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COMPUTER MAPPING OF INDUSTRIAL HYGIENE SAMPLING DATA

Terminal Progress Report

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NIOSHTIC

Acknowledgements

This research was largely stimulated and made possible through the collaborative research atmosphere of the Occupational Health Studies Group in the School of Public Health, University of North Carolina at Chapel Hill. Recognition is due to Wayne Gerber whose original and intent interest in computer mapping precipitated the funded proposal for which this is the final report. In Wayne Gerber's absence, Yoko S. Crume and Ying So organized the data for the examples and devised the elaborate labeling of Maps B1 and B2. The expert programming of Ying So produced the required maps in an efficient, accurate manner. The skillful and patient typing of Pamela Hooker is also gratefully acknowledged.

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I. Introduction

The summarization and presentation of industrial hygiene data has been a point of interest for the Occupational Health Studies Group for a number of years. Computer mapping was explored for these purposes by Gerber, et al. [1977]. Initial results were very favorably received, but the maps produced, of course, interpolated between points where measurements were taken and extrapolated to the boundaries of the sampled area, corresponding to the segment of the manufacturing process of interest. The stability associated with the exposure surface created by these programs is uncertain. Direct variance calculations for a specific point on the floor plan would be cumbersome since the algorithms utilize several local observations and consider their distance from the point on the floor plan. Alternatively, the use of a jackknife procedure was proposed. This report contains the results of research on the use of the jackknife procedure to provide standard error estimates for exposure surfaces created from industrial hygiene sampling data.

II. Description of Industrial Hygiene Data

The materials for this study were industrial hygiene measurements in three different situations, each representing a different type of exposure. The floor plan and sample locations for each situation are given in Appendix A, along with a listing of the measurements utilized in this report. The natural logarithm scale was used in the mapping so that the linear interpolation in the mapping programs would be more appropriate.

(1) Situation #1 is the Heavy Duty Tire Building Area of an automobile tire and tube manufacturing plant. Hexane and toluene measurements are utilized to illustrate the procedure for solvents.

(2) Situation #2 is a rectangular airplane hangar in which noise measurements were recorded at various locations with an airplane engine running. Since the noise measurements are on a logarithm scale, here the dBA scale, the measurements as recorded were used in the mapping program.

(3) Situation #3 is Banbury and Compound Room in the same automobile tire and tube manufacturing plant as in Situation #1. The logarithm of total dust was used in the mapping program.

III. Computer Mapping Programs

Two programs, SYMAP and Surface II, can provide a contour map display of industrial hygiene data. The SYMAP program was chosen for this project because of its simple approach and easy access. The choice of whether to map the logarithm of observations, or the original measurements, is a more important decision than which program to utilize. A transformation of the data so that the linear interpolation and extrapolation procedures of these programs provides a reasonable approximation to the exposure surface is the more important concern.

The surface height is represented by the degree of shading printed on the two dimensional representation of the coordinates of the floor plan and sample locations. See Appendix A for four examples. In these examples the maps are created assuming that a smooth continuum underlies the data values. For more details the SYMAP manual should be consulted.

The SYMAP printer plots for the situations and data presented in Appendix A are reproduced in Appendix B. Notice that Situation #1 has data for two solvents, hence the four maps for three distinct industrial hygiene sampling situations.

There are several features of these maps that are noteworthy:

(1) The sampling points are denoted by a '*' or a digit corresponding to the category of shading of the exposure height.

(2) Rather elaborate labeling can also be worked into the output as is illustrated with the hexane and toluene data.

(3) The total range in these maps was divided into four or five levels, based upon the median and range of the observed values.

The actual program deck used to generate the hexane map is listed as Appendix C.

IV. Jackknife Variance Estimation

The essence of the jackknife procedure is obtaining several parameter estimates by successively deleting single observations. The exposure level at each coordinate of the contour map is the parameter of interest. A jackknife estimate of the variability of the entire surface, and hence each coordinate of the sampled area, is obtained by successively deleting each industrial hygiene measurement. For example, in the Heavy Duty Tire Building Area 16 hexane measurements were taken. Corresponding to the omission of each of the 16 observations in turn, 16 jackknifed maps are produced, each based upon the remaining 15 observations.

To present the procedure algebraically, note that the printer plotter map, for example those in Appendix B, are composed of a shading symbol plotted at each coordinate of the sampled area floor plan. This is the result of a categorization of the smooth exposure level estimates created by the computer program. For any coordinate location on a floor plan, let $\hat{\theta}$ be the estimated exposure level based upon the full set of industrial hygiene measurements. Let $\hat{\theta}_{-i}$ be the estimated exposure level based upon the estimated surface obtained by omitting the i^{th} observation. The jackknife procedure calculates the pseudo-values

$$P_i = n\hat{\theta} - (n-1)\hat{\theta}_{-i} , \tag{1}$$

for i = 1, 2, ...,n, with n being the number of samples available. The jackknifed estimator of the mean surface height at this floor plan coordinate then is

$$\tilde{\theta} = \frac{1}{n}\sum_{i=1}^{n} P_i = n\hat{\theta} - \frac{n-1}{n}\sum_{i=1}^{n}\hat{\theta}_{-i} . \tag{2}$$

More importantly, the jackknife procedure provides a distribution-free estimate of variance for the parameter estimator, specifically

$$\hat{V}(\tilde{\theta}) = \frac{1}{n(n-1)}\sum_{i=1}^{n}(P_i - \tilde{\theta})^2. \tag{3}$$

Equivalently, the sample variance of the pseudo-values P_i divided by n as given in (3) can be computed as follows:

$$\hat{V}(\tilde{\theta}) = \frac{(n-1)^2}{n}\left[\frac{1}{n-1}\sum_{i=1}^{n}(\hat{\theta}_{-i} - \bar{\hat{\theta}}_{-.})^2\right], \tag{4}$$

where $\bar{\hat{\theta}}_{-.}$ is the mean of the $\hat{\theta}_{-i}$. It is form (4) that is utilized in the computer programs developed for the purposes of this research.

Variance (3), or equivalently (4), can also be used to estimate the variance of $\hat{\theta}$, the surface height estimated at each coordinate using the full set of n industrial hygiene samples.

In general, the jackknife estimator $\tilde{\theta}$ in (2) and $\hat{\theta}$ are not equal and the jackknife variance $\hat{V}(\tilde{\theta})$ in (3) or (4) is biased, specifically providing a variance for $\hat{\theta}$ that is too large. However, the use of variance (3) or (4) for $\hat{\theta}$ then will be conservative. The statistically interested reader should examine the review paper by Miller [1974]. The focus here is on the use of the jackknife variance as a guide to the precision of computer maps for industrial hygiene data. Large sample properties of the jackknife procedure are favorable. However, its use in small sample situations, such as described by the data in Appendix A, should be taken only as a guide to the reliability of exposure level estimates from computer mapping programs.

For the computer mapping application then, the surface height estimates for n maps are required. For each map the estimate at each coordinate must be accessed to permit calculation of the $\hat{\theta}_{-i}$ and variance estimate $\hat{V}(\tilde{\theta})$ in (4). This requires saving the map resulting from each deleted industrial hygiene sample so that these calculations can then be performed. Special programs were required and listings of these are contained in Appendix D.

The need for the jackknife variance estimate requires a more in-depth description of the SYMAP computer mapping program. The program calculates an interpolated or extrapolated value at each coordinate within the study area based upon the industrial hygiene sampling data. The interpolation is performed in two steps: first, a primary interpolation is made from the generally irregularly-spaced original sample values to a rectangular matrix of the interpolated values. A second linear interpolation is made between the locations from the primary interpolation. As can be seen, due to the complexity of the two step process of interpolation, the dependence of the final interpolated values upon the original observations is obscure, making direct computation of the standard error of the interpolation intractable. Hence, the rationale for the jackknife approach to this problem becomes essentially one of a necessity.

The sequence of computer programs in Appendix D generates, stores, retrieves, computes the jackknife standard deviations on the interpolated values and produces a map of the jackknife standard deviations. The programs are listed and described below:

(i) Program #1 produces the SYMAP contour map for the toluene data in Appendix A and stores the interpolated values for each coordinate of the study area in a SAS data set.

(ii) Program #2 is a sequence of SYMAP runs in each of which four maps are produced as each of four observations is successively deleted. Additional JCL is required for each batch of four maps that can be produced with one JCL specification of SYMAP. Program #2a produces four maps by successively deleting the first four observations, Program #2b the next four, and so on until the n required maps are produced. These jackknife maps contain the interpolated values for each coordinate of the study area and are stored in a SAS data set.

(iii) Program #3 computes the mean and standard deviation of the jackknife maps stored by the Program #2 series.

(iv) Program #4 produces a contour map of the jackknife standard error of the SYMAP interpolation. The shadings correspond to the 0-50, 50-90, 90-99 and over 99 percentile categories of the standard errors.

V. Results

A. General

The jackknife standard deviation maps for the four data sets in Appendix A are reproduced in Appendix E. Pair-wise comparison of the contour map for the exposure level of the industrial hygiene measurement maps: B1, B2, B3 and B4 of Appendix B and the corresponding jackknife standard deviation maps: E1, E2, E3 and E4, reveals three distinct features.

(1) The least reliable region of the exposure surface is not necessarily where the exposures are greatest. The extrapolation from areas of high levels to areas of low levels can result in the largest standard deviations for the estimated surface. See for example the top (or left) portion of maps B1 and E1, corresponding to hexane measurements in the heavy duty tire building area. Notice that there is no replicate, or neighboring sample, in that area of lowest category of exposure level. This phenomenon occurs again in the center of the map for toluene; see map B2 and the corresponding standard deviations in map E2.

