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A REVIEW OF ARAC'S INVOLVEMENT IN THE TITAN II MISSILE ACCIDENT

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GENERAL

The ARAC response to the Titan II accident near Damascus, Arkansas on 19 September 1980 entailed 12 personnel for periods ranging from 2 to 12 hours. The first call was a "NEST Standby" alert at 0415L (PDT), followed by a request for dispersal calculations at 0615L, personnel callout at 0630L, crude estimates of plausible source term scenarios at 0845-0900L, first model calculations at 1130L and final model calculations at 1500L. While several new firsts were recorded for ARAC, demonstrating expanded capabilities for NEST-type responses, time lines were very long, essential information was very scant to non-existent, and useful communication of final calculations to the accident site impossible. A detailed chronology is found in Appendix A and a list of acronyms and abbreviations is contained in Appendix B.

OVERVIEW

Attached are a series of figures which summarize and depict the events of the day as well as the results of the calculations. Table 1 is a condensed timeline of events as well as a cross reference between ARAC local time (Pacific Daylight Time) and Greenwich Mean Time. Figure 1 lists the available meteorological

TABLE 1. Timelines

PDT (L)	Greenwich (GMT/Z)	Action
18/1700	19/0000	Approximate start of Titan II accident "leak"
18	01	
19	02	
20	03	
21	04	
22	05	
23	06	
19/00	07	
01	08	Approximate Titan II "explosion"
02	09	
03	10	
		LLNL SSA Alerted
04	11	
		ARAC put on "NEST Standby"
05	12	
06	13	DOE/EOC advisory of ARAC involvement
		JNACC request for "dispersal calculations"
		ARAC staff callout initiated
07	14	
		AFGWC/SACWX contacts (precise accident time & WX
08	15	ARAC fully staffed — actions started
		USGS Topography MATHEW/ADPIC
		Manual Topography Site X
		2BPUFF (1000, 70m)
09	16	Brackets of source term
10	17	
11	18	
		First ARAC calculations (2BPUFF)
12	19	
13	20	Second ARAC calculations (2BPUFF)
14	21	
15	22	Third ARAC calculations (ADPIC)
16	23	ARAC termination
17	24	

stations within 200 km of Damascus. Figure 2a, b, and c depict the upper atmosphere conditions at Little Rock, Arkansas approximately 40 km from the accident site about 3-4 hours after the accident. Note the 180° change in wind direction in the lower 1000 metres. This implies that a surface accident pattern would have extended to the southwest while an airborne cloud, such as the full explosion fireball, would have travelled northeast! Figures 3a and b list the data retrieved from AFGWC by the SDM capability. Figures 4a, b, and c are the manually generated topography and Figs. 5a, b, and c are the USGS generated topography for the same grid (Fig. 5a is the full 200 x 200 km topography with a lower left corner at 35°N latitude and 93°W longitude). The Site "X" geography for the Damascus area was generated from the map (Fig. 6a), and data points (Fig. 6b) to produce the relevant simplistic overlay (Fig. 6c). The 2BPUFF input file is shown in Fig. 7. Figures 8a, b, c, and d are the 2BPUFF calculations for the indicated source heights, normalized to 1 kilogram of source material. Figures 9a, b, c, and d depict the initial (a) and 1 hour x-z (b), y-z (c) and x-y (d) particle plots of the ADPIC calculations for a 276 m cloud stabilization height. Figures 10a and b define the normalized integrated air dose and surface deposition patterns respectively for 1 hour after the accident. Figures 11a and b show the final result of the ADPIC calculations overlaid with the site geography as ready for transmission to the field. Even in these calculations one begins to see the effects of the vertical wind shear on the cloud (Figs. 9b and c) and the elongation of the surface patterns to the northeast and southwest of the accident site.

What follows is intended to be a somewhat critical analysis of various components of the ARAC system and its interfaces on this particular problem. The intent is to identify weak points in the system which should be addressed for improvement.

1. Notification, Communications and Startup

This area involves most of the ARAC interfaces, i.e., LLNL Alert Center/SSA, JNACC and DOE/EOC.

a. There are many questions about notification for the problem. Examination of Table 1 reveals the long timelines associated with this accident. A significant attribute of the ARAC system is its capability to estimate environmental consequences should an incident progress to a point where estimates are necessary. However, to accomplish this service the ARAC center should be notified early on even when it is not clear that a significant problem might develop.

b. Accident specification — ARAC was woefully lacking in substantive information regarding the nuclear material in this accident. For valid results it is essential that ARAC know: (1) whether the material was dispersed by an HE detonation and by how much; (2) whether there was a fissle; (3) whether it was involved in a fire with the potential for airborne aerosol. Whichever agency EOC gets the first notification of an accident, they must pursue the accident specification problem until a reasonable or probable picture is available and at the very least provide some brackets on the amount of nuclear material, type incident (HE dispersal explosion, fire, etc.) the time of occurrence, and precise location information.

c. Data flow — Meteorological data at and following the time of an accident is essential for ARAC to make realistic dispersion calculations. The Air Force Global Weather Central (AFGWC) has a very valuable capability to perform a Point Analysis (PA) for all relevant meteorological parameters for any location from its real-time data base. Such a PA was performed shortly after the Titan II accident and sent to the Pentagon, but was unavailable to ARAC. AFGWC did provide other essential meteorological data, as did the SAC Staff Meteorologist and Weather Support Units. For future incidents, arrangements should be made to put LLNL/ARAC as an addressee on Point Analyses done for nuclear accidents (Broken Arrows).

d. Communication of results and ARAC field deployment — Had an actual dispersal of nuclear material taken place, it appears as if the ARAC calculations could not have arrived anywhere near the scene to be of use. No provisions were made to provide a contact phone number of a telecopier location near the scene. If ARAC is to continue to respond to such incidents then provisions should be made for communicating assessment results to personnel tasked with determining the health and safety aspects.

We expect that for this incident DOD/USAF had a health physicist-type individual on-scene within a short period after the accident or an EOD individual trained for nuclear explosives problems. This individual could serve as a point of contact for the relay of essential information to and from the ARAC center to the accident site until the DOE weapons team health physicist and/or ARAC representative arrives. It would be beneficial if all DOD nuclear emergency response organizations and in particular, nuclear explosives trained EOD units were made aware of ARAC's existence, capabilities and accessibility. These same organizations could also determine the availability of or acquire Xerox telecopier units for on-scene receipt of ARAC calculations.

e. Communications and Security — Several problems arose regarding the possibility of transmitting classified information over insecure phone lines (such as the exact location of the missile silo, type and quantity of nuclear material, etc.). The latter was easily handled by courier/runner within LLNL, but the former led to either a security violation by several parties or imprecise location of the source point. Once an accident has occurred, it is important that provisions be made for transmitting precise coordinates of the incident.

f. The Alert manuals had out-of-date FTS prefixes for JNACC. These numbers should either be made invariant or changes fully distributed in advance.

2. ARAC Center Operation

Initial manning of the ARAC center started at 0515L, followed by a callout of personnel beginning at approximately 0620L and gradual arrival of staff between 0710 and 0800L. After initial in-briefing of the staff regarding the problem, a multi-pronged effort was initiated to bring the center up to speed. One effort started with the preparation of a detailed topographic data file from the USGS tape data base. A second effort started to manually generate a topographic data file using a new ARAC code capability. A third effort was begun to prepare a site "X" data base for the Damascus area so that model calculations could be overlaid with local geography (another new ARAC capability). Due to the uncertainty of the source term prescription and hilly terrain, it was decided to not prepare a "flat earth" calculation with the MATHEW/ADPIC codes but wait for the topographic data. About 0900L it was decided that reasonably bracketing dispersal calculations could be made using 10 ton and 1 pound HE equivalent initial detonation conditions. The 2BPUFF model was activated to prepare these sets of calculations.

a. Topography generation — this was by far the most tedious and time consuming part of the ARAC response. The manual method proved very taxing but workable (including two false starts, the process took about 5 hours). Standard map overlay templates are being prepared and a row-by-row rather than point-by-point code entry scheme is being developed. These should reduce the manual method to about 3 hours. The USGS tape data base is also plagued with tediousness, less than fully tested codes, and vulnerability to failed tapes. The process took 5½ hours including a rerun due to a code error. This process will be streamlined, all files put on a system archive and preliminarily processed such that a one hour or less response can be achieved. Resources are being allocated ASAP with a projected completion date of 1 February 1981. This process will also be integrated with the site "X" definition process to assure consistent grid coordinate generation. The final results from the manual topography generation figure (4c) were excellent when compared with the automated system (Fig. 5c) and instill confidence in our capability to handle off-CONUS problems.

b. Site "X" definition — This new capability also worked well with the end result that we were able to prepare a hand generated geography (Fig. 6c) and later overlay this on the ADPIC contours. However, haste and round-off in generating a reference corner coordinate resulted in a horizontal location error of 5 km to the east for the local roads and towns. Total process time took 1½ hours due to several interruptions, hand generation of geography and missing site "X" system documentation.

c. Meteorological data collection — Once the exact time of the accident was established (0745L) action was taken to recover meteorological data back to that time. The SDM capability with AFGWC was used effectively although the output format needs improvement. This can be done locally. ARAC needs to explore the possibility of extracting old data directly from the AWN system.

d. 2BPUFF model — Initial dispersal calculations were provided from this model, although its limitation to provide results within 10 km was a handicap. The very rigid input format (Fig. 7) of this model is highly error prone (as happened for the first attempt at calculations). This model should have its input file changed to free format and its range of application increased to include centerline concentrations from the source point out to 10 km. Improved user documentation is also required.

e. MATHEW/ADPIC models — The MATHEW calculations were accomplished without a problem. The ADPIC model aborted because of a problem in generating source particles above the grid domain. This required ½ hour to identify and fix. Prior to this, a problem or limitation on source prescription to the model resulted in blank output.

f. Plotting code — The contour plotting code could not generate a contour file for the DPR computer because of a coordinate error on the "blank geography" file on the 7600. The generation of "blank geography" for the 7600 codes on a site "X" problem needs to be integrated into the site "X" definition process. A small code will generate a "blank geography" file with only the source coordinates and a site name as input.

g. Dose conversion factors — This continues to be a tedious process highly subject to human error. A procedures writeup with relevant examples, conversion factors and individual model limitations needs to be developed to insure a more error free system.

h. Miscellaneous problems — Delay in implementing the RJET User lockout slowed down the USGS topography code debug process. This feature should be implemented on all 7600's at the start of a problem and removed after the operation is running smoothly. A few non-ARAC personnel came to visit the center despite the sign outside. In the future the inner door should be locked to control access. Labeling of ARAC manuals is inconsistent and reference manuals for all models and procedures is incomplete.

i. An improved checklist or guide for site "X"-type problems should be developed to flag more of the key processes and checkpoints as well as minimizing interruptions of the ARAC center.

SUMMARY

The accident near Damascus, Arkansas pointed out several deficiencies in the ARAC system and its interfaces. In order to provide calculations which can be used for near real-time accident site approach, population evacuation/protection, and cleanup assessment, ARAC must be brought into a problem or potential problem at its first recognition. Pertinent meteorological data in Point Analysis form should be available to ARAC on a priority basis from AFGWC. ARAC topography data generation must be feasible in less than one hour for CONUS accidents/incidents and less than three hours for off-CONUS events. ARAC procedures, models, documentation and training must be improved to absolutely minimize the timeline from first notification to first calculation available for transmission.

ACKNOWLEDGMENTS

The LLNL/ARAC response to this accident was a team effort reflecting directly the capabilities of the current operational staff and many others who have contributed to the development and realization of ARAC as an operational emergency response system for DOE.[1] This work was performed under the auspices of the U. S. Department of Energy by the Lawrence Livermore Laboratory under contract No. W-7405-Eng-48.

REFERENCES

1. Dickerson, M. H. and R. C. Orphan, "Atmospheric Release Advisory Capability," Nuclear Safety, 17(3), May-June 1976.

□□□□GLH	722356	R=	180	3329N	9059W	GREENVILLE MUNI	MS	1	0	0	40	000000
□□□□AWM	723348	R=	101	350[illegible]N	9114W	WEST MEPHIS MUNI	AR	0	0	0	64	001000
□□□□1M1	723400	R=	11	3450N	9216W	NORTH LITTLE ROCK	AR	6	12	12	172	011171
□□□□LIT	723401	R=	0	3444N	9214W	LITTLE ROCK/ADAMS F	AR	1	0	0	78	001171
□□□□LRF	723405	R=	22	3455N	9209W	LITTLE ROCK AFB	AR	1	0	0	95	000000
□□□□ARG	723406	R=	195	3608N	9056W	WALNUT RIDGE MUNI	AR	0	0	0	84	010000
□□□□JBR	723407	R=	188	3550N	9039W	JONESBORO MUNI	AR	1	0	0	84	000000
□□□□HOT	723415	R=	84	3429N	9306W	HOT SPRINGS MEM FLD	AR	1	0	0	169	000000
□□□□PBF	723417	R=	69	3410N	9156W	PINE BLUFF/GRIDER F	AR	1	0	0	65	000000
□□□□ELD	723419	R=	176	3313N	9243W	EL DORADO/GOODWIN	AR	1	0	0	87	000000
□□□□HRO	723446	R=	189	3616N	9309W	HARRISON/BOONE CO	AR	1	0	0	422	000000

FIGURE 1.

STATION: 72340 DATE/TIME: 19 12

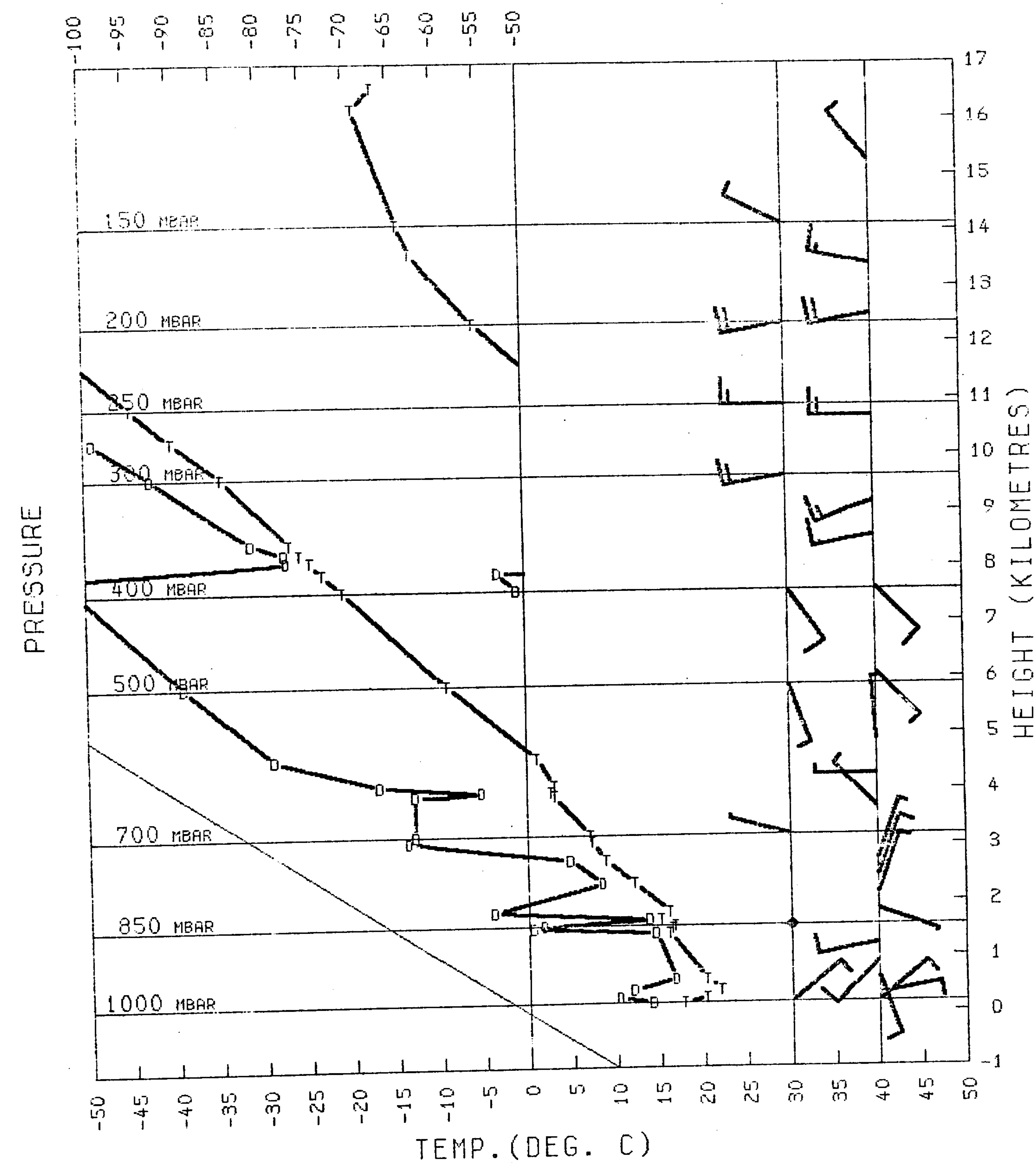


FIGURE 2a.

