, and LPC values. Thus the point raised by EED about Mr. Mancini's suggesting a 10-hour rather than 4-hour time break is immaterial. As indicated in Falk's hearing testimony, the wastewater concentrations will be less than 0.01 of the mean LC50 (50 percent survival) within 1 to 10 hours at the plume centerline, and less than 0.01 of the mean 4-hour LC50 after 4 hours. Furthermore, concentrations will be less than the mean 4-hour LC01 (99 percent survival) at all times.

EED raises the issue of "scientific judgment" being at stake. If EPA's "best judgment" is the mere use of an application factor and 96-hour bioassays, then Du Pont certainly believes that such judgment would be found wanting. The publication "Water Quality Criteria 1972", prepared at EPA's request by the Committee on Water Quality Criteria, Environmental Studies Board, National Academy of Sciences-National Academy of Engineering supports this belief.

That publication gives the methodology on how to deal with intermittent discharges and short-term exposures such as we have in the case of barged wastes. Both the Panel on Freshwater Aquatic Life and Wildlife and the Panel on Marine Aquatic Life and Wildlife considered integrated time-exposure as the concept to use in evaluating effects of short-time exposures of aquatic life to wastes in mixing zones. The waste plume behind a barge is such a zone.

Exhibit A, attached, lists the members of those two panels whose "scientific judgment" resulted in the recommendations in the NAS/NAE report. In Exhibit B are reproduced:

1. The portion of the NAS/NAE report Section III, "Freshwater Aquatic Life and Wildlife", dealing with "Mixing Zones", pp. 112-115;
2. Appendix II-A of Section III, also entitled "Mixing Zones", pp. 403-407; and
3. The portion of the report's Section IV, "Marine Aquatic Life and Wildlife", dealing with "Mixing Zones", pp. 231-232.

Both the Marine and Freshwater Aquatic Life panels subscribe to use of a time-exposure approach in evaluating acceptable exposures of organisms in mixing zones. The panels even indicated how to approach the problem. Their concept is precisely the same as Du Pont's in its June 10 report to Dewling. Exhibit C, attached, clarifies this in calculations done in accordance with those recommended by the Academies' two committees of scientists.

## PANEL ON FRESHWATER AQUATIC LIFE AND WILDLIFE

*Panel Members*

Dr. ALFRED M. BEETON, University of Wisconsin, *Chairman*
Dr. JOHN CAIRNS, JR., Virginia Polytechnic Institute and State University
Dr. CHARLES C. COUTANT, Oak Ridge National Laboratory
Dr. ROLF HARTUNG, University of Michigan
Dr. HOWARD E. JOHNSON, Michigan State University
Dr. RUTH PATRICK, Academy of Natural Sciences of Philadelphia
Dr. LLOYD L. SMITH, JR., University of Minnesota, St. Paul
Dr. JOHN B. SPRAGUE, University of Guelph
Mr. DONALD M. MARTIN, *Scientific Secretary*

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## PANEL ON MARINE AQUATIC LIFE AND WILDLIFE

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# MIXING ZONES

When a liquid discharge is made to a receiving system, a zone of mixing is created. Although recent public, administrative, and scientific emphasis has focused on mixing zones for the dispersion of heated discharges, liquid wastes of all types are included in the following considerations. (For a further discussion of Mixing Zones see Appendix II-A.)

## DEFINITION OF A MIXING ZONE

A mixing zone is a region in which a discharge of quality characteristics different from those of the receiving water is in transit and progressively diluted from the source to the receiving system. In this region water quality characteristics necessary for the protection of aquatic life are based on time-exposure relationships of organisms. The boundary of a mixing zone is where the organism response is no longer time-dependent. At that boundary, receiving system water quality characteristics based on long-term exposure will protect aquatic life.

### Recommendation

**Although water quality characteristics in mixing zones may differ from those in receiving systems, to protect uses in both regions it is recommended that mixing zones be free of substances attributable to discharges or wastes as follows:**

- **materials which form objectionable deposits;**
- **scum, oil and floating debris;**
- **substances producing objectionable color, odor, taste, or turbidity;**
- **conditions which produce objectionable growth of nuisance plants and animals.**

## GENERAL PHYSICAL CONSIDERATIONS

The mass emission rates of the most critical constituents and their relationship to the recommended values of the material in the receiving water body are normally the primary factors determining the system-degradation potential of an effluent. Prior to establishment of a mixing zone the factors described in Waste Capacity of Receiving Waters (Section IV, pp. 228–232) and Assimilative Capacity (This Section, p. 111) should be considered and a decision made on whether the system can assimilate the discharge without damage to beneficial uses. Necessary data bases may include:

- Discharge considerations—flow regime, volume, design, location, rate of mixing and dilution, plume behavior and mass-emission rates of constituents including knowledge of their persistence, toxicity, and chemical or physical behavior with time.
- Receiving system considerations—water quality, local meteorology, flow regime (including low-flow records), magnitude of water exchange at point of discharge, stratification phenomena, waste capacity of the receiving system including retention time, turbulence and speed of flow as factors affecting rate of mixing and passage of entrained or migrating organisms, and morphology of the receiving system as related to plume behavior, and biological phenomena.

Mathematical models based in part on the above considerations are available for a variety of ecosystems and discharges. (See Appendix II-A.) All such mathematical models must be applied with care to each particular discharge and the local situation.

### Recommendation

**To avoid potential biological damage or interference with other uses of the receiving system it is recommended that mixing zone characteristics be defined on a case-by-case basis after determination that the assimilative capacity of the receiving system can safely accommodate the discharge taking into consideration the physical, chemical, and biological characteristics of the discharge and the receiving system, the life history and behavior of organisms in the receiving system, and desired uses of the waters.**

## APPENDIX C

## Application of NAS/NAE Recommendations to Disposal of Du Pont's Grasselli Plant Wastewater

Recommendation of the Committee on Water Quality Criteria (NAS/NAE)

The total time-toxicity exposure history must not cause deleterious effects in affected populations of important species, including the post-exposure effects.

Meeting the Recommendation

A. Approach

The Committee's approach to meeting this recommendation is summarized as follows:

1. Perform toxicity tests on sensitive organisms to provide a profile of the total time-toxicity exposure history (i.e. LC50 as a function of time).
2. Determine, from these data, concentrations required to produce lower levels of mortality (e.g. LC25, LC05, LC02, LC01, etc.).
3. Predict expected waste concentrations in the mixing zone either through mathematical modeling, actual experimentation, or both.
4. Calculate whether the recommendation is met.

To meet the recommendation of the committee, the following equation must be satisfied

$$T/ET_{(x)} \leq 1$$

Because concentrations vary as a function of time within mixing zones, the equation is more appropriately expressed as:

$$\Sigma\,[T/ET_{(x)}] \leq 1$$

where:

T = time of an organism's exposure in the mixing zone to a specified concentration,

ET = the effective time of exposure to the specified concentration which produces (x) percent response in a sample of the organisms.

Thus, this expression states that protection will be achieved when the sum of time-toxicity exposure relationships within a mixing zone is less than unity.

B. Grasselli Wastewater Disposal

Du Pont obtained data required to perform the calculations necessary for determining whether or not the Grasselli Plant's wastewaters meet the recommendation (see June 10 report to R. T. Dewling, EPA Region II). The data provided were:

a. LC50 to *Acartia tonsa* (the most sensitive organism tested) as a function of time

b. Calculated LC01 values for *Acartia tonsa* as a function of time

c. Predicted dispersion of the wastewaters in the wake of a moving barge as a function of time.

These data, summarized in Table I (attached) are used to calculate the values in Table II as follows:

a. Time segments (T) for dispersion are established, and the average concentration for each segment is calculated from dispersion equations.

b. $ET_{(x)}$* is determined for each average concentration. (See attached example calculation.)

The data in Table II are then fitted into the prescribed equation $\Sigma\,[T/ET_{01}] \leq 1$, which becomes:

$$\frac{0.25}{12} + \frac{0.25}{21} + \frac{0.5}{34} + \frac{0.5}{96} + \frac{0.5}{\infty} + \frac{2}{\infty} + \frac{4}{\infty} + \frac{16}{\infty} + \frac{24}{\infty} + \frac{48}{\infty} \cong 0.053 \leq 1$$

Thus, the constraint of the equation is met (i.e. $0.053 \leq 1$) and the determination is made that protection is afforded.

Rationale

A. Test Species

The toxicity of Grasselli Waste--as a function of time--to Acartia tonsa has been used in assessing the appropriateness of the proposed disposal procedure for these watewaters. Acartia tonsa was more sensitive to the Grasselli wastewater than other appropriate sensitive marine organisms tested. Thus Acartia tonsa

---

*In this case, x = 01, so that $ET_{(x)}$ is the effective time required to produce 1% mortality, i.e. the LC01.

toxicity data lends a degree of conservatism to the determination that Du Pont's recommended disposal procedure is appropriate.

B. LC50 and LC01 Calculations

Bioassays were performed on 8-10 different samples of the Grasselli wastewater. Thus the data generated provide information as to variability in the toxicity of individual samples as well as variation in toxicity among samples. Analysis of data was by computerized Probit Analysis and analysis of variance. These statistical techniques afford best possible estimates of waste toxicity on the basis of the raw data obtained. Accuracy of these methods for calculating LC50 and LC01 are well documented in the scientific literature.

C. LC01 as the Estimate of $ET_{(x)}$

Realistically $ET_{(x)}$ can represent any response produced by any concentration of a toxicant, and in practice, there is no single determinable value for $ET_{(x)}$. Therefore, when a parameter is selected for the determination of $ET_{(x)}$ there must be some assurance that the selected value is adequate for the specific case under consideration.

In considering the disposal of the Grasselli wastewaters, LC01 is deemed to be an appropriate and conservative parameter for use in determining $ET_{(x)}$. Our reasoning is as follows:

- The chemical composition of the wastewaters combined with intermittent disposal precludes the occurrence of chronic or subchronic effects among biological species inhabiting the disposal zone.
- Any nonreversible sublethal effects which could possibly be expected would therefore be a result of a single exposure. Such occurrences, while not unknown, are extremely rare. Reversible sublethal effects are frequently observed after single exposures, but generally occur at dose or concentration levels which approach the LC50.
- The mathematical approach to meeting the recommendation of the NAS/NAE committee recognizes that in rare instances, effects other than acute mortality may occur, but also recognizes that the probability of such is related to time-concentration interaction, the slope of the dosage-mortality curve and the asymptote of the time-mortality curve.

We suggest that the probability of these effects occurring as a result of disposal of the Grasselli wastewaters under the requested discharge conditions approaches zero. Thus, the only effects which could possibly result are acute mortalities and consequently LC01 is appropriate for determination of $ET_{(x)}$. (Note that NAS/NAE uses LC02 for determining $ET_{(x)}$ in the example provided on pages 403-407 of Water Quality Criteria 1972).

D. Dispersion Calculations

There can be no denial of the fact that dilution and dispersion will and do occur quite rapidly in the wake of a barge traveling at 5 knots and discharging into a virtually infinite volume of seawater. There may, however, be some doubt as to the initial concentration (Co) of waste which is realized within a few seconds after leaving the discharge orifice. Our calculations yield a value of 620 ppm for Co. As a practical means of estimating the accuracy of this value, the following example is provided in which the mixing zone is confined to the width of the barge, the length of travel (5 hours at 5 knots) and a 5 meter depth.

Example:

Length of zone (5 hours at 5 knots) = 46000M

Width of zone (width of barge) = 15M

Depth of zone = 5M

Thus, Volume of zone = $3.45 \times 10^6$ $M^3$ ($9.115 \times 10^8$ Gal.)

Wastewater volume = $1 \times 10^6$ Gal. per barge load

Thus, concentration in mixing zone = $\frac{1 \times 10^6 \text{ Gal.}}{9.115 \times 10^8 \text{ Gal.}} = 0.11\%$

or 1100 ppm

This value approximates the dispersion prediction. Also, the mathematical constraint of $\Sigma\ [T/ET_{(x)}] \leq 1$ can be met when this value (1100 ppm) is used for Co and the dispersion envelope is correspondingly adjusted.

Rate of dispersion may also be questioned. However, the values .lized for calculation are based on observed worst-case centerline ıcentrations derived from several studies of waste dispersion. Thus, :se values are both appropriate and conservative.

Summary

The data presented by Du Pont have been applied to a mathematical method for determining that disposal of Grasselli wastewaters under the conditions of the requested permit will afford protection to the marine environment. It is felt that this determination is highly appropriate and conservative for the following reasons:

- The methods and concepts utilized in determining that protection is afforded represent best scientific judgement currently available.
- The toxicity data for the most sensitive appropriate bioassay organism were used in the determination.
- Toxicity tests and calculation of LC50 and LC01 were conducted with valid and accurate methodologies.
- Dilution and dispersion data are considered in light of toxicity, and only worst-case wake-centerline concentrations of waste are used in assessing hazardous potential.
- The constraint of the mathematical equation is met even when additional conservative factors are incorporated.

Thus, in conclusion, Du Pont feels that the data previously presented to EPA in conjunction with this documentation provide more than adequate justification for granting the requested special permit with a discharge time of not more than 5 hours for the Grasselli Plant's wastewaters.

JRG/jtd
7/28/75

TABLE I

Mean LC50, LC01 and expected waste concentrations at various time intervals for Grasselli wastewaters.

| Time in Hours | Mean LC50 (ppm) | Mean LC01 (ppm) | Expected Waste Concentration in The Mixing Zone (ppm) |
|---|---|---|---|
| 0 | - | - | 620 |
| 1* | 2519 | 985 | 217 |
| 4* | 1911 | 796 | 62 |
| 8* | 1542 | 660 | 30 |
| 24† | 559 | 312 | < 5 |
| 48† | 462 | 210 | < 5 |
| 96† | 400 | 215 | < 5 |

* n = 8

† n = 10

TABLE II

Values for T and $ET_{(01)}$ based upon toxicity and dispersion data for Grasselli wastewaters.

| Time Segment (Hours) | T (Hours) | Average Waste Concentration (ppm) | $ET_{01}$ (Hours) |
|---|---|---|---|
| 0-0.25 | 0.25 | 530 | 12 |
| 0.25-0.50 | 0.25 | 378 | 21 |
| 0.50-1.0 | 0.5 | 267 | 34 |
| 1-1.5 | 0.5 | 192 | 96 |
| 1.5-2 | 0.5 | 151 | >96 |
| 2-4 | 2 | 99 | >96 |
| 4-8 | 4 | 46 | >96 |
| 8-24 | 16 | <20* | >96 |
| 24-48 | 24 | <5* | >96 |
| 48-96 | 48 | <1* | >96 |

* extrapolated

## EXAMPLE CALCULATION

Determination of $ET_{01}$ and $T/ET_{01}$ for 1 hour

Time segment = 0.5 to 1.0 hours

T = 1.0-0.5 hours = 0.5 hours

A. In Figure 9 of the June 10 report, 1 hour (60 min) is located on the abscissa and the least favorable relative concentration for 60 minutes is found by drawing a line (1) parallel to the ordinate until it intersects the outermost dispersion curve (2). A perpendicular to this line is then constructed (3) so that it intersects the ordinate (4). Relative concentration (Cr) is read from the ordinate and multiplied by the initial concentration (Co) of 620 ppm.

   Thus, at 1 hour Cr = 0.35

   Co X Cr = 620 ppm X 0.35 = 217 ppm

B. The above procedure is repeated for 0.5 hours, which yields a value of 0.51 for Cr.

   Thus, at 0.5 hour

   Co X Cr = 620 ppm X 0.51 = 316 ppm

C. Average wastewater concentration during the time segment 0.5 to 1.0 hours is then determined:

$$\frac{217 \text{ ppm} + 316 \text{ ppm}}{2} = \frac{533}{2} \text{ ppm} = 267 \text{ ppm}$$

D. A waste concentration of 267 ppm is located on the ordinate of Figure 11 of the June 10 report (5). A line (6) parallel to the abscissa is extended until it intersects the mean LC01 curve (7). This intersection is then extended to the abscissa (8) and read as $ET_{01}$ (9). Thus, for the time segment 0.5 to 1 hours, $ET_{01}$ = 34 hours.

E. Finally, $T/ET_{01}$ is determined:

$$T/ET_{01} = 0.5/34 = 0.015$$

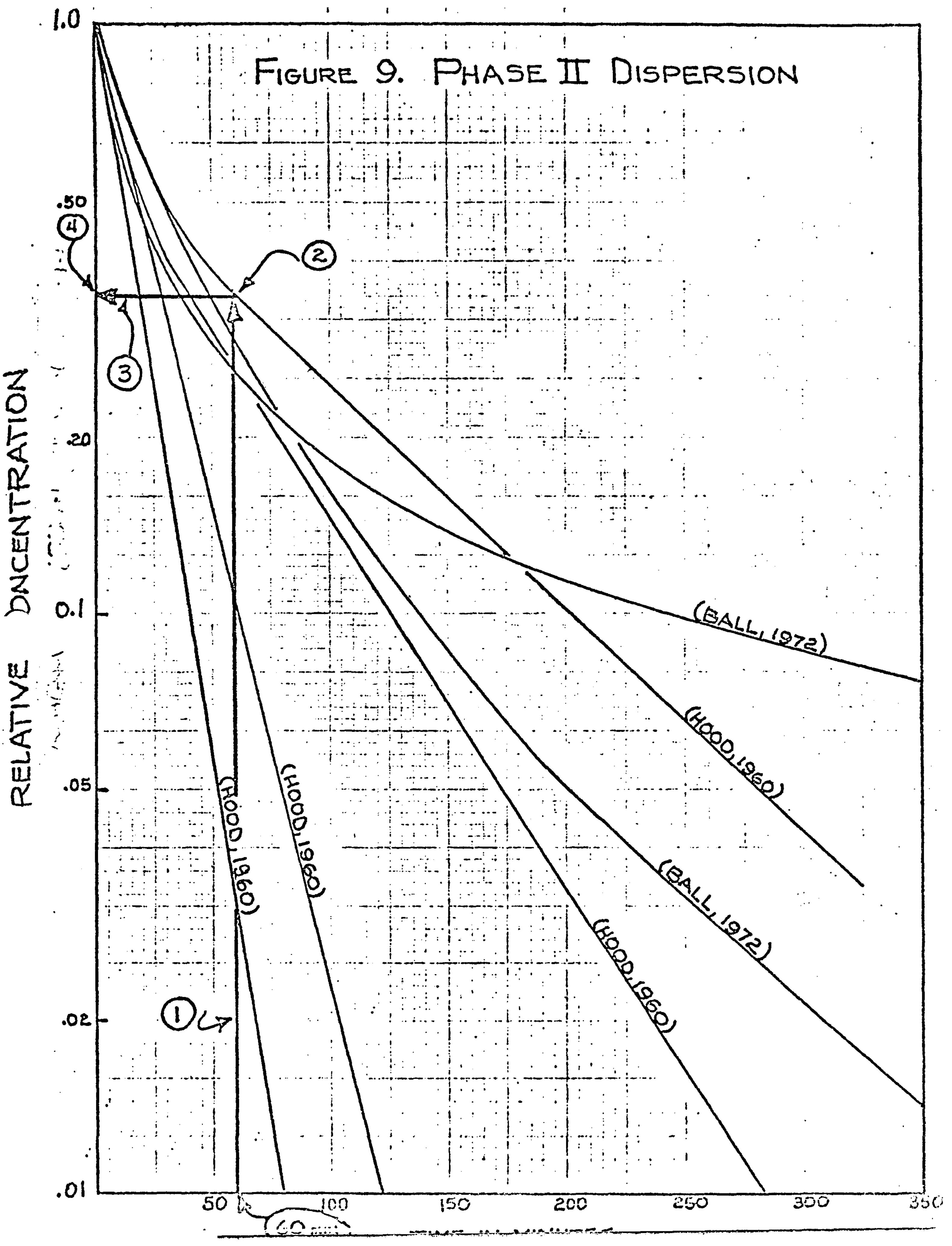
FIGURE 9. PHASE II DISPERSION
RELATIVE CONCENTRATION
1.0
.50
.20
0.1
.05
.02
.01
50
100
150
200
250
300
350
60
1
2
3
4
(BALL, 1972)
(HOOD, 1960)
(BALL, 1972)
(HOOD, 1960)
(HOOD, 1960)
(HOOD, 1960)

