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WYLE RESEARCH REPORT

WR 91-4

ANALYSIS OF ALTERNATIVE NOISE METRICS FOR AIRPORT NOISE ASSESSMENT

Prepared For

BOOZ-ALLEN & HAMILTON, INC.
Transportation Consultation Division
4330 East-West Highway
Bethesda, Maryland 20814

Subcontract No. 09073-150-P0702-88

Prepared By

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Wyle Laboratories
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Arlington, Virginia 22202

(J/N 39409)

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1.0 INTRODUCTION

The Aviation Safety and Noise Abatement Act of 1979 authorized the establishment of a voluntary program of local airport noise compatibility planning, and directed the standardization of the procedure for representing and evaluating airport noise. Specifically, the Act directed the Secretary of Transportation, through regulations, to:

a. Establish a single system of measuring noise, for which there is a highly reliable relationship between the projected noise exposure and surveyed reactions of people to noise, to be uniformly applied in measuring the noise at airports and the areas surrounding the airports;

b. Establish a single system for determining the exposure of individuals to noise which results from the operations of an airport and which includes, but is not limited to, noise intensity, duration, frequency, and time of occurrence; and

c. Identify land uses which are normally compatible with various exposures of individuals to noise. (Public Law 96--193, Sec. 102.)

In response to this legislative mandate, the Federal Aviation Administration (FAA) issued Part 150 of the Federal Aviation Regulations, Airport Noise Compatibility Planning (14 CFR 150) in 1980, and adopted A-weighted Sound Level as the "single" unit for measuring noise, and the Day-Night Average Sound Level (DNL) as the "single system" for determining the exposure of individuals to airport noise.

The selection of A-weighted Sound Level, and especially DNL, was based on the best scientific information available at that time (References 1 to 3). In general, DNL was also adopted by the FAA for its environmental assessments under the National Environmental Policy Act (Reference 4), and by most other federal agencies in their environmental reviews.

Thus, ten years ago, the issue regarding the appropriate metric for determining community noise impact was apparently put to rest, and DNL was generally accepted as the most practical measure of noise exposure and the extent of incompatible land uses. Recently, however, that consensus is being called into question, largely as the result of dissatisfaction with the use of DNL in areas of low ambient noise level. People who live in such areas, and perceive that they are adversely affected by noise sources of relatively low noise level, will not accept the use of any metric which does not "prove" their dissatisfaction. Thus, for example, although such instances may actually involve DNLs well below the levels normally considered compatible with residential land use, those affected will object to such evaluation because it does not substantiate their own perceptions and expectations. Many airport neighbors object to the energy-averaging concept inherent in DNL, and believe that their annoyance is more directly related to single events rather than an average sound level. In addition, the use of logarithms to represent environmental noise levels seems to be too difficult and confusing for proper understanding by the general public. As a result, some metric other than DNL is being sought for airport noise assessments.

It is generally accepted that an individual's reactions to environmental noise within a community will depend on a number of factors, both non-acoustical and acoustical in nature. For example, a large part of that reaction will depend on the activity in which the listener is engaged, his or her expectations of the relative quiet and serenity of the surroundings, his or her attitude toward the source of the noise and the ability to control that source, and his or her feelings of apprehension about the potential danger represented by that noise source. Only a part of the reaction will depend on the physical characteristics of the noise – its spectral intensity, duration, and frequency of occurrence.

Each of these physical characteristics can be measured directly and represented quantitatively. The psychological characteristics of an individual are far more difficult to measure, and are usually unknown. Consequently, metrics have been developed to represent overall community reaction, based on the physical parameters, and are not considered reliable in representing the reactions of individual members of that community.

Over the past 40 years, during which environmental noise, and especially that from transportation vehicles, has become a serious community problem, there were many metrics which were proposed to represent community reactions to environmental noise. All of these metrics are based on the physical characteristics of the noise events involved – those characteristics which can be measured directly and stated quantitatively. In all cases, the goal was a single, unambiguous "figure-of-merit" which reasonably represents the short- or long-term noise impact on a community as a whole, and not necessarily on specific individuals within that community.

Single-event noise metrics are primarily of value in judging the relative noisiness of individual vehicle operations, and measure either the maximum noise level or the time-integrated noise level of a single event. Time-averaged noise metrics are primarily of value in attempting to measure the long-term annoyance of communities (not individuals) to environmental noise, by taking into account the number of noise events along with the noise levels of those events. Interestingly, in the U.S., the first cumulative noise metric was the initial version of the Composite Noise Rating (CNR-I), developed about 1955 by Bolt Beranek & Newman, Inc., for the U.S. Air Force. That metric ranked the octave band spectrum at maximum overall noise level against a template representing human hearing efficiency, and incorporated an approximate energy-average addition to account for the number and duration of noise events, along with a 5 dB addition for nighttime events, another 5 dB penalty for each 6 dB decrease in ambient noise level below about 50 dB, and a third 5 dB penalty if a community had little prior experience with this type of noise.

The concept of penalties for prior experience, background or ambient noise level, evening and/or nighttime noise events, and even seasonal adjustments appears intuitively valid, but most such penalties are often difficult to implement in practice. Subjective tests such as "prior experience" are difficult to apply, since different interests will interpret such guidance quite differently. Consequently, the CNR-I evolved into CNR-II, then into Noise Exposure Forecast (NEF) for aircraft noise, Community Noise Equivalent Level (CNEL) in California, and most recently into the rather rigid DNL, with exactly defined nighttime hours. As each of these metrics evolved, fewer subjective judgments were required to eliminate ambiguities and differing interpretations.

In reviewing concepts for the efficient control of environmental noise by regulation, several basic philosophies are apparent. For the regulation of community noise, there is the need for a single value "figure-of-merit", which

(1) is directly determined by well-defined measurement or calculation procedures using physical parameters, (2) is unambiguous in its determination and interpretation by those who must employ it, (3) is relatively understandable by non-technical people, and (4) provides a reasonably accurate representation of the manner in which the community as a whole reacts to the noise being controlled. This last goal is probably the least important of the four so long as the general tendency indicated by the selected metric represents the same tendency in the judged environmental noise (that is, if the metric decreases numerically, the noise also decreases roughly in the same relationship). In general, DNL meets these goals, despite continued criticism of its use. Recent research has again supported this position (Reference 5).

Inevitably, once a suitable metric has been adopted, numerical standards or guidelines must be established for that metric to represent "normally acceptable" conditions. The adopted "normally acceptable" level must provide a delicate balance between that which is economically and technically achievable without unduly reducing the benefits derived from the noise source, and that which is properly protective of the public health and welfare. Noise regulators face this balancing act constantly. Any practical noise regulation consists of a method for measuring noise effects and an "acceptable" level of those effects which balances the benefits and costs.

This point is especially pertinent in the light of the apparent dissatisfaction with DNL as a metric for regulating community noise. Community members often contend that a single-event noise metric is most meaningful in controlling their noise, and, of course, that level should be the magic 65 dB. They lose sight of the practical matter that a different noise metric will necessarily result in a different numerical value of noise acceptability. This new combination of metric and acceptable criterion in turn will probably represent approximately the same balancing of the benefits and costs as they affect the viability of the noise source.