(2) Areas of instability in the estimated exposure levels can result at locations of highest levels also, especially when these occur near the boundary of the sampled area. Note

especially the bottom right of the pair of Maps B1 and E1 and Maps B2 and E2. Again a pair of observations at this location would have been helpful.

(3) An area of instability can also appear on the "shoulder" of a peak. See especially Maps B3 and E3 on the diagonal to the lower right from the center. This is probably due to the inadequacy of the linear extrapolation from the "top of the hill" to its base.

B. Approximate Confidence Limits

Large sample normality can only be approximately satisfied in these applications but affords a guide to constructing approximate confidence limits. For a specific point on the floor plan of one of the Appendix B maps, the exposure level estimate plus and minus two standard deviations from the corresponding E map location provides approximate 95% confidence limits on the underlying surface. Linear extrapolation from the centers of two adjacent contour heights can be utilized to approximate the surface height on the B map, and likewise the standard error on the E map, for the location of interest.

Although the interpolation details of the confidence interval construction are left to the reader, it is noteworthy that these limits can be very large. For example from the noise map E3, the standard error for portions of that map can be in excess of 5.0 dBA units. Confidence limits constructed for such areas would be essentially the surface height estimate from Map B3 plus and minus 10.0 dBA units. These are <u>extremely</u> large limits reflecting a very unstable estimate of noise level at some locations. Strategies to reduce such variability naturally seem important. The following summary begins to address this important point in the section on Industrial Hygiene Survey Design Implications.

VI. Summary and Applications

A. Summary

Stability of SYMAP contour maps was quantified by the use of a jackknife estimate of the standard deviation. Programs and examples were provided illustrating the results obtainable in a variety of industrial hygiene sampling situations.

B. Industrial Hygiene Survey Design Implications

One observation seems to be apparent from the results of this research. A tool is available to assist in the design of industrial hygiene sampling. Objective means to represent the variance of an estimated exposure surface is available from the maps of Appendix E. Simulation, for example, could be utilized to allocate a fixed number of industrial hygiene samples that would "minimize" the jackknife standard deviation surface map. Various criteria could be proposed to detail what "minimize" is to mean.

Setting such criteria specification aside, as they would require substantial discussion, consider the following illustration. In Figure F1 of Appendix F, the relocation of two samples for total dust in the banbury and compounding area is indicated by arrows. After relocation of the sampling site, they are also assigned values representative of the logarithm of total dust at their new site. Figure F2 is a reduced version of Map B4, representing the "before" contour map. Figure F3 is the same reduction of a SYMAP with the two relocated and adjusted values. This is the "after" SYMAP contour map. These two maps are very comparable as estimates of the logarithm of total dust in this banbury and compounding area.

Figure F4 is the same scale reduction of the jackknife standard deviation map for the "before" situation, specifically a reduction of Map E4. Map E5 is the same scale reduction of the jackknife standard deviation surface for the "after" relocation and adjustment of the two samples. It should be clear that substantial gains have been made in stabilizing the surface estimate with the relocated sample sites with presumed levels representative of their new vicinity. The same number of samples were available for the "before" and "after" scenarios.

Table F1 contains a quantitative comparison of the quantities of the coefficient of variation for the original scale map. This is equivalent to the jackknife standard deviations of the logarithm of milligrams per cubic meter of dust as noted in the footnote of Table F1. Clearly a substantial reduction in the surface variability has been achieved by the relocation and adjustment of these two observations.

Of course, this illustration is somewhat contrived. However, it was motivated by the findings described in Section V, especially (1) and (2). Two areas of Map B4 with large standard deviations were noteably improved by providing a neighboring replicate in these areas.

The programs developed by this research provide the opportunity for improved industrial hygiene sampling design, especially if computer contour maps become a fashionable summarization of industrial hygiene surveys.

C. Personal and Area Sample Comparison and Usage

Jones and Harris [1981] utilized computer mapping to determine exposure levels at all stations in a work area. Fixed location charcoal tube sampling results and time weighted averages based upon percentage of time spent at various locations were thereby computed. These were contrasted with personal charcoal tube sampling results taken simultaneously with the area samples.

The procedure was quite successful and the interested reader is referred to their presentation for more detail. Although the jackknife variance programs presented here were not available at the time of their research, they now could be utilized to compute standard deviations for the time weighted averages created from the fixed point charcoal tube samples and percentage of time spent at each work station.

D. Other Applications

The maps presented here are for daily averages, that is fixed time snapshots. In situations where waves of exposures may relate to process cycles over shorter periods, for example hourly, a series of two or three maps and companion jackknife variance maps could present a moving picture. A sequence of daily weather maps, showing high and low pressure locations, presents considerable information on change. Applied to industrial hygiene sampling situations, the change, as well as the level of exposure, could be presented. Protection of workers to the greatest exposures by management of time-space location of employees could thereby be enhanced.

As a last note, heat exposure could also be very naturally presented by contour maps and the stability of these exposures documented by the jackknife procedures described in this research report.

Selected References

1. Crume, Y.S. (1982). A study of quantitative prediction models for air contaminants in occupational environment. Dissertation in preparation. Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina at Chapel Hill, N.C. 27514.

2. Dougenik, J.A. and D.E. Sheehan. (1977). SYMAP Users Reference Manual, 5th ed. Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University, 48 Quincy St., Cambridge, MA 02138.

3. Gerber, W.S., et al. (1978). "Computer Mapping of Industrial Hygiene Sampling Data." Presented at the American Industrial Hygiene Association Conference, Los Angeles, California (May 11, 1978).

4. Harper, K.R. (1981). A study of potential health hazards in a commercial airline maintenance and overhaul facility. Master's Thesis. Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina at Chapel Hill, N.C. 27514.

5. Miller, R.G. (1974). The jackknife - a review. Biometrika, 61:1-15.

Appendix A: Industrial Hygiene Data

Table A1. Coordinates of Boundaries of Section #1: Heavy Duty Tire Building Area

Corner	Coordinates	
#	Down	Across
1	0.49	2.41
2	0.49	8.86
3	26.01	8.86
4	26.01	2.73
5	14.34	2.73
6	14.08	2.41

Table A2. Hexane and Toluene Measurements and the Sample Locations in Section #1

Observation #	Hexane Measurements		Toluene Measurements		Coordinates	
	Value in PPM	Value in Log Scale	Value in PPM	Value in Log Scale	Down	Across
1	2.70	0.99	0.15	-1.897	3.46	7.92
2	11.36	2.43	0.53	-0.635	3.46	4.19
3	18.97	2.94	0.93	-0.073	6.92	5.51
4	14.04	2.64	0.98	-0.020	9.76	4.08
5	74.12	4.31	3.18	1.157	10.48	6.28
6	85.75	4.45	3.94	1.371	12.55	8.16
7	11.75	2.46	0.68	-0.386	15.17	6.44
8	19.75	2.98	0.91	-0.094	16.04	3.41
9	14.53	2.68	0.86	-0.151	20.26	5.16
10	40.46	3.70	2.14	0.761	23.82	3.17
11	34.59	3.54	1.67	0.513	5.70	8.76
12	31.69	3.46	1.80	0.588	9.46	7.76
13	189.48	5.24	9.76	2.278	12.93	5.81
14	6.81	1.92	0.34	-1.079	19.83	7.72
15	7.13	1.96	0.55	-0.598	21.82	7.36
16	6.42	1.86	0.55	-0.598	17.69	8.22

Source: Crume (1982)

Table A3. Coordinates of Boundaries of Section #2: Airplane Hangar

Corner #	Coordinates Down	Coordinates Across
1	0.0	0.0
2	0.0	5.30
3	0.70	5.30
4	0.70	5.85
5	1.00	5.85
6	1.00	6.30
7	5.00	6.30
8	5.00	5.85
9	5.30	5.85
10	5.30	5.30
12	6.00	0.0

Table A4. Noise Measurements and Sample Locations in Section #2

Observation #	Noise Measurement dBA Scale	Coordinate Down	Coordinate Across
1	90.0	0.20	0.20
2	91.0	0.20	3.20
3	88.0	1.00	5.80
4	92.0	1.50	1.60
5	98.0	1.50	3.20
6	92.0	1.50	4.80
7	91.0	3.00	0.20
8	98.0	3.00	1.60
9	102.0	3.00	3.20
10	93.0	3.00	4.80
11	90.0	3.00	6.30
12	91.0	4.50	1.60
13	99.0	4.50	3.20
14	94.0	4.50	4.80
15	89.0	5.00	5.80
16	90.0	5.80	0.20
17	93.0	5.80	3.20

Source: Harper (1981)

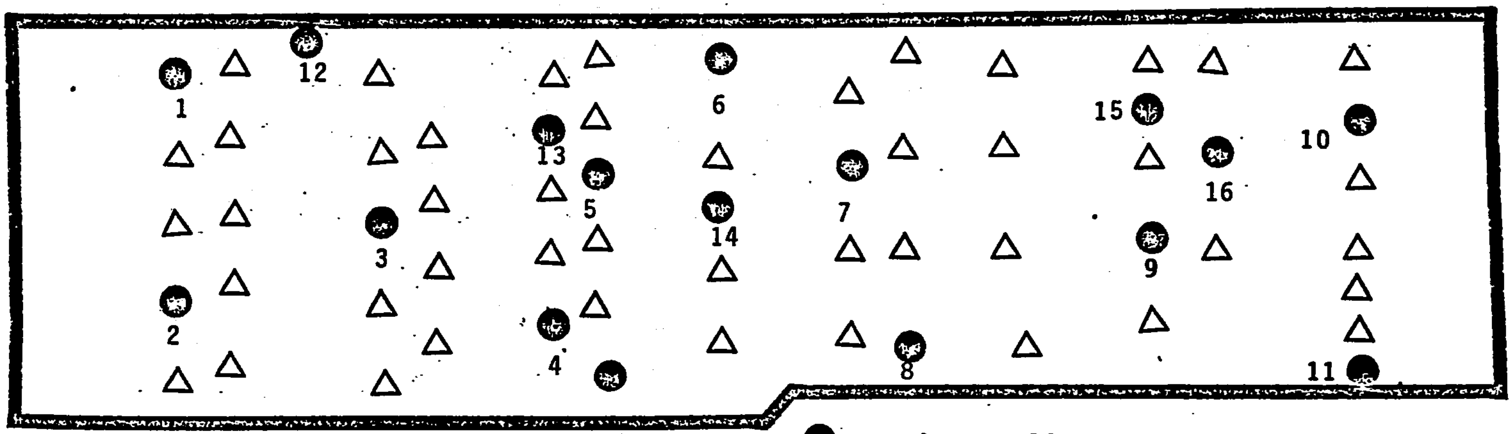
Table A5. Coordinates of Boundaries of Section #3:
Banbury and Compounding Area