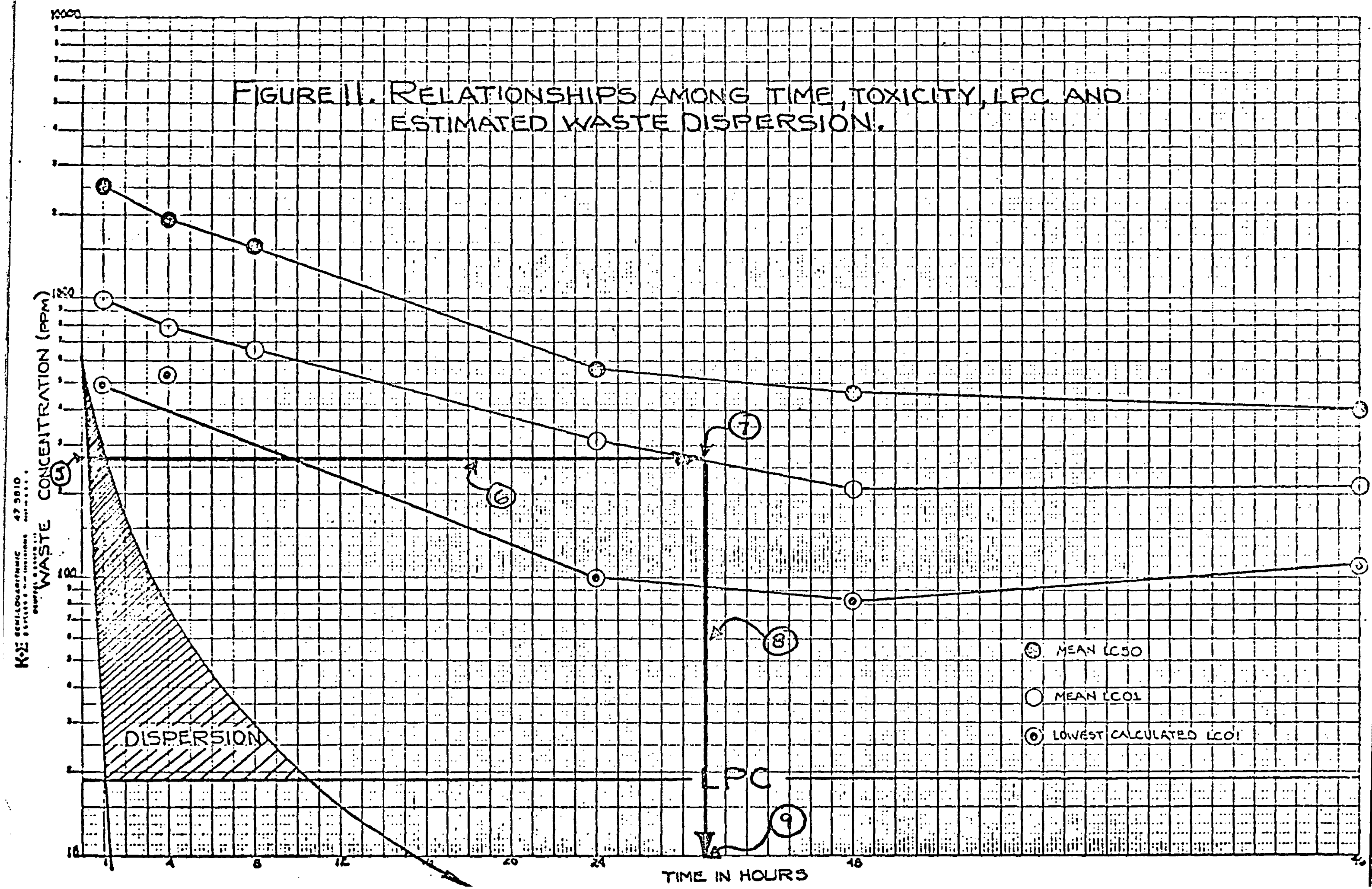

FIGURE 11. RELATIONSHIPS AMONG TIME, TOXICITY, LPC AND ESTIMATED WASTE DISPERSION.
WASTE CONCENTRATION (PPM)
TIME IN HOURS
MEAN LC50
MEAN LC01
LOWEST CALCULATED LC01
DISPERSION
LPC
5
6
7
8
9
1
4
8
12
20
24
48
100
1000

## APPENDIX C

### Application of NAS/NAE Recommendations to Disposal of Du Pont's Grasselli Plant Wastewater

Recommendation of the Committee on Water Quality Criteria (NAS/NAE)

The total time-toxicity exposure history must not cause deleterious effects in affected populations of important species, including the post-exposure effects.

Meeting the Recommendation

A. Approach

The Committee's approach to meeting this recommendation is summarized as follows:

1. Perform toxicity tests on sensitive organisms to provide a profile of the total time-toxicity exposure history (i.e. LC50 as a function of time).
2. Determine, from these data, concentrations required to produce lower levels of mortality (e.g. LC25, LC05, LC02, LC01, etc.).
3. Predict expected waste concentrations in the mixing zone either through mathematical modeling, actual experimentation, or both.
4. Calculate whether the recommendation is met.

To meet the recommendation of the committee, the following equation must be satisfied

$$T/ET_{(x)} \leq 1$$

Because concentrations vary as a function of time within mixing zones, the equation is more appropriately expressed as:

$$\Sigma\,[T/ET_{(x)}] \leq 1$$

where:

T = time of an organism's exposure in the mixing zone to a specified concentration,

ET = the effective time of exposure to the specified concentration which produces (x) percent response in a sample of the organisms.

Thus, this expression states that protection will be achieved when the sum of time-toxicity exposure relationships within a mixing zone is less than unity.

B. Grasselli Wastewater Disposal

Du Pont obtained data required to perform the calculations necessary for determining whether or not the Grasselli Plant's wastewaters meet the recommendation (see June 10 report to R. T. Dewling, EPA Region II). The data provided were:

a. LC50 to _Acartia tonsa_ (the most sensitive organism tested) as a function of time

b. Calculated LC01 values for _Acartia tonsa_ as a function of time

c. Predicted dispersion of the wastewaters in the wake of a moving barge as a function of time.

These data, summarized in Table I (attached) are used to calculate the values in Table II as follows:

a. Time segments (T) for dispersion are established, and the average concentration for each segment is calculated from dispersion equations.

b. $ET_{(x)}^{*}$ is determined for each average concentration. (See attached example calculation.)

The data in Table II are then fitted into the prescribed equation $\Sigma\,[T/ET_{01}] \leq 1$, which becomes:

$$\frac{0.25}{12} + \frac{0.5}{21} + \frac{0.5}{29} + \frac{0.5}{96} = 0.067 \leq 1$$

Thus, the constraint of the equation is met (i.e. $0.067 \leq 1$) and the determination is made that protection is afforded.

Beyond 1.5 hours $ET_{01}$ approaches infinity. However, even if it is conservatively assumed that $ET_{01}$ remains constant at 96 hours for the period 1.5 to 48 hours, the calculated value of $\Sigma\,[T/ET_{01}]$ is 0.55.

This value still satisfies the constraint of the equation.

<u>Rationale</u>

A. Test Species

The toxicity of Grasselli Waste--as a function of time--to <u>Acartia tonsa</u> has been used in assessing the appropriateness of the proposed disposal procedure for these watewaters. <u>Acartia tonsa</u> was more sensitive to the Grasselli wastewater than other appropriate sensitive marine organisms tested. Thus <u>Acartia tonsa</u>

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*In this case, x = 01, so that $ET_{(x)}$ is the effective time required to produce 1% mortality, i.e. the LC01.

toxicity data lends a degree of conservatism to the determination that Du Pont's recommended disposal procedure is appropriate.

B. LC50 and LC01 Calculations

Bioassays were performed on 8-10 different samples of the Grasselli wastewater. Thus the data generated provide information as to variability in the toxicity of individual samples as well as variation in toxicity among samples. Analysis of data was by computerized Probit Analysis and analysis of variance. These statistical techniques afford best possible estimates of waste toxicity on the basis of the raw data obtained. Accuracy of these methods for calculating LC50 and LC01 are well documented in the scientific literature.

C. LC01 as the Estimate of $ET_{(x)}$

Realistically, $ET_{(x)}$ can represent any response produced by any concentration of a toxicant, and in practice, there is no single determinable value for $ET_{(x)}$. Therefore, when a parameter is selected for the determination of $ET_{(x)}$ there must be some assurance that the selected value is adequate for the specific case under consideration.

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- The chemical composition of the wastewaters combined with intermittent disposal precludes the occurrence of chronic or subchronic effects among biological species inhabiting the disposal zone.
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We suggest that the probability of these effects occurring as a result of disposal of the Grasselli wastewaters under the requested discharge conditions approaches zero. Thus, the only effects which could possibly result are acute mortalities and consequently LC01 is appropriate for determination of $ET_{(x)}$. (Note that NAS/NAE uses LC02 for determining $ET_{(x)}$ in the example provided on pages 403-407 of Water Quality Criteria 1972).

D. Dispersion Calculations

There can be no denial of the fact that dilution and dispersion will and do occur quite rapidly in the wake of a barge traveling at 5 knots and discharging into a virtually infinite volume of seawater. There may, however, be some doubt as to the initial concentration (Co) of waste which is realized within a few seconds after leaving the discharge orifice. Our calculations yield a value of 620 ppm for Co. As a practical means of estimating the accuracy of this value, the following example is provided in which the mixing zone is confined to the width of the barge, the length of travel (5 hours at 5 knots) and a 5 meter depth.

Example:

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Width of zone (width of barge) = 15M

Depth of zone = 5M

Thus, Volume of zone = $3.45 \times 10^6$ $M^3$ ($9.115 \times 10^8$ Gal.)

Wastewater volume = $1 \times 10^6$ Gal. per barge load

Thus, concentration in mixing zone = $\frac{1 \times 10^6 \text{ Gal.}}{9.115 \times 10^8 \text{ Gal.}} = 0.11\%$

or 1100 ppm

This value approximates the dispersion prediction. Also, the mathematical constraint of $\Sigma\,[T/ET_{(x)}] \leq 1$ can be met when this value (1100 ppm) is used for Co and the dispersion envelope is correspondingly adjusted.

Rate of dispersion may also be questioned. However, the values utilized for calculation are based on observed worst-case centerline concentrations derived from several studies of waste dispersion. Thus, these values are both appropriate and conservative.

E. Summary

The data presented by Du Pont have been applied to a mathematical method for determining that disposal of Grasselli wastewaters under the conditions of the requested permit will afford protection to the marine environment. It is felt that this determination is highly appropriate and conservative for the following reasons:

- The methods and concepts utilized in determining that protection is afforded represent best scientific judgement currently available.
- The toxicity data for the most sensitive appropriate bioassay organism were used in the determination.
- Toxicity tests and calculation of LC50 and LC01 were conducted with valid and accurate methodologies.
- Dilution and dispersion data are considered in light of toxicity, and only worst-case wake-centerline concentrations of waste are used in assessing hazardous potential.
- The constraint of the mathematical equation is met even when additional conservative factors are incorporated.

Thus, in conclusion, Du Pont feels that the data previously presented to EPA in conjunction with this documentation provide more than adequate justification for granting the requested special permit with a discharge time of not more than 5 hours for the Grasselli Plant's wastewaters.

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7/28/75

TABLE I

Mean LC50, LC01 and expected waste concentrations at various time intervals for Grasselli wastewaters.

| Time in Hours | Mean LC50 (ppm) | Mean LC01 (ppm) | Expected Waste Concentration in The Mixing Zone (ppm) |
|---|---|---|---|
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| 4* | 1911 | 796 | 62 |
| 8* | 1542 | 660 | 30 |
| 24† | 559 | 312 | < 5 |
| 48† | 462 | 210 | < 5 |
| 96† | 400 | 215 | < 5 |

* n = 8

† n = 10

TABLE II

Values for T and $ET_{(01)}$ based upon toxicity and dispersion data for Grasselli wastewaters.

| Time Segment (Hours) | T (Hours) | Average Waste Concentration (ppm) | $ET_{01}$ (Hours) |
|---|---|---|---|
| 0-0.25 | 0.25 | 530 | 12 |
| 0.25-0.50 | 0.25 | 378 | 21 |
| 0.50-1.0 | 0.5 | 267 | 29 |
| 1-1.5 | 0.5 | 192 | 96 |
| 1.5-2 | 0.5 | 151 | >96 |
| 2-4 | 2 | 99 | >96 |
| 4-8 | 4 | 46 | >96 |
| 8-24 | 16 | <20* | >96 |
| 24-48 | 24 | <5* | >96 |
| 48-96 | 48 | <1* | >96 |

* extrapolated

## EXAMPLE CALCULATION

Determination of $ET_{01}$ and $T/ET_{01}$ for 1 hour

Time segment = 0.5 to 1.0 hours

T = 1.0-0.5 hours = 0.5 hours

A. In Figure 9 of the June 10 report, 1 hour (60 min) is located on the abscissa and the least favorable relative concentration for 60 minutes is found by drawing a line ① parallel to the ordinate until it intersects the outermost dispersion curve ②. A perpendicular to this line is then constructed ③ so that it intersects the ordinate ④. Relative concentration (Cr) is read from the ordinate and multiplied by the initial concentration (Co) of 620 ppm.

Thus, at 1 hour Cr = 0.35

Co X Cr = 620 ppm X 0.35 = 217 ppm

B. The above procedure is repeated for 0.5 hours, which yields a value of 0.51 for Cr.

Thus, at 0.5 hour

Co X Cr = 620 ppm X 0.51 = 316 ppm

C. Average wastewater concentration during the time segment 0.5 to 1.0 hours is then determined:

$$\frac{217\ \text{ppm} + 316\ \text{ppm}}{2} = \frac{533}{2}\ \text{ppm} = 267\ \text{ppm}$$

D. A waste concentration of 267 ppm is located on the ordinate of Figure 11 of the June 10 report ⑤. A line ⑥ parallel to the abscissa is extended until it intersects the mean LC01 curve ⑦. This intersection is then extended to the abscissa ⑧ and read as $ET_{01}$ ⑨. Thus, for the time segment 0.5 to 1 hours, $ET_{01}$ = 29 hours.

E. Finally, $T/ET_{01}$ is determined:

$$T/ET_{01} = 0.5/29 = .0017$$

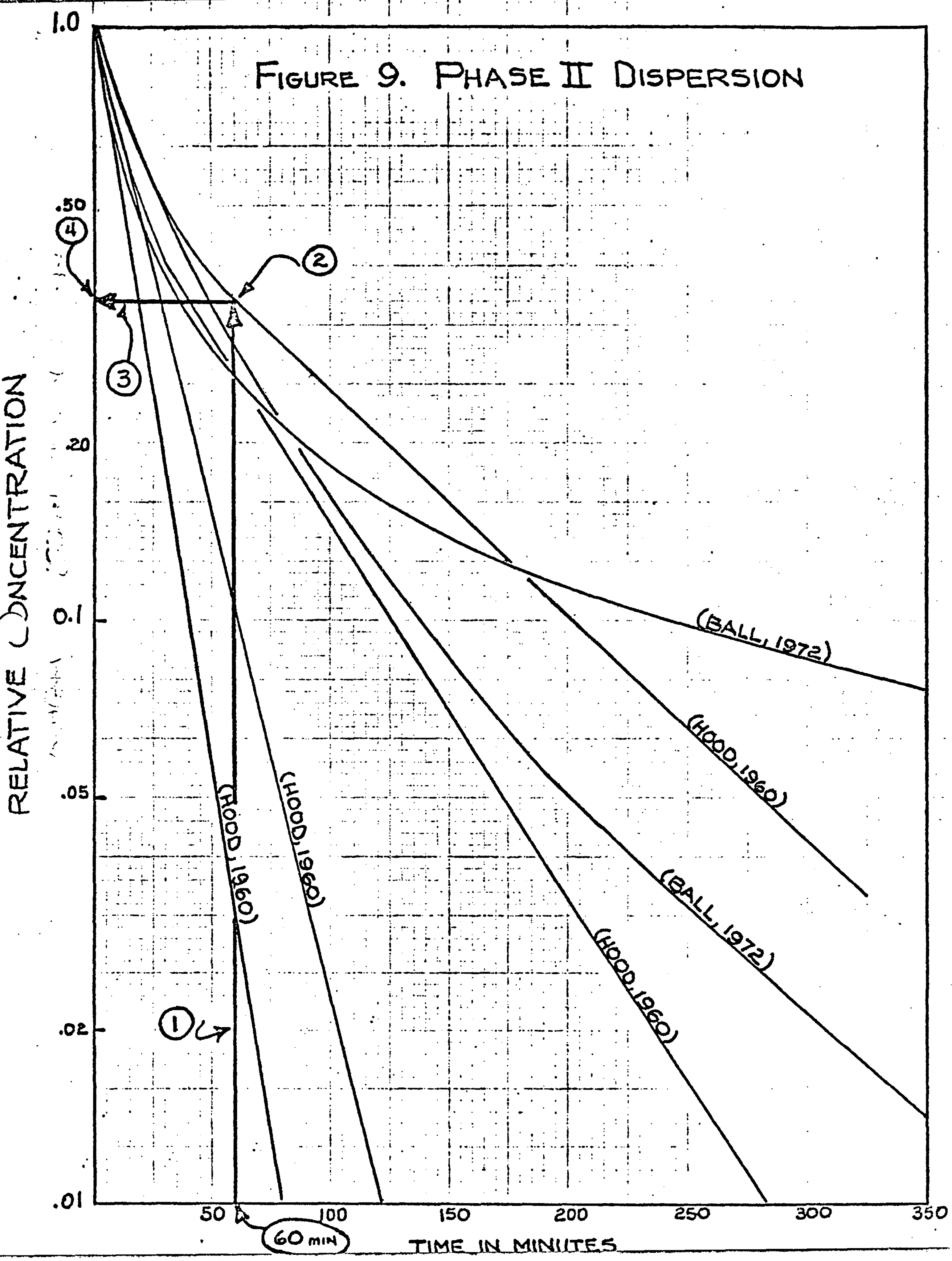


FIGURE 9. PHASE II DISPERSION
1.0
.50
.20
0.1
.05
.02
.01
RELATIVE CONCENTRATION
50
100
150
200
250
300
350
TIME IN MINUTES
60 MIN
1
2
3
4
(HOOD, 1960)
(HOOD, 1960)
(HOOD, 1960)
(HOOD, 1960)
(BALL, 1972)
(BALL, 1972)

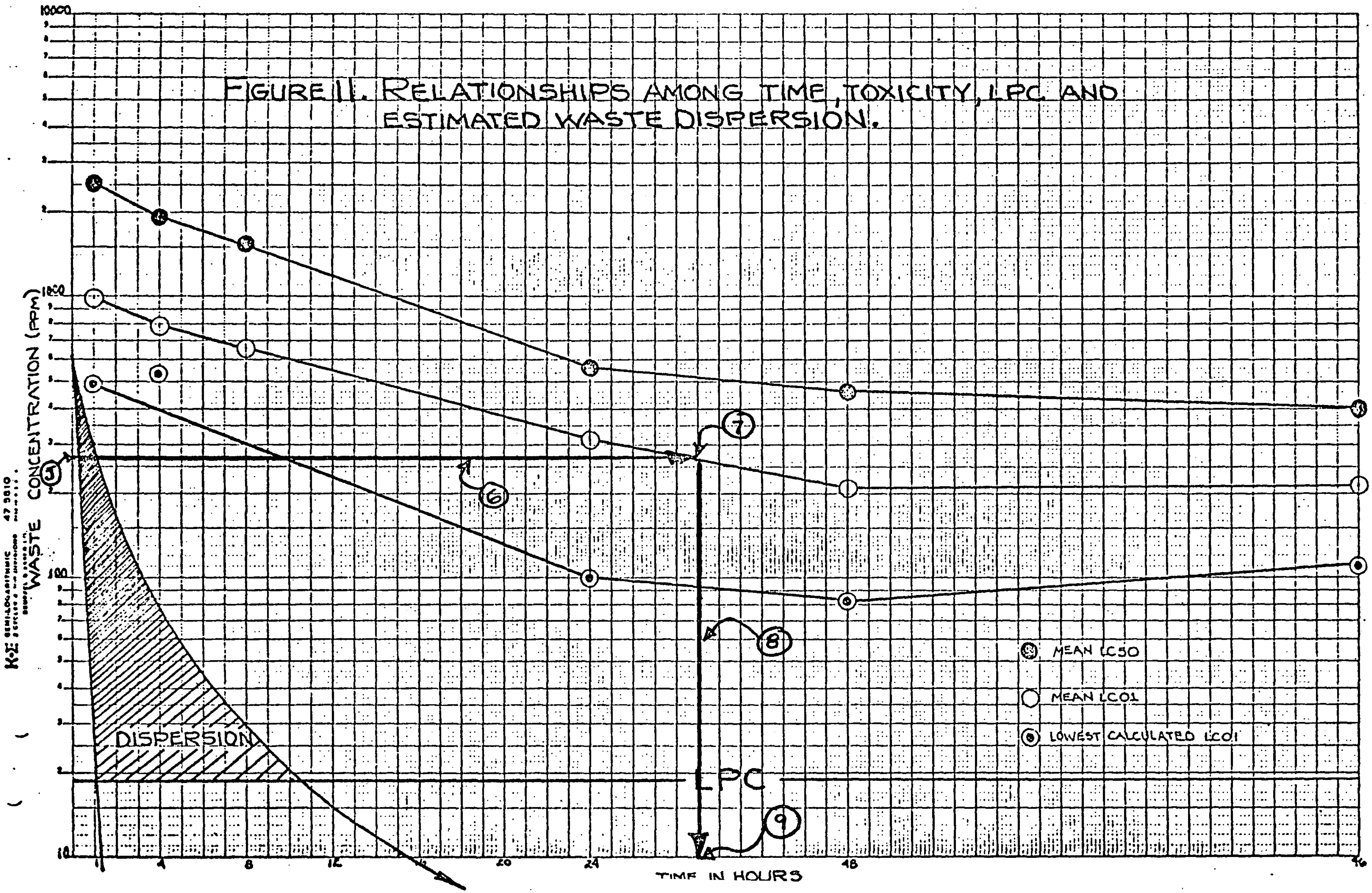



FIGURE 11. RELATIONSHIPS AMONG TIME, TOXICITY, LPC AND ESTIMATED WASTE DISPERSION.