2.0 ANALYSIS PROCEDURE

2.1 Purpose

The purpose of this report is to provide a quantitative analysis to determine if a single-event noise metric will provide additional insight and sensitivity in the assessment of airport community noise impacts, in comparison with the accepted DNL, and whether such a metric would lead to a different decision regarding the adoption of alternative noise abatement actions. By comparing noise impacts around representative airports, determined through the use of a single-event noise metric based on Sound Exposure Level (SEL), with those determined through the use of DNL, and in turn comparing both with an intuitive judgment of those noise impacts, it was intended to determine if the SEL-based metric provided advantages over DNL, primarily on those communities with DNLs less than 65 dB.

2.2 Description of the Data Base

To provide a realistic basis for comparing the efficacy of the two metrics, the study selected eight U.S. airports for analysis purposes. An earlier FAA study (Reference 6) had analyzed the noise characteristics of the U.S. airports providing commercial air service, and had grouped those airports into five categories for analytical purposes. These were:

- Large-size, Long-range airports (LLR) - 6 major airports with average daily operations ranging from 166 to 789;
- Large-size, Medium-range airports (LMR) - 22 major airports with average daily operations ranging from 153 to 791;
- Large-size, Short-range airports (LSR) - 44 major airports with average daily operations ranging from 139 to 628;
- Medium-size, Short-range airports (MSR) - 111 airports with average daily operations ranging from 14 to 72; and
- Small-size, Short-range airports (SSR) - 64 airports with average daily operations ranging from 6 to 29.

Using these categories as a guide, eight airports were selected for analytical purposes, providing a representative sampling of the U.S. airports included above. These selections were also influenced by the amount of information on hand for each, to facilitate quantitative analysis. The selected airports were:

Large-size, Long-range:
Los Angeles International Airport (LAX)

Large-size, Medium-range:
Boston Logan International Airport (BOS)

Large-size, Short-range:
Nashville International Airport (BNA)
Fort Lauderdale International Airport (FLL)
Greater Cincinnati International Airport (CVG)

Medium-size, Short-range:
T.F. Green State Airport (PVD)
Palm Beach International Airport (PBI)

Small-size, Short-range:
Bridgeport Airport (BDR).

Sufficient data were on hand for each of these airports to allow computer analysis with the FAA's Integrated Noise Model.

IT SHOULD BE EMPHASIZED THAT THE SELECTION AND USE OF THESE EIGHT AIRPORTS DO NOT IMPLY ANY UNIQUE CHARACTERISTICS OR OTHER IMPORTANCE IN REGARD TO THEIR NOISE IMPACTS, OR THAT THE NOISE IMPACTS RESULTING FROM THIS ANALYSIS ARE HIGHLY ACCURATE OR REPRESENTATIVE OF THE ACTUAL COMMUNITY NOISE CONDITIONS THERE. THESE AIRPORTS WERE SELECTED SOLELY TO PROVIDE SOME QUANTITATIVE REPRESENTATION OF ACTUAL OPERATING CONDITIONS. SOME OF THE PERTINENT CHARACTERISTICS OF THESE AIRPORTS WERE PURPOSELY ALTERED AND SIMPLIFIED FOR COMPUTATIONAL CONVENIENCE, SO THAT THE RESULTS CANNOT BE TAKEN TO REPRESENT THE ACTUAL AIRPORT CONDITIONS.

2.3 Description of Alternatives Analyzed

To provide a basis for the comparison of noise analyses employing the two different metrics, a base case was assumed for each of the eight airports, approximating the latest available operations information appropriate to each. As noted above, some simplifications were made to facilitate the computations. Inasmuch as the results are intended for comparison purposes only, the absolute accuracy of the assumptions was relatively unimportant. For direct comparison to the base case, four alternative actions were applied at each airport, intended to alter the noise impacts on surrounding communities in a predictable manner, so that the changes in the noise impacts as represented by the metrics could also be compared with the intuitive changes expected. The alternatives used were:

- *Alternative #1* – All nighttime operations (those from 2200 to 0700 the following morning) were converted to daytime operations, with the total number of operations and mix of aircraft types held constant; because of the nighttime penalty of 10 decibels included in the definition of DNL, this alternative was expected to reduce noise impacts around all airports;

- *Alternative #2* – An air cargo hub operation was added to each airport, representing a "Federal Express-like" operation such as that currently present at Memphis International Airport; the addition of a large number of nighttime operations was expected to increase noise impacts substantially around all airports;

- *Alternative #3* – All operations of Stage 2 airplanes at each airport were converted to Stage 3 models of similar performance (but inherently quieter, of course), with the same number of total operations; the substitution of quieter airplanes was expected to reduce noise impacts significantly around all of the airports; and

- *Alternative #4* – Flight tracks were altered as judged beneficial to take advantage of less noise-sensitive areas around each airport; no attempt was made to assure that such changes were practical or to determine if they affected air traffic safety or airport/airspace capacity; the purpose was only to make changes in community noise impacts which should provide some small reductions in those impacts.

Air traffic patterns at BOS have been reviewed and studied in considerable depth during recent years, because of noise problems there. In attempting to apply Alternative #4 to BOS, it was not possible to find any better flight tracks than those already in use there. This alternative was not used for the analyses at BOS.

3.0 SUPPLEMENTAL SOFTWARE

This section describes the supplemental software that was developed for this analysis. Two programs – DNLSEL, which computes numbers of operations that exceed specified SEL levels, and SELCOMP, which generates contour plots of maximum SEL – are described in detail.

3.1 Introduction

In its current form, the Integrated Noise Model (INM), Version 3.9, enables the user to generate DNL contours as well as perform Grid Analyses at specified observer points. The detailed Grid Analysis report lists the 20 noisiest aircraft at those points (ranked in descending order of noise contribution) as well as the maximum SEL associated with each flight and the numbers of day, evening, and nighttime operations.

In order to perform a comparative DNL/SEL analysis, more detailed information is required – first, contour plots of maximum SEL, and second, the numbers of operations that exceed these maximum SEL levels at regularly spaced intervals. This information can then be overlaid on a census tract map of the affected area, and the populations impacted can be estimated. A similar impact analysis can be carried out with the DNL contours, and the results can then be compared.

Thus a set of programs was developed to supplement the INM. This software essentially performs the two tasks described in the previous paragraph. Sections 3.2 and 3.3 describe the programs DNLSEL and SELCOMP, respectively.

3.2 Numbers of Operations – Program DNLSEL

The program DNLSEL was developed in order to compute the numbers of day, evening, and nighttime flight operations that exceed specified maximum SEL levels. This section describes the program and also includes a brief User's Guide.

3.2.1 Description

The program DNLSEL is intended to be used as an additional tool in performing INM analyses. The INM package has not been altered in any way. Briefly, DNLSEL is a modification of the subroutine "EXPOSR" in the INM's COMPUTE module that performs the computations for regular Grid Analysis. DNLSEL does a number of additional computations and generates the following reports:

- *Standard SEL Report* - This shows the numbers of day, evening, and nighttime operations that exceed a specified SEL level at a set of observer points. The SEL level and the observer coordinates are specified by the user in the input file SELGRID.INP. It also gives the DNL values at each of these points. This report is generated by default at the end of each run.

- *Detailed SEL Report* - This shows the numbers of day, evening, and nighttime operations that exceed the five user-specified SEL values at the specified set of observer points. Typically, these five SEL values would be those whose contours are being generated by program SELCOMP (Section 3.3). Only those points where the DNL value is between the minimum and maximum DNL values specified in the input file are reported. In addition to this information, the report also shows the maximum SEL level encountered at each point. This report is generated only if the user asks for it by using the "DETAIL" keyword in the input file SELGRID.INP.