Corner	Coordinates	
#	Down	Across
1	0.17	0.16
2	0.19	7.29
3	5.42	7.31
4	5.43	16.32
5	6.60	15.25
6	7.97	15.27
7	7.98	15.73
8	8.93	15.72
9	8.90	13.94
10	8.60	13.63
11	6.61	13.62
12	6.60	15.25
13	5.43	16.32
14	11.02	16.32
15	11.02	0.15
16	7.26	0.15
17	7.26	0.85
18	3.23	0.85
19	3.23	0.15

Table A6. Total Dust Measurements and the Sample Locations in Section #3

Observation #	Noise Measurement Value	Value in Log Scale	Coordinates Down	Across
1	0.60	-0.51	1.07	4.12
2	0.34	-1.08	2.17	6.23
3	0.47	-0.75	2.48	4.88
4	0.43	-0.84	2.64	2.28
5	0.30	-1.20	3.79	5.21
6	0.57	-0.56	4.58	5.23
7	0.73	-0.31	5.43	5.21
8	0.35	-1.05	6.55	6.23
9	0.29	-1.24	2.16	1.19
10	0.77	-1.00	6.59	4.21
11	0.27	-1.31	6.97	1.17
12	0.66	-0.42	7.61	4.21
13	0.71	-0.34	9.01	5.82
14	0.80	0.05	5.60	9.49
15	0.97	-0.03	9.02	4.58
16	0.46	-0.78	10.89	5.22
17	1.40	-1.27	4.56	1.18
18	1.70	0.53	8.92	2.21
19	1.29	0.25	8.94	1.21
20	1.57	0.41	9.40	3.72
21	0.37	-0.99	9.94	8.24
22	0.40	-0.92	8.96	9.26
23	1.52	0.42	7.69	9.49
24	0.57	-0.56	10.25	12.21
25	0.29	-1.24	7.08	13.23

Figure A1. Schematic of Heavy Duty Tire Building



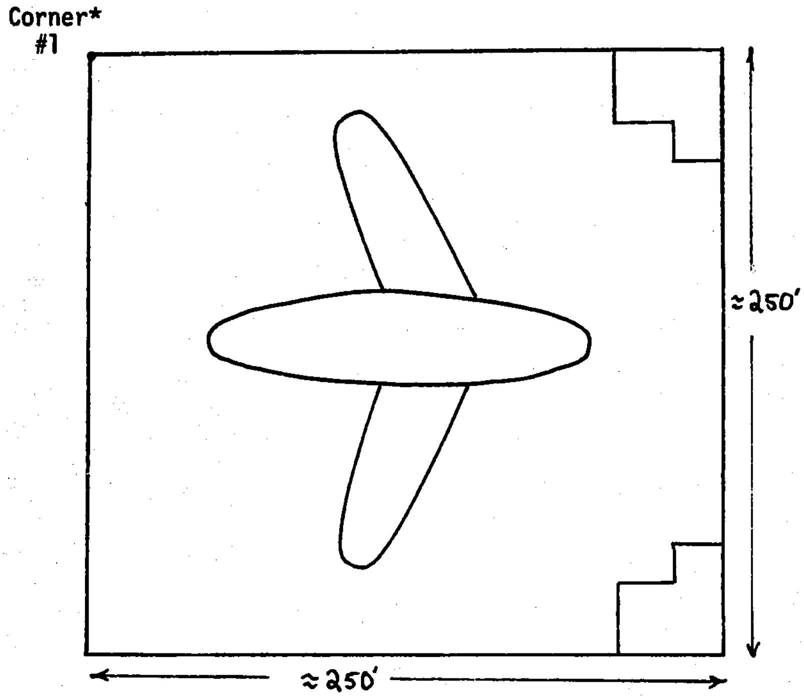
Corner*
#1

...air sampling station
...tire assembly machine (TAM)

1 - 11 ...TAM's
12 - 16 ...service stations

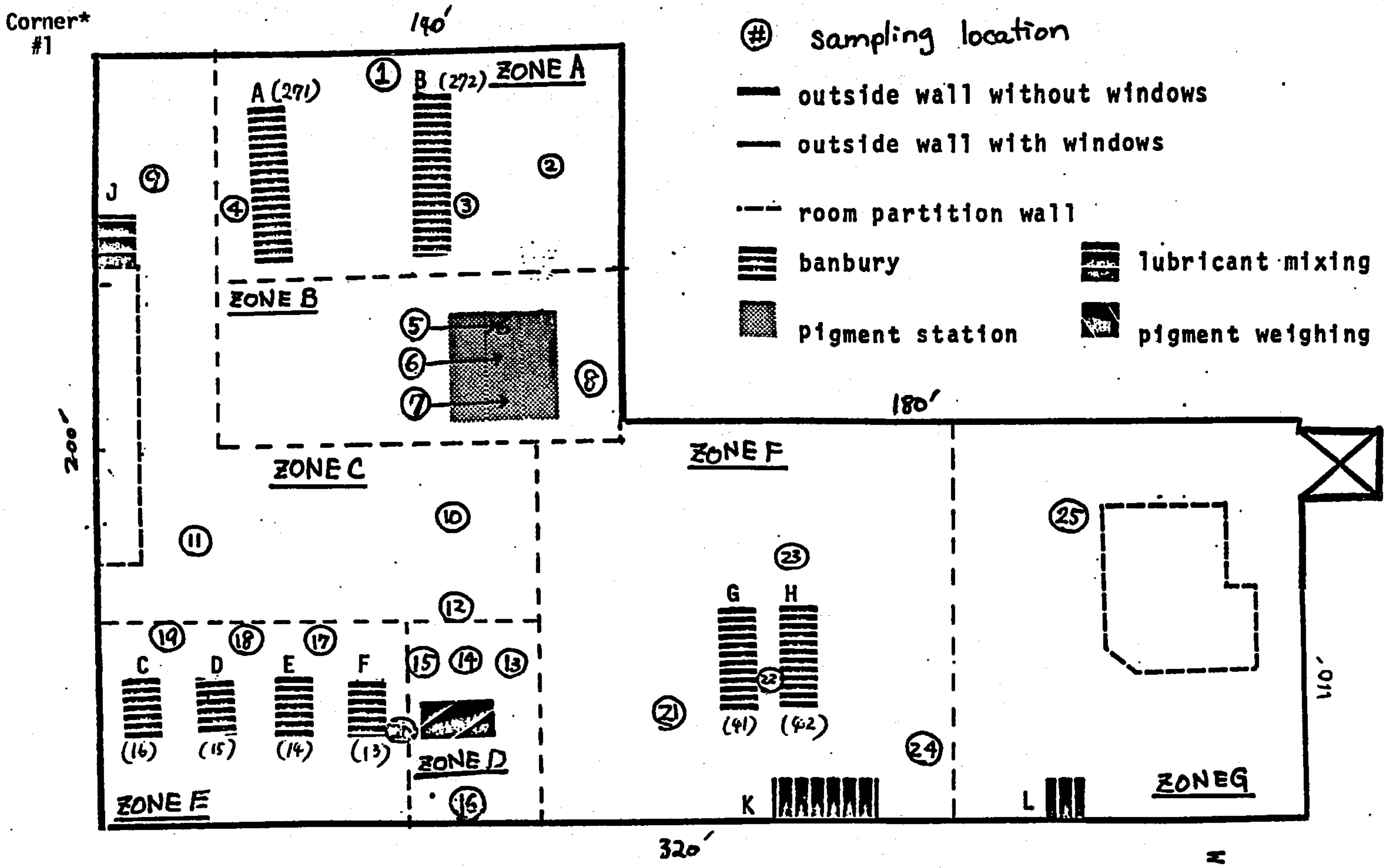
* See coordinates of boundaries in Table A1.

Figure A2. Schematic of Airplane Hangar



* See coordinates of boundaries in Table A3.