G

# APPENDIX G

X-11004 REV. 2-72

DU PONT
ESTABLISHED 1802
E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
GRASSELLI PLANT
LINDEN, NEW JERSEY 07036

INDUSTRIAL CHEMICALS DEPARTMENT

August 14, 1975

P. E. Bermingham, Esquire
Hearing Officer
EPA Region II
26 Federal Plaza
New York, New York 10007

Dear Mr. Bermingham:

OCEAN DUMPING PERMIT NJ-006
E. I. DU PONT DE NEMOURS AND COMPANY
GRASSELLI PLANT - LINDEN, N.J.

At our meeting in Edison on August 6, 1975, P. W. Anderson, EPA Region II, suggested certain options relative to Grasselli's permit and requested Du Pont Company comments.

The purpose of this letter is to advise that in the event EPA determines that a "special" ocean dumping permit in accordance with Du Pont's application will not be issued to the Grasselli Plant, the Du Pont Company would accept under protest the EPA proposal to issue an "interim" ocean dumping permit which for the Grasselli Plant specified a dumping zone of five nautical miles and contained the Special Condition No. 7 of the Tentative Determinations in that any Implementation Plan that may be required, "shall set forth a schedule of deadlines, in accordance with the regional goal to completely phase out ocean dumping by 1981."

The acceptance of any such interim permit by Du Pont should not be construed as acquiescence to EPA's determination in this matter. Du Pont would like to state for the record that we continue to believe that the technical procedure in support of the five-hour maximum dump time presented by Du Pont at the June 12, 1975 Public Hearing and in subsequent correspondence is fully in accordance with EPA's presently promulgated rules and regulations, specifically 40 CFR Part 227 - - "Criteria for the Evaluation of Permit Applications." Section 227.71 states that in determining, "limiting permissible concentrations" that bioassays on "appropriate sensitive marine organisms" shall be "carried out in accordance with approved EPA procedures." We believe that the approach proposed by Du Pont sets forth a sound and technically valid procedure for determining discharge rates in accordance with Section 227.71.

The Du Pont proposal appears to have considerable support from the scientific community (see attachments to the report by Drs. Falk and Gibson submitted under cover of R. D. Turner's July 30, 1975 letter), whereas EPA's approach of applying a 0.01 factor to only 96-hour TLM's appears arbitrary and solely designed to provide a safety margin, irrespective of actual discharge conditions, in "cases where waste of unknown ecological impact is involved" (see 38 FR 28612). We request that consideration of Grasselli Plant's permit application weigh the total scientific data associated with this particular dumping activity, and not be viewed in the context of unspecified and unpublished EPA policy and procedures.

The purpose of the August 6 meeting, from Du Pont's point of view, was to seek EPA's acceptance of our proposal specifically as applied to the Grasselli Plant's pending permit application. We believe such acceptance could be granted by the EPA's Region II Office. The Du Pont Company intends to proceed toward obtaining acceptance of the proposed procedure. We believe the time-toxicity concept embodied in the Du Pont proposal is a technically sound procedure to predict acute toxicity under actual discharge conditions, and is an appropriate and workable procedure for determining discharge rates and "limiting permissible concentrations."

The flexibility inherent in the existing regulations should be exercised in the future. Thank you for your consideration in this matter. Please feel free to call upon the Du Pont Company if you should have any questions or if we can be of any assistance.

Very truly yours,

R. D. TURNER
PLANT MANAGER

RDT:mm

CC: P. W. Anderson
EPA, Region II
Edison, N.J.

T. A. Wastler
Marine Protection Branch
U.S. EPA
Washington, D.C. 20460

# APPENDIX H

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Region II

SUBJECT: Ocean Dumping Permits - June 12, 1975 Hearing DATE: September 2, 1975

FROM: P. E. Bermingham
Regional Hearing Officer PEB

TO: Gerald M. Hansler, P.E.
Regional Administrator

On June 12, 1975 a public hearing was held at 26 Federal Plaza to consider 25 applications for permits to dump waste materials offshore in the Atlantic Ocean. The record was originally held open until July 11, 1975 for the submission of additional data. Subsequently I agreed to postpone this date until August 15, 1975 because of the controversial nature of some of the applications, particularly those of Du Pont and American Cyanamid.

American Cyanamid

The American Cyanamid application was the subject of a separate memorandum addressed to you dated August 18, 1975 in which I recommended the issuance of a permit. In your absence this recommendation was approved by Mr. Herbert Barrack.

Du Pont

Du Pont in its application asked for a special permit (as distinguished from the interim permit granted to it last year) with a discharge time not exceeding five hours. Region II's tentative decision was to issue a special permit to Du Pont to discharge at the 106-mile chemical site. In order to meet the limiting permissible concentration (LPC) of the mixing zone at this site (determined to be 1/100 of the 96-hour $TL_{50}$ value for Acartia tonsa) the proposed permit provided that the waste must be uniformly discharged over a distance of 150 miles. EPA estimated that traversing this distance would require approximately 30 hours.

The issue between EPA and Du Pont with respect to the allowable discharge time was the subject of lengthy written reports and oral presentations by both sides. I find it impossible to present the question and my recommendation with respect thereto without a rather detailed summarization of the respective positions.

In support of its application Du Pont submitted a report detailing the results of bioassay tests on the EPA-specified marine organism that was most sensitive to the company's waste (Acartia tonsa). Du Pont's proposed procedure was based on a time-toxicity concept designed to predict acute toxicity under actual discharge conditions. Du Pont explained its methodology as follows:

1. The limiting permissible concentration (LPC) was established by applying the 0.01 factor specified in Section 227.71 of the EPA ocean dumping regulations to the mean 4-hour $LC_{50}$ or median tolerance limit obtained from bioassay data on <u>Acartia</u>. The basis for this time period is the 4-hour limit for mixing allowed in Section 227.73 of the EPA regulation.

2. The mixing zone volume for achieving the LPC is that allowed for in Sections 227.72 and 227.73 of the regulation. That volume is 20 meters deep and has lateral dimensions 100 meters from the perimeter of the barge beginning at a point when waste release starts to the point when release stops.

3. Bioassay data were determined for periods of exposure of 1, 4, 8, 24, 48, and 96 hours on 8 to 10 replicate waste samples. From the data, $LC_{50}$ (50 percent survival) and $LC_{01}$ (99 percent survival) were calculated by probit analyses. Further statistical analyses showed that the $LC_{50}$ value of any one sample was not statistically different from those of the other samples. Thus, the mean value for all replicates can be used to represent the waste in calculating dispersion time. Our report appends to it computer printouts of all probit analyses.

4. The 4-hour $LC_{50}$ and $LC_{01}$ values were then compared with LPC and expected dispersion patterns. The patterns used were those obtained by Du Pont in studies in the Gulf of Mexico in 1960 and in 1973. Those studies showed that the initial concentration in the immediate wake of the barge is directly proportional to the waste release rate and inversely proportional to the barge speed. Furthermore, subsequent to initial dispersion, a further 1:10 dilution occurs in 0.5 to 3.5 hours. Then, typically, another 1:10 dilution occurs by the 6th to 8th hour after release.

In our analysis, we combined the 4-hour $LC_{50}$ and $LC_{01}$ data with the dispersion data. The results are summarized as follows:

1. At all times, the waste concentrations behind the barge will be less than mean 4-hour $LC_{01}$.

2. The waste concentration will be less than 0.01 of the mean $LC_{50}$ within 1 to 10 hours after discharge at the centerline of the dispersing waste plume.

3. By using a 5-hour dispersion time at a 5-knot barge speed, the waste concentration in the mixing zone permittedin Section 227.73 is less than 0.01 of the mean 4-hour $LC_{50}$ after 4 hours.

   Our analysis shows that extending the dispersion time beyond 5 to, say, 10 or 20 hours does not significantly add to the relative differences in the time-mortality-concentration relationships. Put another way, 5 hours will allow meeting the requirement of Section 227.71. Additional time for dispersion costs fuel and money. It does not add up to a benefit to the ocean environment commensurate with the cost.

Because Mr. Richard Dewling, Director of Region II's Surveillance and Analysis Division, felt that the Du Pont application raised issues of national significance, he referred the company's proposal to EPA headquarters for its answers to the following questions:

1. Do the existing regulations allow for the type of interpretation suggested by Du Pont?

2. From a technical standpoint, can we apply the approach recommended by Du Pont, and if not, why not?

3. If Du Pont's approach is approved, can we apply this concept to all liquid industrial wastes of the same density?

These questions were answered as follows:

1. The Regional Administrator has the discretion to specify the kinds of biological testing required for his Region. Therefore the Region could accept a four hour bioassay test if it felt the test was adequate.

2. In our opinion, we feel that based on the information provided, the Du Pont recommendation should be rejected for the following reasons.

The use of a bioassay test to simulate toxicological reactions to marine ecosystems can, at best, only provide a rough estimate of ecosystem impact. For this reason every effort has been made to provide test procedures that use sensitive marine organisms. The procedures selected for use by a Region must be a compromise between sensitivity of toxicological response, facility of performance, ecological significance of the test species, and the financial cost of running the tests.

ORD in recommending the use of *Acartia tonsa*, *Skeletonema costatum*, and *Menidia menidia*, has made a scientific judgment that essentially states that using these organisms, performing the bioassay tests under standard conditions, and interpreting the results according to the ocean disposal criteria, will provide adequate protection to the marine environment from dumping operations.

Clearly there is nothing sacred about a 96 hour static acute toxicity bioassay test. ORD could have specified tests dealing with such sub-lethal effects as physiology, sensory physiology, behavior, and growth, reproduction and development.

The above sub-lethal effects are not observed in the ORD recommended acute toxicity tests. It is our best scientific judgment that specifying 96 hours for the Acartia bioassay in conjunction with the 0.01 application factor to obtain the LPC, protection is provided to eliminate sub-lethal effects. It is important to note that so-called sub-lethal effects can be just as damaging to a functioning ecosystem as the most obvious lethal effects.

The issue of "scientific judgment" is also at stake here. Any particular judgment can only be vindicated by accruing a great amount of research information. It certainly would not be practical to mount a full research expedition for every ocean dumping permit application. Therefore, we must rely on the "judgment" of our experienced research scientists to provide the technical guidance for the program.

I recognize that Du Pont scientists may take exception to our judgments with judgments of their own. In that case they will have to perform a well balanced and comprehensive research program to prove their case. In our opinion the information provided to date is insufficient to prove the adequacy of their recommended alternative. Some of our specific objections to Du Pont's proposal are as follows:

It is unclear from the appended Du Pont technical material if a four hour bioassay accounts for latency or delayed mortality effects or morbidity. Thus, the observation of no observed mortality in a four hour test may be meaningless particularly when the concentration is roughly four times the value of that obtained after the mortality curve stabilizes at about 24 hours.

Much importance is assigned to Hydroscience's model work and its implication for predicting concentrations at particular time periods. While the material Hydroscience's Mr. Mancini presented (at the Pensacola hearing) suggests 10 hours rather than 4 to be the time break this is somewhat an incidental relationship. No precision or accuracy concerns are expressed related to the model, it's specific applicability, its variability with changing hydrological or meteorlogical conditions etc.

It is common knowledge in toxicological research that slight changes in concentration can produce non-linear effects. However, it is of greater ecological concern to note that the measurable endpoint in the suggested test estimates death of a portion of the population. Such laboratory tests do not speak to possible <u>field</u> effects upon growth, reproduction or metabolism. Prudence would seem to dictate conservative approaches using accepted procedures.

3. Dealing with the possibility of applying the Du Pont concept to other cases of industrial waste disposal, it is our opinion that if it is determined that the concept has validity, then it may be applied to other waste disposals providing those wastes are totally liquid and miscible with water. However such determinations would have to be done on a case-by-case basis.

In response to these answers Du Pont submitted the following comments:

1. In regard to EPA's point with respect to the inability of an acute bioassay to deal with sublethal effects, the consensus of scientific judgment for situations where wastewaters mix with receiving waters is that time-toxicity exposure relationships should be considered in arriving at acceptable practices. Du Pont has done this, not believing that a decision based on only one selected time duration (96 hours) for a bioassay test is the "best" for protecting against sublethal effects.

2. The second point raised by EPA dealt with the additional protection of a 96-hour vs. a 4-hour test. Obviously, the longer test would be the safer if the only consideration were mere use of application factors. But because time-response data were developed for the Grasselli wastewaters, Du Pont considers that an LPC based on a 4-hour test to <u>Acartia</u> <u>tonsa</u> is both appropriate for providing a high level of protection to the marine environment as well as meeting the criteria of 40CFR Part 227.71. Thus, the entire spectrum of time-response data developed during the 96-hour bioassay tests should be used in evaluating permissible wastewater levels. That spectrum of data ought to be, and indeed was, linked to the wastewater concentrations expected in the continually diluting plume behind the moving barge. Clearly, EPA did not even address itself to the validity of these concepts. Rather, it narrowly considered only the use of an application factor applied to a 96-hour test.

3. EPA's third point related to the imprecision of wastewater dispersion predictions. Du Pont recognized this in its proposal by showing an <u>envelope</u> of expected dispersion patterns. Du Pont then compared the least favorable pattern with LC50, LC01, and LPC values. Thus the point raised by EPA about Mr. Mancini's suggesting a 10-hour rather than 4-hour time break is immaterial. The wastewater concentrations will be less than 0.01 of the mean LC50 (50 percent survival) within 1 to 10 hours at the plume <u>centerline</u>, and less than 0.01 of the mean 4-hour LC50 after 4 hours. Furthermore, concentrations will be less than the mean 4-hour LC01 (99 percent survival) at all times.

EPA raises the issue of "scientific judgment" being at stake. If EPA's "best judgment" is the mere use of an application factor and 96-hour bioassays, then Du Pont certainly believes that such judgment would be found wanting. The publication, "Water Quality Criteria 1972" (EPA-R3-73-033, March 1973) prepared at EPA's request by the Committee on Water Quality Criteria, Environmental Studies Board, National Academy of Sciences-National Academy of Engineering, supports this belief.

That publication gives the methodology on how to deal with intermittent discharges and short-term exposures such as we have in the case of barged wastes. Both the Panel on Freshwater Aquatic Life and Wildlife and the Panel on Marine Aquatic Life and Wildlife considered integrated time-exposure as the concept to use in evaluating effects of short-time exposures of aquatic life to wastes in mixing zones. The waste plume behind a barge is such a zone. Both the Marine and Freshwater Aquatic Life panels subscribe to a use of a time-exposure approach in evaluating acceptable exposures of organisms in mixing zones. The panels even indicated how to approach the problem. Their concept is precisely the same as Du Pont's.

In my opinion Du Pont has presented a convincing case for the issuance of a special permit with a discharge time of five hours and I recommend that such a permit be issued. I base this recommendation on the following factors:

1. Region II's basis for determining the LPC by the formula of 1/100 of the 96-hour $TL_{50}$ value for Acartia tonsa is based on a draft paper issued by Washington as a guideline which, in fact, has not been uniformly followed by all regions.

2. The Washington response to Dewling's questions expressly states that in spite of the fact that headquarters does not believe Du Pont's proposal should be approved, the Region has the authority to make its own determination.

3. Section 227.71 of the Regulations dealing with limiting permissible concentrations does not prescribe any fixed method for obtaining bioassay data. On the contrary, it authorizes flexibility in providing for tests "carried out in accordance with approved EPA procedures."

4. Du Pont is asking that Region II approve its proposed procedure, an approval that the Region has authority to give.

5. Du Pont's proposal is based on joint recommendations of the National Academy of Sciences and the National Academy of Engineering contained in "Water Quality Criteria" prepared at EPA's request. That report, in lieu of fixed, arbitrary formulas, supports the theory that in a mixing zone "water quality characteristics necessary for the protection of aquatic life are based on time-exposure relationships of organisms" and that "the objective of mixing zone water quality recommendations is to provide time exposure histories which produce negligible or no effects on populations of critical species in the receiving system," an objective that "can be met by: (a) determination of the pattern of exposure in terms of time and concentration in the mixing zone due either to activities of the organisms, discharge schedule, or currents affecting dispersion; and (b) determination that delayed effects do not occur."

6. EPA's use of a fixed formula specifying 96 hours for Acartia bioassay in conjunction with the 0.01 application factor to obtain the LPC seems unrealistic in situations such as this where the discharges are intermittent rather than continuous and are made with rapidly decreasing concentrations.

7. EPA's precautionary attitude that "prudence would seem to dictate conservative approaches using accepted procedures" is based on the sound premise that alternative procedures should not be substituted unless they include adequate safety factors. But the Du Pont tests did reflect the NAS-NAE recommendation on this point which states:

   "When developing summation of short-term exposure effects it is recommended that safety factors, application factors, or conservative physiological or behavioral responses be incorporated into the bioassay or extrapolation procedures to provide an adequate margin of safety."

In short, Du Pont has submitted a proposal based on its own extensive tests and on the recommendations of NAS-NAE; EPA opposes it because in its scientific judgment "performing the bioassay tests under standard conditions, and interpreting the results according to the ocean disposal criteria will provide adequate protection to the marine environment *** ." In my opinion the latter position is arbitrary and, under the circumstances, unreasonable and I, therefore, recommend that the Du Pont proposed procedure be approved. *

## Other Permits

Except for the blanket recommendation of the American Littoral Society and the Sierra Club that the disposal of all toxic wastes at sea be discontinued (a recommendation that cannot feasibly be attained at this time) no objections were made to the issuance of permits to other applicants and I recommend that they be issued as proposed subject to the following comments:

### Special Condition 7

Several of the applicants have raised objections to the inclusion in the proposed interim permits of special condition 7 requiring the permittee to submit (1) by a specified date a final plan to implement the most environmentally acceptable alternative to ocean dumping of its waste and (2) a schedule of deadlines for the complete phasing out of ocean dumping.

This condition imposes requirements going beyond those set forth in the Act or in the regulations. The latter provide in 40 CFR § 220.3(d)(2) as follows:

> "An interim permit will require the development and active implementation of a plan to either eliminate the discharge entirely from the ocean or to bring it within the limitations of § 227.3"(i.e., the requirements for a special permit)"of this subchapter. Such plans must meet the requirements of § 227.4 of this subchapter. The expiration date of an interim permit will be determined by completion of sequential phases of the development and implementation of the required plan, and will not exceed one year from the date of issue. An interim permit may not be renewed, but a new interim permit may be issued upon application according to Part 221 of this subchapter upon satisfactory completion of each phase of the development and implementation of the plan."

* Not underlined on original

Clearly under this language the permittee has the option of submitting one or the other of two separate implementation plans. One alternative is a plan to eliminate ocean dumping in accordance with a time schedule. The other is a plan to remove from the waste the materials that do not meet the requirements for a special permit as set forth in § 227.3. Region II's condition 7 deprives the permittee of the second option. In most cases this causes no problems because the permittee would not or could not elect that option. But where he does want the choice, he is entitled to it.

The condition also exceeds the regulatory provisions in requiring that the plan to eliminate ocean dumping be based on "the most environmentally acceptable alternative." This language, which finds no sanction in either the law or the regulations, rules out any considerations of technical feasibility and economic costs. In your opinion of October 8, 1974 dealing with the issuance of interim permits you characterized the requirement of developing a satisfactory implementation plan as one involving the selection of "the alternative most economically and environmentally feasible." In my judgment this is the proper standard.

EPA supports the use of its stricter language on the ground that it has never been used to impose alternatives that were not technically feasible or economically reasonable. If this has been the Region's philosophy, it seems to me that it ought to be willing to condition its permits accordingly and I so recommend.

If my recommendations with respect to special condition 7 are accepted, I think the condition should be reworded to read as follows:

> "In accordance with 40 CFR §§ 220.3(d)(2) and 227.4 the permittee shall submit on or before ___________, 1975 a final plan to either eliminate the discharge of its waste entirely from the ocean or to bring it within the limitations of § 227.3.
>
> "If the plan submitted is for the elimination of the discharge from the ocean, it shall set forth an alternative method of disposal that is environmentally acceptable, technically feasible and economically reasonable and a schedule of deadlines for its implementation so as to phase out ocean dumping by ___________. Such plan shall be based on the evaluation of an engineering report previously submitted by the permittee as supplemented by such additional reports as EPA may require. The permittee shall submit quarterly progress reports beginning ___________.