3.2.2 User's Guide

Installation

In order to install the software, copy the executable (extension .EXE) and batch (extension .BAT) file on "INM Supplemental Disk #1" over to the subdirectory where INM output resides. Thus, if the INM is currently running in a subdirectory called \INM, use the following steps to install the software:

1. Type CD \INM <enter>.
2. Place "INM Supplemental Disk #1 - DNLSEL" in drive A.

3. Type COPY A:*.EXE <enter>.
4. Type COPY A:*.BAT <enter>.

The software is now installed and ready for use.

Instructions For Use

1. Run INM just as you would for the airport under consideration. You may or may not choose to perform a Standard Grid Analysis and/or Contour Analysis. If you do so, it MUST be for DNL analysis. The file FOR31.DAT generated by the INM's FLIGHT module is the only file used by DNLSEL.

2. Create/modify the input file SELGRID.INP using any text editor. This file should have the following structure:

```
CASE TEST RUN
AIRPORT EXAMPLE MHA
MILES
GRID
20 -20 1 1 10 10
SEL
85.0
DNL
45.0 80.0
DETAIL
85 90 95 100 105
END
```

Each entry is described below.

- Keyword "CASE" is followed by a brief description of the case being analyzed (the description can be up to 70 characters long).

- Keyword "AIRPORT" gives the name of the airport for which the analysis is being performed.

- Keyword "FEET" (or "MILES") denotes the units of the GRID parameters.

- Keyword "GRID" signifies that the following line contains the following parameters: XSTART, YSTART, XINC, YINC, IXSTEP, IYSTEP. These are the same parameters that are used for INM's Standard Grid Analysis. XSTART and YSTART are the X- and Y-coordinates of the starting point for the regular grid analysis; XINC and YINC are the increments in the X- and Y-directions, respectively, and IXSTEP and IYSTEP are the number of points in the X- and Y-directions that the analysis is to be performed. These values can be in real and/or integer form, but all of them MUST be present. They must all be expressed in the units specified previously – namely, feet or miles.

- Keyword "SEL" signifies that the next line contains the SEL value above which the numbers of operations will be computed. This level is SELIN, and is expressed in decibels. It can be in real or integer format, and must be present.

- Keyword "DNL" signifies that the next line contains the minimum and maximum DNL values between which the SEL analysis will be reported. The values are DNLMIN and DNLMAX, respectively, and are expressed in decibels. They must be present. This is included in order to reduce the amount of printed information.

- Keyword "DETAIL" is optional, and should be used only if a detailed SEL report (described in the previous section) is required. If so, then the next line must have the five SEL levels for which the detailed analysis is required.

- Keyword "END" signifies the end of the input file.

3. A separate batch file has been created to run the program. Enter SELGRID <enter> at the DOS prompt in order to execute it. The file STDSEL.PRT (standard SEL report) will always be generated. If the "DETAIL" option was specified in the input file, DTLSEL.PRT will also be generated.

Notes

1. DNLSEL will always use the file FOR31.DAT created during the last INM run. This file is unique to that particular airport analysis, and is over-written if INM is rerun for a different case. Thus it is important that DNLSEL be run IMMEDIATELY following the appropriate INM run. Alternately, the file FOR31.DAT can be renamed to something else and used later on (taking care to rename it back to FOR31.DAT).

2. In a similar vein, DNLSEL will always use the existing file SELGRID.INP for the SEL analysis. Before running the program for a different airport, make sure that this file has been appropriately edited.

3. The output (extension .PRT) files can grow quite large depending on the step size and number of analysis points. Thus make sure that you have ample space on your hard disk before proceeding with a run.

4. INM's Standard Grid Analysis module limits the number of points that can be analyzed to 20 (from a given start position). DNLSEL has no such limitation. Any number of points can be specified.

3.3 Maximum SEL Contours – Program SELCOMP

The program SELCOMP was developed in order to generate contour plots of specified maximum SEL levels. This section describes the program and also includes a brief User's Guide.

3.3.1 Description

The program SELCOMP is a modification of the subroutine "EXPOSI" in INM's COMPUTE module. It performs the calculations necessary to generate contours of maximum SEL rather than DNL (or CNEL). It uses the same pre-processing software as the INM – namely, the INPUT and FLIGHT modules. These have not been altered in any way.

In theory, a commercial plotting package (e.g., PLOT88) could have been used to generate the SEL contours. Although this is quite attractive in terms of better contour smoothing, reduced computation times, etc., there are some drawbacks to this method. Using a commercial package necessarily means entering into a licensing agreement, something that is best avoided. More importantly, it was felt that both the DNL and SEL contours should be generated using similar algorithms. Thus it was decided that the existing DNL contouring logic would be used to generate the SEL contours.

3.3.2 <u>User's Guide</u>

Installation

In order to use this software, files SELCOMP.EXE and SELCNTUR.BAT should be on the hard disk in the subdirectory where INM output resides. Thus, if the INM is currently running in a subdirectory called \INM, use the following steps to install the software:

1. Type CD \INM <enter>.
2. Place "INM Supplemental Disk #2 - SELCOMP" in drive A.
3. Type COPY A:*.EXE <enter>.
4. Type COPY A:*.BAT <enter>.

The software is now installed and ready for use. The rest of the files are for informational purposes only, and need not be copied.

Instructions for Use

1. Create the input file FOR02.DAT just as you would for a normal INM run. However, in the PROCESSES section, specify the maximum SEL contour levels that you wish to generate (for instance, 85 to 105 dB in 5 dB increments). The statement should read: "CONTOUR LDN AT 85 90 95 100 105". Note that the key word "LDN" is used instead of "SEL". This

is because the INPUT module has not been modified, as it would have to be if the key word "SEL" needed to be added.

2. A separate batch file has been created to run the program. Type SELCNTUR <enter>. The INPUT and FLIGHT modules will first be executed, followed by SELCOMP. The results will be stored on a disk file called SELINM.OUT. The SEL contour file, FOR33.DAT, can be plotted in the normal manner using INMPLOT or INMDRAW.

4.0 CALCULATION OF IMPACTS

This section describes the technique used to compute the areas and total number of people impacted by aircraft operations around the candidate airports. It also describes the results of these computations.

4.1 Introduction

The areas enclosed by the DNL and SEL contours are calculated by the COMPUTE and SELCOMP module, respectively, and are printed at the bottom of the contour plots as well as in the output files that these programs generate (INM.OUT and SELINM.OUT, respectively). Thus tabulating these data is a straightforward task. It should be noted that these areas do not distinguish between land and bodies of water. Thus, in the case of airports near major bodies of water, the actual populated areas impacted can decrease substantially.

On the other hand, determining the populations impacted by aircraft operations is a time-consuming and labor-intensive task. Several methods can be used to analyze the impacts for the DNL and SEL contours independent of each other. However, the method finally selected had to be one that would allow a correct comparison of the two different noise metrics. The alternate techniques that were tried as well as the one that was eventually chosen are described in the following section.

The results for BDR (Bridgeport) have not been considered in this analysis. This is due to the fact that the contours associated with this airport are very small in relation to the scale of the census tract map (1 inch = 2 miles), making it difficult to accurately determine the populations impacted by operations at this airport.