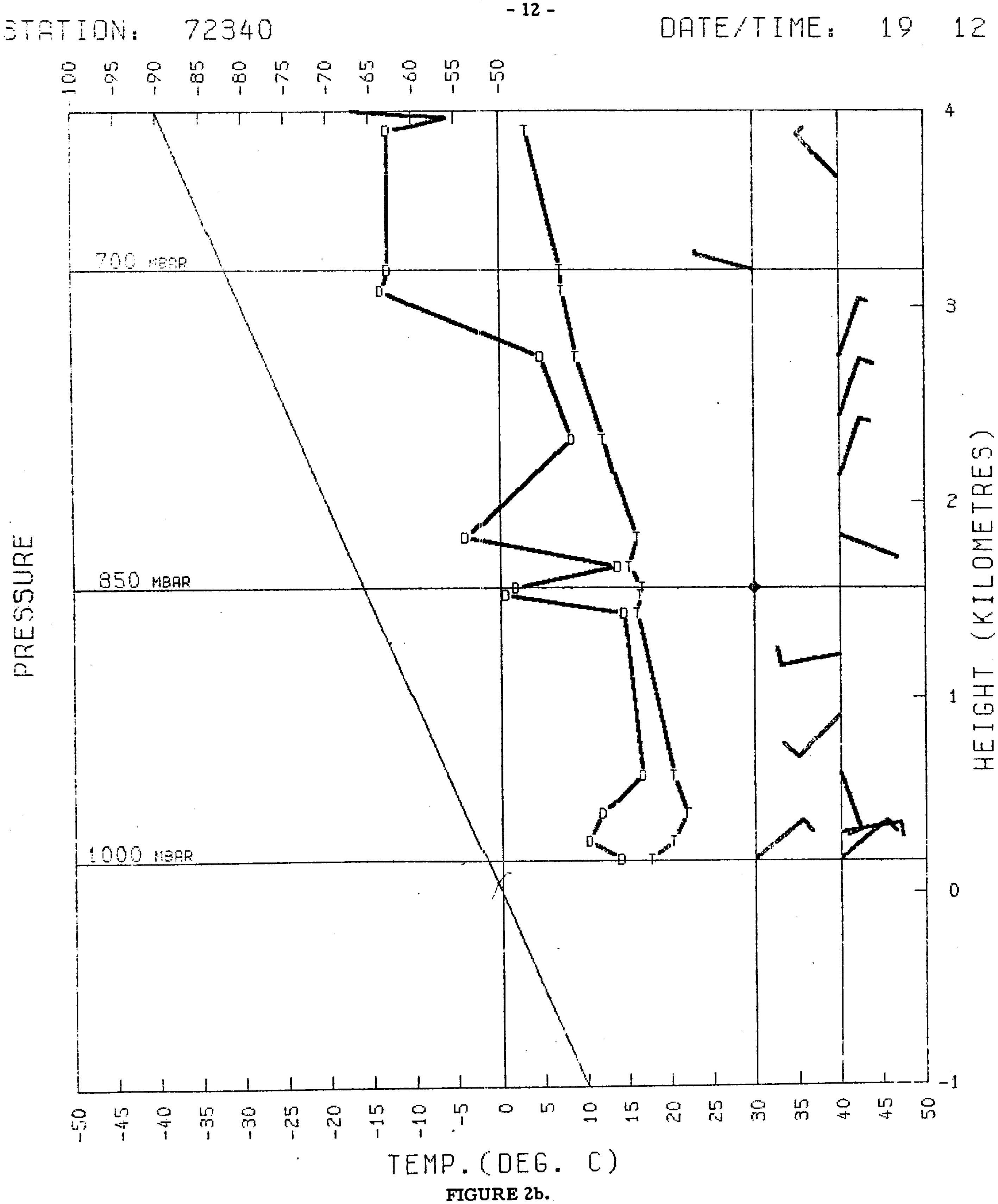

STATION: 72340
DATE/TIME: 19 12
-100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50
700 MBAR
850 MBAR
1000 MBAR
PRESSURE
HEIGHT (KILOMETRES)
4
3
2
1
0
-1
-50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50
TEMP. (DEG. C)

FIGURE 2b.

STATION:72340 DATE/TIME 19 AI 12Z

HEIGHT(FT,KM)		WIND		
554	0.169	50 DEG	6 KTS	3.08 M/S
1000	0.305	80 DEG	6 KTS	3.08 M/S
2000	0.610	160 DEG	6 KTS	3.08 M/S
3000	0.914	225 DEG	8 KTS	4.11 M/S
4000	1.219	260 DEG	7 KTS	3.60 M/S
6000	1.829	110 DEG	1 KTS	.51 M/S
7000	2.134	20 DEG	4 KTS	2.05 M/S
8000	2.438	20 DEG	6 KTS	3.08 M/S
9000	2.743	20 DEG	3 KTS	1.54 M/S
12000	3.658	315 DEG	4 KTS	2.05 M/S
14000	4.267	270 DEG	3 KTS	1.54 M/S
16000	4.877	355 DEG	2 KTS	1.02 M/S
20000	6.096	135 DEG	5 KTS	2.57 M/S
25000	7.620	135 DEG	9 KTS	4.62 M/S
28000	8.534	260 DEG	11 KTS	5.65 M/S
30000	9.144	250 DEG	15 KTS	7.71 M/S
35000	10.668	270 DEG	16 KTS	8.23 M/S
41000	12.497	260 DEG	19 KTS	9.77 M/S
44000	13.411	280 DEG	13 KTS	6.68 M/S
50000	15.240	320 DEG	5 KTS	2.57 M/S
53000	16.154	270 DEG	3 KTS	1.54 M/S

FIGURE 2c.

```
LLLSDM10 SITE LRF
DATA TIME 80SEP19 0800Z, RAN 1524Z

                                  SSFSF SFSFS SFCSFC SSSSS SFCSFC SFC
WMO       ICAO LAT    LON         TWIWI VSPRP PRETEM LLLMH DEWAPP SNODEF
               DEG    DEG         8DEKT WMWMW DMBC   8 W   C      IN
80SEP19 0800Z
723407 JBR  3550N09039W 20000 6100M 202 16 MMMMM   13MMM
723405 LRF  3455N09209W 20103 6005M 196 19 MMMMM   16MMM
723401 LIT  3444N09214W 71203 5645M 194 19 MMMMM   16MMM
723419 ELD  3313N09248W 70000 6100M 185 23 MMMMM   21MMM
723446 HRO  3616N09309W 00000 6300M 200 18 MMMMM   17MMM
```

```
LLLSDM11 SITE LRF 0900Z
DATA TIME 80SEP19 0900Z, RAN 1532Z

                                  SSFSF SFSFS SFCSFC SSSSS SFCSFC SFC
WMO       ICAO LAT    LON         TWIWI VSPRP PRETEM LLLMH DEWAPP SNODEF
               DEG    DEG         8DEKT WMWMW DMBC   8 W   C      IN
80SEP19 0900Z
723407 JBR  3550N09039W 20404 6100M 208 17 MMMMM   14+07
723405 LRF  3455N09209W 20000 6005M 198 18 M0M08   15+03
723401 LIT  3444N09214W 20303 5645M 196 18 MMMMM   14+02
723419 ELD  3313N09248W 70000 6045M 185 22 MMMMM   21+03
723446 HRO  3616N09309W 00904 6300M 199 18 MMMMM   18+03
```

```
LLLSDM12 SITE LRF 1000Z
DATA TIME 80SEP19 1000Z, RAN 1533Z

                                  SSFSF SFSFS SFCSFC SSSSS SFCSFC SFC
WMO       ICAO LAT    LON         TWIWI VSPRP PRETEM LLLMH DEWAPP SNODEP
               DEG    DEG         8DEKT WMWMW DMBC   8 W   C      IN
80SEP19 1000Z
723407 JBR  3550N09033W 20403 6100M 208 16 MMMMM   13MMM
723405 LRF  3455N09209W 20000 6045M 194 18 MMMMM   14MMM
                                 05

723401 LIT  3444N09214W 20505 5845M 194 18 MMMMM   14MMM
723419 ELD  3313N09243W 20000 6045M 185 22 MMMMM   20MMM
723446 HRO  3616N09309W 00000 6300M 198 18 MMMMM   17MMM
```

```
LLLSDM13 SITE LRF 1100Z
DATA TIME 80SEP19 1100Z, RAN 1535Z

                                  SSFSF SFSFS SFCSFC SSSSS SFCSFC SFC
WMO       ICAO LAT    LON         TWIWI VSPRP PRETEM LLLMH DEWAPP SNODEP
               DEG    DEG         8DEKT WMWMW DMBC   8 W   C      IN
80SEP19 1100Z
723407 JBR  3550N09033W 00000 6100M 208 16 MMMMM   13MMM
722356 GLH  3329N09059W 00105 6900M MMM 20 MMMMM   15MMM
723417 PBF  3410N09156W 00000 5605M MMMMMM MMMMM MMMMMM
723405 LRF  3455N09209W 00000 6100M 196 18 MMMMM   13MMM
723401 LIT  3444N09214W 20503 5845M 196 18 MMMMM   13MMM
                                 05

723419 ELD  3313N09248W 20000 5845M 189 21 MMMMM   19MMM
723415 HOT  3429N09306W 20905 6100M MMM 23 MMMMM   18MMM
723446 HRO  3616N09309W 01207 5645M 200 17 MMMMM   17MMM
```

FIGURE 3a.

LLLSDM14 SITE LRF 1200Z
DATA TIME 80SEP19 1200Z, RAN 1537Z

WMO	ICAO	LAT DEG LON DEG	SSFSF TWIWI 8DEKT	SFSFS VSPRP WMWMW	SFCSFC PRETEM DMBC	SSSSS LLLMH 8 W	SFCSFC DEWAPP C	SFC SNODEP IN
80SEP19 1200Z								
723407	JBR	3550N09039W	00604	5805M	212 16	MMMMM	13+03	
722356	GLH	3329N09059W	20105	5805M	MMM 19	MMMMM	14MMM	
723417	PBF	3410N09156W	20000	5605M	MMMMMM	MMMMM	MMMMMM	
723405	LRF	3455N09209W	21004	6005M	202 18	M0M01	13+03	
723401	LIT	3444N09214W	20805	5304M	199 18	MMMMM	13+03	
				05				
723400	1M1	3450N09216W	10705	61021	196 18	00905	14+03	
723419	ELD	3313N09248W	20704	3245M	193 21	MMMMM	20+03	
				05				
723415	HOT	3429N09306W	81006	6100M	MMM 22	MMMMM	17MMM	
723446	HRO	3616N09309W	01307	3245M	200 17	MMMMM	17MMM	

LLLSDM15 SITE LRF 1300Z
DATA TIME 80SEP19 1300Z, RAN 1538Z

WMO	ICAO	LAT DEG LON DEG	SSFSF TWIWI 8DEKT	SFSFS VSPRP WMWMW	SFCSFC PRETEM DMBC	SSSSS LLLMH 8 W	SFCSFC DEWAPP C	SFC SNODEP IN
80SEP19 1300Z								
722356	GLH	3329N09059W	20404	6900M	MMM 21	MMMMM	16MMM	
723417	PBF	3410N09156W	20000	5605M	MMMMMM	MMMMM	MMMMMM	
723405	LRF	3455N09209W	00703	6005M	203 18	MMMMM	13MMM	
723401	LIT	3444N09214W	00505	5804M	202 18	MMMMM	14MMM	
				05				
723419	ELD	3313N09248W	20603	3245M	197 21	MMMMM	19MMM	
				05				
723415	HOT	3429N09306W	01006	6600M	MMM 22	MMMMM	17MMM	
723446	HRO	3616N09309W	01407	3245M	204 17	MMMMM	17MMM	

LLLSDM16 SITE LRF 1400Z
DATA TIME 80SEP19 1400Z, RAN 1539Z

WMO	ICAO	LAT DEG LON DEG	SSFSF TWIWI 8DEKT	SFSFS VSPRP WMWMW	SFCSFC PRETEM DMBC	SSSSS LLLMH 8 W	SFCSFC DEWAPP C	SFC SNODEP IN
80SEP19 1400Z								
723407	JBR	3550N09039W	00804	5805M	216 19	MMMMM	15MMM	
722356	GLH	3329N09059W	20806	6900M	MMM 24	MMMMM	16MMM	
723417	PBF	3410N09156W	01303	6005M	196 22	MMMMM	15MMM	
723405	LRF	3455N09209W	01005	6005M	203 19	MMMMM	14MMM	
723401	LIT	3444N09214W	00806	5805M	202 21	MMMMM	14MMM	
				04				
723419	ELD	3313N09248W	21205	5645M	197 23	MMMMM	19MMM	
				05				
723415	HOT	3429N09306W	01207	6100M	MMM 23	MMMMM	16MMM	
723446	HRO	3616N09309W	01506	4845M	204 18	MMMMM	17MMM	

FIGURE 3b.