"If the plan is to bring the discharge within the limitations of § 227.3, it shall meet the requirements of § 227.4, including adherence to the following implementation schedule:

__________________________________________

__________________________________________"

Although the regulations require an implementation plan for the elimination of ocean dumping only by holders of interim permits who cannot or will not meet the requirements for a special permit, Region II incorporates its condition 7 in special permits too. It appears in the proposed special permit to be issued to Du Pont. The Region's justification for doing this is a 1974 opinion of an attorney in the General Counsel's office which concludes that a special ocean dumping permit can "be conditioned so as to require the applicant to investigate, develop, or implement where feasible, and document such investigation, development or implementation, appropriate alternative locations and methods of disposal or recycling, including land-based alternatives, of the waste materials permitted for ocean disposal generated by the applicant." This conclusion was supported by the provision in s 223.1(g) authorizing the inclusion in permits of "other terms and conditions."

If my conclusion is correct that an interim permit holder has the option under the regulations of satisfying the requirements for a special permit or of phasing out his ocean dumping, that option is indeed a Hobson's choice when such a permittee opts for a special permit and is then told that the route he elected not to take must nevertheless be followed.

The above-referred to legal opinion does not say that condition 7 must be incorporated in special permits. It merely says that it may be imposed if the Regional Administrator deems it necessary or appropriate. In my view it should be omitted. If this view is not accepted, the language should be changed to reflect the limitation expressly stated in the opinion that any plan to eliminate ocean dumping be implemented "where feasible." This connotes a consideration of technical and economic factors as well as those that are environmentally acceptable and the language should so provide.

Allied Chemical

Allied Chemical's application asked for a discharge volume of 22.6 million gallons. The proposed permit is limited to 15 million gallons based on the company's discharge rate over the past two years. The Region prefers to use the lower figure with the commitment that if Allied can during the permit period demonstrate a need for an increase in volume, "the Region would be receptive to a modification request." With this understanding I endorse the 15 million quantity.

Allied Chemical also asked that special condition 5 be changed by substituting Menidia beryllina for Menidia menidia as one of three designated sensitive marine organisms because of the unavailability of the latter on a year-round basis and it also asked that its own bioassay analysis be limited to Acartia tonsa or Acartia clausi because it is the most sensitive to the company's wastes.

The Region's comments on these points are set out below:

> "We fully recognize Menidia menidia may not be obtained in vast quantities on a year-round basis from local coastal waters; however, there are two options available to this ocean dumping permittee and others in the Region. At least one of the available laboratories locally has established a culture of these fish within their facilities, thus providing a supply of these organisms on a year-round basis. The other option available would be the stabilization of the waste sample by freezing and subsequent analysis when the organism Menidia menidia is more abundant in local waters. We prefer that the permittees utilize laboratory cultures, if available.
>
> " *** The Region earlier this year designated three test organisms - Skeletonema costatum, Acartia tonsa or Acartia clausii, and Menidia menidia for use in determining the relative toxicity of waste transported to the ocean. In addition, for the period of this permit, that is for a one-year period, we are requiring that the permit holders provide information on the organism Artemia salina which has been used as a ranking test organism for the past 2-3 years. This will allow, hopefully, the comparison of of data generated during the earlier years of the ocean dumping program with those generated from the three new test organisms. We have determined that these data are needed over at least a one-year period in order to provide an adequate data base. While it is premature to establish the requirements for analytical determinations in future permits (next year),

> we will consider Allied Chemical's suggestion that the bioassay requirements be restricted to only 'the' most appropriate sensitive marine organisms in setting up future analytical requirements."

In the light of these comments I recommend that special condition 5 be incorporated in the permit as proposed by the Region.

In addition Allied requested that the requirement to conduct petroleum hydrocarbon analyses be postponed until appropriate analytical procedures are established. To this the Region replied as follows:

> "We transmitted to Mr. R. Sobel of Allied Chemical Corp. on July 8, 1975, a copy of the procedure for the analysis of petroleum hydrocarbon as requested in the July 3rd letter. In further telephone communications on July 28th with Mr. Gouck, I suggested that the company test this procedure in the near future and present the results to Mr. McKenna, the Region's Quality Assurance Officer and myself; we will then evaluate the applicability of this analytical procedure to Allied Chemical's highly acidic waste and if deemed inappropriate, will recommend to the Enforcement Division that the permit be modified to exclude this procedure. However, as this particular water quality parameter is useful in determining both the amount of material being transported to the respective dump sites and in reference to the noncontravention of criteria as established in Part 227, we recommend that it be included in this, as well as other, permits proposed for issuance."

I endorse this procedure.

<u>Attachments</u>

Attached is the complete record consisting of the following:

1. Public announcement of complete applications (Notice No. 75-388, May 9, 1975).

2. Newspaper advertisements of No. 1 above.

3. Letter dated Apr. 30, 1975 from EPA to NY State Department of Environmental Conservation requesting

certification with respect to five of the applications and the State's reply thereto dated June 4, 1975.

4. A copy of the draft form of permit.

5. Copies of the individual forms of special condition 7 for each permittee.

6. Transcript of the public hearing held on June 12, 1975.

7. Letter dated June 10, 1975 from McCarter & English, attorneys for Reheis Chemical Co. requesting additional time to submit an engineering report and EPA's comments with respect thereto dated July 17, 1975.

8. Letter dated May 21, 1975 from Chevron Oil Co. with respect to special conditions 5 and 6 and EPA's responses thereto dated June 4, 1975 and June 9, 1975.

9. Letter from Allied Chemical dated July 3, 1975 with respect to special conditions 2, 5 and 7 and EPA's comments on 2 and 5 dated July 29, 1975.

10. Letter from Merck Chemical dated June 12, 1975 with respect to special condition 7.

11. Memorandum from Peter W. Anderson, Chief of the Marine Protection Program commenting on Allied Chemical's and Merck Chemical's objections to special condition 7.

12. Copy of statement by U.S. Coast Guard on its involvement in ocean disposal.

13. Copies of documents relating to the Du Pont proposals for a discharge time not exceeding five hours:

    a. Statement of Richard D. Turner, Manager of Du Pont's Grasseli plant presented at the June 12 hearing.

    b. Statement of Dr. Lloyd L. Falk of Du Pont's Engineering Department presented at the June 12 hearing.

    c. Du Pont's report on release conditions based on testing appropriate sensitive marine organisms in support of its Grasselli application

d. Du Pont's engineering report on Waste Dispersion at Sea dated July 31, 1973.

e. Du Pont's engineering report on Deep Sea Disposal of Wastes from its Houston plant.

f. Memorandum dated June 13, 1975 from Richard T. Dewling, Director of Region II's Surveillance and Analysis Division to Dr. A. J. McErlean, Acting Director of EPA's Ecological Effects Division submitting three questions with respect to Du Pont's application.

g. Memorandum dated July 8, 1975 from Dr. McErlean to Mr. Dewling answering the questions referred to in f.

h. Du Pont's comments on Dr. McErlean's memorandum of July 8, 1975.

i. Letter dated August 14, 1975 from Du Pont.

14. My earlier report to you of August 18, 1975 with respect to American Cyanamid's application to which is attached:

a. A joint statement submitted by the American Littoral Society and the Sierra Club objecting generally to the disposal of any toxic wastes at sea and particularly to American Cyanamid's application.

b. American Cyanamid's comments in response to the objections referred to in a.

c. Letter dated July 25, 1975 from American Cyanamid with respect to that part of its application covering wastes from a new product.

d. Memorandum from Mr. Peter W. Anderson recommending issuance of a permit subject to certain specified conditions.

e. Letter dated August 15, 1975 from the American Littoral Society and the Sierra Club to Mr. Anderson replying to American Cyanamid's comments referred to in b. A copy of this communication was not received by me until August 19, 1975 too late to be reflected in my recommendations of August 18, 1975.

cc without attachments:

25 companies listed in public notice

Peter W. Anderson

Peter B. Devine

J. Kevin Healy

Sandra Kunsberg

William J. Librizzi, Jr.

Meyer Scolnick

Ross E. Austin
E.I. du Pont de Nemours & Co.
Wilmington, Delaware 19898

David K. Bullock
American Littoral Society
Sandy Hook, Highlands, NJ

Glen Stice
Sierra Club
50 West 40th Street
New York, New York 10018

Francis E.P. McCarter
McCarter & English
550 Broad Street
Newark, New Jersey 07102

Nicholas D. Englese
4 Irving Place (Rm 1026)
New York, New York 10003

# APPENDIX I

IC-11004 REV. 2-72

DU PONT
ESTABLISHED 1802

E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
GRASSELLI PLANT
LINDEN, NEW JERSEY 07036

INDUSTRIAL CHEMICALS DEPARTMENT

March 23, 1976

Mr. William J. Librizzi, Director
Surveillance and Analysis Division
Environmental Protection Agency
Raritan Depot, Building 10
Edison, New Jersey 08817

Dear Mr. Librizzi:

In keeping with Du Pont's verbal commitment made during the meeting of February 6, 1976 in Edison, we are attaching descriptions of the toxicological/biological studies we intend to perform in support of our concept of utilizing time-toxicity-dispersion relationships for determining the release time for our barged wastewater.

It is our understanding that these studies will provide sufficient answers to questions raised by Region II and ORD opposite acceptance of the time-toxicity method for calculating release times for ocean-disposed wastewaters.

These studies were formulated by Dr. James R. Gibson, Chief, Aquatic Toxicology of our Haskell Laboratory and should you or any of your staff have questions or require additional information, please feel free to contact Dr. Gibson at (302-366-4675).

Very truly yours,

RICHARD D. TURNER
PLANT MANAGER

RDT/rik
attachments

TESTS TO BE PERFORMED

A. Acute assays

Static assays will be conducted with 20 fish at each test concentration and control to determine the 0.5-, 1-, 2-, 4-, 8-, 12-, 24-, 48-, and 96-hour LC50's (concentrations lethal to 50% of test organisms) of both unaltered and neutralized (pH adjusted to that of the control) test materials. These tests will be performed with fry, juveniles and adult fish. Additional tests with adult fish will be conducted with a stock solution of NaOH in distilled water at a pH equal to that of the raw wastewater. This series of tests will provide an evaluation of any pH effect.

To assess any residual effect of the test material, surviving fish will be removed from the test concentrations and placed in static, aerated, uncontaminated sea water. They will be maintained (with feeding) for an additional 7 days with observations every 24 hours.

B. Time-independent LC50 (lethal threshold concentration) assay

A proportional diluter (Mount and Grungs, 1967), constructed for 0.75 dilution, will be utilized to determine the concentration of pH adjusted test material which is lethal to 50% of sheepshead minnow fry "... exposed for periods sufficiently long that acute lethal action has ceased" (Sprague, 1970). The time-independent LC50 will be estimated at the time when no mortality occurs within a time period equivalent to the period within which any fish died previously at that concentration. For example, if mortality occurred in a concentration after 24 hours, the time-independent LC50 would be estimated at 48 hours if no additional mortality had occurred within that period. If the time-independent LC50 cannot be determined within 21 days, the test will be terminated.

As in the acute tests, surviving fish will be placed in uncontaminated sea water for an additional period of 7 days in order to determine any residual toxic effects.

C. Sublethal assays

A proportional diluter will be utilized to determine the effect of the pH adjusted test material on sheepshead minnow embryo survival, hatching success, and fry survival for 28 days.

Female fish will be induced to spawn by injection with human chorionic gonadotrophic hormone. Testes will be excised from males and the eggs will be fertilized. Within 1 hour after fertilization, groups of 50 eggs each will be placed in different concentrations of the test material and the test begun. (Hatching should occur 4-6 days later). Eggs and fry will be counted daily until hatching is complete.

Thereafter fry survival growth and development will be monitored daily for 28 days posthatch.

Growth of fry (total length) will be determined photometrically at the end of the exposure according to the method of McKim and

Benoit (1971). Mean wet weights of pooled fish from each treatment will also be determined.

Residual toxicity will be determined by placing surviving fish in uncontaminated water for 14 days at the end of the exposure. An EC50 will be calculated for each parameter.

D. Chronic assay

A chronic (full life cycle) test, using pH-adjusted wastewater, will be conducted according to the methods developed by EPA's Gulf Breeze Environmental Research Laboratory.

E. Pulse dose assays

1. Single pulse

Based on data from the ocean disposal dispersion model, four initial concentrations of the raw wastewater in sea water will be established by spiking with appropriate amounts of the test material. Concentrations used will be based on the initial concentrations expected in the wake of a barge discharging the wastewater at rates of 0.5, 1, 5, and 10 hours per barge load. Then, uncontaminated sea water will flow into the test containers to achieve a desired dilution rate. Two dilution rates will be utilized with each concentration.

Three life stages - fry, juvenile, and adult - of the sheepshead minnow will be tested, unless previous tests have shown that the various life stages respond similarly to the wastewater.

Surviving animals from each concentration will be observed for an additional 7 days.

2. Multiple pulse

Four initial concentrations (as in the single spike-pulse test) will be established and one dilution rate will be employed for each concentration. In addition, each spike will be repeated 4 times within 7 days, on days selected randomly, in order to simulate a repeated disposal situation.

Three sheepshead minnow life stages will be tested, unless previous tests have shown the various life stages to respond similarly to the wastewater.

After the exposures, flow of uncontaminated water will continue and surviving fish will be observed for a minimum of 7 days thereafter.

In all experiments, test animals will be observed closely and any abnormal behavior noted and reported.

JRG/jtd
3/11/76

## II. SIGNIFICANCE OF TESTS

### A. Acute bioassays

The time toxicity concept, as developed and proposed by Du Pont, uses acute toxicity data in conjunction with dispersion data for calculating release time for barged wastewaters. The use of acute bioassays is felt to be the most realistic approach, since ocean disposal presents, primarily, an acute toxicological problem. Considerable emphasis is therefore placed upon the results of acute bioassays with *Cyprinodon variegatus*.

Results of these bioassays will be used in constructing a time toxicity dispersion model for *C. variegatus*. These data will also be compared with similar data obtained for other species, so that the model developed for *C. variegatus* can be extrapolated to more sensitive species.

### B. Residual toxicity tests

Results of these tests will allow for refinement of the LC50 estimates. Also, post-exposure LC50's, zero acute mortality levels and post-exposure sublethal effects will be determined during these tests.

### C. Threshold LC50

This test is designed to determine the limit of acute lethal action for the wastewaters; i.e., the asymptote of the acute dose-response curve. Data from this test will also assess the cumulative toxic potential of the wastewaters, and will be used to calculate thresholds for other levels of mortality (e.g., LC01).

D. Subchronic tests

These tests will assess effects, other than acute toxicity, which may result from exposure to the wastewaters. An EC50 will be calculated for each effect noted.

E. Chronic assay

Data from this test will define effect and no-effect levels for the wastewaters in terms of the full life cycle of *C. variegatus*.

F. Pulse-dose bioassays

These tests are designed to simulate--in the laboratory--exposures to declining wastewater concentrations, as would be experienced by an organism in the wake of a moving barge during wastewater disposal. By varying initial concentration (simulating different disposal rates) and the rate of dilution (simulating different dispersion rates), time, initial concentration, dispersion rate and toxicity interactions can be calculated.

Multiple pulse-dose tests will simulate multiple exposures of organisms to wastewater discharge. These tests will also provide additional data on the cumulative toxic potential of the wastewaters.

G. Summary

Upon completion of all tests, data will be available which define the following:

- Acute toxicity of the wastewaters as a function of time to *C. variegatus*.
- Comparative acute toxicity of the wastewaters among several species of marine organisms.
- Residual, or post-exposure toxicity of the wastewaters.
- Mortality thresholds for the wastewaters.
- Zero acute mortality level.
- Cumulative toxic potential of the wastewaters.
- Effect of the wastewaters on fertilization, egg hatchability, fry survival, growth and development.
- Absolute effect and no-effect levels for the wastewaters in terms of the complete life cycle of *C. variegatus*.
- Effects of exposure to declining wastewater concentrations--for both single and multiple discharges.
- Effects of exposure to sublethal concentrations of the wastewaters.
- Post-exposure sublethal effects.

JRG/jtd
3-11-76

## REFERENCES


McKim, J. M. and D. A. Benoit. 1971. Effects of long-term exposures to copper on survival, growth, and reproduction of brook trout (Salvelinus fontinalis). J. Fish. Res. Bd. Canada 28: 655-662.

Mount, D. I. and W. A. Brungs. 1967. A simplified dosing apparatus for fish toxicological studies. Water Res. 1: 21-29.

Sprague, J. B. 1969. Measurement of pollutant toxicity to fish. Bioassay methods for acute toxicity. Water Res. 3: 793-821.

U.S. Environmental Protection Agency. 1975. Methods for acute toxicity tests with fish, macroinvertebrates, and amphibians. Ecological Research Series EPA-660/3-75-009: 61.

IC-11304 REV. 2-72

E. I. du Pont de Nemours & Company
INCORPORATED
Grasselli Plant
Linden, New Jersey 07036

Industrial Chemicals Department

July 13, 1976

Dr. Richard D. Spear
Surveillance and Analysis Division
Environmental Protection Agency
Region II
Raritan Depot
Edison, NJ 08817

Dear Dr. Spear:

On May 12, 1976 we met with you and your staff to discuss our plans for conducting tests at the 106-site on the dispersion of barged wastes from Du Pont's Grasselli Plant. Since that time, we have selected EG&G Environmental Consultants of Waltham, MA to do the study.

As we pointed out in our meeting, use of the barge "Sparkling Waters" has certain problems. Primary of these is the ability to know or measure the discharge rate at any particular moment. Consequently, we are exploring use of another barge which has pumping facilities. This would allow waste release at a known rate.

Mr. C. F. Hopper of our Grasselli Plant has been exploring this aspect and has been in touch with Mr. Peter Anderson of your office. This matter is presently unresolved, but we will advise you of final arrangements when made.

My primary purpose is to advise you of our dispersion monitoring study plan. A description of this plan is attached. Dr. Lloyd L. Falk of our Engineering Department has worked closely with EG&G Environmental Consultants in formulating the plan. Should you or any of your staff have questions or require additional information, please feel free to contact Dr. Falk at (302-366-2889).

We will have sufficient space aboard the research vessel to have a Region II observer present during the field programs. We shall let you know specifics on this when available.

Very truly yours,

Richard D. Turner
Plant Manager

RDT:car
Attachment

## DU PONT GRASSELLI PLANT - DISPERSION MONITORING STUDY

We propose to study waste dispersion using Rhodamine WT as the primary tracer material. The fluorescent dye will be added to the barge at the plant dock. When the barge discharges or pumps the waste into the ocean, transects will be made through the barge wake at right angles to the direction of barge travel. During these transects dye concentrations will be sampled at 4 depths on a continuous basis using a system consisting of a towed array of 4 hoses, 4 fluorometers, and a large capacity pump. The transects will begin immediately after release of the waste and continue for 8-12 hours or until the dye is lost. Figures 1 and 2 schematically show the systems to be used.

Simultanteously with the fluorescent dye measurements, pH will be continuously monitored at the same 4 depths using in-line pH sensors. The continuous dye and pH data will be recorded along with time, position, and the depth of the lower-most intake hose by a digital data logger. This method will provide data in much greater detail than has been obtained in previous barge dispersion studies reported in the literature. The picture of waste concentration as a function of space and time will be greatly improved.

In addition to the continuous dye and pH monitoring, vertical profiles of dye and pH will be obtained several times during the study by lowering a single hose system through the water column. This profiling will allow greater delineation of the vertical distribution of the waste as well as provide a method for sampling at greater depth than the towed array, if needed. It will also provide a reliable back-up system in case operational problems preclude the use of the towed array. In addition, Niskin bottles and a hydrographic winch will be available as further back-up in case of failure of both pumping systems.

A series of measurements defining the ambient sea and meterological conditions will be performed prior to and during the dispersion study. These measurements will include a conductivity-temperature-depth (CTD) survey of the area, current measurements obtained from the tracks of 4 drogues set to track water at 4 depths, and background measurements of fluorescence and pH. Wind, wave, air temperature, and humidity will also be monitored during the study.

The study will be broken down into specific tasks. These include preparatory activities, a preliminary measurement program, conduct of the field program, analysis of the data, and publication of a final report.

1. Preparatory Activities

Rather extensive preparatory activities will be required to accomplish the study proposed. These preparatory activities will include:

a. Assembly and test of the continuous sampling system including the hose array with depressor, weight, fairing, depth sensor, fluorometers, pH meters, pump, and pump manifold.

b. Interfacing of the digital acquisition system to the fluorometer output, pH meter output, and Loran C information.

c. The mobilization of equipment including fluorometers, pH meters, drogues, CTD, and any other equipment such as pumps, rigging of the research vessel, etc.

d. Planning of the field activities, sampling requirements, and analysis techniques to be used.

2. Preliminary Measurement Program

A field trial of the towed sampling system will be done on Du Pont's Edge Moor Plant's waste in the disposal area located between 38°30' and 38°35' N latitude and 74°15' and 74°25' W longitude. The towed array and digital acquisition system, as well as the four-in-line fluorometers and pH meters will be tested by running the tests under field conditions.