At an early stage of the analysis it became evident that extending the SEL population impact computations to 85 dB was extremely time-consuming, since these contours extend outward for very large distances – far greater than even the lowest DNL level (55 dB) contour. Since this study seeks to compare the two metrics, it was decided that the analysis would be limited to the region affected by DNL 55 dB and higher. It was therefore agreed upon by all the parties involved in this study to limit the analysis to SEL levels of 90 dB and higher – although the 90 dB SEL contour also usually extends beyond the DNL 55 dB contour.

4.2 Technique to Determine Population Impacts

The techniques described below were used to determine the populations impacted by aircraft operations around each of the candidate airports and for all the scenarios described earlier.

In all instances, the 1980 census tract maps and the associated "Census of Population and Housing" document prepared by the U.S. Census Bureau were used to determine the impacted populations. The maps are generally drawn at a standard scale where 1 inch represents 2 miles. However, densely populated areas are sometimes drawn at a more refined scale. Insofar as the eight candidate airports are concerned, all the maps were at the standard scale except Nashville, which is represented at a scale of 1 inch equals 4 miles.

The coordinate system that is used in the INM is normally a right-handed one with the origin located at some prominent feature, such as the end of a runway or the intersection of two runways. However, this choice is entirely arbitrary and is determined by the user. Thus, before any analysis was attempted, each of the candidate airports' runways was accurately located and drawn on the associated census tract map at the appropriate scale. The origin of the coordinate system was consistent with the INM input files.

All the noise contours were plotted at the same scale as their associated census tract maps. They were then copied onto transparent sheets so that they could be overlaid on the maps.

In the previous chapter it was noted that the program DNLSEL generates a detailed report that gives the DNL value as well as the numbers of operations that exceed certain maximum SEL values at regular intervals. For the purpose of this analysis, all the cases yielded detailed reports at one-mile intervals. Thus a regular square grid was prepared on a large transparent sheet such that it could be overlaid on the census tract maps and the information in the detailed reports could be used.

Technique #1

For a given DNL contour plot, the following method was used to determine the impacted population.

First, the contour plot was positioned on top of the map, with the runways correctly aligned. All the census tracts that lay within the contours were determined. The total population for each of these tracts was then determined from the "Census of Population and Housing" publication.

To determine the population within each contour range of a census tract:

i. A one-eighth-inch grid map was overlaid on the census tract and the total number of grid cells within that tract was determined.

ii. The total population of the tract was divided by the total number of grid cells determined in step i, above, to obtain a population-per-grid cell.

iii. The number of grid cells within each contour range in this census tract was determined, and this was multiplied by the population-per-grid cell to obtain the population impacted within that contour range.

Once the population impacted within each contour range had been computed for all the census tracts, they were summed to determine the total population impacted in each contour range for the airport and scenario being analyzed.

This method is possibly the most accurate way to determine the numbers of people impacted by the different DNL contours. However, this technique is not appropriate for the maximum SEL contours, since what is required is not merely the number of persons that lie within each contour range, but rather the "people-incidents" – that is, the number of persons that are exposed to a given SEL level multiplied by the number of operations that exceed that level. For this analysis, what was called for were the "people-incidents" that exceed 90, 95, 100, and 105 dB.

However, for completeness the technique described above was also used for the SEL contours to determine the number of persons that are impacted within each contour range – that is, without the additional computation of the "people-incidents". A comparison of the two results (DNL and SEL) yielded no meaningful information.

Technique #2

The first step in this technique was the same as in the previous one – namely, the contour plot was positioned on top of the map, with the runways correctly aligned. All the census tracts that lay within the different contour ranges were determined. The total population for each of these tracts was then determined from the "Census of Population and Housing" publication.

To determine the population per square mile within each contour range of a census tract:

i. The census tract was overlaid with a one-eighth-inch grid and the number of grid squares within that tract were counted.

ii. The total population of the tract was divided by the total number of grid squares to determine the total population per grid.

iii. The population-per-grid square was multiplied by 4 or 16 if the census tract map scale was 1 inch = 2 miles, or 1 inch = 4 miles, respectively, to obtain the population per square mile.

In order to obtain the "people-incidents", the detailed report generated by the program DNLSEL was entered into a computer spreadsheet. As described previously, this report contains the numbers of operations that exceed each SEL level at the centers of one square mile areas. The census tract in which each of these points lay was identified, and the population per square mile for that census tract (determined earlier) was multiplied by the numbers of operations in each SEL range (that is, greater than 90, 95, 100, and 105 dB) to yield the corresponding "people-incident" count. These are then summed over each of the SEL ranges to obtain the total people-incidents for the airport being considered. Since the numbers of operations in the detailed report are cumulative, the result of these computations is a table of cumulative "people-incidents".

The same methodology was adopted to compute the populations impacted within the DNL contours. Apart from the SEL values and numbers of operations, the detailed reports also list the DNL value at the centers of the one-square-mile areas. The population within each of these areas had already been tabulated in the computer spreadsheets while performing the computations of the "people-incidents". It was then a relatively straightforward procedure to sum up these populations based on whether the points lay within 55 and 59.9 dB, 60 and 64.9 dB, and so on up to 80 dB. The totals that were generated at the end of this analysis gave the populations impacted within the DNL 55-60 dB, 60-65 dB, etc., "bands". These were then appropriately summed to obtain the cumulative totals that are shown in the following sections.

4.3 DNL Analysis Results

The results of the DNL analyses, for both the areas and populations impacted, were consistent with that which was expected. The relative changes from the base case agreed intuitively with the expected changes for all of the seven airports, especially for those areas outside the DNL 65 dB contour. These trends are tabulated in Table 4-1 (impacted areas) and Table 4-2 (impacted populations), and are presented graphically in Figures 4-1 through 4-14. The DNL contours are included in Appendix A. Note that the areas and population counts are cumulative; that is, the values shown represent the totals enclosed within each noise contour. And, because of the small noise impacts found for BDR, its results are not considered meaningful and are not included in the following discussion.

Although the noise contours are displayed for DNLs from 55 through 80 dB in 5 decibel increments, the areas and populations counts are tabulated only for 75 dB and below. For all of the airports analyzed, no residential populations were impacted by DNLs above 80 dB. Thus this level of impact was disregarded. Addressing each of the alternatives examined:

- *Alternative #1 (no night operations):* Because of the 10 dB nighttime penalty incorporated in the DNL, the elimination of nighttime operations at an airport should reduce the extent of the DNL noise contours, depending on the proportion of nighttime operations in each case;