Figure A3. Schematic of Banbury and Compounding

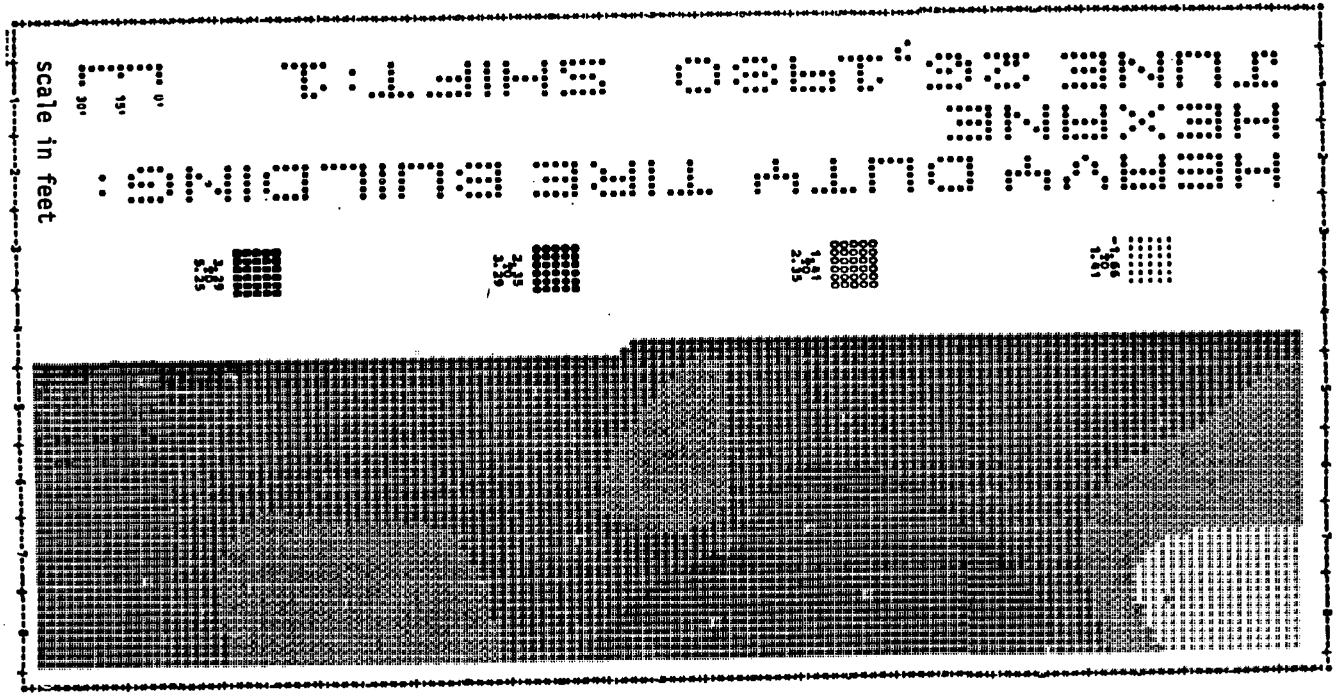


BANBURY AND COMPOUND ROOM (SECOND FLOOR)

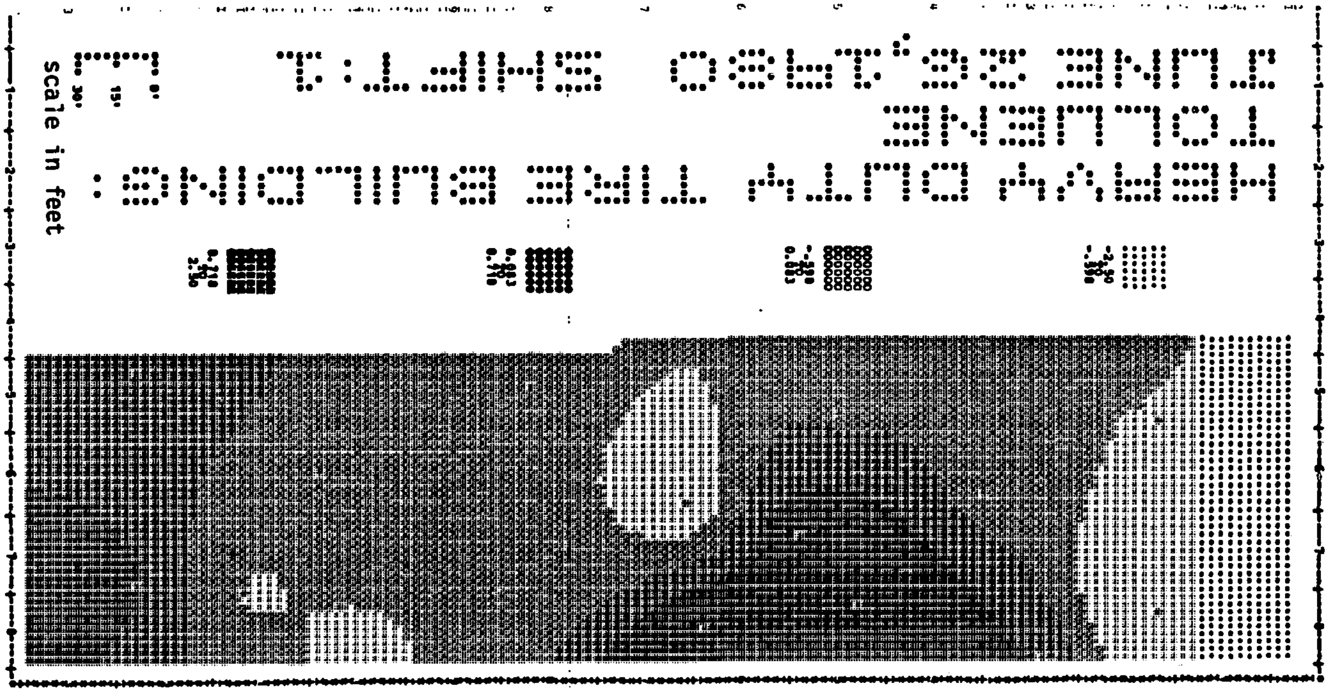
* See coordinates of boundaries in Table A5.

Appendix B: SYMAP Contour Maps for Four Industrial Hygiene Sampling Measurements

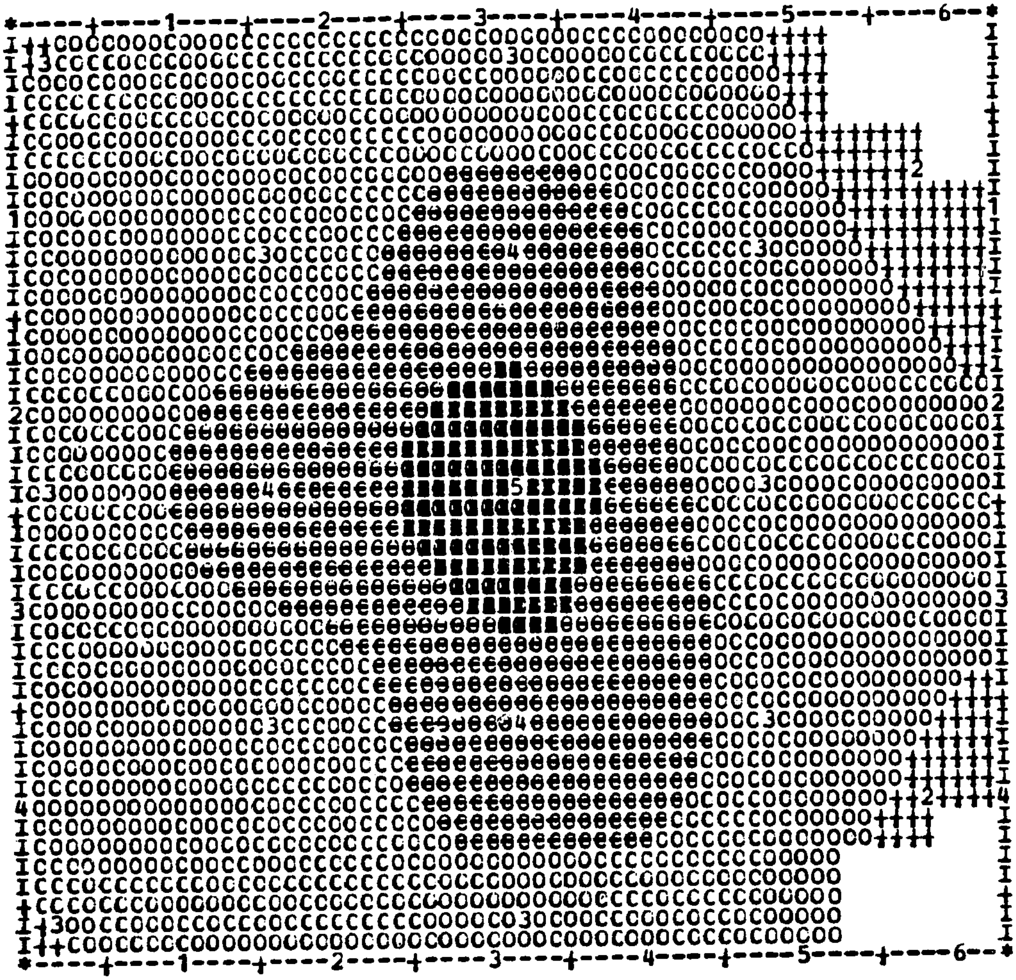
MAP B1. Hexane Contours for Heavy Duty Tire Building Area
(Units are logarithm of parts per million)



MAP B2. Toluene Contours for Heavy Duty Tire Building Area
(Units are logarithm of parts per million)