3. Field Program

a. CTD Measurements - Profiles of temperature, conductivity (for salinity), and depth (and, therefore, density) will be measured in the vicinity of the dump site one day prior to the waste disposal. These measurements will be made with a Plessey Model 9040 CTD and recorded on magnetic tape. A grid centered on the study site will be sampled, providing information on pycnocline depth to be used in positioning depths of the towed sampling array.

b. Current Measurement Program - A one-day drogue study will be done concurrently with the continuous barge waste monitoring. The drogue experiment will consist of the deployment of 4 large cruciform drogues set to track wastes at 4 depths determined by the depth of the pycnocline. The drogues will be deployed from the ship and the integrated currents observed will be used to describe the current shear present at the time of the dispersion study. The drogues will consist of large nylon cruciforms with ballast, attached to a pole and pole float at the surface by a thin wire. At the top of the pole, a small radar reflector will enable the ship to find the drogues. This drogue study is recommended as being the most cost-effective method of determining the average current shear during the measurement period.

c. Background Fluorescence and pH - During field checkout of the pumping system and hose array, background values of fluorescence and pH will be determined. Several profiles will confirm the normal pH range and the expected background fluorescence (equivalent to about 0.1 ppb or less of Rhodamine).

d. Wind, Waves, Air Temperature, and Humidity Measurements - Wind velocity, air temperature, and humidity will be measured at approximately 2-hour intervals by ship personnel. Wave height and period will be estimated at this time by shipboard observers.

e. Dispersion Measurement Program - The dispersion of the waste field will be measured by continuously sampling the concentration of Rhodamine WT in the barge waste. The Rhodamine concentration inside the barge will be about 300 ppm. After 10 hours, it is expected that the maximum dye concentration will be at least 5 ppb, which is at least an order of magnitude above the minimum discernible level.

   Sampling of dye concentration will be accomplished using a towed, 4-hose array coupled to 4 fluorometers set up for continuous measurement as shown in Figures 1 and 2. The depth of the 4 sampling intakes will be determined in the field from the depth of the pycnocline as measured by the CTD. The sampling system will be assembled on board the research ship so as to pump from four levels between 5 m and pycnocline depth at equally spaced intervals. This system will be towed through the water held in a nearly vertical position by the placement of an aerodynamically shaped weight (~1000 lbs.) at the lower end of strain cable, and by the attachment of a small depressor (EG&G Model 285) at a point about 6 meters from the bottom of the cable. The sampling system was designed based on experience at EG&G with towed arrays and continuous fluorometry, and from consideration of several similar, though less complex, systems described in the literature.

On board the ship the dye concentration will be determined by 4 continuous-flow Turner fluorometers. In addition, 4 pH meters will be placed in line beyond the fluorometers to continuously monitor pH. The signals from both these sets of instruments will be recorded on 2-4 channel strip chart recorders as well as on a digital data acquisition system which will record the information on magnetic tape. Signals from the depth sensor and Loran C receiver may also be recorded on tape. Temperature of the water at each depth will be monitored occasionally using in-line mercury thermometers.

Discrete samples may be taken from the pumped stream at the sampling orifices shown in Figure 2 as needed if problems with the continuous sampling scheme occur. In addition, a separate hose and pump capable of taking vertical profiles as well as discrete samples will be available. A second back-up system, Niskin bottles on a hydrographic wire, will be used to collect discrete samples if necessary.

Analyses of discrete samples for Rhodamine concentration will be performed in the laboratory. Position of the survey vessel will be determined by recording Loran C coordinates at the beginning and end of each straight-line transect. More precise distance measurements will be accomplished by deploying a drogue, with radar reflector, in the center of the waste plume and using radar to measure the distance from this drogue. Thus, absolute position will be available from the Loran C information and more precise relative position will be available from radar.

Vertical profiles of dye concentration and pH will be obtained at approximately 2-hour intervals during the measurement period to further delineate the vertical structure of the waste field. An additional hose and pump will be used for the vertical profiling to monitor waste falling below the deepest continuous sampling intake. The system will be designed to pump from a maximum depth of 100 m. The increased vertical resolution provided by this profiling information will allow careful calculation of the total dye measured to determine the reliability of measurement in terms of the total percentage of waste observed.

f. Laboratory Analysis Program - Determination of Rhodamine concentration and pH from the discrete seawater samples will be made at EG&G, Environmetnal Consultants. Rhodamine concentrations will be determined on a batch basis using a Turner fluorometer with a single-sample, high-sensitivity door.

4. <u>Analysis Program</u>

a. CTD measurements recorded on magnetic tape will be tabulated and put into a computer program which calculates density and dynamic height. Graphs of the density structure will be produced.

b. Average currents measured over the course of the experiment will be tabulated from the drogue position information.

c. Background fluorescence and pH will be tabulated and used in the analysis of these variables.

d. Wind velocity, wave height and direction, air temperature, and humidity estimates will be tabulated and used to better describe ambient sea and meteorological conditions.

e. Data reduction of the continuous dispersion measurements will involve the reading of the tape from the digital data acquisition system and the processing of the data to produce dye concentration in ppb (analogous to waste concentration), pH, depth, and position. pH and dye concentration will be computer-plotted for each transect and hand-contoured. The fluorometers will be calibrated in the laboratory prior to the field program. The readings obtained from the glass pH electrodes will be corrected for the buffer system used to calibrate the electrodes. Voltage from the glass reference electrode couple and corresponding temperature will be converted to pH using the Nernst equation with appropriate parametric values. Results from analysis of discrete samples for Rhodamine will be included in the waste concentration plots.

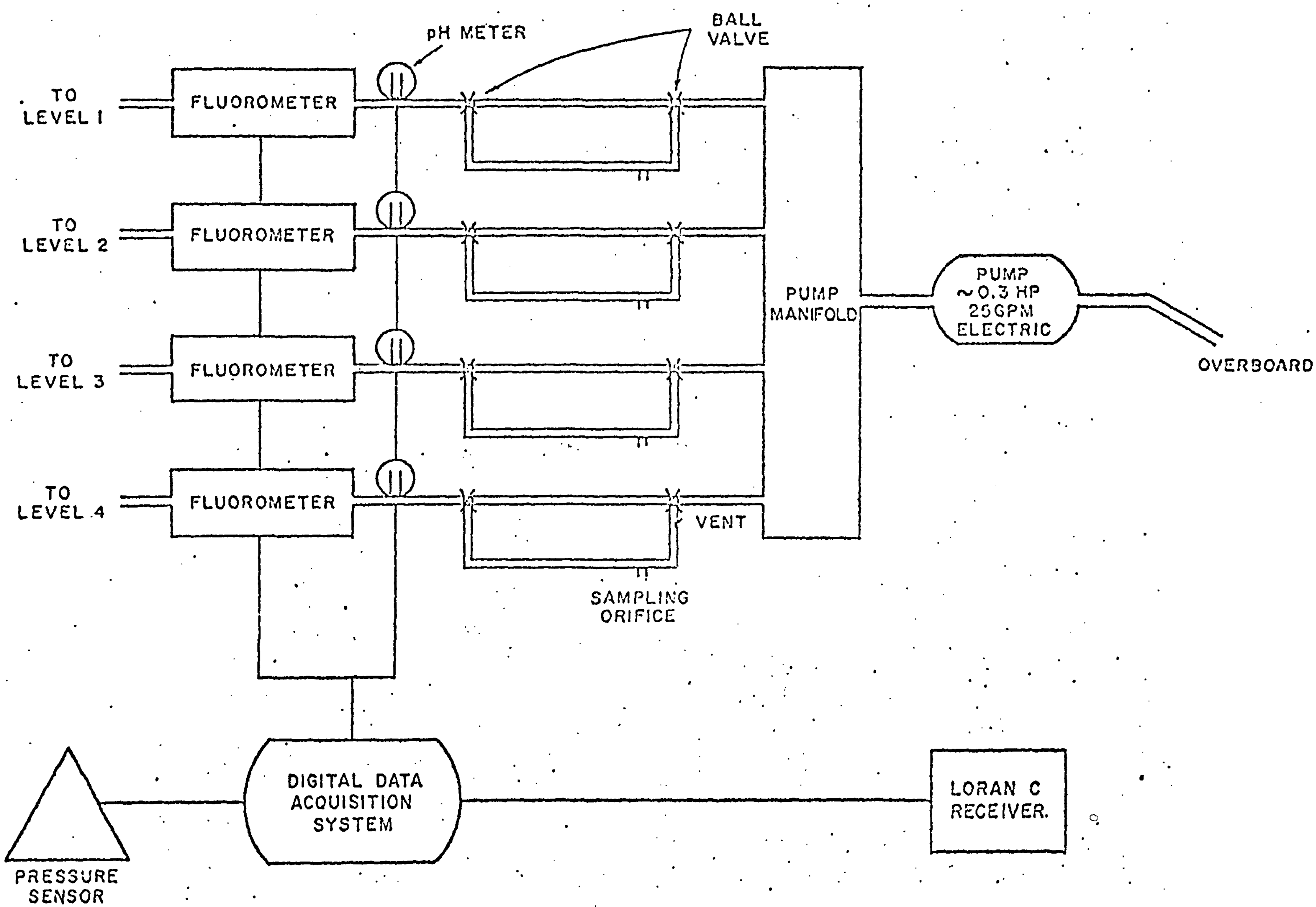



Figure 2

Schematic of pumping system.

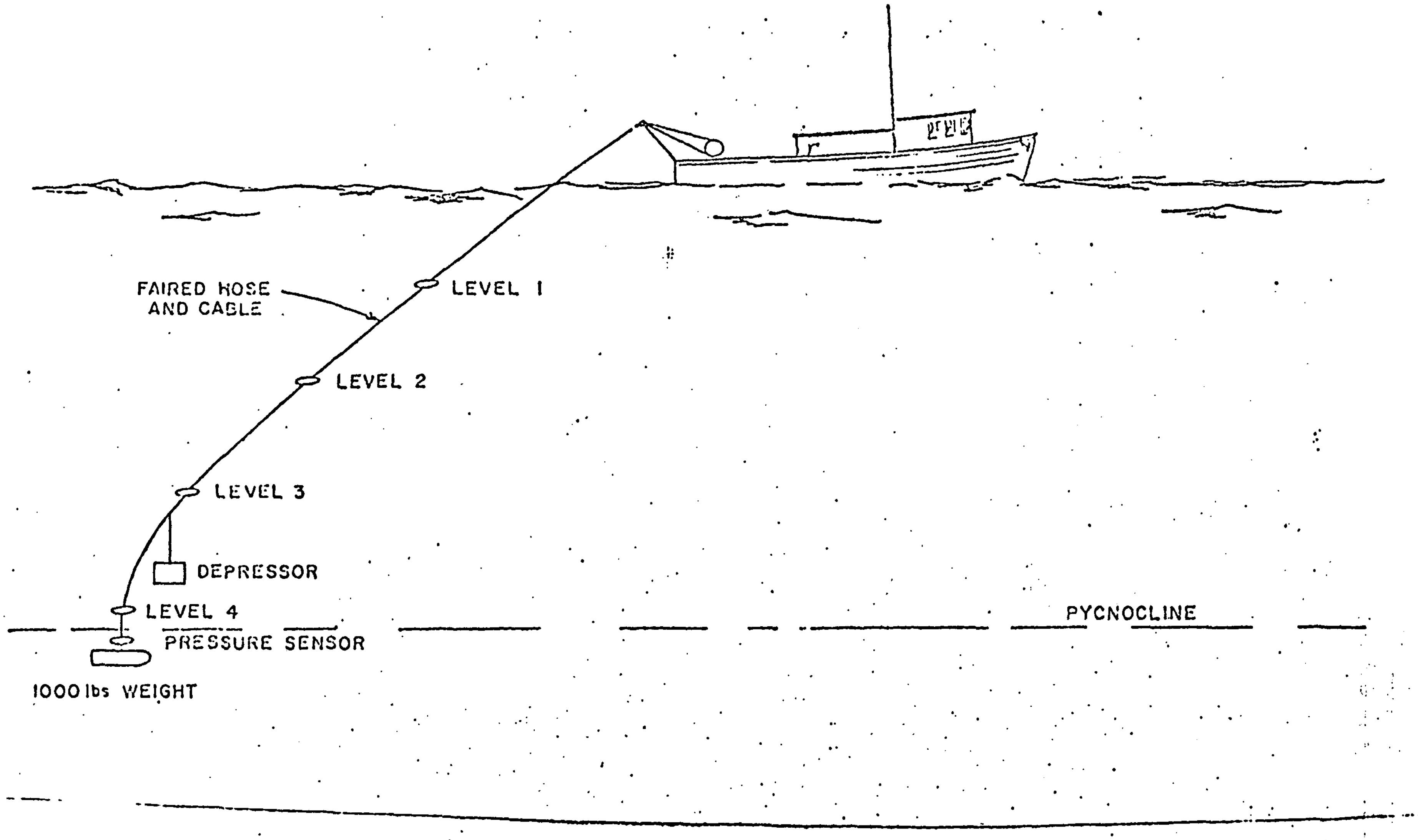



Figure 1. Towed sampling system showing the positions of the 4 sampling intakes (levels 1 through 4) in relation to the pycnocline.

J

APPENDIX J

cc: P. W. Anderson, EPA Region II
W. C. Muir, EPA Region III
P. R. Parrish, Bionomics Marine Lab.

July 19, 1976

Dr. John H. Gentile
National Marine Water Quality Lab
U.S. Environmental Protection Agency
Narragansett, Rhode Island 02882

Mr. David J. Hansen
U.S. Environmental Protection Agency
Gulf Breeze Environmental Research Lab
Gulf Breeze, Florida 32561

Dr. Royal J. Nadeau
U.S. Environmental Protection Agency
Raritan Depot, Building 10
Edison, New Jersey 08817

Gentlemen:

As we agreed during our May 18, 1976 meeting at Narragansett; Du Pont is submitting the attached revised proposals.

It is our understanding that with the inclusion of these changes the studies proposed are deemed to be adequate for applying the time-toxicity approach to the determination of wastewater release time.

Specific changes included are:

- Adding of 0.25 and 0.75 hour bioassays to the section on acute studies.
- Using total mortality (post-exposure plus exposure) as the basis for LC50 calculations.
- Reducing post-exposure observation from 7 to 4 days.
- Exposing 1 spawning group from the chronic study to a pulsed-dose of wastewater.
- Using an every-other-day exposure frequency for multiple pulse-dose experiments.

In addition to these agreed-upon changes, we agreed to perform a chronic exposure with Mysidopsis bahia--providing that the methodology for this test was sufficiently developed within a period of time which would allow completion of the test before 1976 public hearings.

I have asked Rod Parrish of Bionomics Marine Laboratory to communicate directly with Region II (P. W. Anderson) regarding quality assurance.

Also, as we agreed, progress reports will be forwarded to you and the Regional Offices as results are received and data are analyzed.

Should you have questions or require clarification on any of the items addressed in this letter or the attachments, please contact me.

Sincerely,

James R. Gibson, Ph.D.
Chief, Aquatic Toxicology

JRG/jtd
Attachments

K

# APPENDIX K

cc: P. W. Anderson, EPA Region II
P. R. Parrish, Bionomics Marine Lab.

ES-3574 REV. 1-75

DU PONT
ESTABLISHED 1802

E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
WILMINGTON, DELAWARE 19898
CENTRAL RESEARCH & DEVELOPMENT DEPARTMENT

HASKELL LABORATORY
FOR
TOXICOLOGY AND INDUSTRIAL MEDICINE

August 31, 1976

Dr. John H. Gentile
National Marine Water Quality Lab
U. S. Environmental Protection Agency
Narragansett, Rhode Island 02882

Mr. David J. Hansen
U. S. Environmental Protection Agency
Gulf Breeze Environmental Research Lab
Gulf Breeze, Florida 32561

Dr. Royal J. Nadeau
U. S. Environmental Protection Agency
Raritan Depot, Building 10
Edison, New Jersey 08817

Gentlemen:

In keeping with the commitment made during our May 18, 1976 meeting, I am forwarding a progress report on our toxicological studies with Grasselli Plant wastewaters. The data reported here represent about 50 percent of the total to be collected.

We will attempt to provide additional data as they become available between now and the September 20 public hearing, but since we had not anticipated this early a hearing date, we may not be able to supply a complete data package by that time. Should you have questions regarding these data, please feel free to contact me at 302-366-4675.

Sincerely,

James R. Gibson, Ph.D.
Chief, Aquatic Toxicology

JRG/ks
Attachment

# PROGRESS REPORT ON TOXICOLOGICAL STUDIES

## WITH DU PONT'S GRASSELLI PLANT WASTEWATER

## A. ACUTE TOXICITY

Tables I, II, and III summarize LC50's for the wastewaters (raw and pH-adjusted) to three life stages of *C. variegatus* under static exposure conditions. Please note that all LC50 values reflect mortality experienced during both exposure and a 21-day post-exposure period.

## B. THRESHOLD LC50

Table IV presents raw data obtained during the threshold LC50 test. This study was conducted under dynamic exposure conditions with 30-day juvenile fish; pH-adjusted wastewater was used for exposures. Probit analysis yields a Threshold LC50 value of 1840 ppm with 95% confidence limits of 1525 and 2219 ppm.

## C. SUBCHRONIC STUDIES

These tests are complete. There were no apparent effects on egg hatchability, growth development, behavior or mortality at pH-adjusted wastewater concentrations of 1687 ppm or below. Concentrations of 2500 ppm and above had meaningful effects on mortality.

## D. CHRONIC STUDIES

This study is in day 144. Fish have reached sexual maturity and have completed the first spawning. At present, only mortality data are available for this study.

These data indicate that 1500 ppm (or less) pH-adjusted wastewater is without effect.

## E. PULSE-DOSE BIOASSAYS

Several experiments have been completed with both *C. variegatus* and *Palaemontes*. Data are presently being analyzed.

## F. MYSIDOPSIS STUDIES

Preliminary work has been completed, but data are unavailable. Chronic study should be started this week, i.e. before September 3.

JRG/ks
8/31/76

TABLE I. LC50's* OF GRASSELLI WASTEWATER TO 1-7 DAY OLD FRY OF *C. VARIEGATUS* FOR VARIOUS EXPOSURE TIMES.

| EXPOSURE TIME (HR) | LC50 in ppm (95% CL) | |
|---|---|---|
| | RAW WASTE | pH ADJUSTED WASTE |
| 0.25 | > 100000 | > 100000 |
| 0.5 | 38000 ( ) | > 100000 |
| 0.75 | | 80214 (39530-161408) |
| 1.0 | 20182 (14108-24112) | 38799 (32561-45139) |
| 2.0 | | |
| 4.0 | | 43240 (28397-50431) |
| 8.0 | 9019 (6148-10732) | 8006 (5863-9666) |
| 12.0 | 4269 (3133-5001) | 6659 (4303-8480) |
| 24.0 | 2771 (2596-2957) | 3813 (3527-4126) |
| 48.0 | 2439 ( ) | 4221 (2229-4965) |
| 96.0 | 1269 (1043-1467) | |

* LC50 values reflect mortality which occurred during exposure plus a 96-hour post-exposure period.

TABLE II. LC50's* OF GRASSELLI WASTE WATER TO 30 DAY OLD JUVENILE *C. VARIEGATUS* FOR VARIOUS EXPOSURE TIME.

| EXPOSURE TIME (HR) | LC50 in ppm (95% CL) | |
|---|---|---|
| | RAW WASTE | pH ADJUSTED WASTE |
| 0.25 | | |
| 0.5 | 28448 (18265-36758) | 78288 ( ) |
| 0.75 | | |
| 1.0 | 18570 (16162-20485) | |
| 2.0 | 12376 (10834-14558) | 18360 ( ) |
| 4.0 | 10453 (8955-11733) | 11397 (10235-12431) |
| 8.0 | 11616 (10724-12549) | 9347 (8366-10743) |
| 12.0 | 6731 (6133-7318) | 9403 (8550-10223) |
| 24.0 | 3074 (2822-3336) | 3842 (3513-4152) |
| 48.0 | 2542 ( ) | |
| 96.0 | 1249 (1027-1383) | 1327 ( ) |

* LC50 values reflect mortality which occurred during exposure plus a 96-hour post-exposure period.

TABLE III. LC50's* OF GRASSELLI WASTEWATER TO ADULT C. VARIEGATUS FOR VARIOUS EXPOSURE TIMES.

| EXPOSURE TIME (HR) | LC50 in ppm (95% CL) | |
|---|---|---|
| | RAW WASTE | pH ADJUSTED WASTE |
| 0.25 | > 100000 | > 100000 |
| 0.5 | | > 100000 |
| 0.75 | 59420 (39750-81200) | 86401 ( ) |
| 1.0 | 20018 ( ) | 43555 (34359-52745) |
| 2.0 | 20192 ( ) | 57734 ( ) |
| 4.0 | 14172 (11691-16717) | 10414 ( ) |
| 8.0 | 8629 ( ) | 6355 (4977-7524) |
| 12.0 | 6433 ( ) | 6567 (4229-7756) |
| 24.0 | 5226 (4595-5743) | 5774 ( ) |
| 48.0 | 2703 ( ) | 3400 ( ) |
| 96.0 | 1370 (679-1634) | 2286 (1832-2559) |

* LC50 values reflect mortality which occurred during exposure plus a 96-hour post-exposure period.