Table 4-1

Summary of Areas Impacted by Levels Exceeding DNL 55 dB

Airport	Scenario	Impacted Areas, Square Miles Day-Night Average Sound Level (DNL) Greater Than				
		55 dB	60 dB	65 dB	70 dB	75 dB
LAX	BASE	183.5	77.0	32.5	16.1	9.1
	ALT #1	115.3 -37%	48.8 -37%	22.0 -32%	11.9 -26%	6.5 -29%
	ALT #2	279.2 52%	118.2 54%	46.9 44%	21.9 36%	11.4 25%
	ALT #3	78.5 -57%	33.3 -57%	13.8 -58%	6.7 -58%	2.2 -76%
	ALT #4	181.1 -1%	77.0 0%	32.6 0%	16.2 1%	8.8 -3%
BOS	BASE	119.8	58.1	28.0	11.9	4.4
	ALT #1	86.8 -28%	42.4 -27%	20.3 -28%	8.0 -33%	3.0 -32%
	ALT #2	246.1 105%	106.7 84%	52.0 86%	26.0 118%	10.5 139%
	ALT #3	29.5 -75%	10.6 -82%	4.2 -85%	2.1 -82%	1.0 -77%
	ALT #4	NA	NA	NA	NA	NA
BNA	BASE	71.3	35.9	15.9	5.3	1.9
	ALT #1	62.2 -13%	31.7 -12%	13.8 -13%	4.8 -9%	1.7 -11%
	ALT #2	222.2 212%	99.8 178%	49.3 210%	25.8 387%	9.9 421%
	ALT #3	16.8 -76%	6.4 -82%	2.6 -84%	1.2 -77%	0.4 -79%
	ALT #4	66.9 -6%	35.5 -1%	16.3 3%	5.3 0%	2.0 5%
FLL	BASE	26.8	14.4	8.0	3.6	1.4
	ALT #1	22.0 -18%	11.9 -17%	6.4 -20%	2.6 -28%	1.0 -29%
	ALT #2	44.4 66%	25.0 74%	14.4 80%	7.8 117%	3.6 157%
	ALT #3	14.8 -45%	7.1 -51%	3.0 -63%	1.3 -64%	0.7 -50%
	ALT #4	25.4 -5%	14.2 -1%	8.2 3%	3.7 3%	1.3 -7%

NOTE: Percentages denote change relative to the base case.

Table 4-1 (Continued)

Airport	Scenario	Impacted Areas, Square Miles Day-Night Average Sound Level (DNL) Greater Than				
		55 dB	60 dB	65 dB	70 dB	75 dB
CVG	BASE	129.4	54.7	25.1	10.5	4.1
	ALT #1	65.2	30.7	13.5	5.3	2.1
		-50%	-44%	-46%	-50%	-49%
	ALT #2	245.7	118.8	54.6	27.9	10.9
		90%	117%	118%	166%	166%
	ALT #3	34.0	13.2	4.9	2.3	0.7
		-74%	-76%	-80%	-78%	-83%
	ALT #4	130.3	53.9	25.2	10.6	4.1
		1%	-1%	0%	1%	0%
PVD	BASE	39.1	16.9	6.3	2.2	0.7
	ALT #1	24.5	9.3	3.3	1.1	0.4
		-37%	-45%	-48%	-50%	-43%
	ALT #2	84.4	40.9	19.4	7.3	2.4
		116%	142%	208%	232%	243%
	ALT #3	7.4	2.6	0.9	0.3	0.1
		-81%	-85%	-86%	-86%	-86%
	ALT #4	36.6	17.3	6.7	2.2	0.8
		-6%	2%	6%	0%	14%
PBI	BASE	37.4	17.8	7.6	2.9	1.1
	ALT #1	36.7	17.4	7.5	2.9	1.1
		-2%	-2%	-1%	0%	0%
	ALT #2	182.3	81.7	39.2	19.0	8.1
		387%	359%	416%	555%	636%
	ALT #3	13.1	5.5	2.3	1.0	0.5
		-65%	-69%	-70%	-66%	-55%
	ALT #4	37.5	17.8	7.9	3.0	1.1
		0%	0%	4%	3%	0%
BDR	BASE	4.3	1.8	0.7	0.3	0.1
	ALT #1	4.1	1.7	0.7	0.3	0.1
		-5%	-6%	0%	0%	0%
	ALT #2	62.9	31.8	15.3	5.9	2.0
		1363%	1667%	2086%	1867%	1900%
	ALT #3	4.3	1.8	0.7	0.3	0.1
		0%	0%	0%	0%	0%
	ALT #4	4.8	1.8	0.7	0.3	0.1
		12%	0%	0%	0%	0%

Table 4-2

Summary of Populations Impacted by
Levels Exceeding DNL 55 dB

Airport	Scenario	Impacted Populations				
		Day-Night Average Sound Level (DNL) Greater Than				
		55 dB	60 dB	65 dB	70 dB	75 dB
LAX	BASE	482,325	263,354	99,594	38,416	13,504
	ALT #1	385,612 -20%	185,484 -30%	71,034 -29%	38,416 0%	0 -100%
	ALT #2	545,526 13%	342,572 30%	140,908 41%	60,474 57%	13,504 0%
	ALT #3	304,280 -37%	172,822 -34%	59,162 -41%	38,416 0%	13,504 0%
	ALT #4	412,698 -14%	247,818 -6%	86,090 -14%	24,912 -35%	0 -100%
BOS	BASE	246,080	111,840	60,064	4,496	0
	ALT #1	188,326 -23%	73,670 -34%	24,448 -59%	2,400 -47%	224 ---
	ALT #2	376,521 53%	220,656 97%	86,432 44%	59,840 1231%	4,272 ---
	ALT #3	49,600 -80%	12,112 -89%	224 -100%	224 -95%	0 0%
	ALT #4	NA	NA	NA	NA	NA
BNA	BASE	81,008	50,896	28,512	2,499	0
	ALT #1	72,174 -11%	45,940 -10%	21,529 -24%	2,499 0%	0 0%
	ALT #2	144,523 78%	102,062 101%	64,495 126%	37,702 1409%	13,568 ---
	ALT #3	36,935 -54%	1,950 -96%	0 -100%	0 -100%	0 0%
	ALT #4	85,195 5%	50,524 -1%	28,668 1%	2,499 0%	0 0%
FLL	BASE	52,064	30,944	19,344	12,144	0
	ALT #1	47,408 -9%	28,512 -8%	14,576 -25%	2,480 -80%	0 0%
	ALT #2	69,864 34%	48,776 58%	27,312 41%	14,576 20%	12,144 -
	ALT #3	34,556 -34%	18,188 -41%	9,644 -50%	0 -100%	0 0%
	ALT #4	46,384 -11%	30,944 0%	19,344 0%	12,144 0%	0 0%

NOTE: Percentages denote change relative to the base case.

Table 4-2 (Continued)

Airport	Scenario	Impacted Populations Day-Night Average Sound Level (DNL) Greater Than				
		55 dB	60 dB	65 dB	70 dB	75 dB
CVG	BASE	94,592	39,994	11,901	4,455	608
	ALT #1	45,371	17,307	4,867	814	304
		-52%	-57%	-59%	-82%	-50%
	ALT #2	260,060	114,009	40,043	15,971	4,656
		175%	185%	236%	258%	666%
	ALT #3	28,707	9,176	3,387	716	0
		-70%	-77%	-72%	-84%	-100%
	ALT #4	95,786	36,899	12,733	4,455	608
		1%	-8%	7%	0%	0%
PVD	BASE	103,392	43,408	15,696	4,032	1,344
	ALT #1	60,064	21,552	5,376	4,032	0
		-42%	-50%	-66%	0%	-100%
	ALT #2	207,680	108,368	42,912	16,000	2,688
		101%	150%	173%	297%	100%
	ALT #3	17,040	5,376	1,344	0	0
		-84%	-88%	-91%	-100%	-100%
	ALT #4	85,964	38,544	12,672	4,032	1,344
		-17%	-11%	-19%	0%	0%
PBI	BASE	71,653	22,147	13,910	7,368	41
	ALT #1	70,040	21,699	13,910	7,368	41
		-2%	-2%	0%	0%	0%
	ALT #2	160,975	106,784	64,363	16,472	6,541
		125%	382%	363%	124%	15854%
	ALT #3	15,335	10,549	7,200	41	0
		-79%	-52%	-48%	-99%	-100%
	ALT #4	74,652	24,100	13,910	7,368	41
		4%	9%	0%	0%	0%
BDR	BASE	2,144	2,144	0	0	0
	ALT #1	2,144	2,144	0	0	0
		0%	0%	0%	0%	0%
	ALT #2	140,436	67,360	11,072	2,144	0
		6450%	3042%	-	-	0%
	ALT #3	2,144	2,144	0	0	0
		0%	0%	0%	0%	0%
	ALT #4	3,216	2,144	0	0	0
		50%	0%	0%	0%	0%