MAP B3. Noise Contours for Airplane Hangar

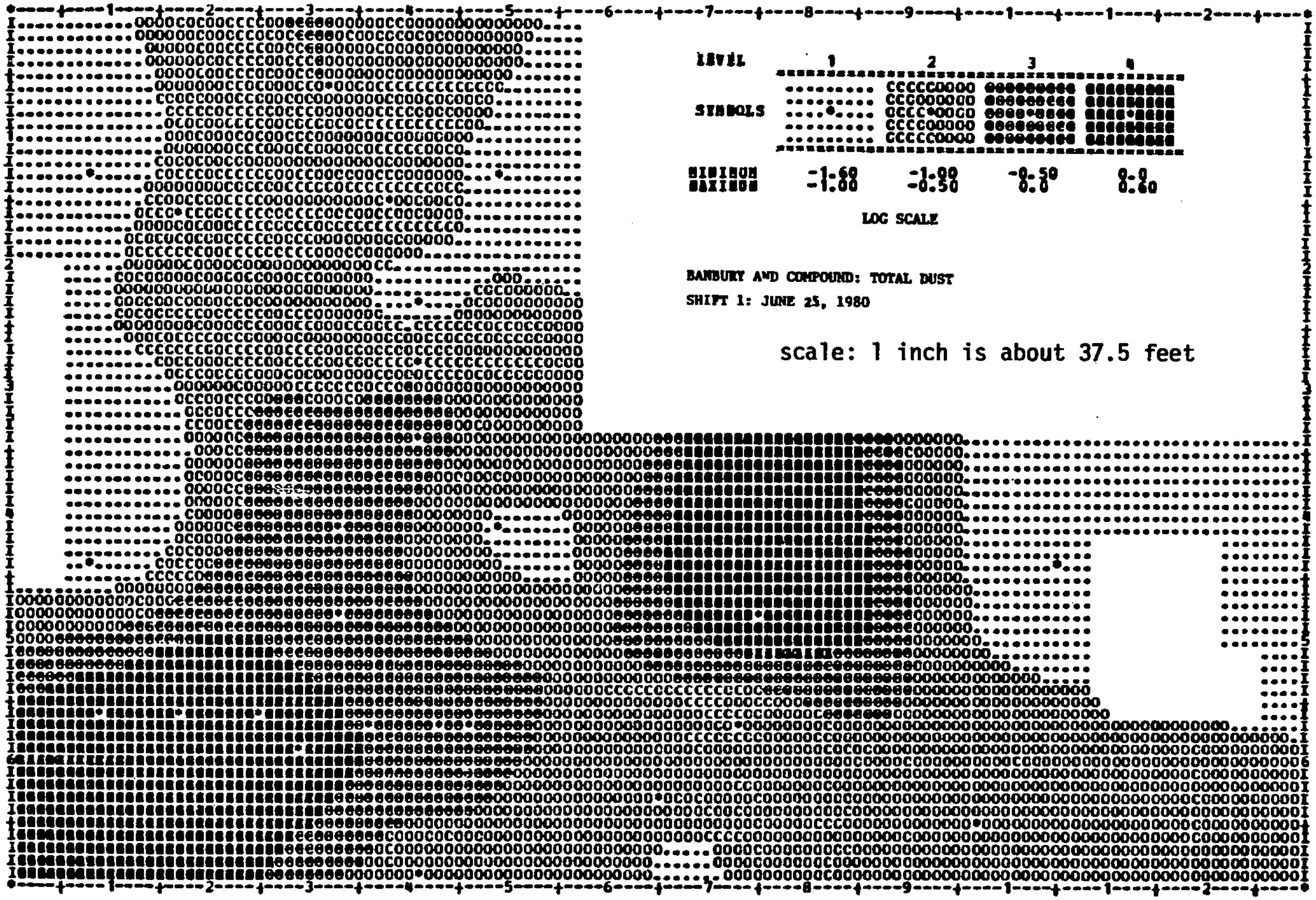


SYMBOLS

SYMBOLS	....1....	++++2++++	0000300C0	eeee4eeee	████5████
MINIMUM	80.00	85.00	90.00	95.00	100.00
MAXIMUM	85.00	90.00	95.00	100.00	105.00

scale: 1 inch is about 40 feet.

MAP B4. Total Dust Contours for Banbury and Compounding Area
(Units are logarithm of milligrams per cubic meter)



Appendix C: Listing of SYMAP Program Deck to Produce Hexane Map

```
//* *****CONTOUR MAP CF THE HEXANE DATA (SHIFT1: JUNE 26, 1980)******
//* FOR DETAIL USAGE OF SYMAP, CNE SHOULD REFER TO :
//*          SYMAP USER'S REFERENCE MANUAL
//*                       BY
//*          J.A. DOUGENIK & D.A. SHEEHAN.
//* THE USER-PROVIDED DATA CONSIST OF THE FOLLOWING PACKAGES:
//* A-OUTLINE: THIS PACKAGES SPECIFIES THE BOUNDARIES OF THE STUDY AREA
//*
//* B-DATA POINTS: THIS PACKAGE SPECIFIES THE LOCATION OF THE DATA
//* POINTS
//*
//* C-OTOLENGENDS: THIS PACKAGE IS OPTIONAL AND CAN BE USED TO SPECIFY
//* THE SYMBOLISM AND LOCATIONS OF ANY SUPPLEMENTARY INFORMATION TO BE
//* PLACED ON THE MAP
//*
//* E-VALUES: THIS PACKAGE IS USED TO DEFINE THE DATA VALUES TO BE
//* MAPPED IN THE SAME ORDER AS THEIR CORRESPONDING DATA POINTS IN THE
//* B-DATA POINT PACKAGE
//*
//* F-MAP: THIS PACKAGE SPECIFIES TO THE PROGRAM THAT A MAP IS TO BE
//* PRODUCED USING INFORMATION CONTAINED IN THE PREVIOUS PACKAGES.  IT
//* IS USED TO SPECIFY THE TITLE AND TO DEFINE PRACTICALLY ALL ASPECTS
//* OF THE APPEARANCE OF THE OUTPUT MAP
//*
//* EACH PACKAGE IS INITIATED BY THE PACKAGE NAME AND ENDED WITH A
//* '99999' LINE
//STEP1 EXEC SAS
//* 'SOLVENTS' AND 'LEGENDS' ARE 2 SAS DATASETS IN THE SAS DATABASE
//* 'UNC.GG.E591V.CARSTENS.HEALTH.OCCUP.DATA'; 'SOLVENTS' CONTAINS
//* DATA OF ALL CHEMICALS FOR ALL DATES AND SHIFTS; 'LEGENDS' CONTAINS
//* THE OTOLENGENDS FOR PRINTING THE CHEMICALS, DATES AND SHIFTS. THIS
//* STEP IS TO SELECT THE APPROPRIATE SUBSET OF DATA AND OTOLENGENDS
//* AS THE INPUTTING E-VALUES AND C-OTOLENGENDS PACKAGES FOR THE SYMAP.
//IN DD DSN=UNC.GG.E591V.CARSTENS.HEALTH.OCCUP.DATA,DISP=OLD
//VALUE1 DD DSN=&&DATA1,UNIT=DISK,SPACE=(TRK,(1,1)),
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=12000),DISP=(NEW,PASS)
//LEGEND DD DSN=&&LEGEND,UNIT=DISK,SPACE=(TRK,(1,1)),
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=12000),DISP=(NEW,PASS)
//SYSIN DD *
DATA ONE;
*THIS DATA STEP SELECTS ALL DATA OF SHIFT 1 ON JUNE 26*;
  SET IN.SOLVENTS;
   IF DATE=26 AND SHIFT=1;
     IF SAMPLE NE 2 THEN DELETE;
     IF LOCATION > 16 THEN DELETE;
DATA _NULL_;
*THIS DATA STEP SELECTS THE HEXANE DATA AND PUTS THEM ON AN OS FILE
 IN THE FORMAT OF THE E-VALUES PACKAGE FOR THE SYMAP*;
   SET ONE  END=EOF;
  FILE PRINT;
```

```
      IF LOCATION NE _N_ THEN PUT 'SAMPLE LOCATION ' LOCATION
        ' NOT IN POSITION ' _N_ ' AS IT SHOULD BE.  MAP MAY BE INCORRECT';
    FILE VALUE1;
     PUT @11 HEXANE  10.3  @73 DATE  @76 SHIFT  @78 LOCATION;
     IF EOF THEN PUT @1 '99999';
 DATA THREE;
 *THIS DATA STEP TOGETHER WITH THE NEXT ONE PREPARE THE C-CTOLENGENDS
  PACKAGE ON AN OS FILE AS INPUT TO THE SYMAP*;
    SET IN.LEGENDS  END=EOF;
    IF ALL=1 OR
       CHEMICAL='HEXANE'  OR
       DATE=6  OR
       SHIFT=1;
 DATA _NULL_;
     SET TWO  END=EOF;
    FILE LEGEND;
    IF _N_=1 THEN PUT
       @6 '.' @10 'A' @18 '3.1' @28 '1.5'/
       @18 '4.0'  @28 '1.5'  /  @18 '4.0'  @28 '0.5' /
       @18 '3.1'  @28 '0.5'  /  @18 '3.1'  @28 '1.5'  /
       @6 'O' @10 'A'  @18 '9.0'  @28 '1.5'  /
       @17 '10.0'  @28 '1.5'  /  @17 '10.0'  @28 '0.5'  /
       @18 '9.0'  @28 '0.5'  /  @18 '9.0'  @28 '1.5'  /
       @6 'O-'  @10 'A'  @17 '15.0'  @28 '1.5'  /
       @17 '16.0'  @28 '1.5'  /  @17 '16.0'  @28 '0.5'  /
       @17 '15.0'  @28 '0.5'  /  @17 '15.0'  @28 '1.5'  /
       @6 'OXA'  @10 'A'  @17 '21.0'  @28 '1.5'  /
       @17 '22.0'  @28 '1.5'  /  @17 '22.0'  @28 '0.5'  /
       @17 '21.0'  @28 '0.5'  /  @17 '21.0'  @28 '1.5'/
       @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '17.0' @41 '8.0' /'0.00'/
       @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '48.0' @41 '8.0' /'0.10'/
       @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '79.0' @41 '8.0' /'0.20'/
       @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '110.' @41 '8.0' /'OVER'/
       @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '111.' @41 '8.0' /'0.30'/
       @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '18.0' @41 '9.0' / 'TO' /
       @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '49.0' @41 '9.0' / 'TO' /
       @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '80.0' @41 '9.0' / 'TO' /
       @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '19.0' @41 '8.0' /'0.10'/
       @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '50.0' @41 '8.0' /'0.20'/
       @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '81.0' @41 '8.0' /'0.30';
     IF HORIZ=0 THEN
     PUT @1 '-' @4 LENGTH 2.  @10 'P'  @18 '1.0'  @27 '-0.5'  @31 ROWS 10.1
        @41 COLS 10.1   /   @1 LEGEND $CHAR50. ;
     ELSE PUT   @4 LENGTH 2.  @10 'P'  @18 '1.0'  @27 '-0.5'  @31 ROWS 10.1
        @41 COLS 10.1   /   @1 LEGEND $CHAR50. ;
     IF EOF THEN PUT @1 '99999';
  //STEP2 EXEC SYMAP
  /* THIS EXEC STEP WILL PERFORM THE CONTOUR MAP TECHNIQUE
  //FT26F001 DD DSN=&&LEGEND,DISP=(OLD,DELETE)
  //FT27F001 DD DSN=&&DATA1,DISP=(OLD,DELETE)
```

```
//G.SYSIN DD *
/* THE A-OUTLINES PACKAGE CONTAINS THE VERTICES OF THE BOUNDARIES OF THE
/* THE MAP
A-OUTLINES              X
           000.49     002.41
          0.49        008.86
           026.01     008.86
           026.01     002.73
           014.34     002.73
           014.08     002.41
           000.49     002.41
99999
B-DATA POINTS           X
           003.46     007.92
           003.46     004.19
           006.92     005.51
           009.76     004.08
           010.48     006.28
           012.55     008.16
           015.17     006.44
           016.04     003.41
           020.26     005.16
           023.82     007.28
           023.87     003.17
           005.70     008.76
           009.46     007.76
           012.93     005.81
           019.83     007.72
           021.82     007.36
           017.69     008.22
99999
/* THE C-OTOLEGENDS AND E-VALUES PACKAGES ARE INPUTTED FROM PREVIOUSLY
/* PREVIOUSLY CREATED FILES.
C-OTOLEGENDS                                                    MAP26
E-VALUES                                                        REW27
/* THE TITLE OF THE OUTPUT IS 'COMPLETE MAP/ HEXANE(LOG VALUE)/JUNE 26,
/* 1980 SHIFT:1'; THE MAP IS 17 INCHES LONG; IT HAS 4 CLASS INTERVALS;
/* THE VALUE RANGE MINIMUM RANGE IS -1.66 AND THE VALUE MAXIMUM RANGE
/* IS 5.25; THE RANGES OF THE CLASS INTERVALS ARE PROPORTIONAL TO
/* 3.07, 0.94,0.94 AND 1.96 RESPECTIVELY; THE MAP MARGINS ARE 0.25
/* AT TOP, 4.25 AT LEFT, 0.25 AT BOTTOM AND .25 AT RIGHT; A FILE
/* WHICH CONTAINS THE CALCULATED VALUE AT EACH LOCATION OF THE MAP
/* IS CREATED.
F-MAP
DATUM 17 DELETED
HEXANE
JUNE 26, 1980   SHIFT:1
    1       17.
    3       4.0
    4       0.0
```

```
     5      4.6
     6        .10      .10      .10       4.3
     7
   -X
 .OCO      ****              @
    A

     8
    14        .25   4.25      .25       .25
    18        -1.0
    21
 99999
 999999
//STEP3 EXEC SAS,R=298K
/* THIS EXEC STEP WILL STORE THE VALUES CREATED IN THE PREVIOUS EXEC
/* IN A SAS DATASET WITH THE VARIABLE NAME MAPO.
//D1 DD DSN=&&SYMMU,DISP=(OLD,DELETE)
//FUN DD DSN=UNC.B.E552V.SO.HEXANE,DISP=OLD
//SYSIN DD *
DATA FUN.HEXANE1;
  RETAIN CCUNT 0;
  INFILE D1;INPUT MAP17 RB4. @@;
  CCUNT=CCUNT+1      ;
  IF (CCUNT LE 24) THEN DELETE;
  NCOUNT=CCUNT-24 ;
  NCOL=MOD(NCOUNT,86);
  IF NCOL=0 THEN NCOL=86;
  NROW=(NCOUNT-NCOL)/86+1;
  IF (NROW LE 2) OR (NROW EQ 135) THEN DELETE;
  IF (NCOL LE 42) OR (NCOL GT 84) THEN DELETE;
  KEEP MAPO;
```