TABLE IV. SUMMARY OF TIME-INDEPENDENT TOXICITY TEST WITH GRASSELLI pH-ADJUSTED WASTE WATER.

| NOMINAL CONCENTRATION (ppm) | EXPOSURE 24 h No. (%) | 48 h No. (%) | 96 h No. (%) | 144 h No. (%) | 192 h No. (%) | 240 h No. (%) | RESIDUAL 336 h No. (%) |
|---|---|---|---|---|---|---|---|
| Control | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 1,050 ppm | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 1,400 ppm | 0 (0) | 0 (0) | 0 (0) | 3 (15) | 5 (25) | 5 (25) | 5 (25) |
| 1,867 ppm | 0 (0) | 0 (0) | 0 (0) | 4 (20) | 4 (20) | 4 (20) | 4 (20) |
| 2,489 ppm | 0 (0) | 0 (0) | 1 (5) | 4 (45) | 18 (90) | 18 (90) | 18 (90) |
| 3,319 ppm | 7 (35) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) |
| 4,425 ppm | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) |
| 5,900 ppm | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) |

TABLE V. SUMMARY OF MORTALITY EXPERIENCED BY C. VARIEGATUS DURING THE FIRST 28 DAYS POST-HATCH AS A RESULT OF EXPOSURE TO VARIOUS CONCENTRATIONS OF pH-ADJUSTED GRASSELLI WASTEWATER.

| Nominal Concentration (µl/1; ppm) | MORTALITY | | | | | |
|---|---|---|---|---|---|---|
| | EXPOSURE | | | | RESIDUAL | |
| | Day 14 | | Day 28 | | Day 42 | |
| | Number | (%) | Number | (%) | Number | (%) |
| Control A | 1 | (2.5) | 2 | (5.0) | 2 | (5.0) |
| Control B | 0 | (0) | 0 | (0) | 0 | (0) |
| 712 ppm A | 0 | (0) | 0 | (0) | 0 | (0) |
| 712 ppm B | 0 | (0) | 0 | (0) | 0 | (0) |
| 949 ppm A | 4 | (10.0) | 4 | (10.0) | 4 | (10.0) |
| 949 ppm B | 1 | (2.5) | 1 | (2.5) | 1 | (2.5) |
| 1,266 ppm A | 0 | (0) | 0 | (0) | 0 | (0) |
| 1,266 ppm B | 0 | (0) | 3 | (7.5) | 4 | (10.0) |
| 1,687 ppm A | 3 | (7.5) | 4 | (10.0) | 4 | (10.0) |
| 1,687 ppm B | 0 | (0) | 0 | (0) | 0 | (0) |
| 2,250 ppm A | 2 | (5.0) | 10 | (25.0) | 11 | (27.5) |
| 2,250 ppm B | 19 | (47.5) | 28 | (70.0) | 28 | (70.0) |
| 3,000 ppm A | 38 | (95.0) | 39 | (97.5) | 39 | (97.5) |
| 3,000 ppm B | 30 | (75.0) | 39 | (97.5) | 39 | (97.5) |
| 4,000 ppm A | 39 | (97.5) | 40 | (100) | 40 | (100) |
| 4,000 ppm B | 40 | (100) | 40 | (100) | 40 | (100) |

TABLE VI. MEAN LENGTH AMONG GROUPS OF *C. VARIEGATUS* FRY EXPOSED TO pH-ADJUSTED GRASSELLI WASTEWATER DURING THE FIRST 28 DAYS POST-HATCH.

| Nominal Concentration (µl/l;ppm) | Mean standard length (in centimeters) and standard deviation | | |
| --- | --- | --- | --- |
| | EXPOSURE | | RESIDUAL |
| | Day 14 | Day 28 | Day 42 |
| Control A | 0.5 ± 0.1 | 1.2 ± 0.2 | 1.3 ± 0.2 |
| Control B | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 712 ppm A | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 712 ppm B | 0.8 ± 0.2 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 949 ppm A | 0.5 ± 0.1 | 1.2 ± 0.1 | 1.4 ± 0.1 |
| 949 ppm B | 0.6 ± 0.2 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 1,266 ppm A | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 1,266 ppm B | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 1,687 ppm A | 0.5 ± 0.2 | 1.2 ± 0.2 | 1.3 ± 0.2 |
| 1,687 ppm B | -[a] | 1.3 ± 0.1 | 1.3 ± 0.1 |
| 2,250 ppm A | 0.5 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.2 |
| 2,250 ppm B | 0.5 ± 0.1 | 1.4 ± 0.1 | 1.7 ± 0.2 |
| 3,000 ppm A | 0.5 ± 0.1 | 1.6 ± 0.0 | 2.4 ± 0.0 |
| 3,000 ppm B | 0.5 ± 0.0 | 1.8 ± 0.0 | 2.5 ± 0.0 |
| 4,000 ppm A | -[b] | - | - |
| 4,000 ppm B | -[b] | - | - |

[a] No measurements

[b] No fish

# APPENDIX L

STATEMENT OF LLOYD L. FALK
ON BEHALF OF
E.I. DU PONT DE NEMOURS & COMPANY, INC.
AT THE PUBLIC HEARING OF THE
ENVIRONMENTAL PROTECTION AGENCY
ON OCEAN DISPOSAL PERMITS
NEW YORK, NY, SEPTEMBER 20, 1976

My name is Lloyd L. Falk. I am a Principal Consultant in the Engineering Department of the Du Pont Company, Wilmington, Delaware.

Both EPA's existing and recently proposed ocean dumping regulations under the Marine Protection, Research and Sanctuaries Act require the use of bioassays on appropriate sensitive marine organisms in establishing permissible concentrations of wastes during ocean disposal operations. Region II has specified the appropriate sensitive marine organisms to be tested are the zooplankton *Acartia tonsa*, the phytoplankton *Skeletonema costatum*, and the finfish *Menidia menidia*.

In accordance with conditions of our existing permit, Du Pont has routinely tested these organisms, using EPA-approved methodology, and submitted data to Region II. The zooplankton, *Acartia tonsa*, exhibits the greatest sensitivity to our wastewater. Prior to the June 12, 1975 public hearing on our existing permit, we submitted to Region II a report (R. D. Turner to R.T. Dewling, 6/10/76) detailing our calculations of the release time based on *Acartia* data. We request that that report be made a part of the record of this hearing.

In brief, we proposed last year that, at a five-hour dispersion time and a five-knot barge speed, the wastewater concentration in the barge wake would not adversely affect ocean resources and would thus meet the requirements for a Special Permit. We also concluded that extending the dispersion time beyond five to, say, ten or 20 hours does not significantly affect time-mortality-concentration relationships we discussed. Put another way, five hours will allow meeting the requirement of Section 227.71.

Since our proposal of June 1975, we have discussed our suggested methodology in more detail with Region II personnel as well as with those of EPA's Office of Research and Development. We agreed to EPA's request to undertake additional studies to demonstrate the soundness of this concept.

These studies encompass two main facets of experimentation. The first involves field studies of the rates at which wastewater actually disperses at the 106-site with a five-hour discharge rate. The second involves detailed acute and chronic bioassays of our wastewater with appropriate marine organisms.

Dr. J. R. Gibson of Du Pont's Haskell Laboratory will discuss the bioassay studies following my statement today. Mr. Turner submitted the dispersion study scope of work to Dr. Richard Spear of Region II on July 13, 1976. We request that that letter be made a part of the record of today's hearing. I intend now to review briefly the field dispersion studies.

The field dispersion study is being carried out by EG&G Environmental Consultants of Waltham, Massachusetts. The dispersion test itself was conducted on September 9. While, for that reason, we have no details yet on the results, preliminary data show that the dispersion rate will be about what we had predicted last year.

The field study was carried out in the following manner:

The barge Grasselli normally uses is the "Sparkling Waters." It could not easily be modified on a temporary basis for the test to assure uniform waste discharge equivalent to a five-hour discharge rate. We have, therefore, selected the "Blue Line 108" which could be modified to allow a uniform rate of discharge by pumping.

The Grasselli wastewater was tagged with about 300 ppm of Rhodamine WT, a fluorescent dye. Transects were made through the barge wake as soon as possible after the wastewater was pumped into the ocean. During these transects, seawater was pumped from four depths on a continuous basis with a system consisting of a towed array of four hoses and four pumps. The seawater passed through four fluorometers and four pH meters, one set for each hose. Hoses were set to sample at 5, 15, 30 and 47 meters. During the test, the sea was relatively calm, wind was light, and an intense thermocline was present. These conditions would be least likely to enhance waste dispersion.

The dye and pH data were recorded on a digital data logger. This method provides data in much greater detail than has been obtained in previous barge dispersion studies reported in the literature. The picture of waste concentration as a function of space and time will be greatly improved.

Evaluation of the survey data is now being done by EG&G Environmental Consultants. We anticipate that a final report will be available before the end of October. At that time, it will be submitted to EPA for review. The results of that dispersion study will be combined with the bioassay data being developed to assess the reasonableness of our proposed five-hour dispersion time. We are confident that the results will show that a dispersion time of five hours or even less would be entirely consistent with criteria in Section 227 of the ocean dumping regulations for a Special Permit.

I would like at this time to introduce Dr. J. R. Gibson of our Haskell Laboratory who will discuss bioassay studies being done to substantiate that our methodology will closely evaluate the actual impact of our dumping operation on marine organisms.

STATEMENT OF DR. J. R. GIBSON
ON BEHALF OF DU PONT'S
GRASSELLI PLANT
AT
PUBLIC HEARING
SEPTEMBER 20, 1976, NEW YORK, NY

Good morning. My name is J. Robert Gibson. I am Chief of Aquatic Toxicology at Du Pont's Haskell Laboratory for Toxicology and Industrial Medicine in Newark, Delaware. My statement concerns toxicological and biological studies which Du Pont has performed to assess the environmental effects of ocean disposed wastewaters from its Grasselli Plant at Linden, New Jersey.

We believe that the data from these and other studies will fully support our request for a Special Ocean Disposal Permit which allows for a wastewater release time of approximately five hours or less.

Prior to the 1974 and 1975 public hearings regarding the Grasselli Plant permit, Du Pont developed and submitted data which were felt to be adequate to allow EPA to make a determination to grant a Special Permit for disposal of the Grasselli wastewaters. The EPA in 1975 made the determination that these wastewaters could be discharged under a Special Permit, but held that the requested release time of five hours was not justified on the basis of the data presented.

As a result of this determination, Du Pont elected to accept an interim permit and to work closely with the EPA in undertaking a more extensive research program, which we and the EPA felt would generate the data necessary for making a valid scientific determination as to an appropriate release time for these wastewaters.

Dr. Falk has discussed the studies which were performed to determine how the Grasselli wastewaters disperse after their release from a moving barge. The second part of our research program, which I will discuss, included a variety of toxicological studies which assessed the effects of the wastewaters on marine species.

I want to briefly summarize what we have found in these studies to date. The complete data package on the toxicological studies will be submitted to EPA after the hearing as a supplement to my statement. We request that the hearing record remain open until the final report is submitted.

In previous years, the data we submitted to EPA in support of our Special Permit request were acute data, from which a Limiting Permissible Concentration could be calculated. This year, however, our toxicological data includes results of subacute/subchronic and chronic studies as well as results of additional acute studies. These data, in conjunction with our previous toxicological data and dispersion data, represent the most comprehensive assessment of an ocean-disposal situation ever made.

To date, we have completed all the acute studies, the subacute/ subchronic studies and one of the two chronic studies.

The acute data, which describe the toxicity (LC50) of the wastewaters as a function of time and concentration, supplement the acute data we have submitted previously. The first series of slides present these data in both graphical and tabular forms.

The next slide summarizes the results of a Threshold LC50 Test. This test defines the extent of acute lethal action of the wastewater under continuous exposure conditions. These first few slides have dealt with lethal action of the wastewaters. The next several slides deal with sublethal effects of the wastewaters under continuous flow conditions.

Slide

Slide

Slide

Etc.

The next series of slides present data from our chronic (i.e., full-life-cycle) study.

Slide

Slide

Etc.

The most significant feature of this last slide is that we have been able to determine the concentration at or below which the wastewater is without any adverse effect upon the organism during its entire life span. This concentration is 750 ppm. It is important to recognize that these organisms were exposed continuously to this concentration of wastewater, and that this concentration is the no-effect concentration. What this means in terms of ocean disposal is simply that once the wastewaters have dispersed to a concentration equivalent to 750 ppm, the wastewaters cannot produce any adverse toxicological or biological effects. Furthermore, this concentration is the Limiting Permissible Concentration or LPC.

The concept of a Limiting Permissible Concentration (LPC) in determining acceptable discharge rates (i.e., release times) for ocean disposed wastewaters is acceptable and adequate in cases where the only available data on wastewater toxicity are results of acute bioassays. To our knowledge, EPA adopted this concept because of its acceptability and its flexibility in administering a broad and complex situation. LPC, in reality, is an <u>estimate</u> of a concentration which will be without effect in the marine environment (i.e., a chronic no-effect level).

As more data are accumulated on the toxicology of a particular wastewater, the LPC becomes of less and less practical utility. In other words, the LPC is used because certain data are not available. It follows that, when additional data are obtained, they should replace the LPC and should be used for determining discharge rate. We now have the data necessary for supplanting the LPC.

In addition to the fact that it is an estimate, the LPC concept has one great disadvantage in ocean-disposal situations; this being that it does not take into account the potential toxic effects of higher-than-LPC concentrations; i.e., it does not acknowledge continuous wastewater dispersion. Rather, the LPC concept implies that dispersion occurs instantaneously to the LPC and then proceeds no further. This does not happen.

The waste concentrations in the wake of a moving barge immediately begin to decline after release and finally - at some point in time - decline to levels indistinguishable from normal seawater concentrations of waste constituents. The rate of concentration decline is what we studied in the dispersion studies described by Dr. Falk. When those results are analyzed, we will know accurately the time required for dispersion to take wastewater concentrations down to an actual no-effect level, and we will know what concentrations exist and for how long they exist during the time between

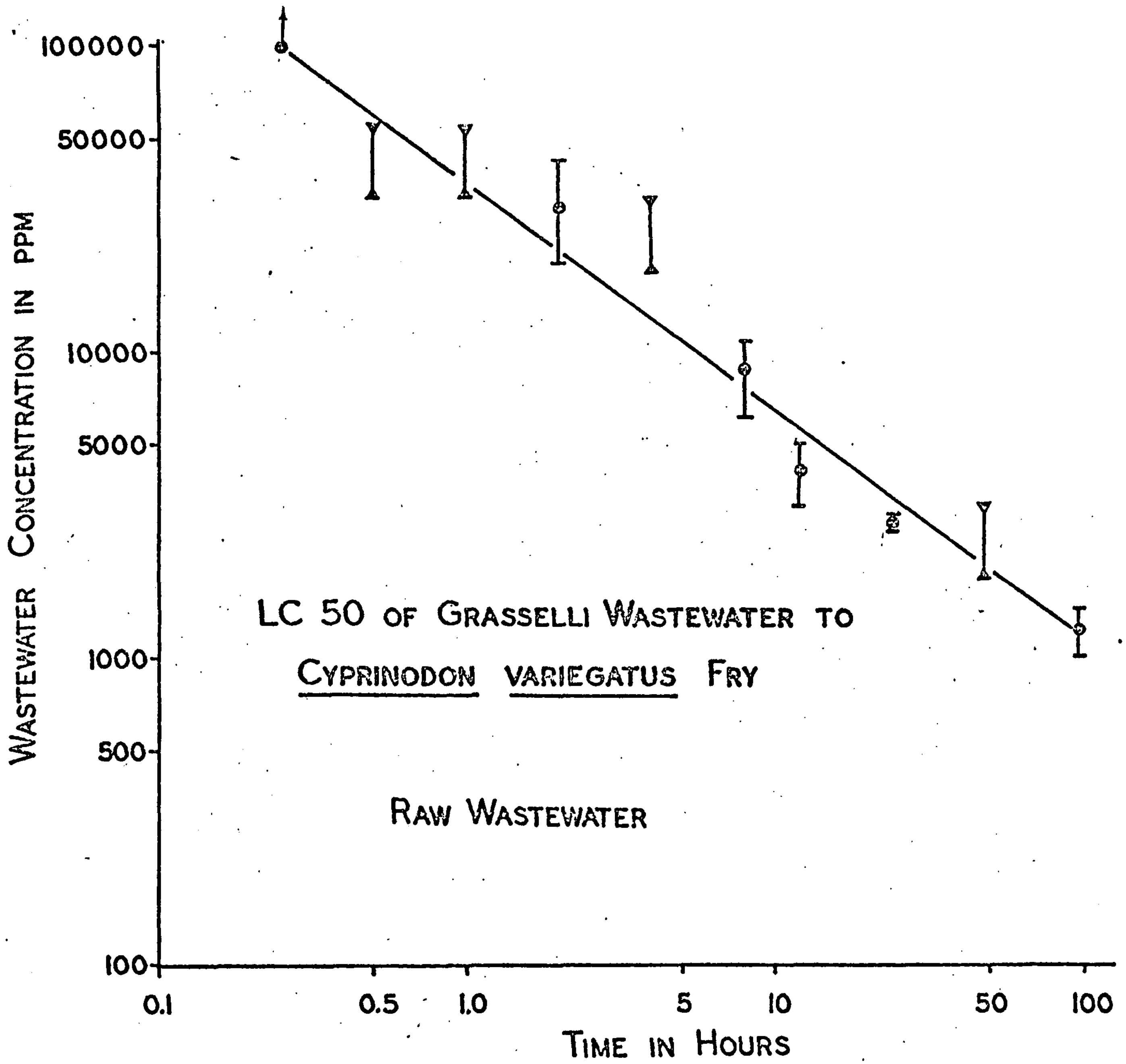
With this knowledge, the exposure times and concentrations involved can be considered in light of the acute and subacute data and thus a determination can be made as to whether effects would occur as a result of exposure to these higher than no-effect concentrations for the periods of time involved. I think that the next few slides will effectively illustrate this approach to determining release time.

Slides

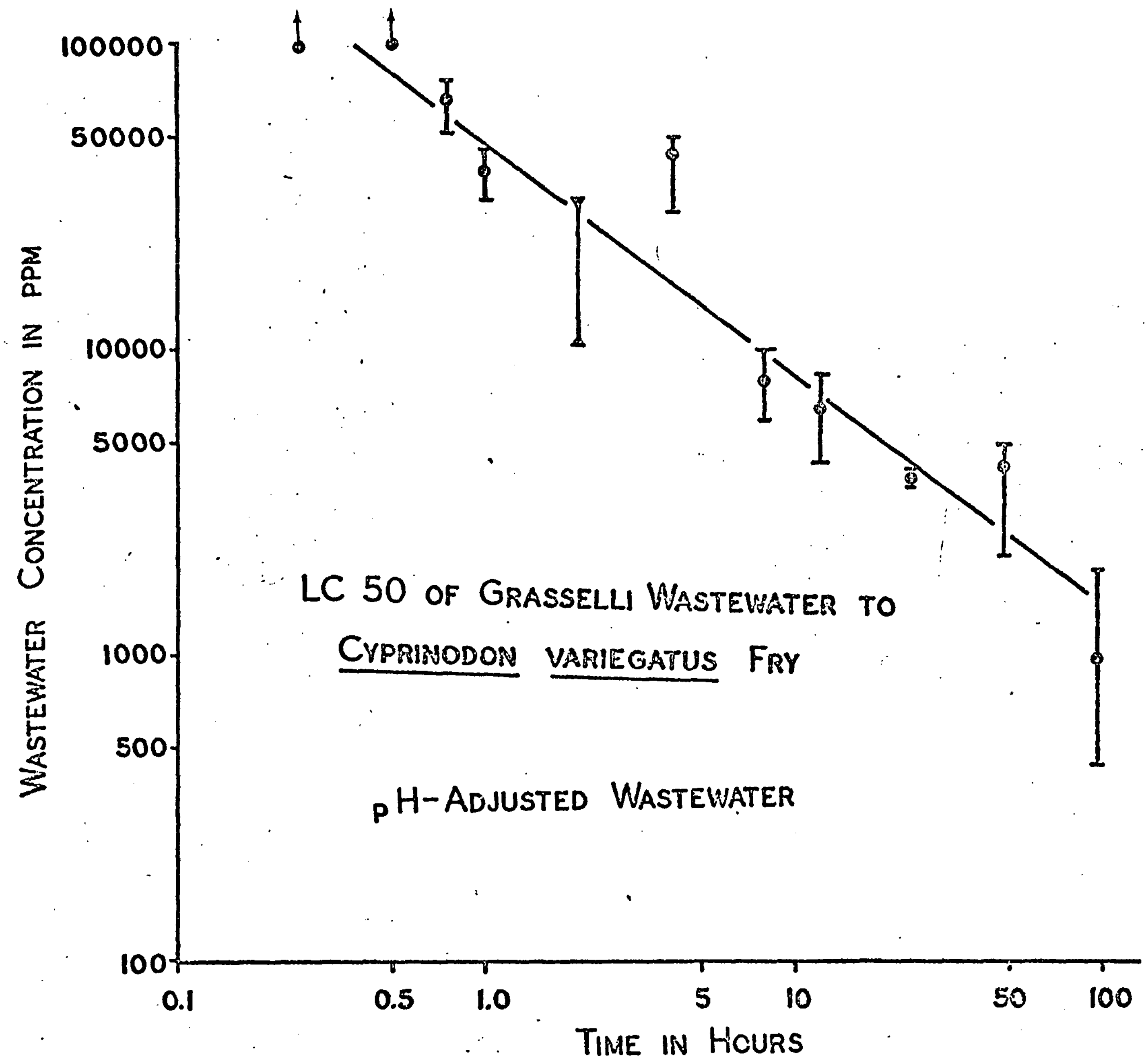
As a final check to insure the adequacy and safety of this approach, we ran a series of experiments in which fish and shrimp were exposed to declining wastewater concentrations. These experiments are summarized in the next few slides.