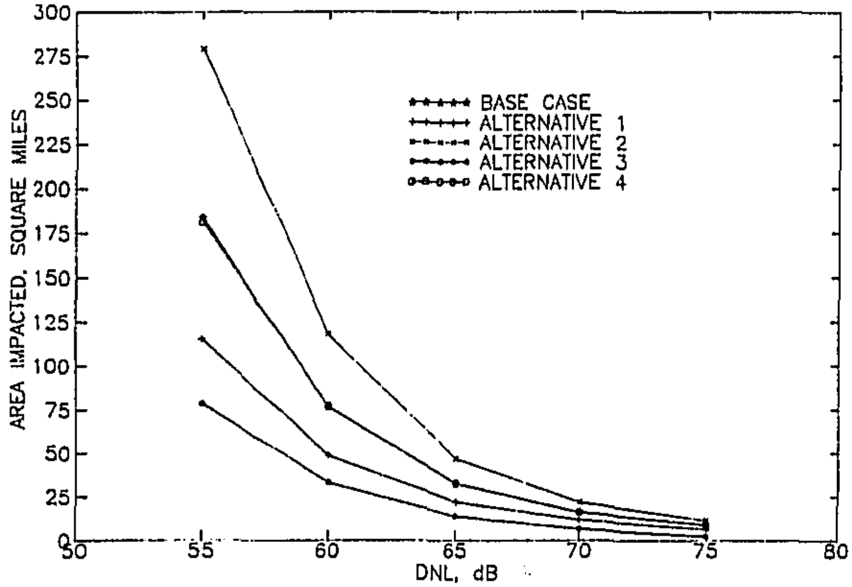


Figure 4-1. Los Angeles International Airport (LAX): Area Impacted by Levels Greater than DNL 55 dB.

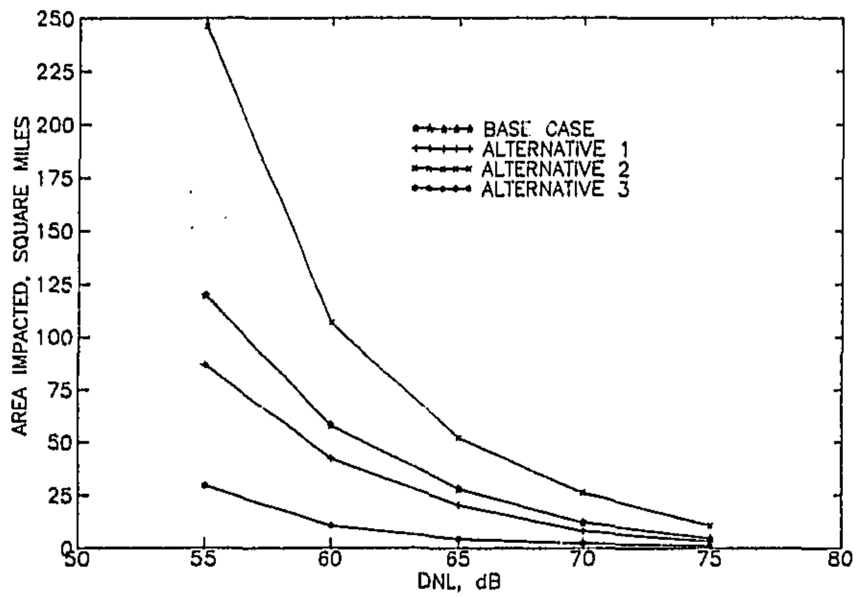


Figure 4-2. Boston Logan International Airport (BOS): Area Impacted by Levels Greater than DNL 55 dB.

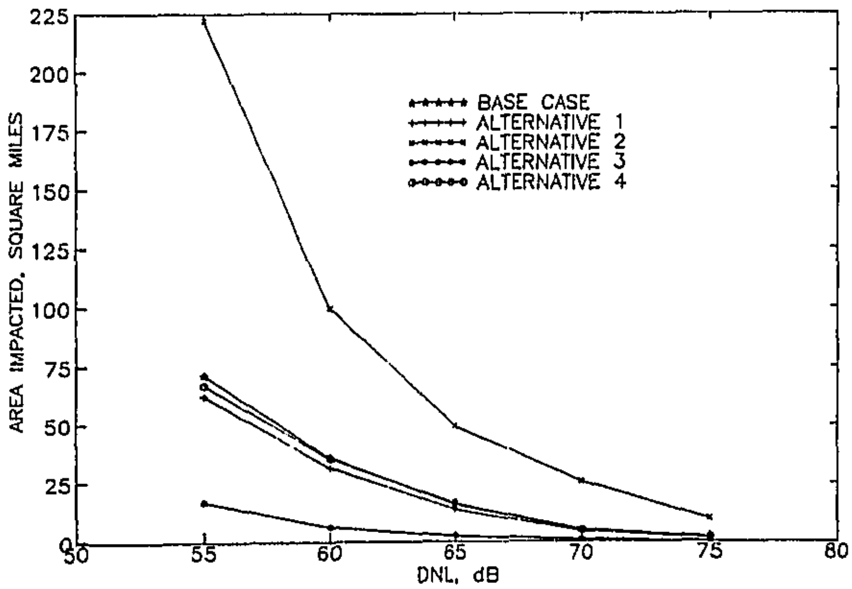


Figure 4-3. Nashville International Airport (BNA): Area Impacted by Levels Greater than DNL 55 dB.

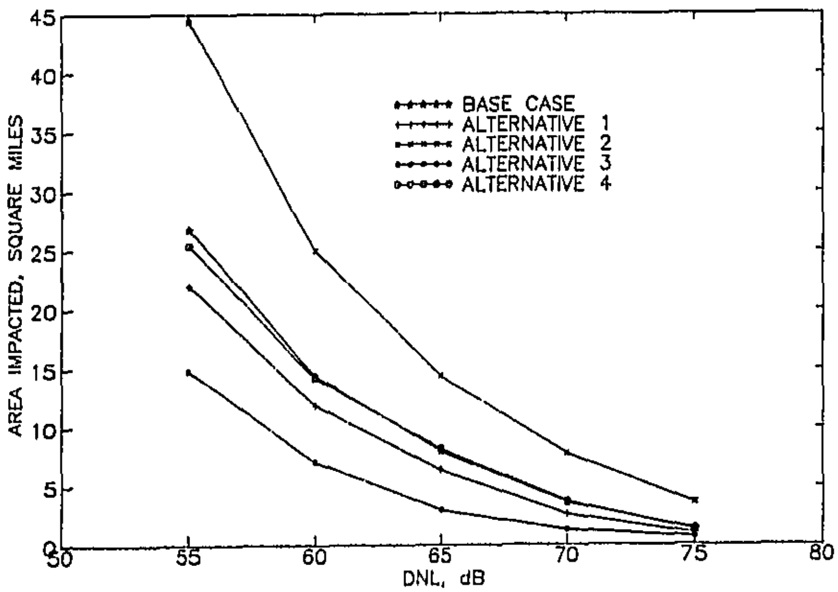


Figure 4-4. Fort Lauderdale International Airport (FLL): Area Impacted by Levels Greater than DNL 55 dB.