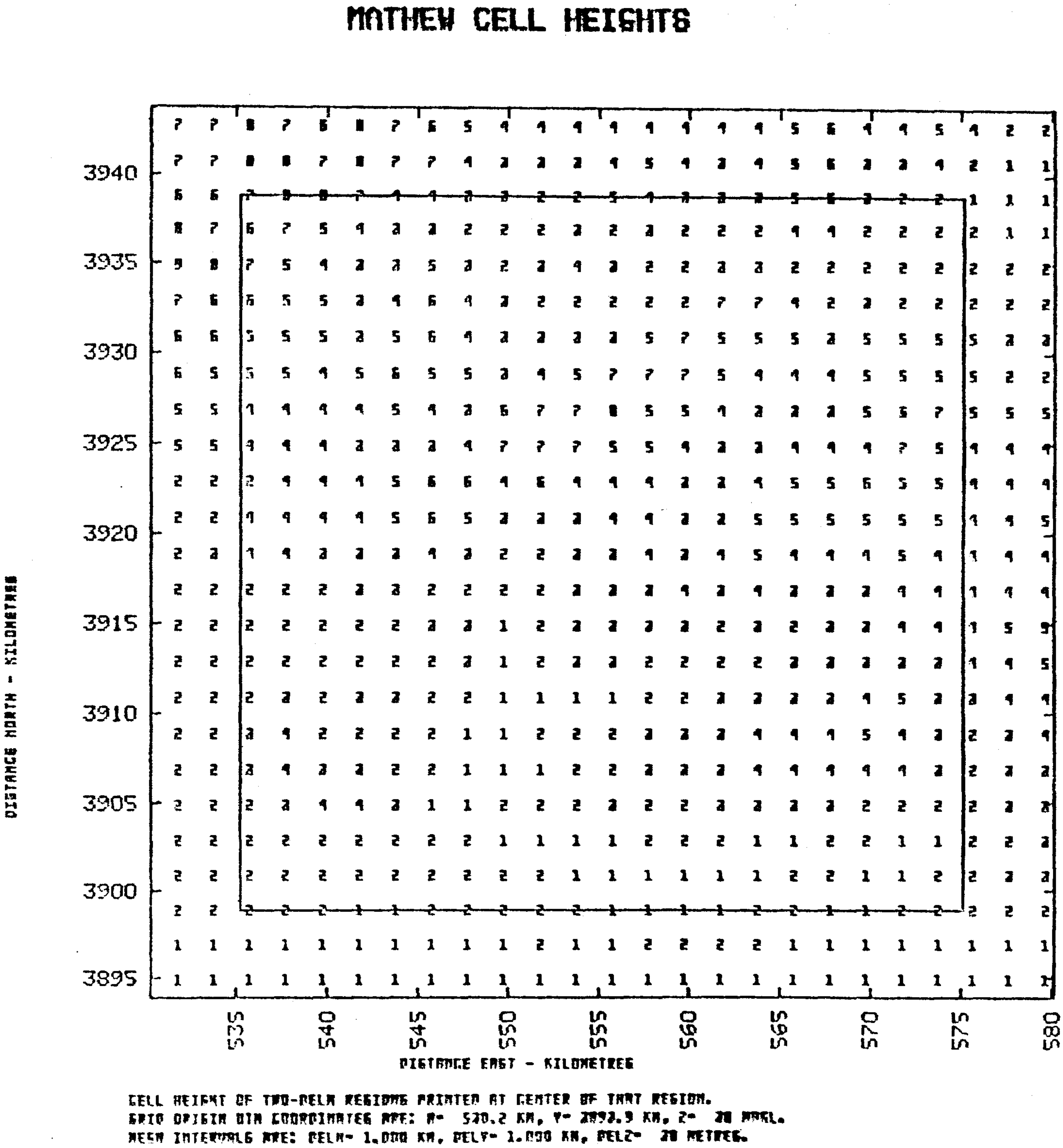

MATHEW CELL HEIGHTS
DISTANCE NORTH - KILOMETRES
3940
3935
3930
3925
3920
3915
3910
3905
3900
3895
535
540
545
550
555
560
565
570
575
580
DISTANCE EAST - KILOMETRES
CELL HEIGHT OF TWO-DELX REGIONS PRINTED AT CENTER OF THAT REGION.
MESH INTERVALS ARE: DELX= 1.000 KM, DELY= 1.000 KM, DELZ= 20 METRES.

FIGURE 4b.

100	100	110	100	90	110	100	90	80	70	70	70	70	70	70	70	70	80	90	70	70	80	70	50	50
100	100	110	110	100	110	100	100	70	60	60	60	70	80	70	60	70	80	90	60	60	70	50	40	40
90	90	100	110	110	100	70	70	60	60	50	50	80	70	60	60	50	80	90	60	50	50	50	40	40
110	10	90	100	80	70	60	60	50	50	50	60	50	60	50	50	50	70	70	50	50	50	50	40	40
120	110	100	80	70	60	60	80	60	50	60	70	60	50	50	60	50	50	50	50	50	50	50	50	50
10	90	90	80	80	60	70	90	70	60	50	50	40	50	50	100	100	70	50	60	50	50	50	50	50
90	90	80	80	80	60	80	90	70	50	60	60	60	80	100	80	80	80	60	80	80	80	80	50	50
90	80	80	80	70	80	90	80	80	60	70	80	100	100	100	80	70	70	70	80	80	80	80	50	50
80	80	70	70	70	80	80	70	60	90	100	100	110	80	80	70	60	60	60	80	90	10	80	80	80
80	80	70	70	70	60	60	60	70	100	100	100	800	800	700	60	60	70	70	70	10	80	70	70	70
50	50	50	70	70	70	80	90	90	70	900	700	700	700	600	60	70	80	80	90	80	80	70	70	70
50	50	70	70	70	70	80	90	80	60	600	600	700	700	600	60	80	80	80	80	80	80	70	70	70
80	60	70	70	80	70	60	70	60	50	500	600	800	700	600	70	80	70	70	70	80	70	70	70	70
50	50	50	50	50	50	60	50	50	50	500	600	600	60	700	60	70	60	60	60	70	70	70	70	80
50	50	50	50	50	80	50	60	60	40	500	[illegible]	[illegible]	800	[illegible]	50	60	50	60	60	10	70	70	80	80
50	50	50	50	50	80	50	50	40	40	50	60	60	50	50	50	50	60	60	60	80	80	70	70	80
50	50	50	60	50	60	60	50	50	40	40	40	40	50	50	60	60	60	60	70	80	80	60	70	70
50	50	60	70	50	50	50	50	40	50	50	50	50	60	60	60	70	70	70	80	70	60	50	60	70
50	50	60	70	60	60	50	50	40	80	40	50	50	60	60	60	70	70	70	70	70	60	50	60	60
50	50	50	60	70	70	50	50	40	40	50	50	50	60	50	60	60	60	60	50	50	50	50	60	60
50	50	50	50	60	50	50	50	50	40	40	40	40	50	50	50	40	40	50	50	40	40	50	50	60
50	50	50	50	50	50	50	50	50	50	50	40	40	40	40	40	40	50	50	40	40	50	50	60	60
50	50	50	50	50	40	40	40	50	50	50	50	40	40	40	40	50	50	40	40	50	50	50	50	50
40	40	40	40	40	40	40	40	40	40	50	40	40	50	50	50	50	40	40	40	40	40	40	40	40
40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40

50 = 2
60 - 3
70 - 4
80 - 5
90 - 4
100 - 2

FIGURE 4a.

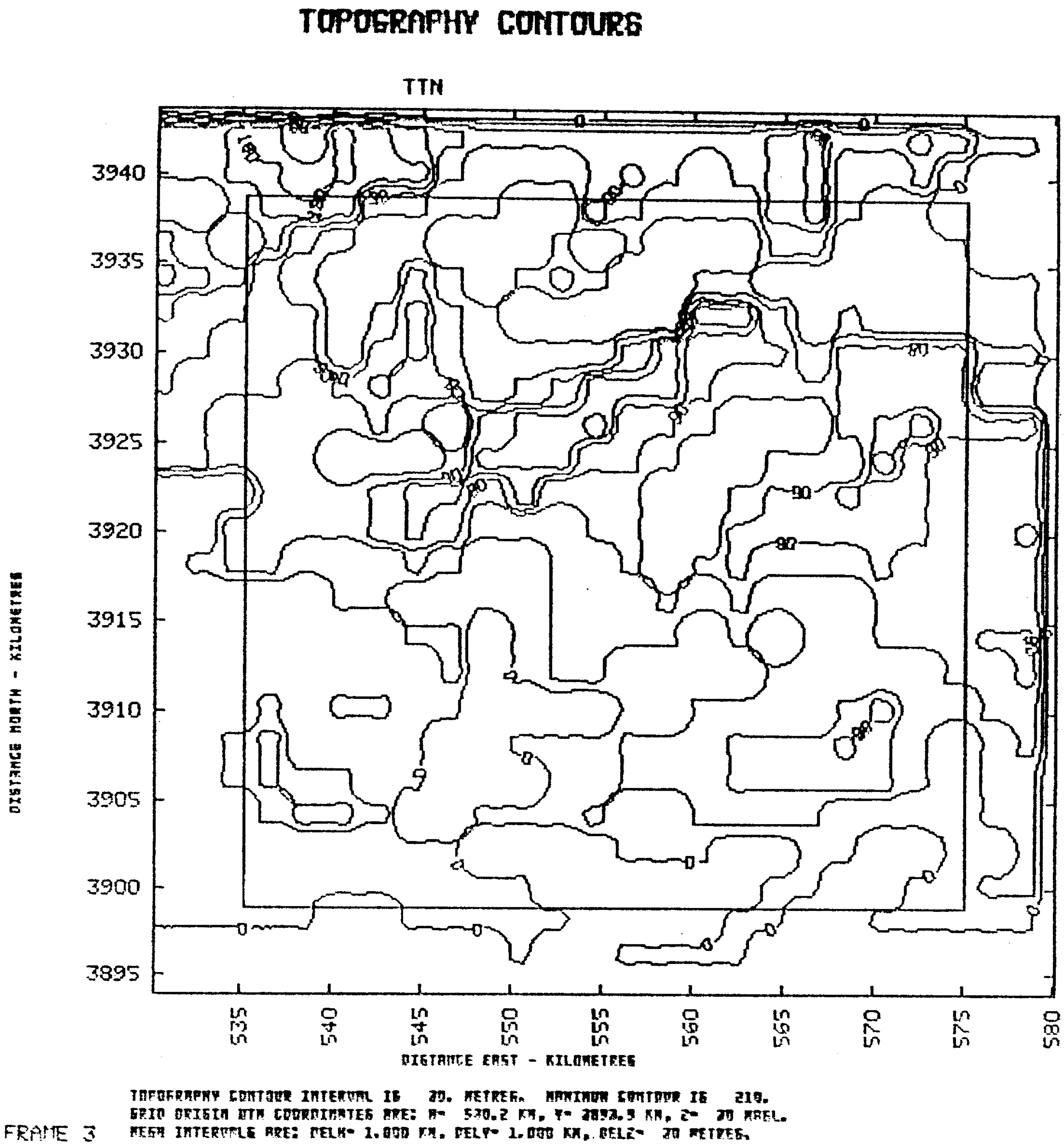

TOPOGRAPHY CONTOURS
TTN
DISTANCE NORTH - KILOMETRES
3940
3935
3930
3925
3920
3915
3910
3905
3900
3895
535
540
545
550
555
560
565
570
575
580
DISTANCE EAST - KILOMETRES
TOPOGRAPHY CONTOUR INTERVAL IS 20. METRES. MAXIMUM CONTOUR IS 210.
GRID ORIGIN UTM COORDINATES ARE: X= 530.2 KM, Y= 3893.5 KM, Z= 20 MASL.
FRAME 3
MESH INTERVALS ARE: DELX= 1.000 KM, DELY= 1.000 KM, DELZ= 20 METRES.

FIGURE 4c.

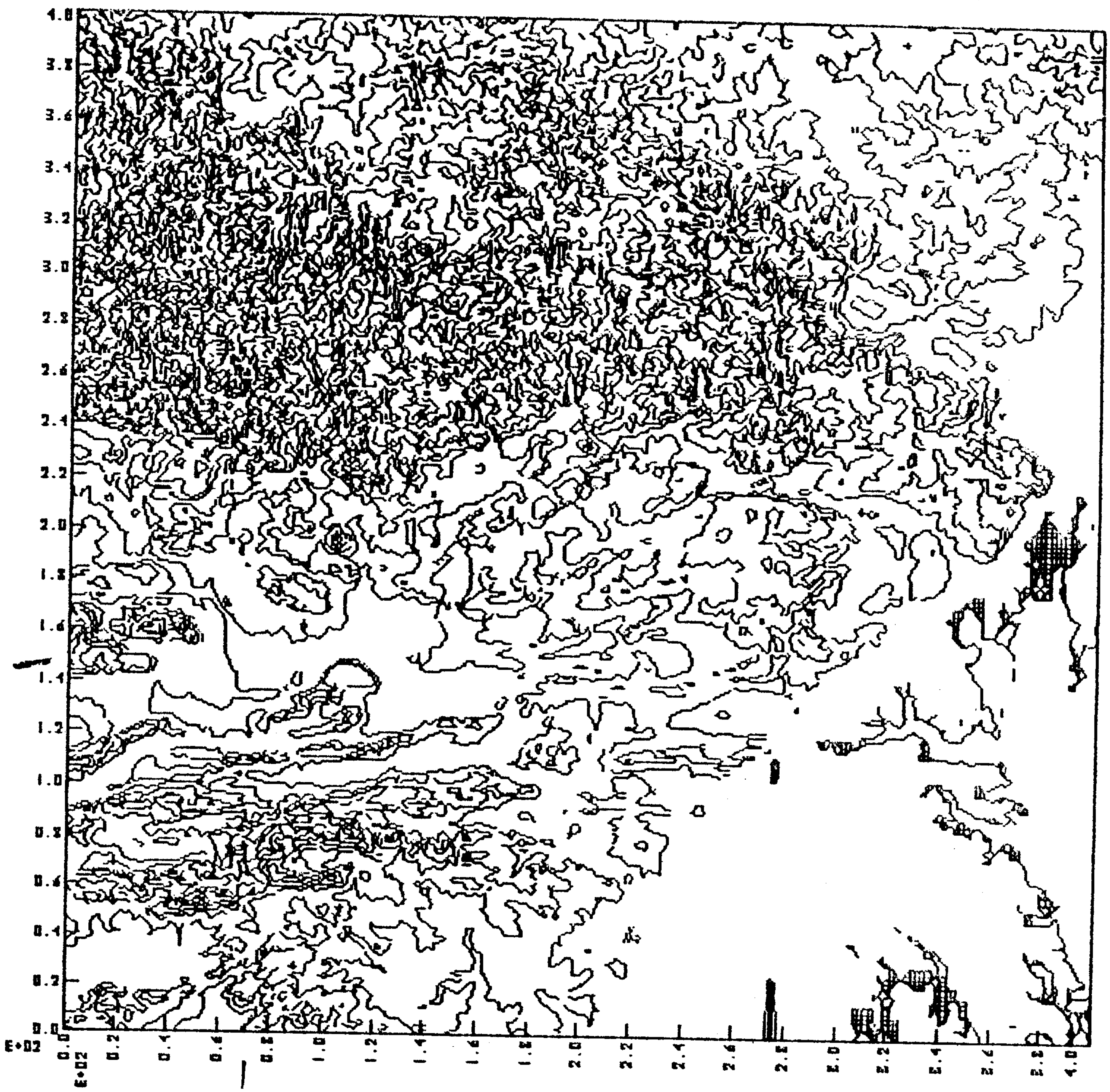

4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
E+02
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
E+02

FIGURE 5a.