Appendix D.*

Computer Programs: Jackknife Inputs, Computations and Maps

Program #1: Produce Contour Map with All Data

Program #2: Produce n Jackknife Maps

Program #3: Compute Jackknife Means and Standard Deviations

Program #4: Produce Jackknife Standard Deviation Map

* For additional description, see text at end of Section IV.

D1

```
//* ******CONTOUR MAP OF THE TOLUENE DATA (SHIFT1: JUNE 26, 1980)******
//* FOR DETAIL USAGE OF SYMAP, ONE SHOULD REFER TO :
//*        SYMAP USER'S REFERENCE MANUAL
//*                         BY
//*        J.A. DOUGENIK & D.A. SHEEHAN.
//* THE USER-PROVIDED DATA CONSIST OF THE FOLLOWING PACKAGES:
//* A-OUTLINE: THIS PACKAGES SPECIFIES THE BOUNDARIES OF THE STUDY AREA
//*
//* B-DATA POINTS: THIS PACKAGE SPECIFIES THE LOCATION OF THE DATA
//* POINTS
//*
//* C-OTOLENGENDS: THIS PACKAGE IS OPTIONAL AND CAN BE USED TO SPECIFY
//* THE SYMBOLISM AND LOCATIONS OF ANY SUPPLEMENTARY INFORMATION TO BE
//* PLACED ON THE MAP
//*
//* E-VALUES: THIS PACKAGE IS USED TO DEFINE THE DATA VALUES TO BE
//* MAPPED IN THE SAME ORDER AS THEIR CORRESPONDING DATA POINTS IN THE
//* B-DATA POINT PACKAGE
//*
//* F-MAP: THIS PACKAGE SPECIFIES TO THE PROGRAM THAT A MAP IS TO BE
//* PRODUCED USING INFORMATION CONTAINED IN THE PREVIOUS PACKAGES.  IT
//* IS USED TO SPECIFY THE TITLE AND TO DEFINE PRACTICALLY ALL ASPECTS
//* OF THE APPEARANCE OF THE OUTPUT MAP
//*
//* EACH PACKAGE IS INITIATED BY THE PACKAGE NAME AND ENDED WITH A
//* '99999' LINE
//STEP1 EXEC SAS
//* 'SOLVENTS' AND 'LEGENDS' ARE 2 SAS DATASETS IN THE SAS DATABASE
//* 'UNC.GG.E591V.CASTENS.HEALTH.OCCUP.DATA'; 'SOLVENTS' CONTAINS
//* DATA OF ALL CHEMICALS FOR ALL DATES AND SHIFTS; 'LEGENDS' CONTAINS
//* THE OTOLENGENDS FOR PRINTING THE CHEMICALS, DATES AND SHIFTS. THIS
//* STEP IS TO SELECT THE APPROPRIATE SUBSET OF DATA AND OTOLENGENDS
//* AS THE INPUTTING E-VALUES AND C-OTOLENGENDS PACKAGES FOR THE SYMAP.
//IN DD DSN=UNC.GG.E591V.CARSTENS.HEALTH.OCCUP.DATA,DISP=OLD
//VALUE1 DD DSN=&&DATA1,UNIT=DISK,SPACE=(TRK,(1,1)),
//  DCB=(RECFM=FB,LRECL=80,BLKSIZE=12000),DISP=(NEW,PASS)
//LEGEND DD DSN=&&LEGEND,UNIT=DISK,SPACE=(TRK,(1,1)),
//  DCB=(RECFM=FB,LRECL=80,BLKSIZE=12000),DISP=(NEW,PASS)
//SYSIN DD *
DATA ONE;
*THIS DATA STEP SELECTS ALL DATA OF SHIFT 1 ON JUNE 26*;
  SET IN.SOLVENTS;
   IF DATE=26 AND SHIFT=1;
     IF SAMPLE NE 2 THEN DELETE;
     IF LOCATION > 16 THEN DELETE;
DATA _NULL_;
*THIS DATA STEP SELECTS THE TOLUENE DATA AND PUTS THEM ON AN OS FILE
 IN THE FORMAT OF THE E-VALUES PACKAGE FOR THE SYMAP*;
      LTOL=LOG(TOLUENE);
  FILE PRINT;
```