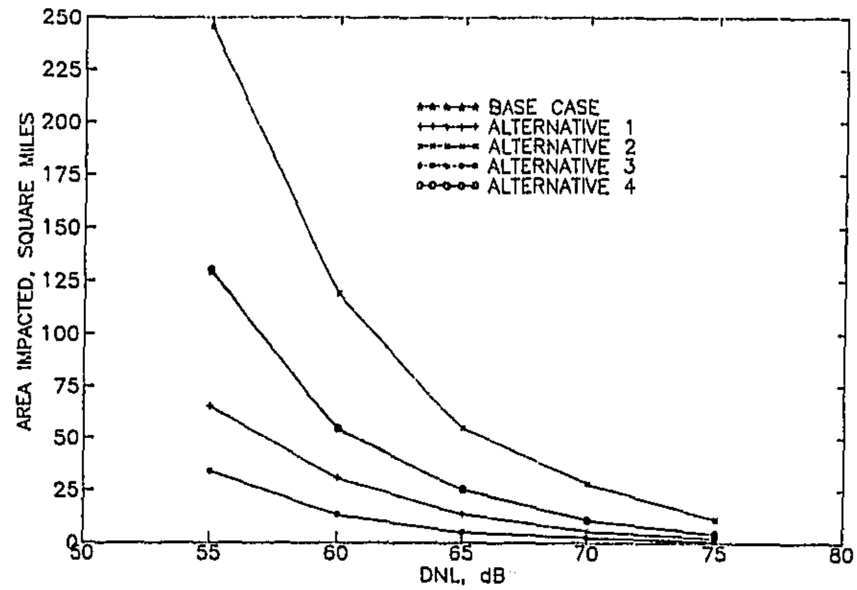


Figure 4-5. Cincinnati International Airport (CVG): Area Impacted by Levels Greater than DNL 55 dB.

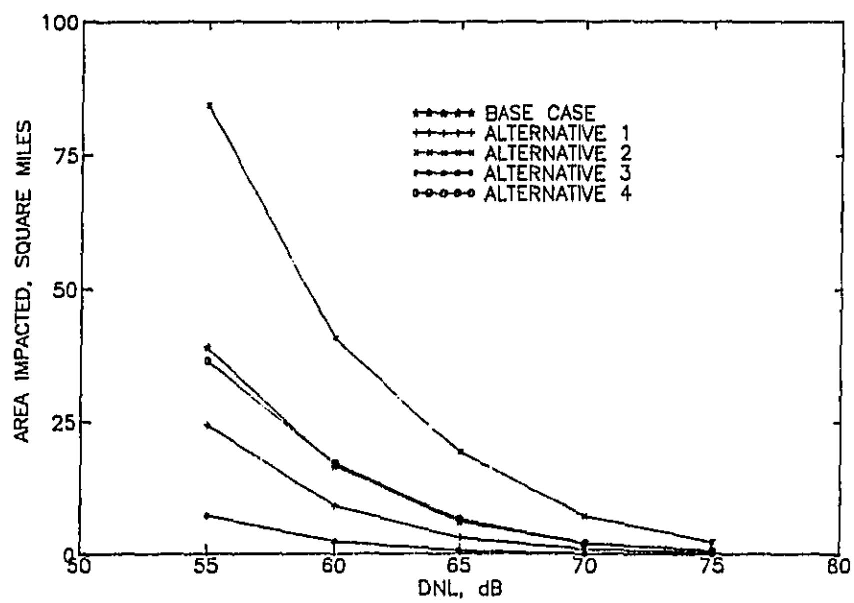


Figure 4-6. T.F. Green State Airport (PVD): Area Impacted by Levels Greater than DNL 55 dB.

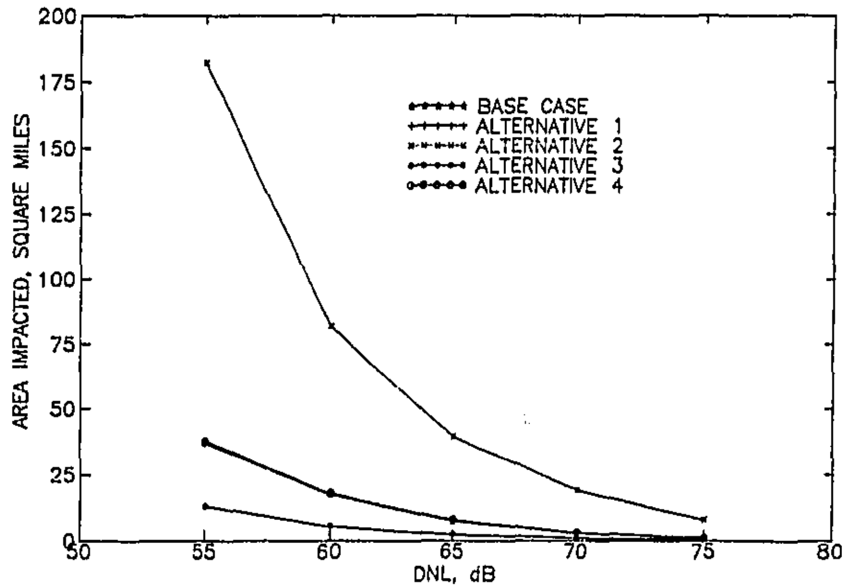


Figure 4-7. Palm Beach International Airport (PBI): Area Impacted by Levels Greater than DNL 55 dB.

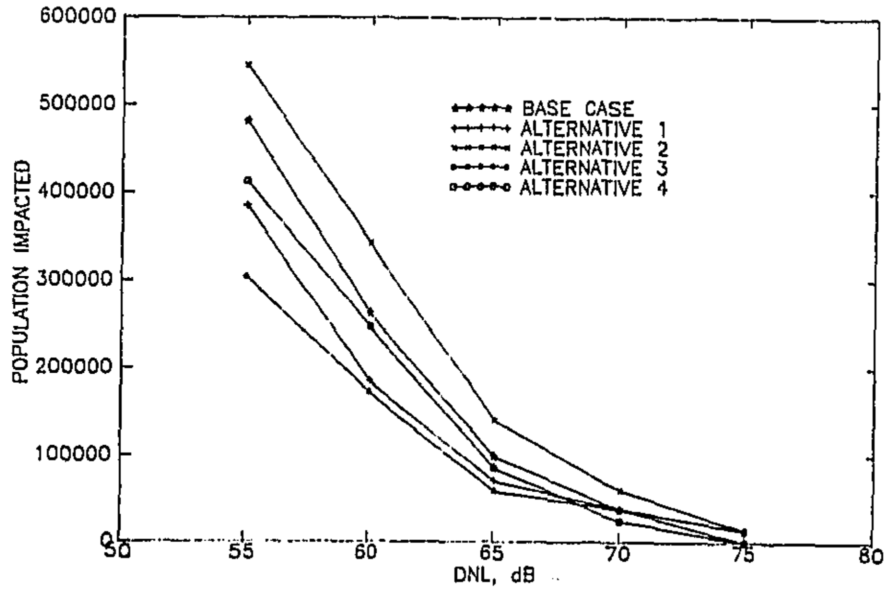


Figure 4-8. Los Angeles International Airport (LAX): People Impacted by Levels Greater than DNL 55 dB.