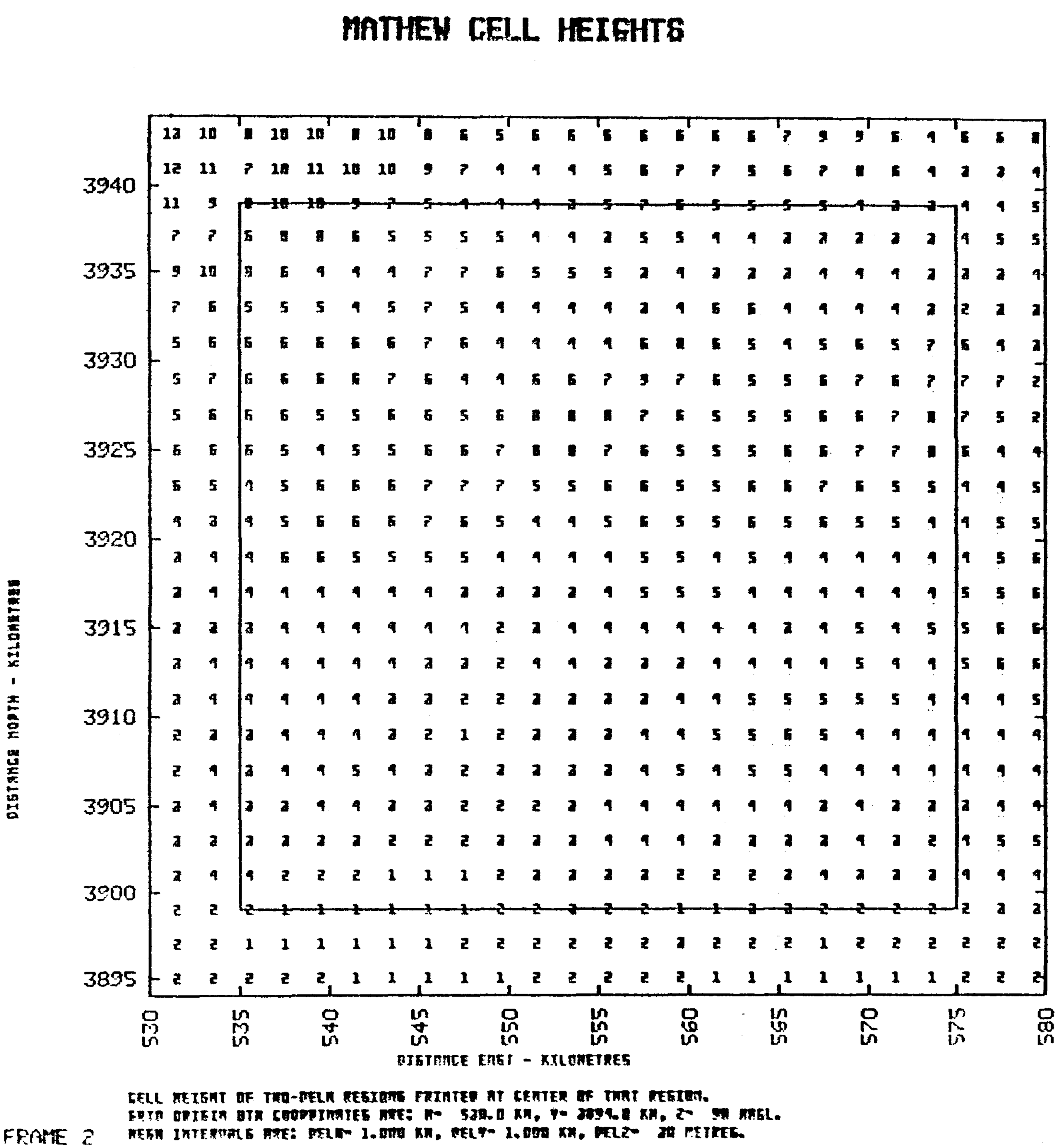
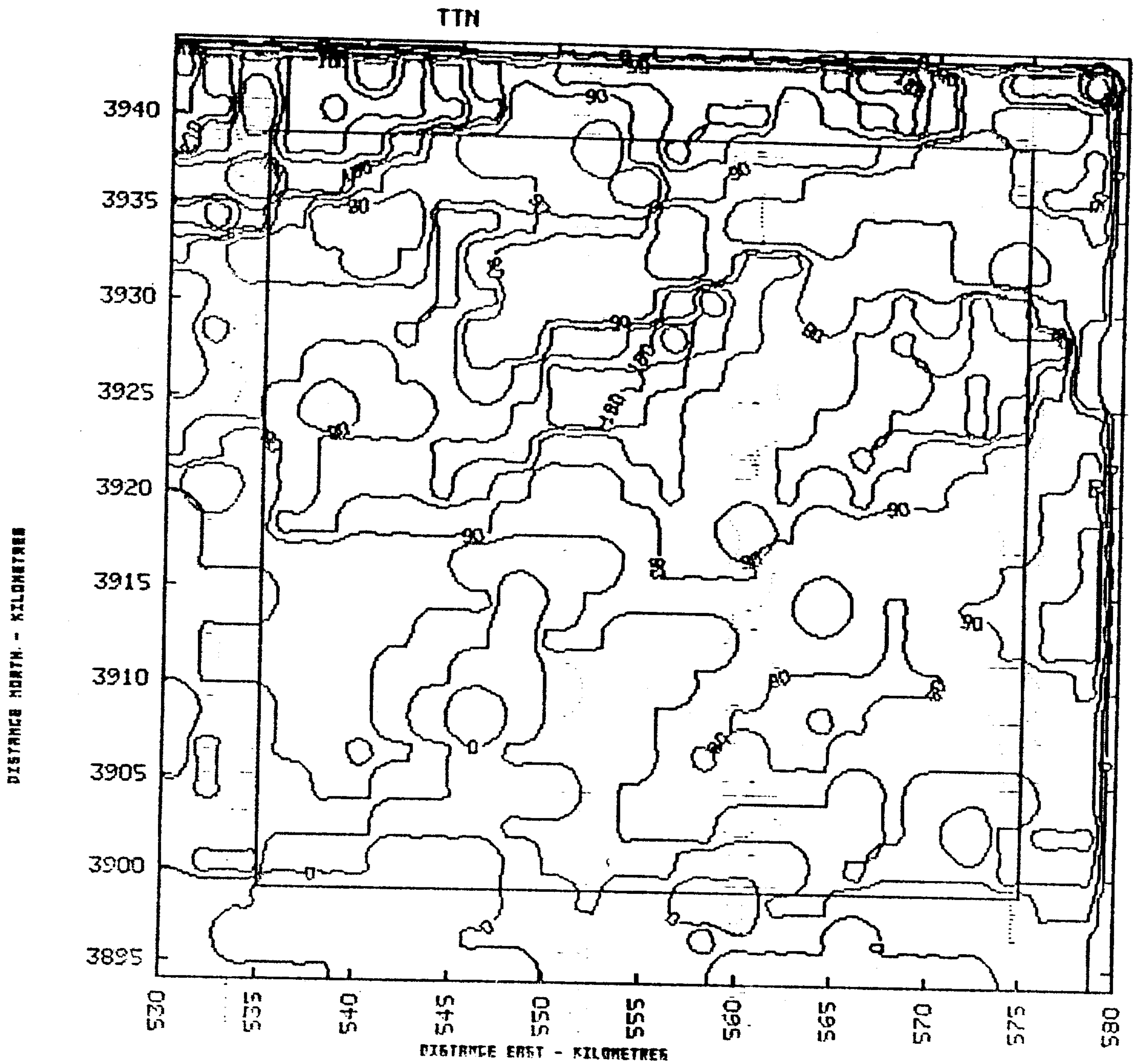

MATHEW CELL HEIGHTS
DISTANCE NORTH - KILOMETRES
DISTANCE EAST - KILOMETRES
CELL HEIGHT OF TWO-PELR REGIONS PRINTED AT CENTER OF THAT REGION.
DATA ORIGIN UTM COORDINATES ARE: X= 530.0 KM, Y= 3894.0 KM, Z= 98 MASL.
MESH INTERVALS ARE: DELX= 1.000 KM, DELY= 1.000 KM, DELZ= 20 METRES.
FRAME 2

FIGURE 5b.

TOPOGRAPHY CONTOURS



TOPOGRAPHY CONTOUR INTERVAL IS 20. METRES. MINIMUM CONTOUR IS 220.
GRID ORIGIN UTM COORDINATES ARE: X= 520.0 KM, Y= 3894.0 KM, Z= 32 MASL.
FRAME 3 MESH INTERVALS ARE: DELX= 1.000 KM, DELY= 1.000 KM, DELZ= 20 METRES.

FIGURE 5c.

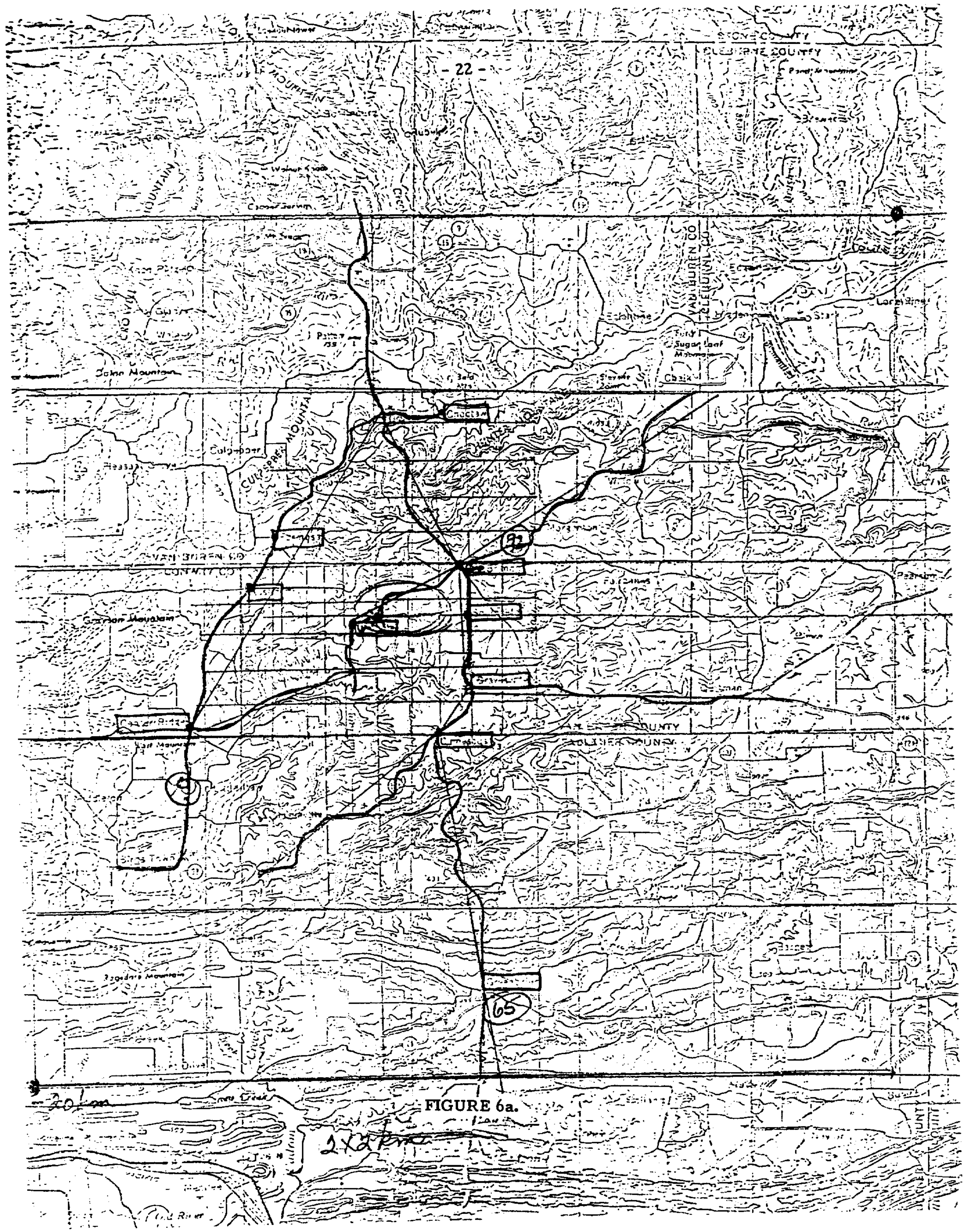

STONE COUNTY
CLEBURNE COUNTY
VAN BUREN CO
Walnut Knob
John Mountain
Choctaw
Culpepper Mountain
Garrison Mountain
Sugar Loaf Mountain
Chalk
Cedar Bridge
FAULKNER COUNTY
92
65

FIGURE 6a.

SITE LRF

Parameter

Lower Left	3894. 529.
Center	3918.869N 554.696E
Upper Right	3944. 579.

Towns

	UTM North	UTM East
Whip	3918.	553.
Bee Ranch	3921.	559.
Graves	3915.	560.
Southside	3919.	560.
Damascus	3911.	558.
Choctaw	3931.	559.
Center Ridge	3912.	543.
Green	3897.	560.
Austin	3921.	547.
Formosa	3924.	549.

Roads

HWY 9	(3912., 543.) - (3931., 555.)
HWY 65	(3931., 555.) - (3922., 560.) - (3915., 560.) - (3911., 558.) - (3897., 560)
HWY 92	(3912., 543.) - (3916., 552.) - (3919., 552.) - (3922., 560.) - (3932., 575.)
	(3903., 548.) - (3911., 558.)
	(3911., 558.) - (3911., 578.)

FIGURE 6b.

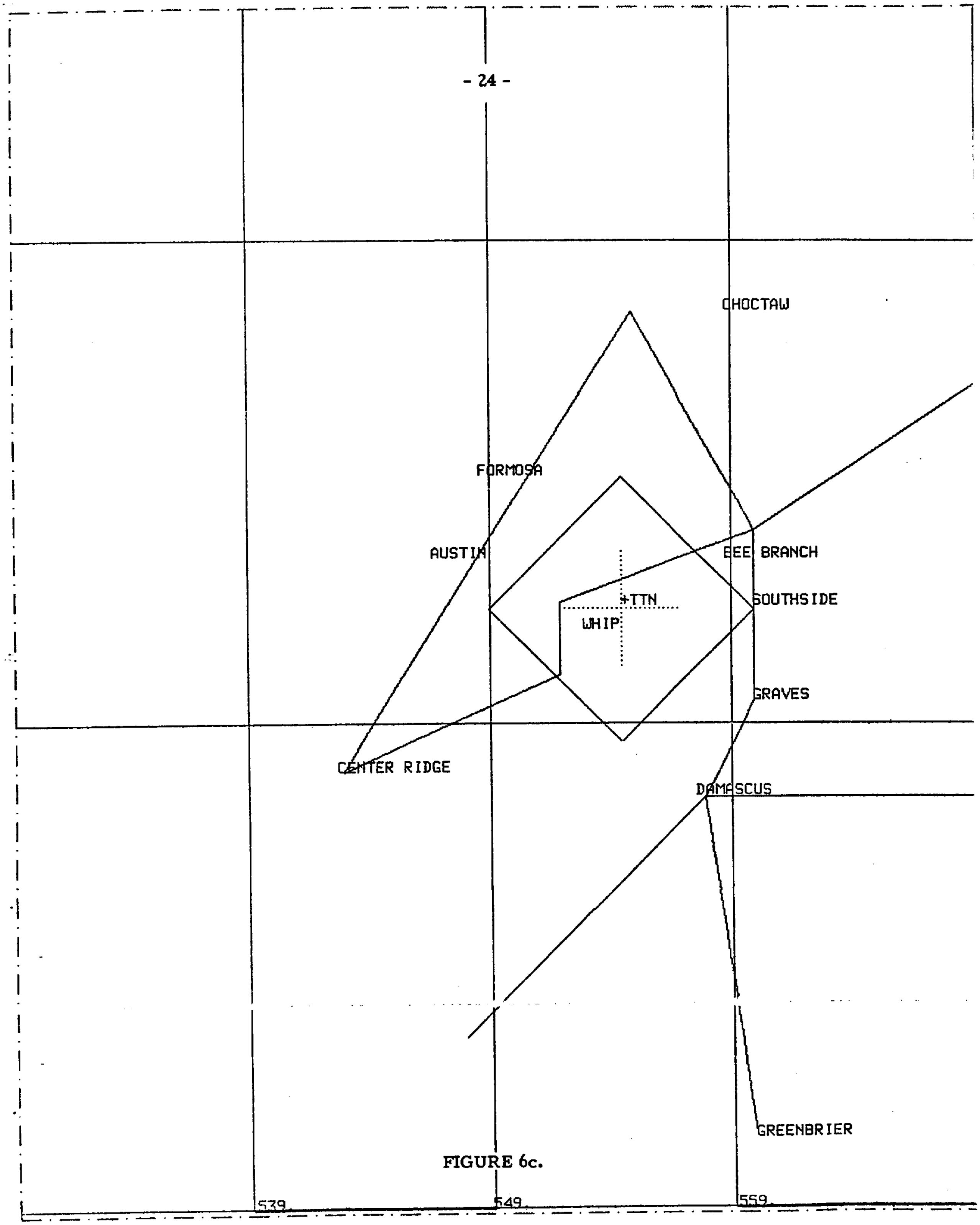


FIGURE 6c.