D2

```
    IF LOCATION NE _N_ THEN PUT 'SAMPLE LOCATION '  LOCATION
      ' NOT IN POSITION ' _N_ ' AS IT SHOULD BE.  MAP MAY BE INCORRECT';
  FILE VALUE1;
   PUT @11 LTOL   10.3  @73 DATE  @76 SHIFT  @78 LOCATION;
   IF EOF THEN PUT @1 '99999';
DATA TWO:
*THIS DATA STEP TOGETHER WITH THE NEXT ONE PREPARE THE C-OTOLENGENDS
 PACKAGE ON AN OS FILE AS INPUT TO THE SYMAP*;
  SET IN.LEGENDS  END=EOF;
  IF ALL=1 OR
     CHEMICAL='TOLUENE'  OR
     DATE=6  OR
     SHIFT= 1;
DATA _NULL_;
   SET TWO  END=EOF;
  FILE LEGEND;
  IF _N_=1 THEN PUT
     @6 '.' @10 'A' @18 '3.1' @28 '1.5'/
     @18 '4.0'  @28 '1.5'  /  @18 '4.0'  @28 '0.5' /
     @18 '3.1'  @28 '0.5'  /  @18 '3.1'  @28 '1.5'  /
     @6 'O' @10 'A'  @18 '9.0'  @28 '1.5'  /
     @17 '10.0'  @28 '1.5'  /  @17 '10.0'  @28 '0.5'  /
     @18 '9.0'  @28 '0.5'  /  @18 '9.0'  @28 '1.5'  /
     @6 'O-'  @10 'A'  @17 '15.0'  @28 '1.5'  /
     @17 '16.0'  @28 '1.5'  /  @17 '16.0'  @28 '0.5'  /
     @17 '15.0'  @28 '0.5'  /  @17 '15.0'  @28 '1.5'  /
     @6 'OXA'  @10 'A'  @17 '21.0'  @28 '1.5'  /
     @17 '22.0'  @28 '1.5'  /  @17 '22.0'  @28 '0.5'  /
     @17 '21.0'  @28 '0.5'  /  @17 '21.0'  @28 '1.5'/
     @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '17.0' @41 '7.0' /'-2.50'/
     @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '19.0' @41 '7.0' /'-.598'/
     @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '50.0' @41 '7.0' /'0.083'/
     @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '81.0' @41 '7.0' /'0.718'/
     @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '18.0' @41 '9.0' / 'TO' /
     @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '49.0' @41 '9.0' / 'TO' /
     @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '80.0' @41 '9.0' / 'TO' /
     @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '48.0' @41 '7.0' /'-.598'/
     @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '79.0' @41 '7.0' /'0.083'/
     @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '110.' @41 '7.0' /'0.718';
     @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '112' @41 '8.0' /'2.5'/;
  IF HORIZ=0 THEN
  PUT @1 '-' @4 LENGTH 2.  @10 'P'  @18 '1.0'  @27 '-0.5'  @31 ROWS 10.1
     @41 COLS 10.1   /   @1 LEGEND $CHAR50. ;
  ELSE PUT  @4 LENGTH 2.  @10 'P'  @18 '1.0'  @27 '-0.5'  @31 ROWS 10.1
     @41 COLS 10.1   /   @1 LEGEND $CHAR50. ;
  IF EOF THEN PUT @1 '99999';
//STEP2 EXEC SYMAP
//*THIS EXEC STEP WILL PERFORM THE CONTOUR MAP TECHNIQUE
//FT26F001 DD DSN=&&LEGEND,DISP=(OLD,DELETE)
//FT27F001 DD DSN=&&DATA1,DISP=(OLD,DELETE)
```

D3

```
//G.SYSIN DD *
//* THE A-OUTLINES PACKAGE CONTAINS THE VERTICES OF THE BOUNDARIES OF THE
//* THE MAP
A-OUTIINES              X
               000.49    002.41
               000.49    008.86
               026.01    008.86
               026.01    002.73
               014.34    002.73
               014.08    002.41
               000.49    002.41
99999
B-DATA POINTS           X
               003.46    007.92
               003.46    004.19
               006.92    005.51
               009.76    004.08
               010.48    006.28
               012.55    008.16
               015.17    006.44
               016.04    003.41
               020.26    005.16
               023.82    007.28
               023.87    003.17
               005.70    008.76
               009.46    007.76
               012.93    005.81
               019.63    007.72
               021.82    007.36
               017.69    008.22
99999
//* THE C-OTOLENGENDS AND E-VALUES PACKAGES ARE INPUTTED FROM THE
//* PREVIOUSLY CREATED FILES.
C-OTOLEGENDS                                                      MAP26
E-VALUES                                                          REW27
//* THE TITLE OF THE OUTPUT IS 'COMPLETE MAP / TOLUENE(LOG VALUE)/JUNE 26
//* 1980 SHIFT:1'; THE MAP IS 17 INCHES LONG; IT HAS 4 CLASS INTERVALS;
//* THE VALUE MINIMUM RANGE IS -2.50 AND THE VALUE MAXIMUM RANGE
//* IS 2.50; THE RANGES OF THE CLASS INTERVALS ARE PROPORTIONAL TO
//* 1.902, 0.681, 0.635 AND 1.782 RESPECTIVELY; THE MAP MARGINS ARE 0.25
//* AT TOP, 4.25 AT LEFT, 0.25 AT BOTTOM AND .25 AT RIGHT; A FILE
//* WHICH CONTAINS THE CALCULATED VALUE AT EACH LOCATION OF THE MAP
//* IS CREATED.
COMPLETE MAP
TOLUENE
JUNE 26, 1980  SHIFT:1
     1        17.
     3        4.0
     4        -2.50
```

```
    5        2.50
    6         1.902     0.681     0.635       1.782
    7
   -X
.000      ****                @
    A

    8
   14          .25    4.25         .25         .25
   18          -1.0
   21
99999
999999
//STEP3 EXEC SAS,R=298K
//*THIS EXEC STEP WILL STORE THE VALUES CREATED IN THE PREVIOUS STEP
//*IN A SAS DATASET WITH THE VARIABLE NAME MAPO.
//D1 DD DSN=&&SYMVU,DISP=(OLD,DELETE)
//FUN DD DSN=UNC.B.E552V.SO.TOLUENE,DISP=OLD
//SYSIN DD *
DATA FUN.TOLO;
   RETAIN COUNT 0;
   INFILE D1;INPUT MAP17 RB4. @@;
   COUNT=COUNT+1      ;
   IF (COUNT LE 24) THEN DELETE;
   NCOUNT=COUNT-24 ;
   NCOL=MOD(NCOUNT,86);
   IF NCOL=0 THEN NCOL=86;
   NROW=(NCOUNT-NCOL)/86+1;
   IF (NROW LE 2) OR (NROW EQ 135) THEN DELETE;
   IF (NCOL LE 42) OR (NCOL GT 84) THEN DELETE;
   KEEP MAPO;
```