Slides

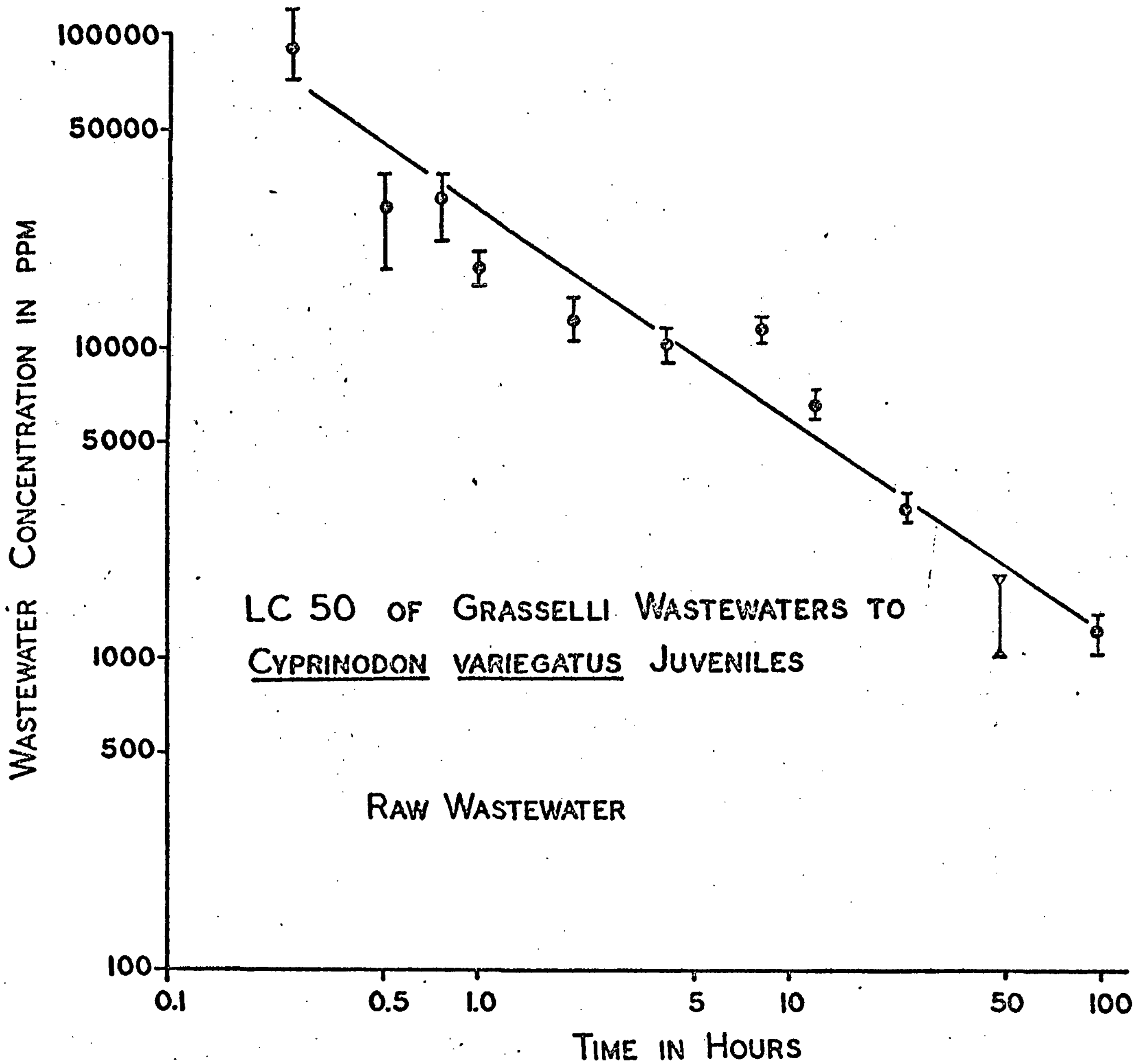
In summary, based upon the results we have obtained to date, we firmly believe that these wastewaters can be discharged into the ocean with a release time of approximately five hours with no environmental effects. When the results of the recent dispersion study at the actual disposal site are analyzed and coupled with the comprehensive toxicity data I have just discussed, we will be able to very accurately determine a discharge rate which will insure that disposal of these wastewaters presents no hazard in the marine environment.



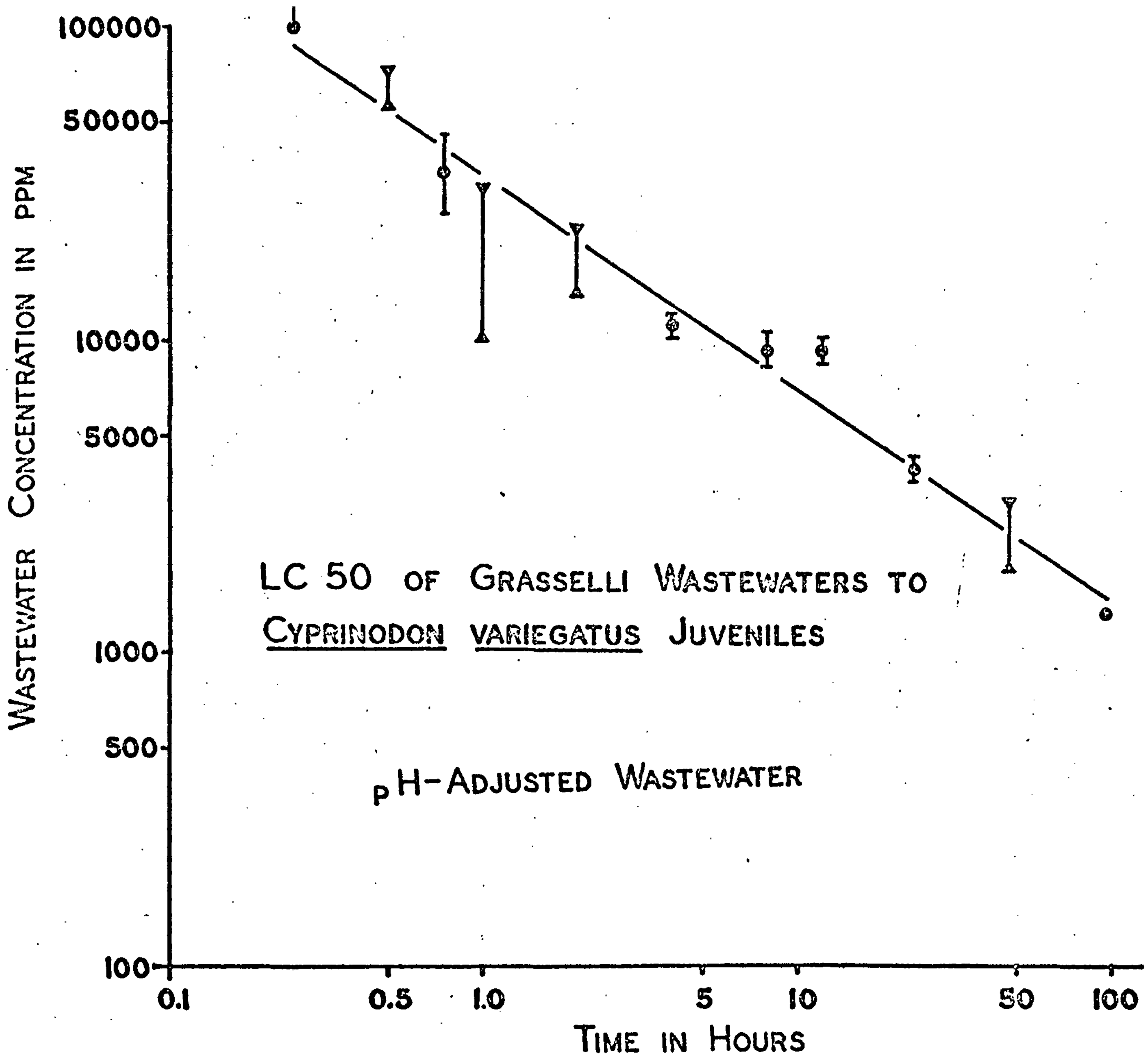
WASTEWATER CONCENTRATION IN PPM
100000
50000
10000
5000
1000
500
100
0.1
0.5
1.0
5
10
50
100
TIME IN HOURS
LC 50 OF GRASSELLI WASTEWATER TO
CYPRINODON VARIEGATUS FRY
RAW WASTEWATER



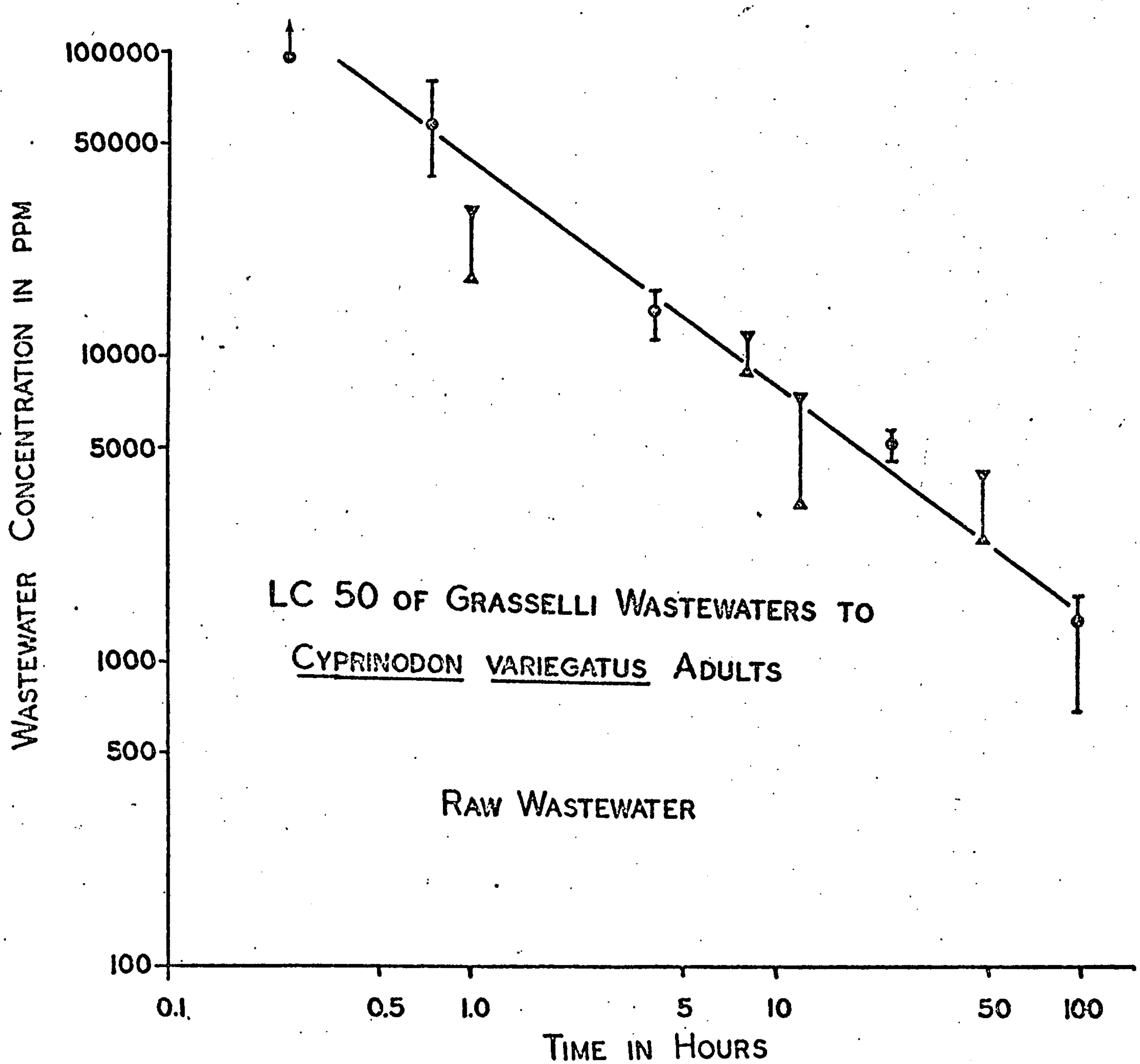
LC 50 of Grasselli Wastewater to
Cyprinodon variegatus Fry
pH-Adjusted Wastewater
Wastewater Concentration in PPM
100000
50000
10000
5000
1000
500
100
0.1
0.5
1.0
5
10
50
100
Time in Hours

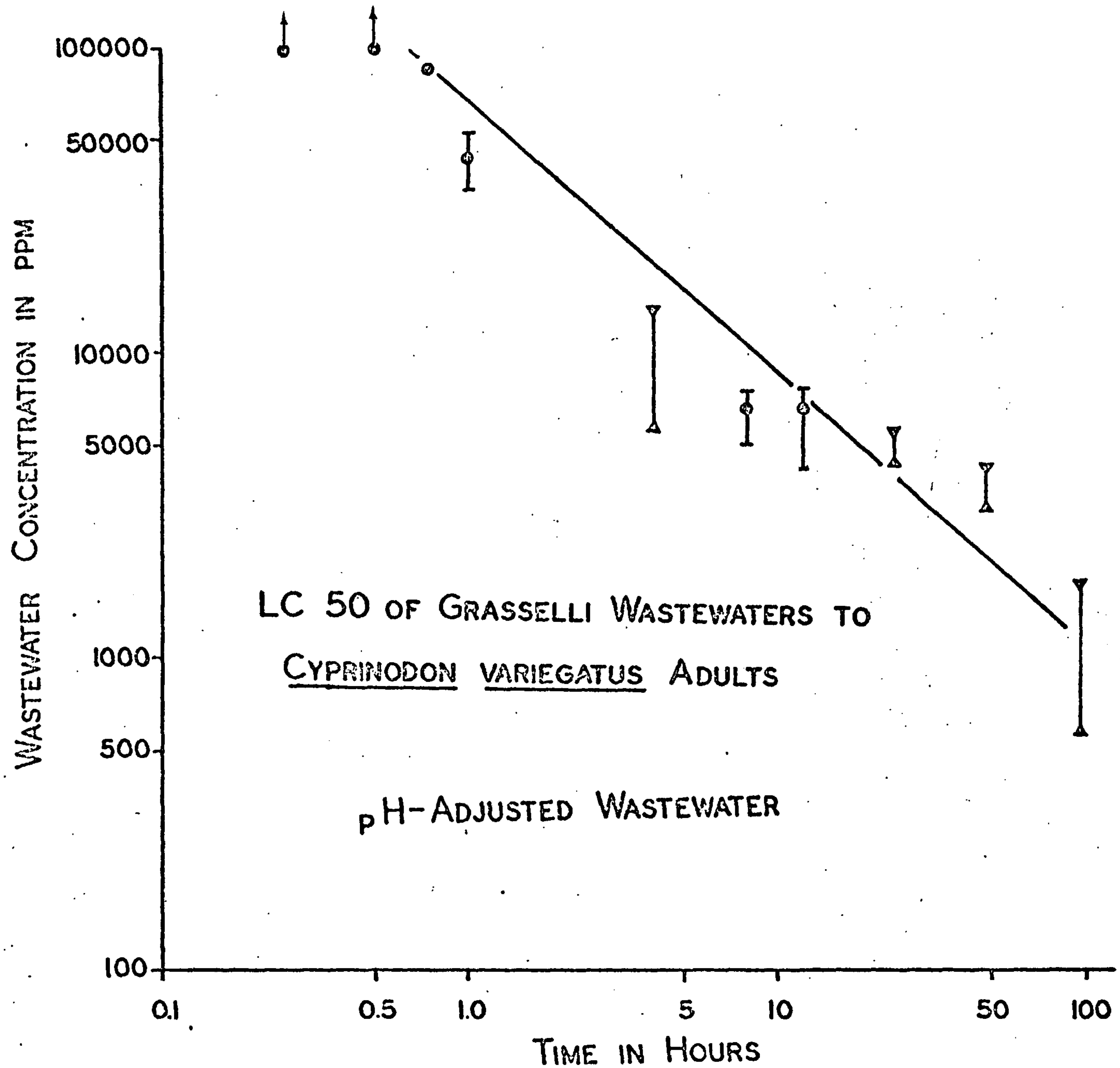


100000
50000
10000
5000
1000
500
100
0.1
0.5
1.0
5
10
50
100
WASTEWATER CONCENTRATION IN PPM
TIME IN HOURS
LC 50 OF GRASSELLI WASTEWATERS TO
CYPRINODON VARIEGATUS JUVENILES
RAW WASTEWATER

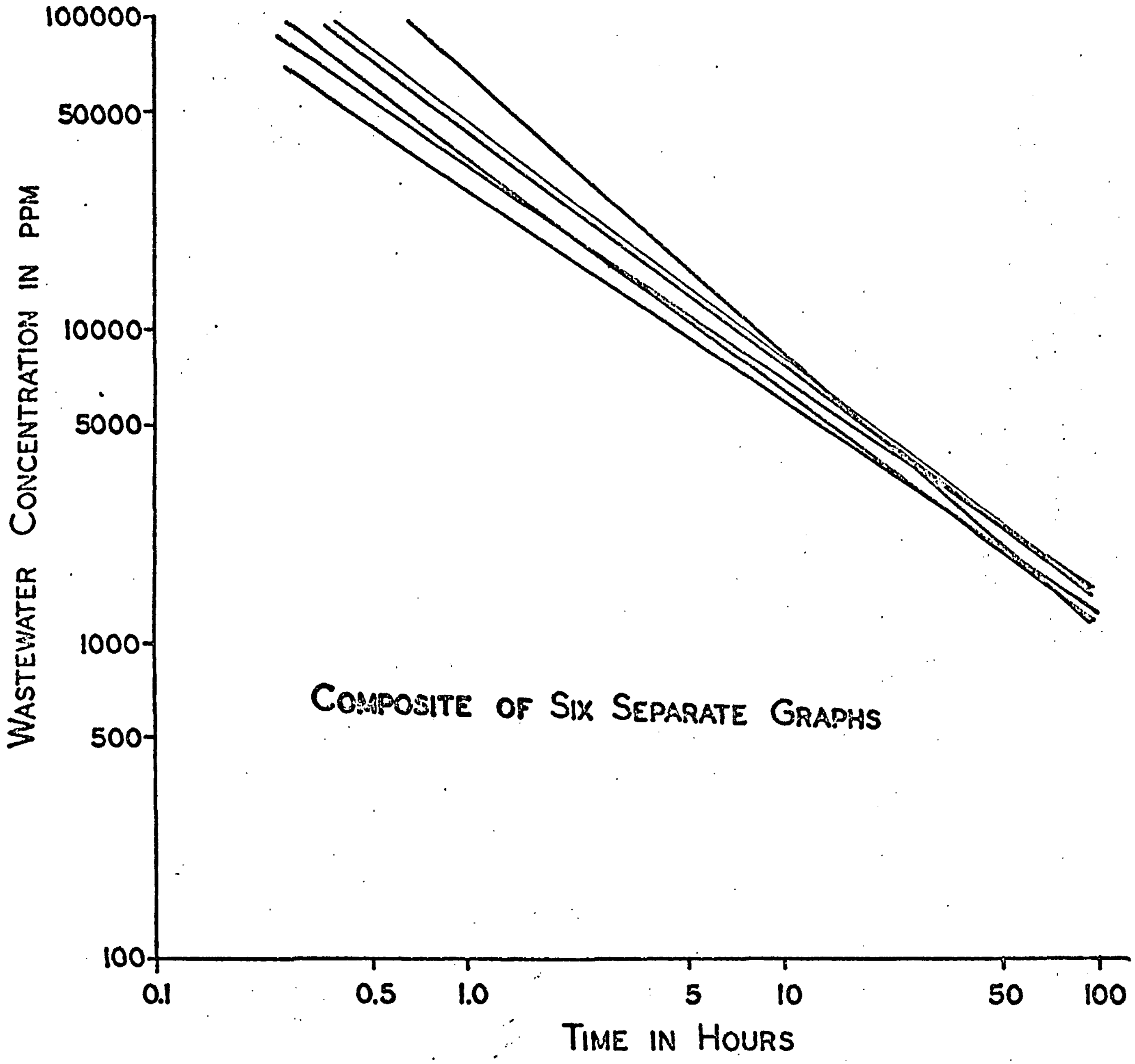


LC 50 of Grasselli Wastewaters to
Cyprinodon variegatus Juveniles
pH-Adjusted Wastewater
Wastewater Concentration in PPM
100000
50000
10000
5000
1000
500
100
0.1
0.5
1.0
5
10
50
100
Time in Hours