X = 554.586 , Y = 3918.905

```
  LRF TITANII PROBLEM, CLD CTR HGT = 70 M
UBAR= 3.0     ZTOP= 10000.    RO= 70.       ZO= 70.      JCP= 6
INVC= 4         INFP=3           B1= 10000.      B2= 50000.       B3= 100000.
KEPLOT= 1    VDEP= 1.    DIV= 6.    CRT= -1.  RAINTP= 8000.
 ZZZZZZZ
01    0.0        0.        70.    100.    1.      2.       1.      1600.    2100.     0.
02    24.        0.        70.    200.    1.      2.       1.      1600.    2100.     0.
-1
01 FISSION PARTICLES          0.00  E 00  1.0   E 00
 1 FISSION PRODUCTS-PART  CLOUD    - WHOLE BODY        1.2 E-09
 2 FISSION PRODUCTS-PART  FALLOUT - WHOLE BODY        1.7 E-11
 3 FISSION PRODUCTS-PART  INHALATION -                 0.0
 4 FISSION PRODUCTS-PART  MILK PATH  -                 0.0
 5 FISSION PRODUCTS-PART  SOIL ROOT  -                 0.0
 6 FISSION PRODUCTS-PART  SEA FOOD       - NO INFO     0.0
 7 FISSION PRODUCTS-PART  FRESH WATER F - NO INFO     0.0
02 FISSION GAS                0.00  E 00  1.0   E 00
 1 FISSION PRODUCTS-GAS   CLOUD    - WHOLE BODY        2.0 E-09
 2 FISSION PRODUCTS-GAS   FALLOUT - WHOLE BODY        0.0
 3 FISSION PRODUCTS-GAS   INHALATION                   0.0
 4 FISSION PRODUCTS-GAS   MILK PATH                    0.0
 5 FISSION PRODUCTS-GAS   SOIL ROOT                    0.0
 6 FISSION PRODUCTS-GAS   SEA FOOD       -NO INFO      0.0
 7 FISSION PRODUCTS-GAS   FRESH WATER F -NO INFO      0.0
03 STUFF                      2.2   E 09  1.00  E 10
 1 STUFF                  CLOUD    - WHOLE BODY        0.0
 2 STUFF                  FALLOUT - WHOLE BODY        0.0
 3 STUFF                  INHALATION -                 1.2 E-08       R m³ / pCi sec
 4 STUFF  TVC MEAN OF     MILK PATH  -                 0.0
 5 STUFF                  SOIL ROOT                    0.0
 6 STUFF                  SEA FOOD       -NO INFO      0.0
 7 STUFF                  FRESH WATER F -NO INFO      0.0
08 TOTAL ACTIVITY             0.0   E 00  0.00  E 00  0.00  E 00
 1 TOTAL ACTIVITY         CLOUD    - WHOLE BODY        0.0
 2 TOTAL ACTIVITY         FALLOUT - WHOLE BODY        0.0
 3 TOTAL ACTIVITY         INHALATION -                 0.0
 4 TOTAL ACTIVITY         MILK PATH                    0.0
 5 TOTAL ACTIVITY         SOIL ROOT                    0.0
 6 TOTAL ACTIVITY         SEA FOOD       -NO INFO      0.0
 7 TOTAL ACTIVITY         FRESH WATER F -NO INFO      0.0

 2 4 6 8(1)2 4 6 8(2)2 4 6 8(3)2 4 6 8(4)2 4 6 8(5)2 4 6 8(6)2 4 6 8(7)2 4 6 8(
01    0.0        0.        70.    100.    1.      2.       1.      1600.    2100.     0.
```

FIGURE 7.

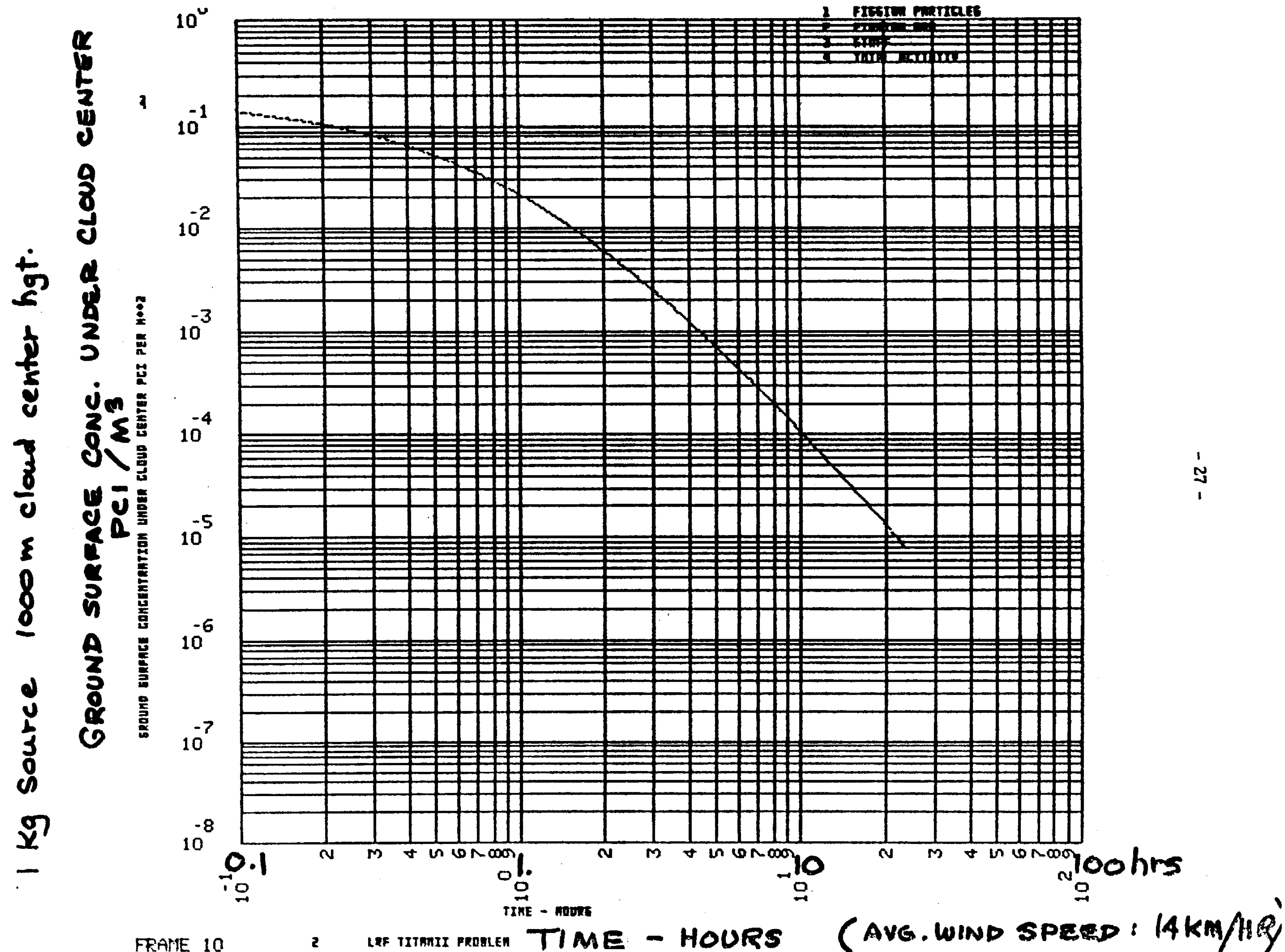

1 Kg Source 1000 m cloud center hgt.
GROUND SURFACE CONC. UNDER CLOUD CENTER
PCI / M3
GROUND SURFACE CONCENTRATION UNDER CLOUD CENTER PCI PER M**2
1 FISSION PARTICLES
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
0.1
1.
10
100 hrs
10^{-1}
10^{0}
10^{1}
10^{2}
TIME - HOURS
FRAME 10
2
LRF TITANII PROBLEM
TIME - HOURS
(AVG. WIND SPEED: 14KM/HR)

FIGURE 8b.

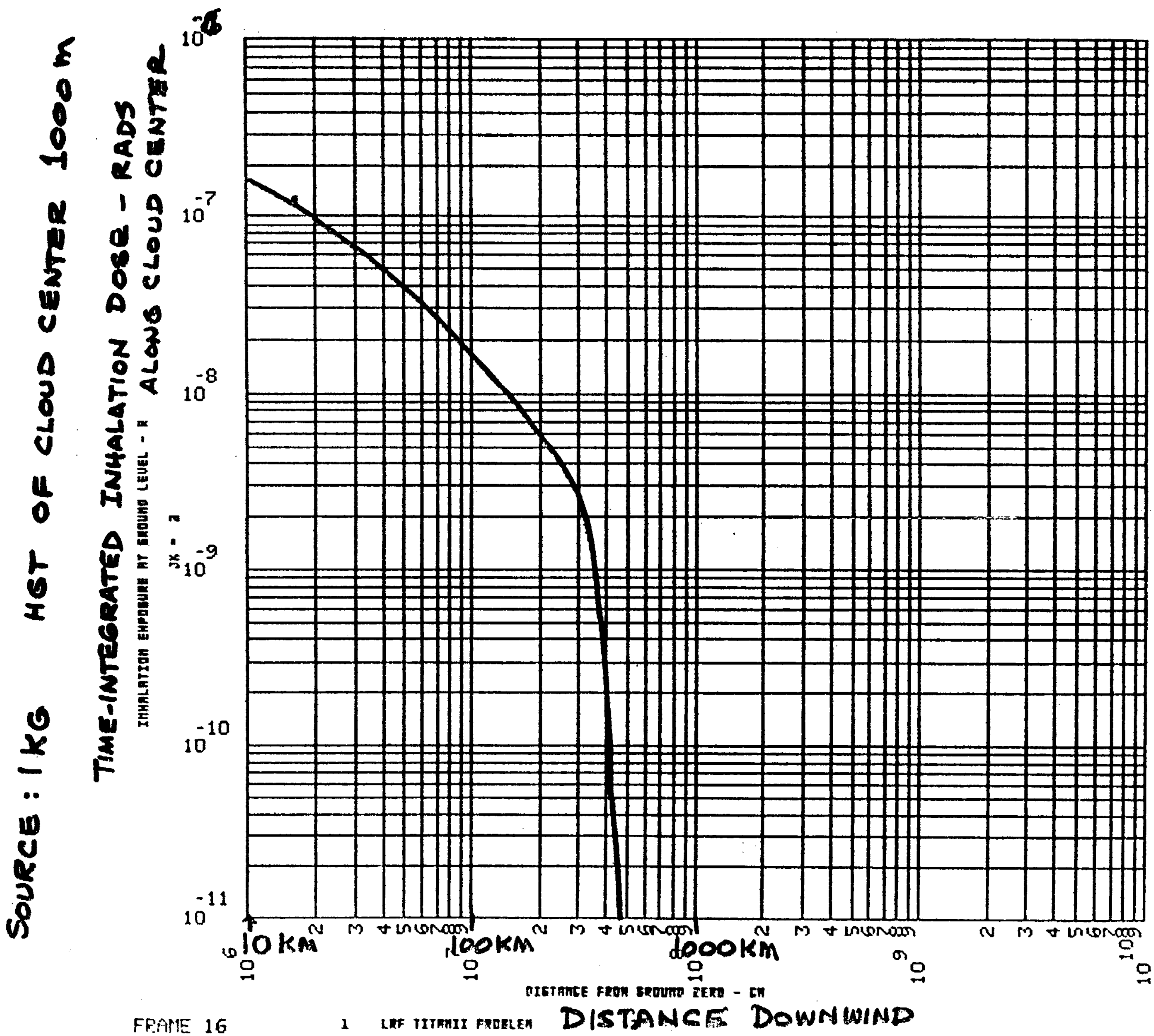

SOURCE: 1 KG HGT OF CLOUD CENTER 1000 m
TIME-INTEGRATED INHALATION DOSE - RADS ALONG CLOUD CENTER
INHALATION EXPOSURE AT GROUND LEVEL - R
10^-7
10^-8
10^-9
10^-10
10^-11
10 KM
100 KM
1000 KM
DISTANCE FROM GROUND ZERO - CM
DISTANCE DOWNWIND
FRAME 16
1 LRF TITAN II PROBLEM

FIGURE 8a.