Appendix D: Program #2a

```
//* CONTOUR MAPS OF THE TOLUENE DATA (SHIFT 1: JUNE 26, 1980)
//* WITH THE FIRST FOUR DATA POINTS SUCCESSIVELY DELETED.
//STEP1 EXEC SAS
//* FOUR TEMPORARY FILES ARE CREATED, EACH CONTAINS A SUBSET
//* OF THE DATA BY DELETING AN APPROPRIATE DATA POINT. A C-
//* OTOLENGENDS PACKAGE FILE (AS IN PROGRAM A) IS ALSO CREATED.
//IN DD DSN=UNC.GG.E591V.CARSTENS.HEALTH.OCCUP.DATA,DISP=OLD
//VALUE1 DD DSN=&&DATA1,UNIT=DISK,SPACE=(TRK,(1,1)),
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=12000),DISP=(NEW,PASS)
//VALUE2 DD DSN=&&DATA2,UNIT=DISK,SPACE=(TRK,(1,1)),
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=12000),DISP=(NEW,PASS)
//VALUE3 DD DSN=&&DATA3,UNIT=DISK,SPACE=(TRK,(1,1)),
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=12000),DISP=(NEW,PASS)
//VALUE4 DD DSN=&&DATA4,UNIT=DISK,SPACE=(TRK,(1,1)),
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=12000),DISP=(NEW,PASS)
//LEGEND DD DSN=&&LEGEND,UNIT=DISK,SPACE=(TRK,(1,1)),
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=12000),DISP=(NEW,PASS)
//SYSIN DD *
DATA ONE;
  SET IN.SOLVENTS;
  IF DATE=26 AND SHIFT=1;
  IF SAMPLE NE 2 THEN DELETE;
  IF LOCATION GT 16 THEN DELETE;
  LTOL=LOG(TOLUENE);
  KEEP SAMPLE DATE SHIFT LOCATION TOLUENE LTOL;
PROC PRINT DATA=ONE;
DATA _NULL_;
  SET ONE END=EOF;
  FILE VALUE1;
  IF _N_=1  THEN PUT @17 '-1.0';
    ELSE PUT @11 LTOL 10.6 @73 DATE @76 SHIFT @78 LOCATION;
    IF EOF THEN PUT @1 '99999';
DATA _NULL_;
  SET ONE END=EOF;
  FILE VALUE2;
  IF _N_=2  THEN PUT @17 '-1.0';
    ELSE PUT @11 LTOL 10.6 @73 DATE @76 SHIFT @78 LOCATION;
    IF EOF THEN PUT @1 '99999';
DATA _NULL_;
  SET ONE END=EOF;
  FILE VALUE3;
  IF _N_=3  THEN PUT @17 '-1.0';
    ELSE PUT @11 LTOL 10.6 @73 DATE @76 SHIFT @78 LOCATION;
    IF EOF THEN PUT @1 '99999';
DATA _NULL_;
  SET ONE END=EOF;
  FILE VALUE4;
  IF _N_=4  THEN PUT @17 '-1.0';
    ELSE PUT @11 LTOL 10.6 @73 DATE @76 SHIFT @78 LOCATION;
    IF EOF THEN PUT @1 '99999';
DATA THREE;
  SET IN.LEGENDS  END=EOF;
  IF ALL=1 OR
```

```
      CHEMICAL='TOLUENE' OR
      DATE=6  OR
      SHIFT=1;
DATA FOUR;
    SET THREE   END=EOF;
   FILE LEGEND;
   IF _N_=1 THEN PUT
      @6 '.' @10 'A' @18 '3.1' @28 '1.5'/
      @18 '4.0'  @28 '1.5'  /  @18 '4.0'  @28 '0.5' /
      @18 '3.1'  @28 '0.5'  /  @18 '3.1'  @28 '1.5'  /
      @6 'O' @10 'A'  @18 '9.0'  @28 '1.5'  /
      @17 '10.0'  @28 '1.5'  /  @17 '10.0'  @28 '0.5'  /
      @18 '9.0'  @28 '0.5'  /  @18 '9.0'  @28 '1.5'  /
      @6 'O-'  @10 'A'  @17 '15.0'  @28 '1.5'  /
      @17 '16.0'  @28 '1.5'  /  @17 '16.0'  @28 '0.5'  /
      @17 '15.0'  @28 '0.5'  /  @17 '15.0'  @28 '1.5'  /
      @6 'OXA'  @10 'A'  @17 '21.0'  @28 '1.5'  /
      @17 '22.0'  @28 '1.5'  /  @17 '22.0'  @28 '0.5'  /
      @17 '21.0'  @28 '0.5'  /  @17 '21.0'  @28 '1.5'/
      @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '17.0' @41 '7.0' /'-2.50'/
      @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '19.0' @41 '7.0' /'-.598'/
      @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '50.0' @41 '7.0' /'0.083'/
      @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '81.0' @41 '7.0' /'0.718'/
      @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '18.0' @41 '9.0' / 'TO' /
      @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '49.0' @41 '9.0' / 'TO' /
      @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '80.0' @41 '9.0' / 'TO' /
      @5 '2' @10 'P' @18 '1.0' @27 '-.5' @31 '111.' @41 '9.0' /'TO'/
      @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '48.0' @41 '7.0' /'-.598'/
      @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '79.0' @41 '7.0' /'0.083'/
      @5 '5' @10 'P' @18 '1.0' @27 '-.5' @31 '110.' @41 '7.0' /'0.718'/
      @5 '4' @10 'P' @18 '1.0' @27 '-.5' @31 '112.' @41 '8.0' /'2.50'/;
   IF HORIZ=0 THEN
   PUT @1 '-' @4 LENGTH 2.  @10 'P'  @18 '1.0'  @27 '-0.5'  @31 ROWS 10.1
      @41 COLS 10.1   /   @1 LEGEND $CHAR50. ;
   ELSE PUT   @4 LENGTH 2.  @10 'P'  @18 '1.0'  @27 '-0.5'  @31 ROWS 10.1
      @41 COLS 10.1   /   @1 LEGEND $CHAR50. ;
   IF EOF THEN PUT @1 '99999';
//STEP2 EXEC SYMAP
//  THE A-OUTLINE, B-DATA POINTS, C-OTOLENGENDS AND F-MAP PACKAGES
//  REMAIN THE SAME FOR THE FOUR MAPS.  A MAP WILL BE CREATED FOR
//  A F-MAP PACKAGE BY USING A E-VALUES PACKAGE AND ALL OTHER
//  PACKAGES WHICH HAVE NOT BEEN REPLACED OR DELETED.
//FT26F001 DD DSN=&&LEGEND,DISP=(OLD,DELETE)
//FT27F001 DD DSN=&&DATA1,DISP=(OLD,DELETE)
//FT28F001 DD DSN=&&DATA2,DISP=(OLD,DELETE)
//FT29F001 DD DSN=&&DATA3,DISP=(OLD,DELETE)
//FT30F001 DD DSN=&&DATA4,DISP=(OLD,DELETE)
//G.SYSIN DD *
A-OUTLINES            X
           000.49     002.41
          0.49        008.86
           026.01     008.86
           026.01     002.73
           014.34     002.73
```

```
               014.08    002.41
               000.49    002.41
99999
B-DATA POINTS            X
               003.46    007.92
               003.46    004.19
               006.92    005.51
               009.76    004.08
               010.48    006.28
               012.55    008.16
               015.17    006.44
               016.04    003.41
               020.26    005.16
               023.82    007.28
               023.87    003.17
               005.70    008.76
               009.46    007.76
               012.93    005.81
               019.83    007.72
               021.82    007.36
99999
C-OTOLEGENDS                                                    MAP26
E-VALUES                                                        REW27
F-MAP
1ST DATUM DELETED
TOIUENE (LOG VALUE)
JUNE 26, 1980  SHIFT:1
     1       17.
     3       4.0
     4     -2.50
     5     2.50
     6     1.902      .681       .635       1.782
     7
  -X
.000       ****              @
   A

     8
    14          .25     4.25       .25        .25
    18          -1.0
    21
99999
E-VALUES                                                        REW28
F-MAP
2ND DATUM DELETED
TOIUENE (LOG VALUE)
JUNE 26, 1980  SHIFT:1
     1       17.
     3       4.0
     4     -2.50
```

```
    5      2.50
    6      1.902     .681      .635      1.782
    7
  -X
.000      ****             @
   A

    8
   14         .25    4.25        .25        .25
   18        -1.0
   21
99999
E-VALUES                                               REW29
F-MAP
3RD DATUM DELETED
TOLUENE (LOG VALUE)
JUNE 26, 1980  SHIFT:1
    1       17.
    3       4.0
    4      -2.50
    5      2.50
    6      1.902     .681      .635      1.782
    7
  -X
.000      ****             @
   A

    8
   14         .25    4.25        .25        .25
   18        -1.0
   21
99999
E-VALUES                                               REW30
F-MAP
4TH DATUM DELETED
TOLUENE (LOG VALUE)
JUNE 26, 1980  SHIFT:1
    1       17.
    3       4.0
    4      -2.50
    5      2.50
    6      '.902     .681      .635      1.782
    7
  -X
.000      ****             @
   A

    8
   14         .25    4.25        .25        .25
   18        -1.0
   21
99999
999999
```

D9

```
//STEP3 EXEC SAS
//* THE REINTERPOLATED VALUES CREATED IN THE PREVIOUS STEP ARE
//* STORED IN A SAS DATASET.  MAP1 IS THE VARIABLE NAME WHICH
//* CORRESPONDS TO THE DELETION OF THE FIRST DATA POINT AND SO
//* FORTH.
//D1 DD DSN=&&SYMVU,DISP=(OLD,DELETE)
//D2 DD DSN=&&SYMVU2,DISP=(OLD,DELETE)
//D3 DD DSN=&&SYMVU3,DISP=(OLD,DELETE)
//D4 DD DSN=&&SYMVU4,DISP=(OLD,DELETE)
//FUN DD DSN=UNC.OHS.F2287.SO.TOLUENE,DISP=OLD
//SYSIN DD *
DATA FUN.TOL1;
RETAIN COUNT 0;
INFILE D1;INPUT MAP1    RB4. @@;
INFILE D2;INPUT MAP2    RB4. @@;
INFILE D3;INPUT MAP3    RB4. @@;
INFILE D4;INPUT MAP4    RB4. @@;
COUNT=COUNT+1      ;
IF (COUNT LE 24) THEN DELETE;
NCOUNT=COUNT-24 ;
NCOL=MOD(NCOUNT,86);
IF NCOL=0 THEN NCOL=86;
NROW=(NCOUNT-NCOL)/86+1;
IF (NROW LE 2) OR (NROW EQ 135) THEN DELETE;
IF (NCOL LE 42) OR (NCOL GT 84) THEN DELETE;
KEEP MAP1-MAP4;
//
```

```
//* THE MEAN AND THE STANDARD DEVIATION OF THE JACKKNIFE DISTRIBUTION.
// EXEC SAS,R=298K
//FUN DD DSN=UNC.OHS.F228Z.SO.TOLUENE,DISP=OLD
//SYSIN DD *
DATA FUN.JK;
  ARRAY MAP (I) MAP1-MAP16;
  ARRAY X (I) X1-X16;
  SET FUN.TOL0;
  SET FUN.TOL1;
  SET FUN.TOL2;
  SET FUN.TOL3;
  SET FUN.TOL4;
* X1,..,X16 ARE THE PSEUDO-VALUES;
  DO OVER MAP;
    X=16*MAP0-15*MAP;
  END;
* JKMEAN AND JKSTD ARE THE MEAN AND THE STANDARD DEVIATION;
  JKMEAN=MEAN(OF X1-X16);
  JKSTD=STD(OF MAP1-MAP16)*15/SQRT(16);
  KEEP JKMEAN JKSTD;
```

```
//* CONTOUR MAP OF THE JACKKNIFE STANDARD ERROR OF THE SYMAP IN-
//* TERPOLATION OF THE TOLUENE DATA.
// EXEC SAS
//FUN DD DSN=UNC.OHS.F228Z.SO.TOLUENE,DISP=SHR
//SYSIN DD *
* THIS DATA STEP ASSIGN THE APPROPRIATE SYMBOLS WHICH CORRESPOND
  TO  THE DIFFERENT REGIONS OF THE CONTOUR MAP;
DATA ONE(KEEP=P Q R COL);
  LENGTH P Q R $1;
    SET FUN.JK;
    MAP=JKSTD/4.0;
    A=0.0;B=0.44576;C=0.8725;D=1.4658;
    COL=MOD(_N_,42); IF COL=0 THEN COL=42;
    IF _N_=600 OR
        _N_=624 OR
        _N_=1134 OR
        _N_=1365 OR
        _N_=1925 OR
        _N_=1985 OR
        _N_=2168 OR
        _N_=2600 OR
        _N_=2668 OR
        _N_=3177 OR
        _N_=3325 OR
        _N_=3734 OR
        _N_=4193 OR
        _N_=4260 OR
        _N_ 4611 OR
        _N_-5045 OR
        _N_=5072 THEN P='*';
    ELSE DO;
      IF (_N_ LE 2982 OR COL GT 2) AND (_N_ NE 2941) THEN DO;
    IF (A LE MAP LE B) THEN P='.';
    IF (B LE MAP LE C) THEN P='O';
    IF ( C LE MAP LE D) THEN DO; P='-';Q='O';END;
    IF (MAP GE D       ) THEN DO;P='X';Q='O';R='A'; END;END;
      END;

*THIS DATA STEP PRINT OUT THE CONTOUR MAP OF THE STANDARD ERROR;

DATA _NULL_;
   RETAIN COUNT 0;
   LENGTH P1-P42 Q1-Q42 R1-R42 $1;
   MACRO MESSAGE
    @1 BDY
    @4 W $CHAR33.
    @44 P1
    @45 P2
    @46 P3
    @47 P4
    @48 P5
    @49 P6
    @50 P7
    @51 P8
    @52 P9
    @53 P10
    @54 P11
    @55 P12
    @56 P13
    @57 P14
    @58 P15
```