100000
50000
10000
5000
1000
500
100
Wastewater Concentration in PPM
0.1
0.5
1.0
5
10
50
100
Time in Hours
LC 50 of Grasselli Wastewaters to
Cyprinodon variegatus Adults
Raw Wastewater



LC 50 of Grasselli Wastewaters to
Cyprinodon variegatus Adults
pH-Adjusted Wastewater
Wastewater Concentration in ppm
100000
50000
10000
5000
1000
500
100
0.1
0.5
1.0
5
10
50
100
Time in Hours


100000
50000
10000
5000
1000
500
100
Wastewater Concentration in ppm
Composite of Six Separate Graphs
0.1
0.5
1.0
5
10
50
100
Time in Hours

## EFFECT OF GRASSELLI WASTEWATER ON HATCHABILITY OF *CYPRINODON VARIEGATUS* EGGS

| Wastewater Concentration (ppm) | Source of Data | Mean Percent Hatch |
|---|---|---|
| 188 | Chronic Study | 98 |
| 375 | Chronic Study | 96 |
| 712 | Subchronic Study | 95 |
| 750 | Chronic Study | 95 |
| 949 | Subchronic Study | 89 |
| 1266 | Subchronic Study | 95 |
| 1500 | Chronic Study | 86 |
| 1687 | Subchronic Study | 94 |
| 2250 | Subchronic Study | 94 |
| 3000 | Subchronic Study | 96 |
| 4000 | Subchronic Study | 98 |
| Control | Subchronic Study | 96 |
| Control | Chronic Study | 98.5 |

## LC50'S* OF GRASSELLI WASTEWATER TO 1-7 DAY OLD FRY OF *C. VARIEGATUS* FOR VARIOUS EXPOSURE TIMES

| Exposure Time (Hr.) | LC50 in ppm (95% CL) Raw Waste | LC50 in ppm (95% CL) pH Adjusted Waste |
|---|---|---|
| 0.25 | > 100000 | > 100000 |
| 0.5 | < 56000 > 32000 | > 100000 |
| 0.75 | 79742 (51643-118604) | 67529 (52379-77942) |
| 1.0 | < 56000 > 32000 | 38799 (32561-45139) |
| 2.0 | 30806 (19022-41969) | < 32000 > 10000 |
| 4.0 | < 32000 > 18000 | 43240 (28397-50431) |
| 8.0 | 9019 (6148-10732) | 8006 (5863-9666) |
| 12.0 | 4269 (3133-5001) | 6659 (4303-8480) |
| 24.0 | 2771 (2596-2957) | 3813 (3527-4126) |
| 48.0 | < 3200 > 1800 | 4221 (2229-4965) |
| 96.0 | 1269 (1043-1467) | 978 (442-1916) |

* LC50 values reflect mortality which occurred during exposure plus a 96-hour post-exposure period.

LC50'S*OF GRASSELLI WASTEWATER TO 30-DAY-OLD JUVENILE *C. VARIEGATUS* FOR VARIOUS EXPOSURE TIME

| Exposure Time (Hr.) | LC50 in ppm (95% CL) | |
|---|---|---|
| | Raw Waste | pH Adjusted Waste |
| 0.25 | 93595 (73385-107358) | > 100000 |
| 0.5 | 28448 (18265-36758) | < 75000 > 56000 |
| 0.75 | 30661 (27733-36656) | 34095 (26028-46283) |
| 1.0 | 18570 (16162-20485) | < 32000 > 10000 |
| 2.0 | 12376 (10834-14558) | < 24000 > 14000 |
| 4.0 | 10453 (8955-11733) | 11397 (10235-12431) |
| 8.0 | 11616 (10724-12549) | 9347 (8366-10743) |
| 12.0 | 6731 (6133-7318) | 9403 (8550-10223) |
| 24.0 | 3074 (2822-3336) | 3842 (3513-4152) |
| 48.0 | < 1800 > 1000 | < 3200 > 1800 |
| 96.0 | 1249 (1027-1383) | 1327 |

* LC50 values reflect mortality which occurred during exposure plus a 96-hour post-exposure period.

LC50'S* OF GRASSELLI WASTEWATER TO ADULT *C. VARIEGATUS* FOR VARIOUS EXPOSURE TIMES

| Exposure Time (Hr.) | LC50 in ppm (95% CL) | |
|---|---|---|
| | Raw Waste | pH Adjusted Waste |
| 0.25 | > 100000 | > 100000 |
| 0.5 | 43900 | > 100000 |
| 0.75 | 59420 (39750-81200) | 86401 |
| 1.0 | < 32000 > 18000 | 43555 (34359-52745) |
| 2.0 | | 57734 |
| 4.0 | 14172 (11691-16717) | < 14000 > 5600 |
| 8.0 | < 12000 > 8700 | 6355 (4977-7524) |
| 12.0 | < 7500 > 3200 | 6567 (4229-7756) |
| 24.0 | 5226 (4595-5743) | 5774 |
| 48.0 | < 4200 > 2400 | < 4200 > 3200 |
| 96.0 | 1370 (679-1634) | |

* LC50 values reflect mortality which occurred during exposure plus a 96-hour post-exposure period.

SUMMARY OF MORTALITY EXPERIENCED BY C. VARIEGATUS DURING THE FIRST 28 DAYS POST-HATCH AS A RESULT OF EXPOSURE TO VARIOUS CONCENTRATIONS OF pH-ADJUSTED GRASSELLI WASTEWATER

| Concentration (µl/1; ppm) | Mortality | | | | | |
|---|---|---|---|---|---|---|
| | Exposure | | | | Post-Exposure | |
| | Day 14 | | Day 28 | | Day 42 | |
| | Number | (%) | Number | (%) | Number | (%) |
| Control A | 1 | (2.5) | 2 | (5.0) | 2 | (5.0) |
| Control B | 0 | (0) | 0 | (0) | 0 | (0) |
| 712 ppm A | 0 | (0) | 0 | (0) | 0 | (0) |
| 712 ppm B | 0 | (0) | 0 | (0) | 0 | (0) |
| 949 ppm A | 4 | (10.0) | 4 | (10.0) | 4 | (10.0) |
| 949 ppm B | 1 | (2.5) | 1 | (2.5) | 1 | (2.5) |
| 1,266 ppm A | 0 | (0) | 0 | (0) | 0 | (0) |
| 1,266 ppm B | 0 | (0) | 3 | (7.5) | 4 | (10.0) |
| 1,687 ppm A | 3 | (7.5) | 4 | (10.0) | 4 | (10.0) |
| 1,687 ppm B | 0 | (0) | 0 | (0) | 0 | (0) |
| 2,250 ppm A | 2 | (5.0) | 10 | (25.0) | 11 | (27.5) |
| 2,250 ppm B | 19 | (47.5) | 28 | (70.0) | 28 | (70.0) |
| 3,000 ppm A | 38 | (95.0) | 39 | (97.5) | 39 | (97.5) |
| 3,000 ppm B | 30 | (75.0) | 39 | (97.5) | 39 | (97.5) |
| 4,000 ppm A | 39 | (97.5) | 40 | (100) | 40 | (100) |
| 4,000 ppm B | 40 | (100) | 40 | (100) | 40 | (100) |

MEAN LENGTH AMONG GROUPS OF C. VARIEGATUS FRY EXPOSED TO pH-ADJUSTED GRASSELLI WASTEWATER DURING THE FIRST 28 DAYS POST-HATCH

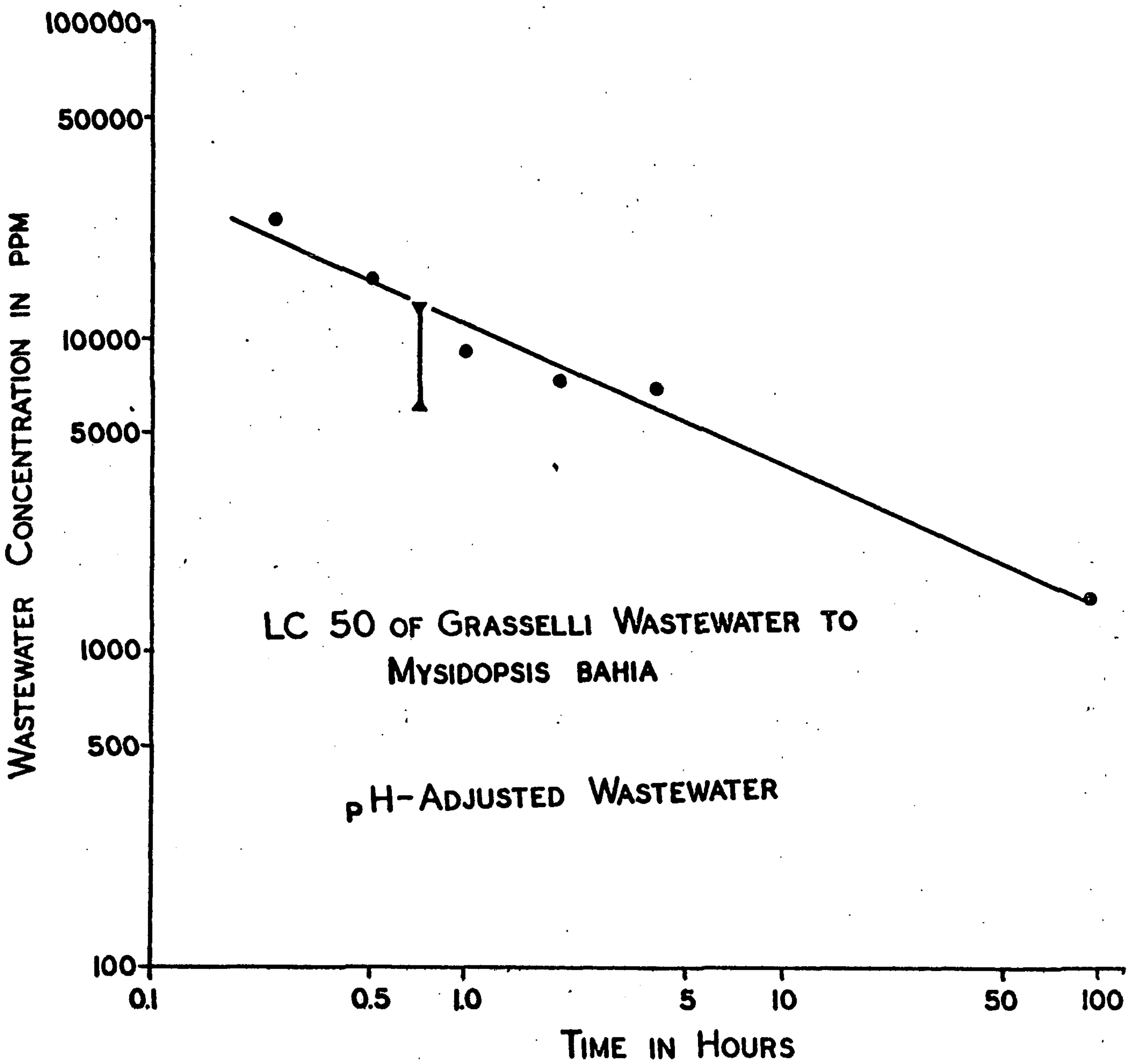
| Nominal Concentration (µl/1; ppm) | Mean Standard Length (in Centimeters) and Standard Deviation | | |
|---|---|---|---|
| | Exposure | | Post-Exposure |
| | Day 14 | Day 28 | Day 42 |
| Control A | 0.5 ± 0.1 | 1.2 ± 0.2 | 1.3 ± 0.2 |
| Control B | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 712 ppm A | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 712 ppm B | 0.8 ± 0.2 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 949 ppm A | 0.5 ± 0.1 | 1.2 ± 0.1 | 1.4 ± 0.1 |
| 949 ppm B | 0.6 ± 0.2 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 1,266 ppm A | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 1,266 ppm B | 0.6 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1 |
| 1,687 ppm A | 0.5 ± 0.2 | 1.2 ± 0.2 | 1.3 ± 0.2 |
| 1,687 ppm B | -[a] | 1.3 ± 0.1 | 1.3 ± 0.1 |
| 2,250 ppm A | 0.5 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.2 |
| 2,250 ppm B | 0.5 ± 0.1 | 1.4 ± 0.1 | 1.7 ± 0.2 |
| 3,000 ppm A | 0.5 ± 0.1 | 1.6 ± 0.0 | 2.4 ± 0.0 |
| 3,000 ppm B | 0.5 ± 0.0 | 1.8 ± 0.0 | 2.5 ± 0.0 |
| 4,000 ppm A | -[b] | - | - |
| 4,000 ppm B | -[b] | - | - |

[a] No measurements

[b] No fish

## SUMMARY OF TIME-INDEPENDENT TOXICITY TEST WITH GRASSELLI pH-ADJUSTED WASTEWATER

| Nominal Concentration (ppm) | Mortality: Exposure 24 hr. No. (%) | 48 hr. No. (%) | 96 hr. No. (%) | 144 hr. No. (%) | 192 hr. No. (%) | 240 hr. No. (%) | Post-Exposure 336 hr. No. (%) |
|---|---|---|---|---|---|---|---|
| Control | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 1,050 ppm | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 1,400 ppm | 0 (0) | 0 (0) | 0 (0) | 3 (15) | 5 (25) | 5 (25) | 5 (25) |
| 1,867 ppm | 0 (0) | 0 (0) | 0 (0) | 4 (20) | 4 (20) | 4 (20) | 4 (20) |
| 2,489 ppm | 0 (0) | 0 (0) | 1 (5) | 4 (45) | 18 (90) | 18 (90) | 18 (90) |
| 3,319 ppm | 7 (35) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) |
| 4,425 ppm | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) |
| 5,900 ppm | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) | 20 (100) |



100000
50000
10000
5000
1000
500
100
0.1
0.5
1.0
5
10
50
100
Wastewater Concentration in PPM
Time in Hours
LC 50 of Grasselli Wastewater to Mysidopsis bahia
pH-Adjusted Wastewater

SURVIVAL OF *C. VARIEGATUS* EXPOSED FOR THE FIRST 150 DAYS OF THEIR LIFE CYCLE TO VARIOUS CONCENTRATIONS OF pH-ADJUSTED GRASSELLI WASTEWATER

| Wastewater Concentration (ppm) | % Survival Through 150 Days | |
|---|---|---|
| | Replicate A | Replicate B |
| 188 | 100 | 100 |
| 375 | 100 | 100 |
| 750 | 100 | 100 |
| 1500 | 100 | 96 |
| 3000 | 0 | 0 |
| Control | 100 | 100 |

EGG PRODUCTION AMONG FEMALE *C. VARIEGATUS* EXPOSED TO VARIOUS CONCENTRATIONS OF pH-ADJUSTED GRASSELLI WASTEWATER

| Wastewater Concentration (ppm) | Number of Eggs Produced* First Spawning | Second Spawning |
|---|---|---|
| 188 | 1010 | 1095 |
| 375 | 999 | 1177 |
| 750 | 1162 | 908 |
| 1500 | 1064 | 1373 |
| Control | 2270 | 848 |

* Total of two replications at each spawning period.

PERCENT HATCHABILITY OF EGGS PRODUCED BY FEMALE *C. VARIEGATUS* WHICH HAD BEEN EXPOSED TO VARIOUS CONCENTRATIONS OF pH-ADJUSTED WASTEWATER

| Wastewater Concentration (ppm) | Mean Percent Hatch* | |
|---|---|---|
| | First Spawning | Second Spawning |
| 188 | 98 | 97 |
| 375 | 96 | 86 |
| 750 | 95 | 84 |
| 1500 | 86 | 90 |
| Control | 99 | 96 |

* Average of two replications at each spawning period.

SURVIVAL OF SECOND GENERATION *C. VARIEGATUS* FRY EXPOSED TO VARIOUS CONCENTRATIONS OF pH-ADJUSTED GRASSELLI WASTEWATER

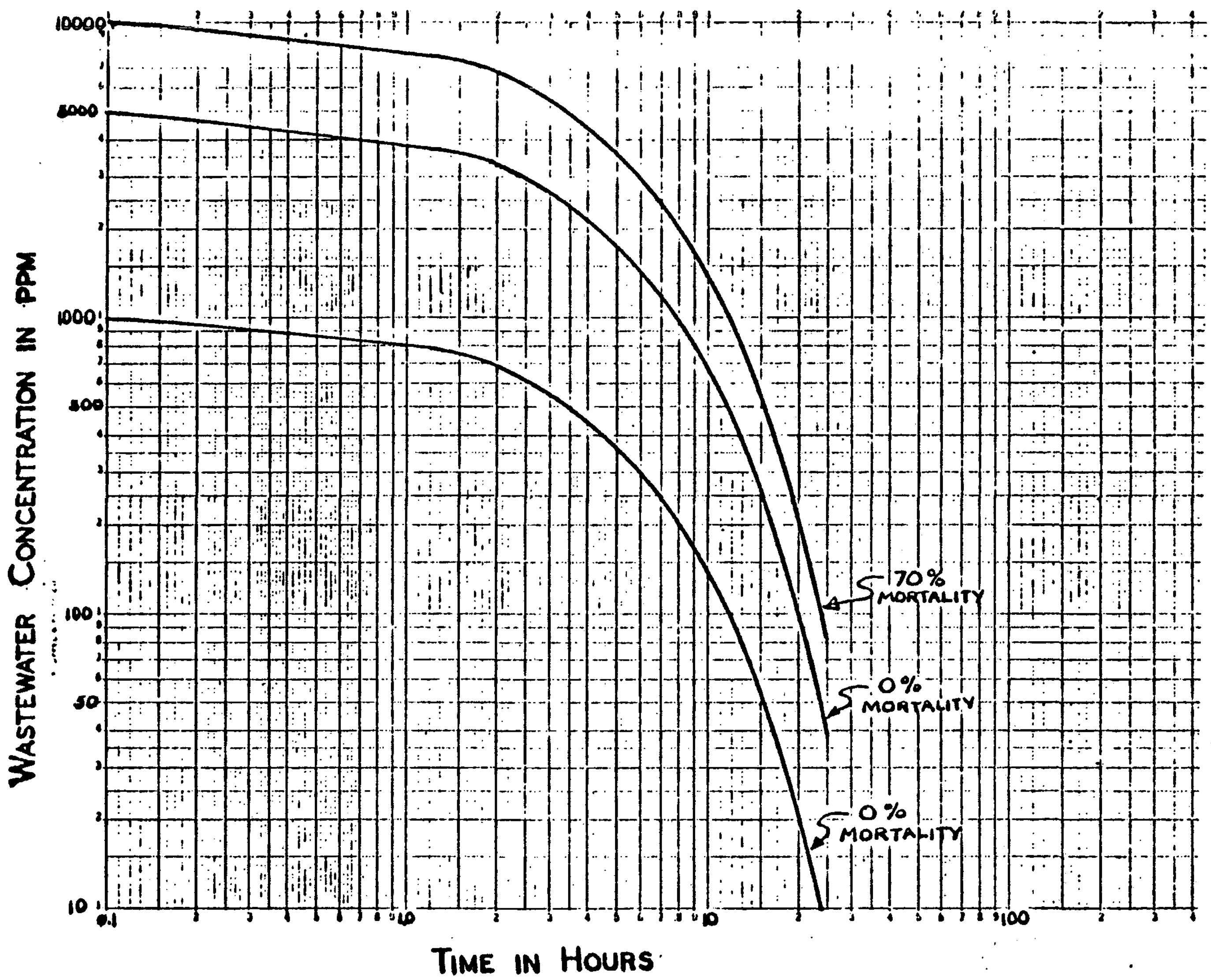
| Wastewater Concentration (ppm) | % Survival |
|---|---|
| 188 | 100 |
| 375 | 85 |
| 750 | 93 |
| 1500 | 95 |
| Control | 93 |

SUMMARY OF EFFECTS OBSERVED DURING
CHRONIC EXPOSURE OF *C. VARIEGATUS* TO VARIOUS CONCENTRATIONS
OF pH-ADJUSTED GRASSELLI WASTEWATER

| Wastewater Concentration (ppm) | Observed Effects Through 150 Days of Exposure |
|---|---|
| 188 | None |
| 375 | None |
| 750 | None |
| 1500 | Slightly Impaired Egg Hatchability* |
| 3000 | Complete Mortality |
| Control | None |

* This effect may not be due to direct action of the wastewaters.

SIMULATED WASTEWATER DISPERSIONS TO WHICH C. VARIEGATUS WERE EXPOSED FOR 24 HOURS



SIMULATED WASTEWATER DISPERSIONS TO WHICH C. VARIEGATUS WERE EXPOSED FOR 24 HOURS