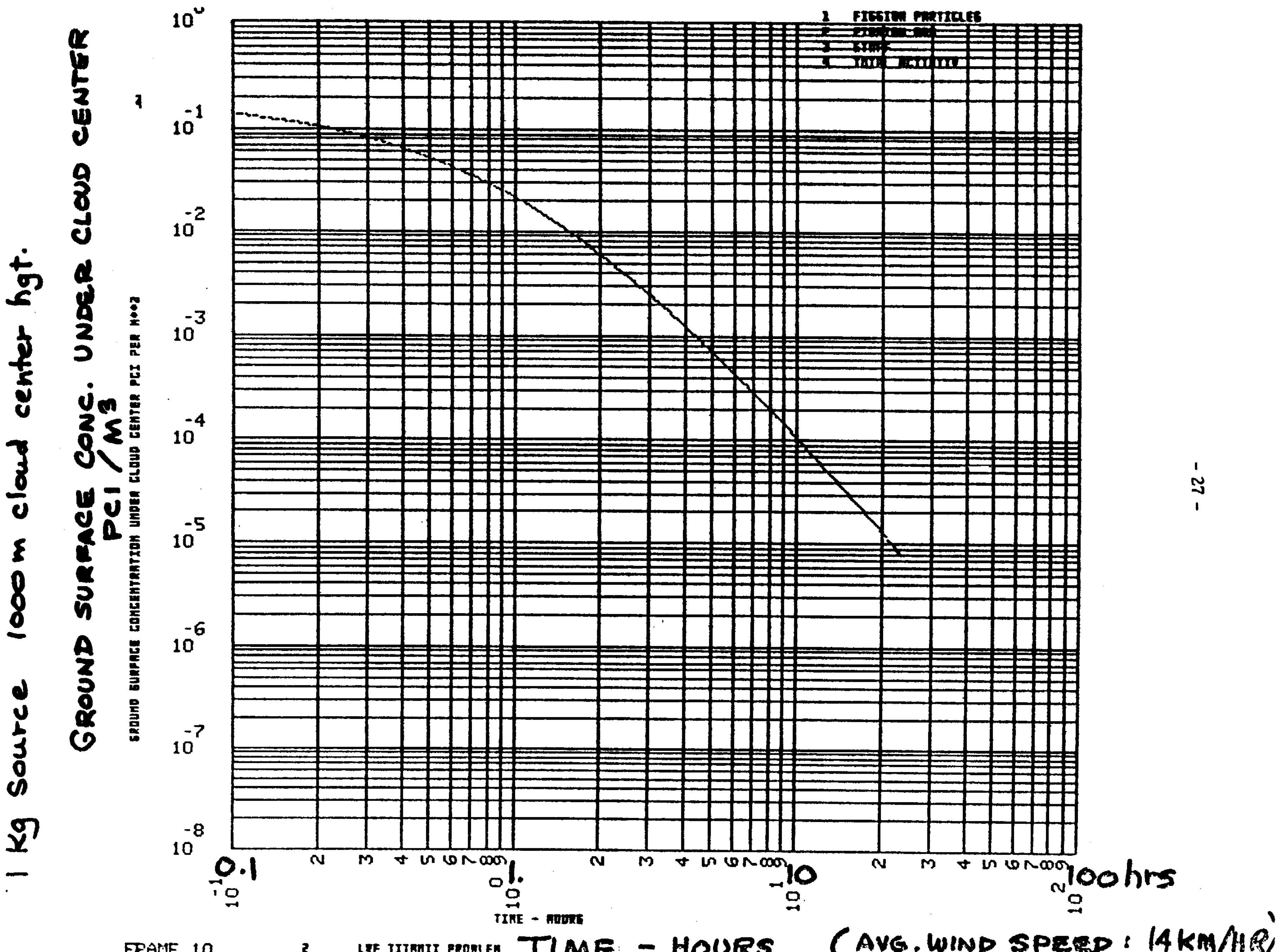
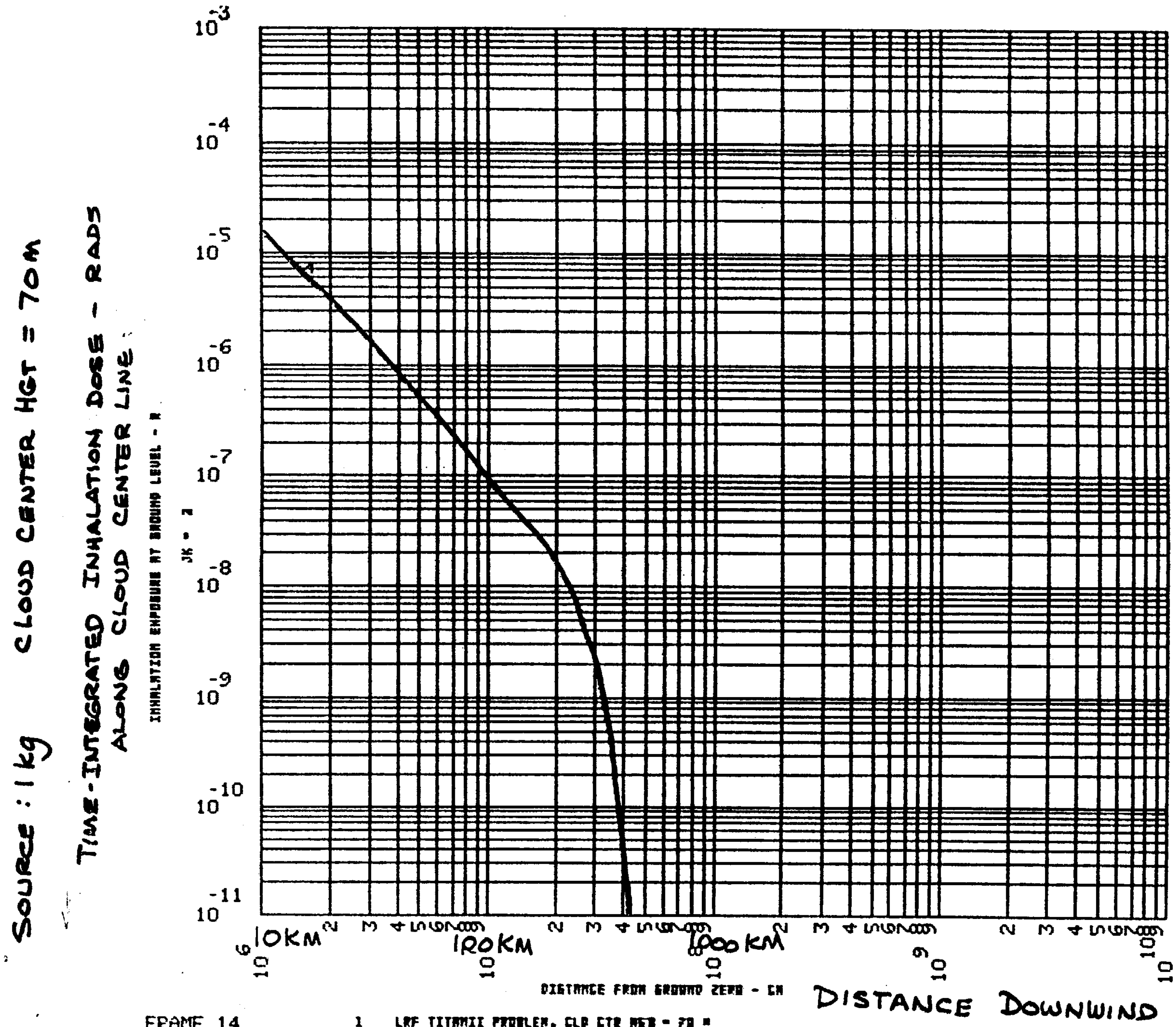

1 Kg Source 1000 m cloud center hgt.
GROUND SURFACE CONC. UNDER CLOUD CENTER
PCI / M3
GROUND SURFACE CONCENTRATION UNDER CLOUD CENTER PCI PER M**3
1 FISSION PARTICLES
TIME - HOURS
0.1
1.
10
100 hrs
FRAME 10
2
LRF TITAN II PROBLEM
TIME - HOURS
(AVG. WIND SPEED: 14 KM/HR)

FIGURE 8b.



NOTE - HIGHER DOSES <10 KM FROM SOURCE.

CODE WAS DESIGNED FOR HIGHER CLOUDS THAN 70m; CODE DOES NOT CALCULATE VALUES CLOSER THAN 10 KM.

FIGURE 8c.

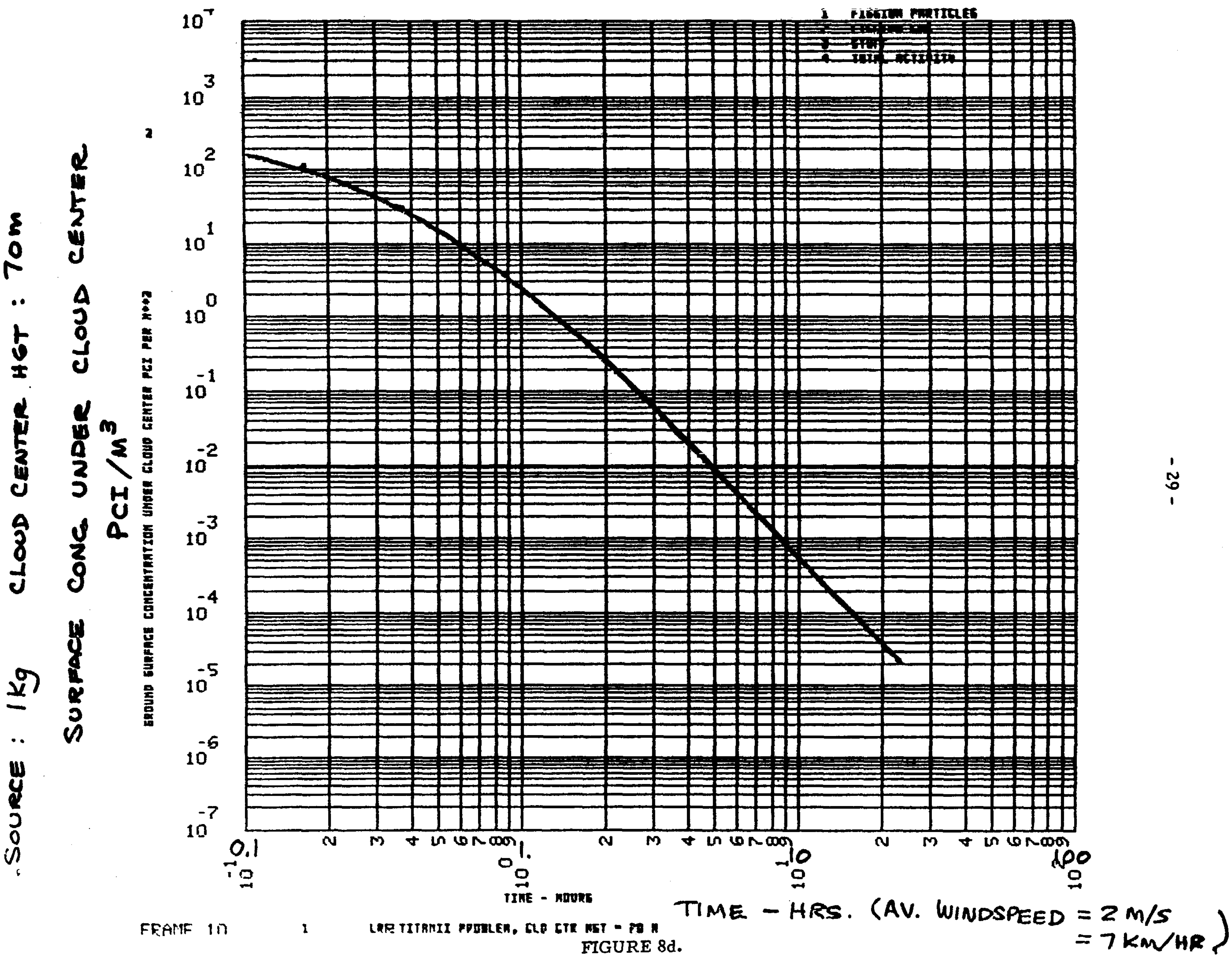

SOURCE : 1Kg   CLOUD CENTER HGT : 70m
SURFACE CONC UNDER CLOUD CENTER
PCI/M^3
GROUND SURFACE CONCENTRATION UNDER CLOUD CENTER PCI PER M**3
TIME - HOURS
TIME - HRS. (AV. WINDSPEED = 2 M/S = 7 KM/HR)
1 FISSION PARTICLES
3 STUFF
4 TOTAL ACTIVITY
FRAME 10   1   LRR TITANII PROBLEM, CLD CTR HGT = 70 M

FIGURE 8d.

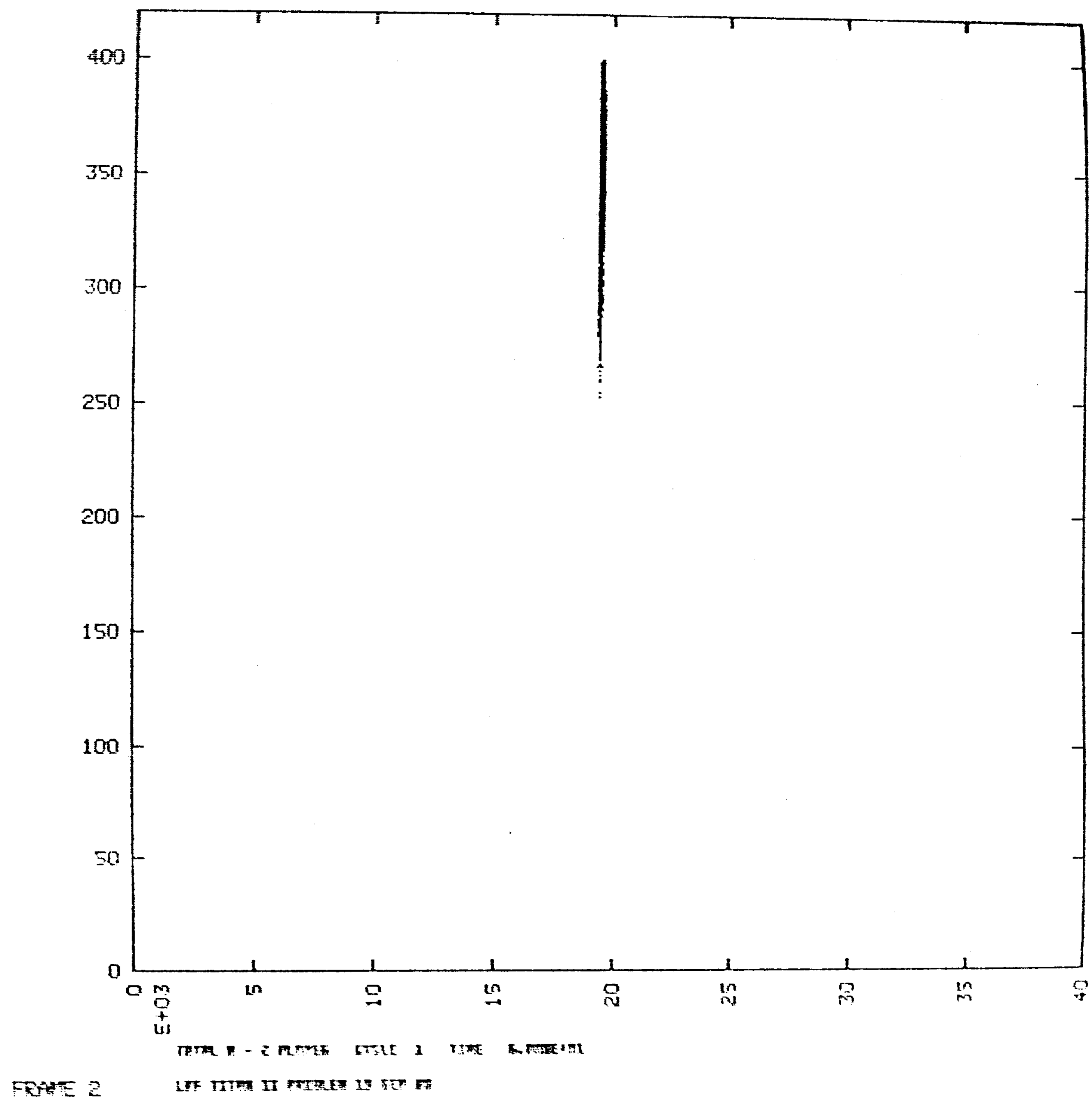


FIGURE 9a.

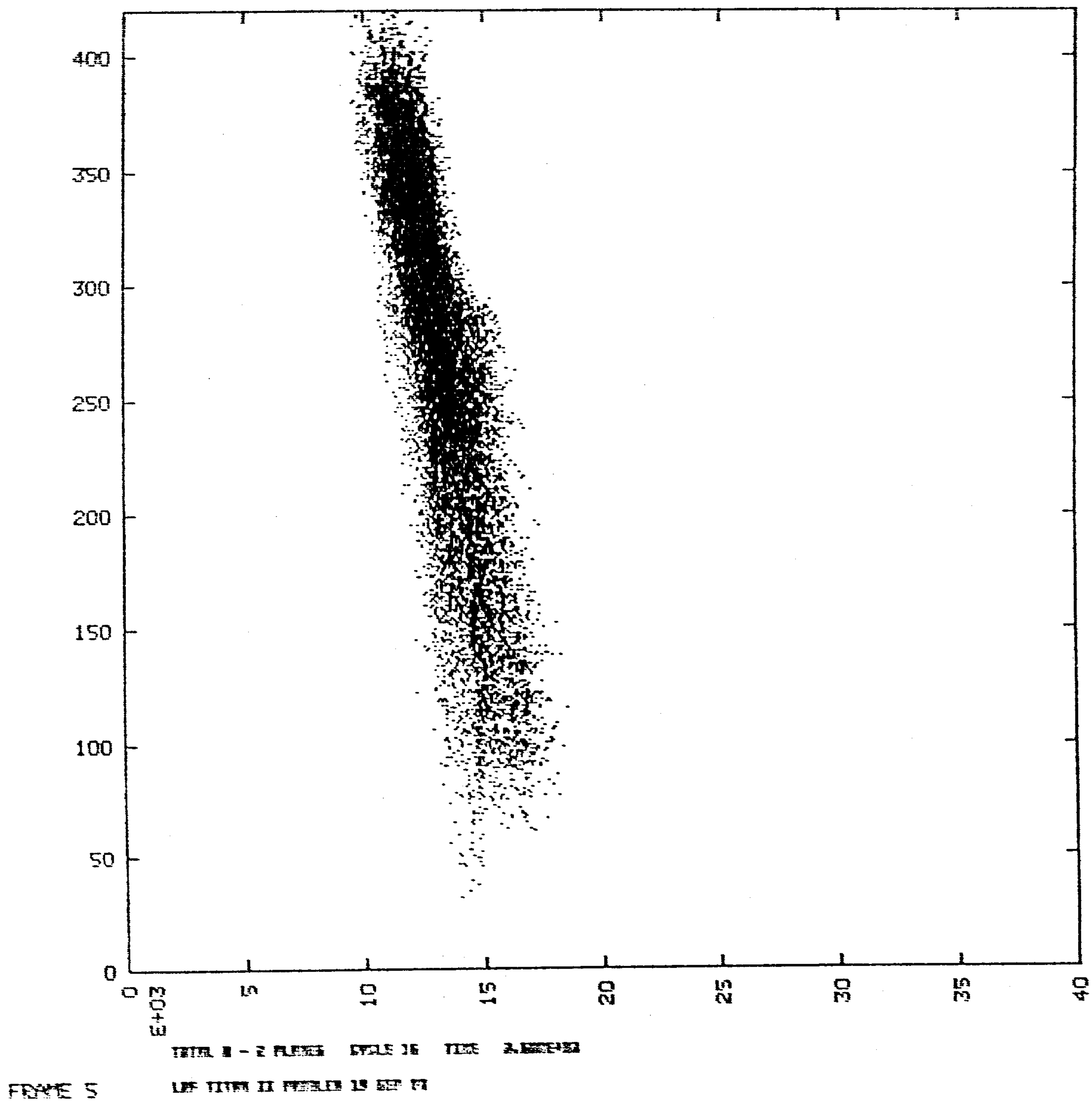


FIGURE 9b.

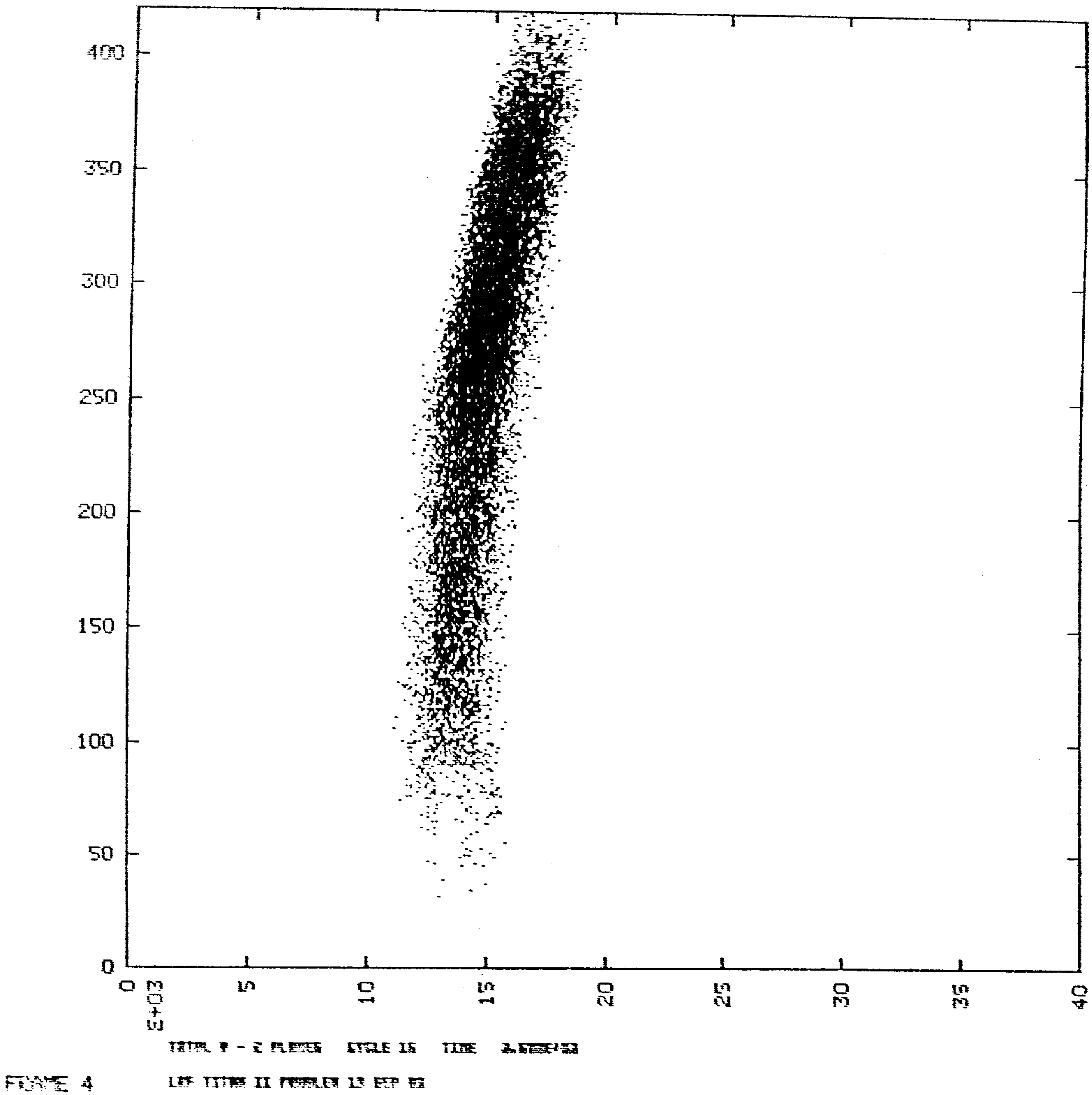


FIGURE 9c.

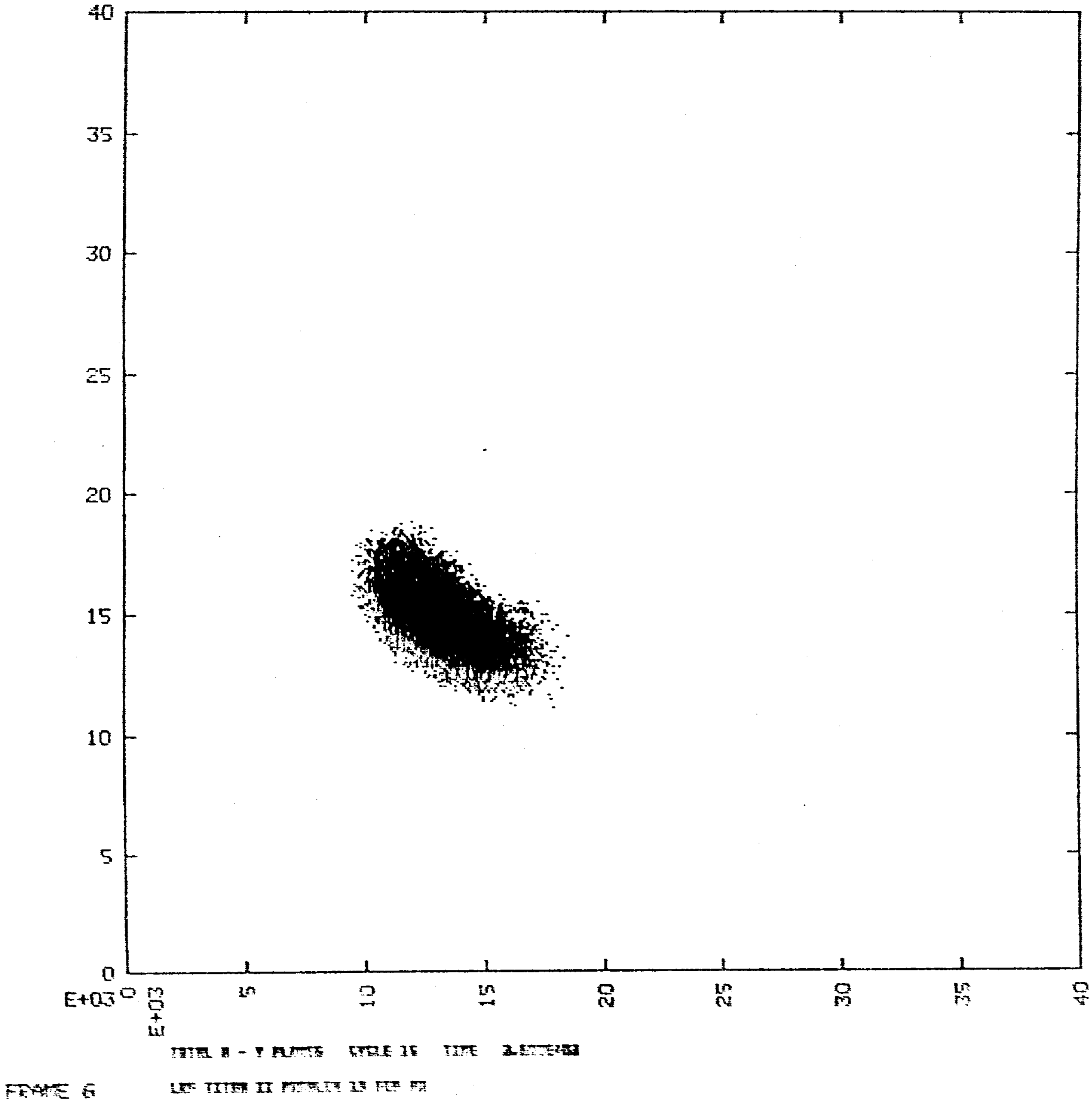


FIGURE 9d.

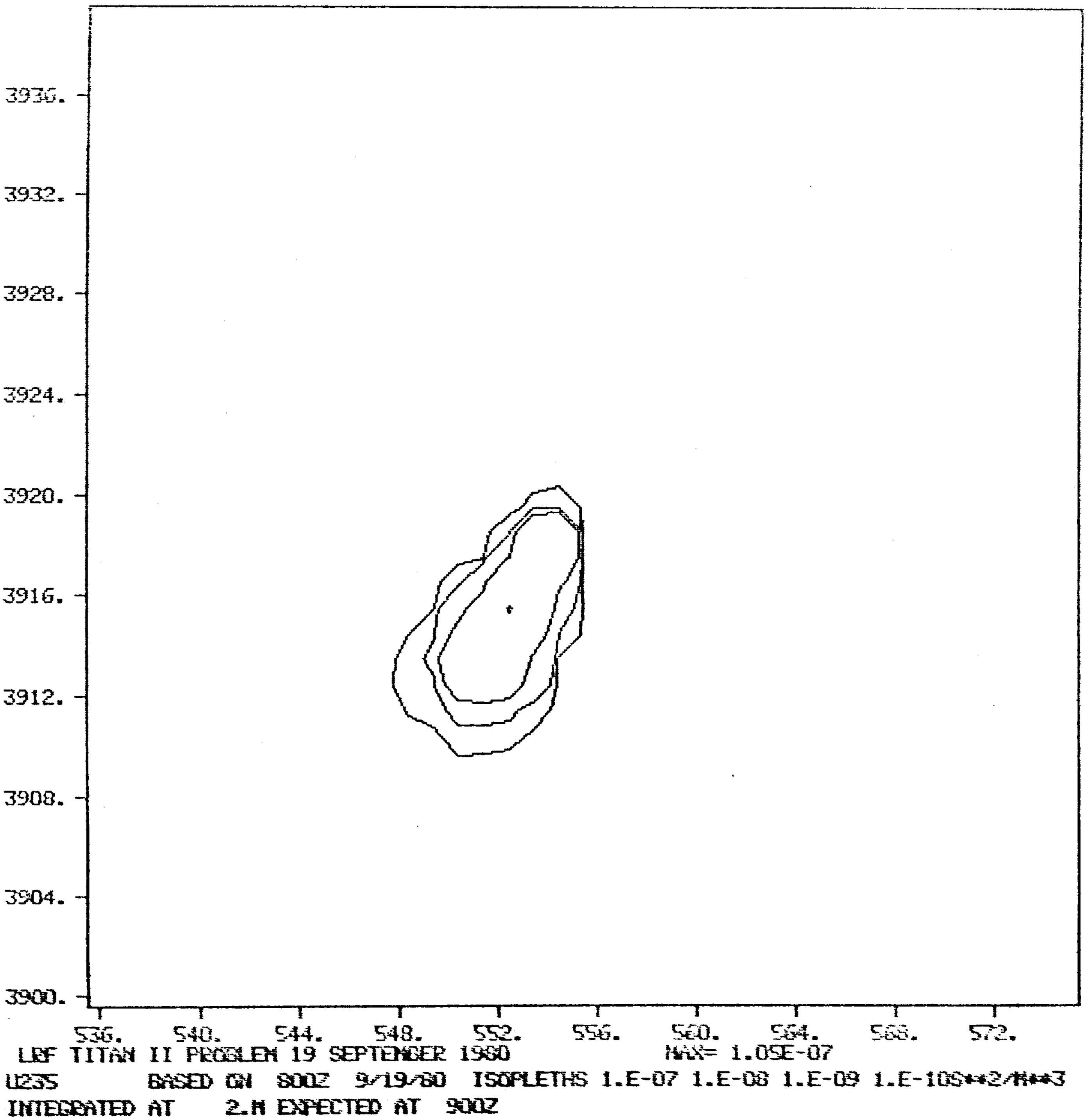

3936.
3932.
3928.
3924.
3920.
3916.
3912.
3908.
3904.
3900.
536.
540.
544.
548.
552.
556.
560.
564.
568.
572.
LRF TITAN II PROBLEM 19 SEPTEMBER 1980
MAX= 1.05E-07
U235 BASED ON 800Z 9/19/80 ISOPLETHS 1.E-07 1.E-08 1.E-09 1.E-10S**2/M**3
INTEGRATED AT 2.M EXPECTED AT 900Z

FIGURE 10a.

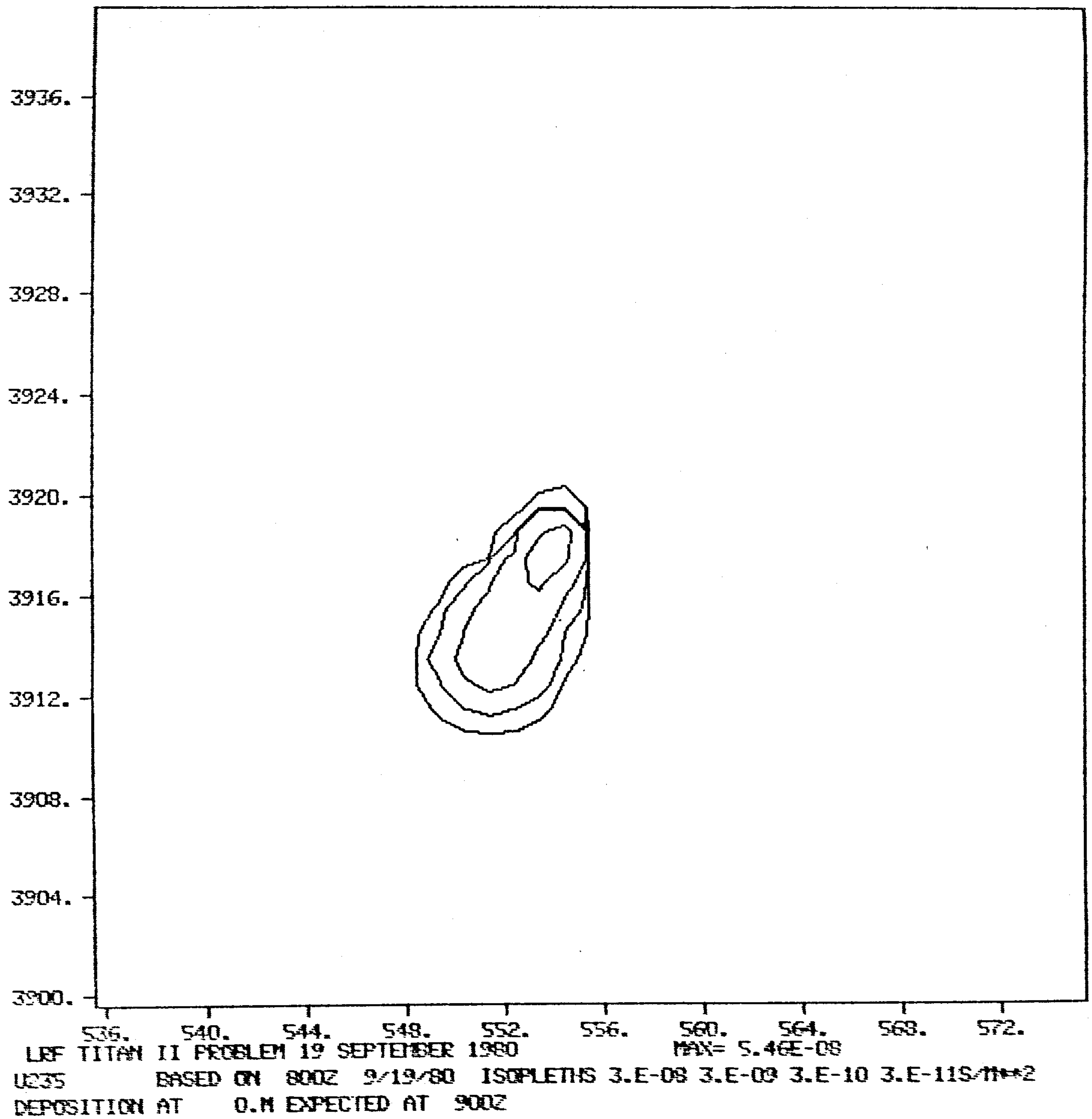

3936.
3932.
3928.
3924.
3920.
3916.
3912.
3908.
3904.
3900.
536.
540.
544.
548.
552.
556.
560.
564.
568.
572.
LRF TITAN II PROBLEM 19 SEPTEMBER 1980
MAX= 5.46E-08
U235 BASED ON 800Z 9/19/80 ISOPLETHS 3.E-08 3.E-09 3.E-10 3.E-11S/M**2
DEPOSITION AT 0.M EXPECTED AT 900Z

FIGURE 10b.

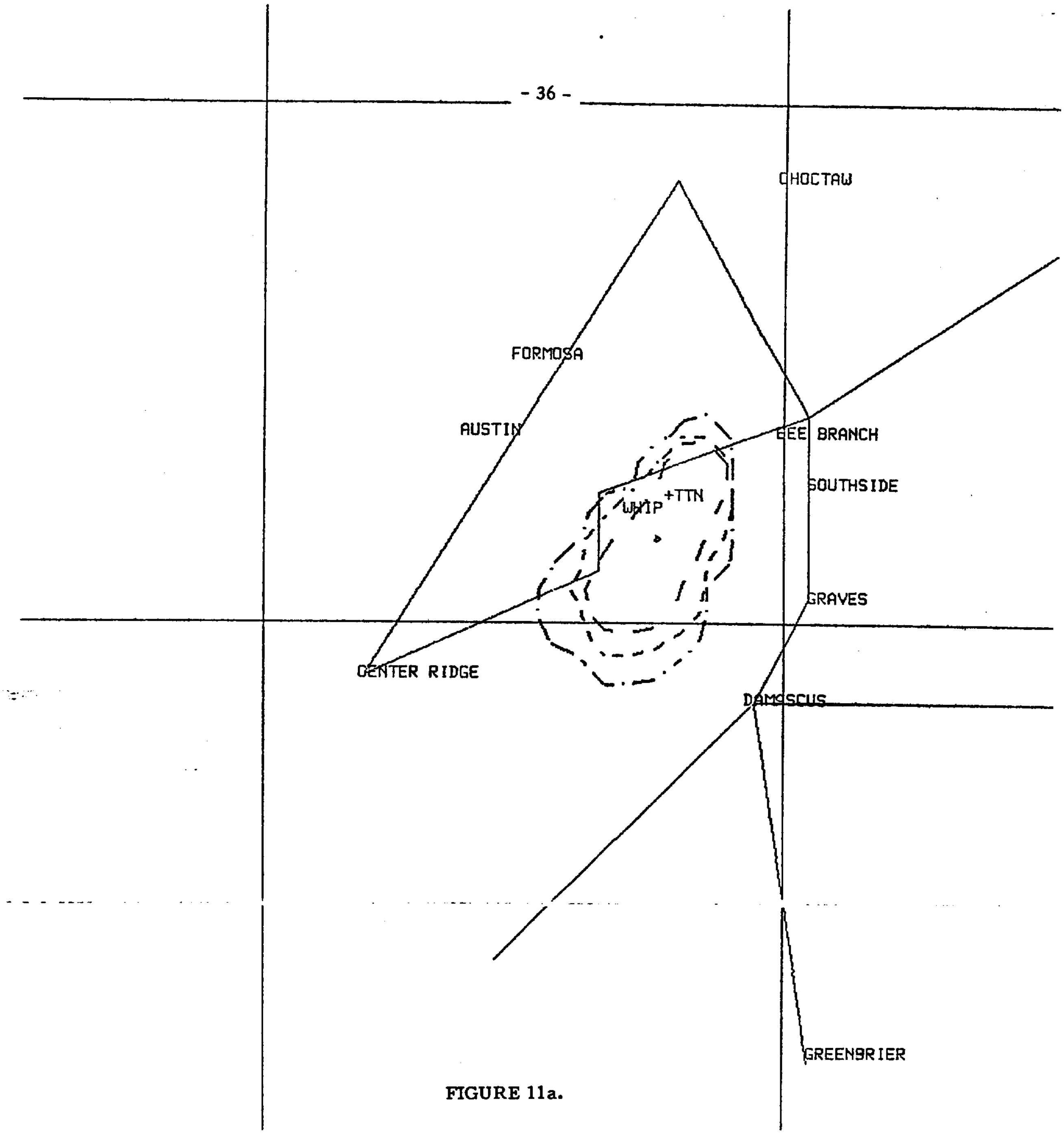


FIGURE 11a.

1. INTEGRATED SURFACE AIR-ADPIC
CURRENT T/D 9/25/80 16:50
S;S; 9/19/80 8:00 VALID; 9/19/80 9:00

LRF TITAN II PROBLEM 19 SEPTEMBER 1980 MAX= 1.05E-07
U235 BASED ON 800Z 9/19/80 ISOPLETHS 1.E-07 1.E-08 1.E-09 1.E-10S**2/M**3
INTEGRATED AT 2.M EXPECTED AT 900Z

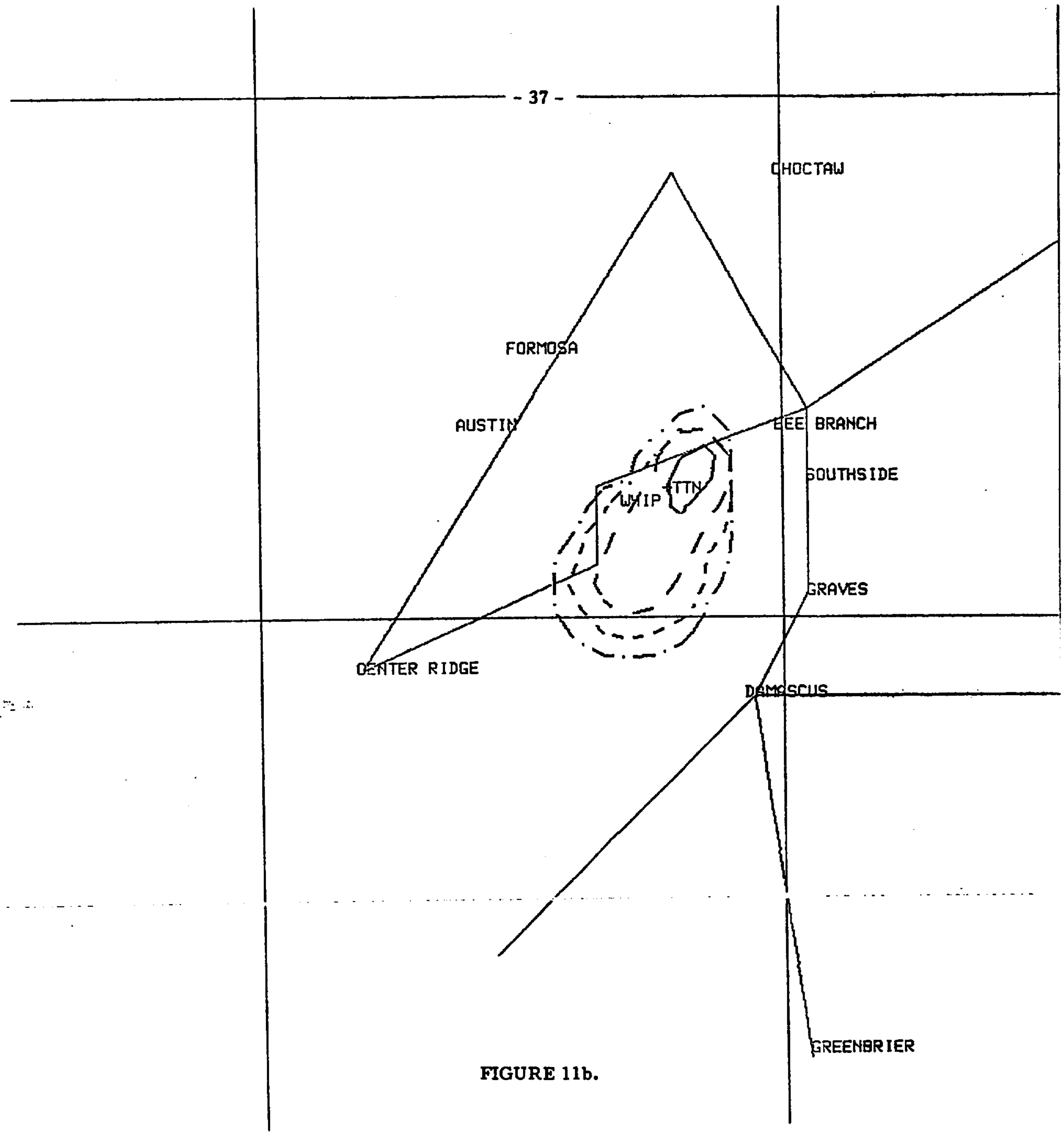


FIGURE 11b.

3. GROUND DEPOSITION-ADPIC
CURRENT T/D 9/25/80 17:08
S:S: 9/19/80 8:00 VALID: 9/19/80 9:00

LRF TITAN II PROBLEM 19 SEPTEMBER 1980 MAX= 5.46E-08
U235 BASED ON 800Z 9/19/80 ISOPLETHS 3.E-08 3.E-09 3.E-10 3.E-11S/M**2
DEPOSITION AT 0.M EXPECTED AT 900Z

APPENDIX A: CHRONOLOGY OF EVENTS

19/0000-0030Z Start of missile fuel leak.

0800Z Missile fuel explosion in silo.

1015Z LLNL SSA contacted (Bill Nelson).

1118Z ARAC contacted for NEST-type Standby.

1202Z Tom Sullivan arrives at Alert Center — vacant.

1210Z Tom Sullivan arrives at ARAC center, located Damascus/Conway

1230Z Tom Sullivan ran RAT* for meteorological data around Damascus.

Found surface, upper air stations.

Terrain — quite hilly, presenting transport problems.

1230Z Tom Sullivan notified Police dispatcher of his presence at ARAC center, requested he pass fact to Bill Nelson. Dispatcher advised that Albuquerque had deployed a NEST team.

1255Z Fritz Wolff called from DOE/EOC and relayed information concerning Oak Ridge deployment, negative reports on activity from USAF, EACT meeting to decide/act on request for assistance.

1315Z Police dispatcher called to relay a request for calculations of dispersion downwind of the accident site for the Albuquerque team (deployed). Also provided lat/lon coordinates of $30^{o}24'51"$N and $90^{o}23'50"$W (which turned out to be bad). Also learned LLNL first called at 1015 (0315L), home phone number of Bill Nelson. Tried to contact re bad coordinates — phone busy.

1320-1340Z Called out four additional ARAC staff members.

1428Z Fritz Wolff called again. DOE supporting/assisting

0800Z = accident time

"still no known radioactivity"

Albuquerque deployment of a team at USAF request

SSA - Bill Chambers (NEST) + Jay Wecsler, Jerry Dummer

He will try to establish a contact and phone number in Arkansas.

Coordinates from Fritz (DOE) good to the nearest minute:

35°24'N and 92°23'W

"Plume went several thousand feet in the air"

I requested he seek out source/accident characteristics

Team assembling

1510Z Ira Morrison — called and provided/confirmed the coordinates (to the nearest second)

I requested source/accident characteristics.

1532Z Talked with JNACC again — Bill Sayer

Requested information on the source/accident characteristic.

No answer on explosion vs. fire.

Fireball to 1000-2000 feet or higher in IR at night (personal estimate) also a plume at 200 feet.

No radioactivity on patients, fuel leak in silo then "it went".

EOD at site "Warhead may be recoverable"!

"Stability type B, 10% of oxidizer left, silo flooded, Puff-type release, small residual fire"

"USAF personnel from Pinebluff went within 1000 feet downwind and no activity"

After considerable discussion of possible source terms we decided on calculations for puff with (a) all HE and (b) 10% HE.

1545Z Talked with Walt Nervik about Alert Center knowledge of accident. Reiterated ARAC need for specific source prescription. He suggested using: (a) 10 ton (fuel) contribution (explosive) and (b) all HE.

1600Z Decided to have Ken Peterson/George Greenly prepare 2BPUFF-type calculations while the input topography files were being generated for MATHEW/ADPIC.

1600Z Dan Rodriguez went as courier to Alert Center to get actual source term information

1630Z Dan returned.

1730Z Ken Peterson had first results done but bad values due to DCON format.

1815Z First results done, called JNACC for telecopier number — bad number, always busy. Finally got back to JNACC at 1845Z, they got a new number at approximately 1900Z.

First transmission at 1915Z-1935Z (from 2BPUFF).

1835Z Fritz Wolff relayed "Probably no nuclear source at all" Probably in a "weapon recover phase", may not need or may need ARAC for recovery support.

2030Z Second set of 2BPUFF calculations sent (70m)

2145Z JNACC called Alert center "wind-down" from Dave Foster relayed by Wade Patterson.

I called JNACC/Jack Roeder and he said they were winding down. "Thanks" and that's all for this one.

2200Z Finished the MATHEW/ADPIC calculations for a normalized source with 276 m stabilization height and actual topography.

2215Z Problem with output file for the ARAC DPR system — could not marry the site "X" geography with the output contours.

2300Z ARAC involvement terminated after quick debrief/critique and storage of all computer files.

APPENDIX B: ACRONYMS AND ABBREVIATIONS

ADPIC	Atmospheric Dispersion Particle-in-Cell Model
AFGWC	Air Force Global Weather Central
ARAC	Atmospheric Release Advisory Capability
AWN	Automated Weather Net
DPR	Data Processor
EACT	Emergency Action Coordinating Team
EOC	Emergency Operations Center
EOD	Explosive Ordinace Disposal
FTS	Federal TeleCommunications System
HE	High Explosive
IR	Infrared Radiation
JNACC	Joint Nuclear Accident Coordinating Center
LLNL	Lawrence Livermore National Laboratory
MATHEW	Mass-Adjusted, Three-Dimensional Wind Field Model
NEST	Nuclear Emergency Search Team
PA	Point Analysis
RAT*	Radius Around Target code
RJET	Remote Job Entry Terminal
SSA	Senior Scientific Advisor
USGS	U. S. Geological Service
UTM	Universal Transverse Mercator Reference System
2BPUFF	An ARAC Large Cloud Dispersion Code