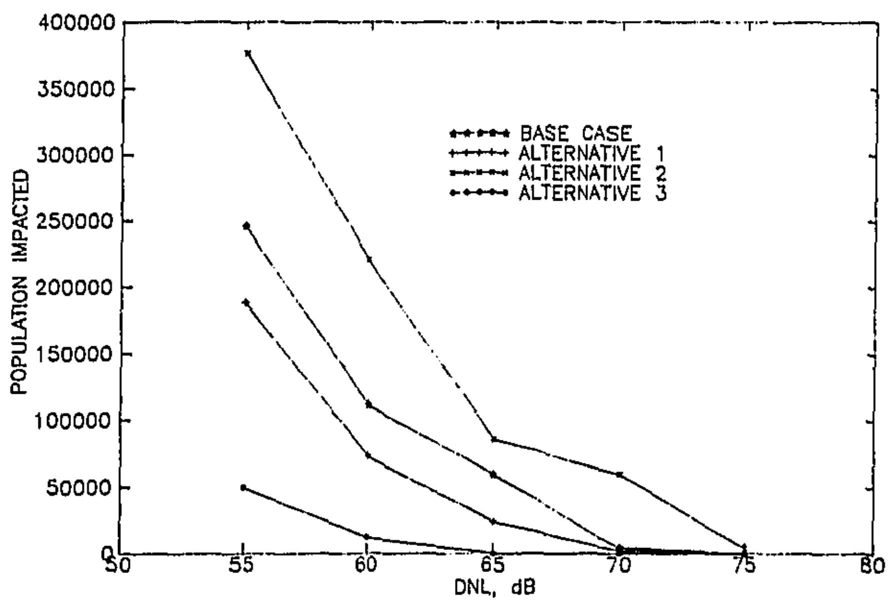


Figure 4-9. Boston Logan International Airport (BOS): People Impacted by Levels Greater than DNL 55 dB.

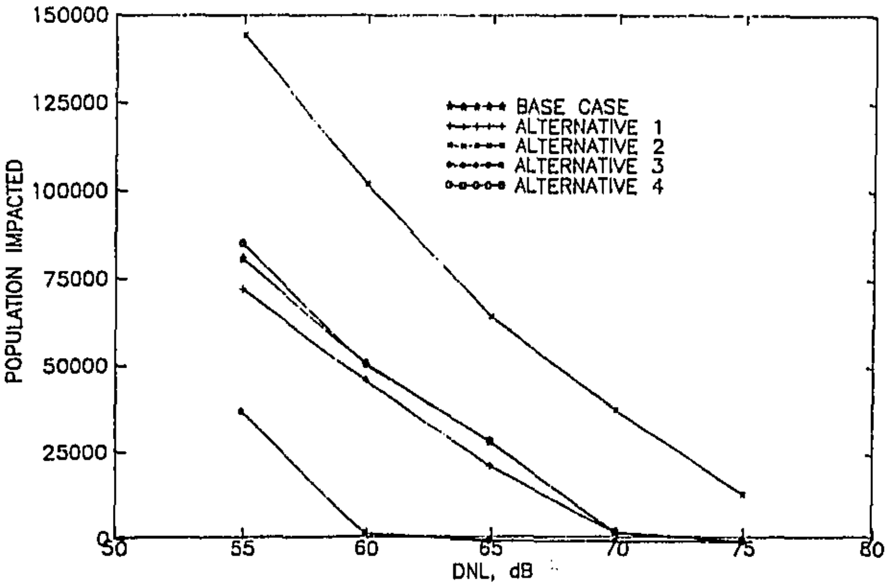


Figure 4-10. Nashville International Airport (BNA): People Impacted by Levels Greater than DNL 55 dB.

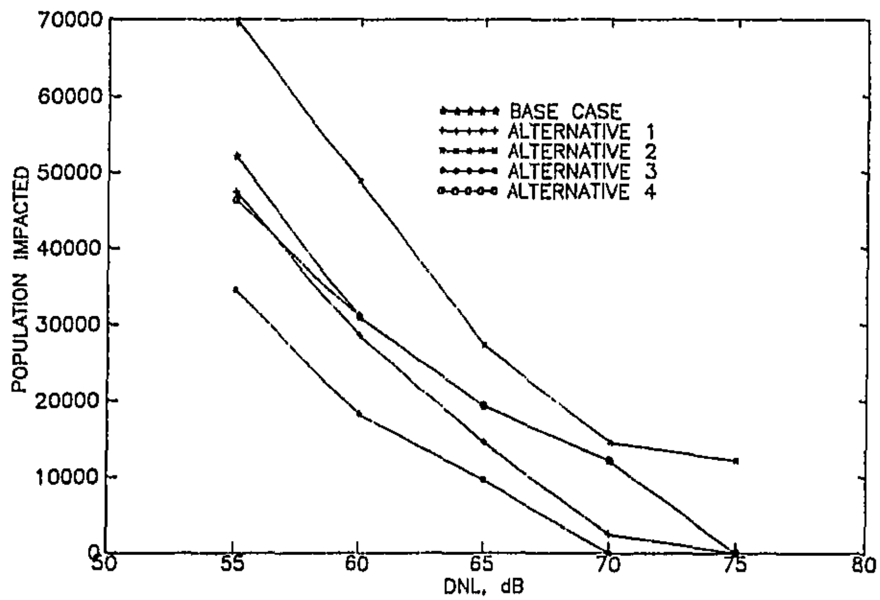


Figure 4-11. Fort Lauderdale International Airport (FLL): People Impacted by Levels Greater than DNL 55 dB.

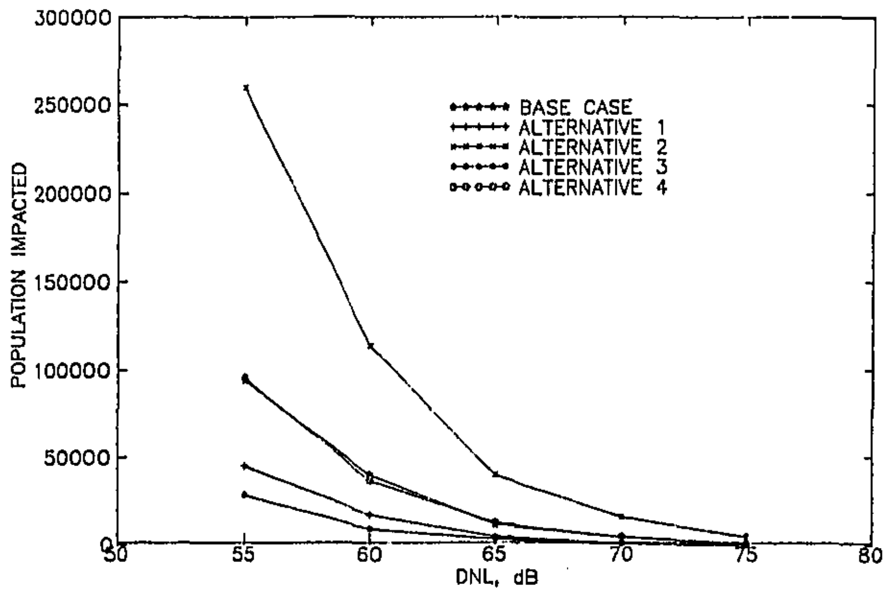


Figure 4-12. Cincinnati International Airport (CVG): People Impacted by Levels Greater than DNL 55 dB.

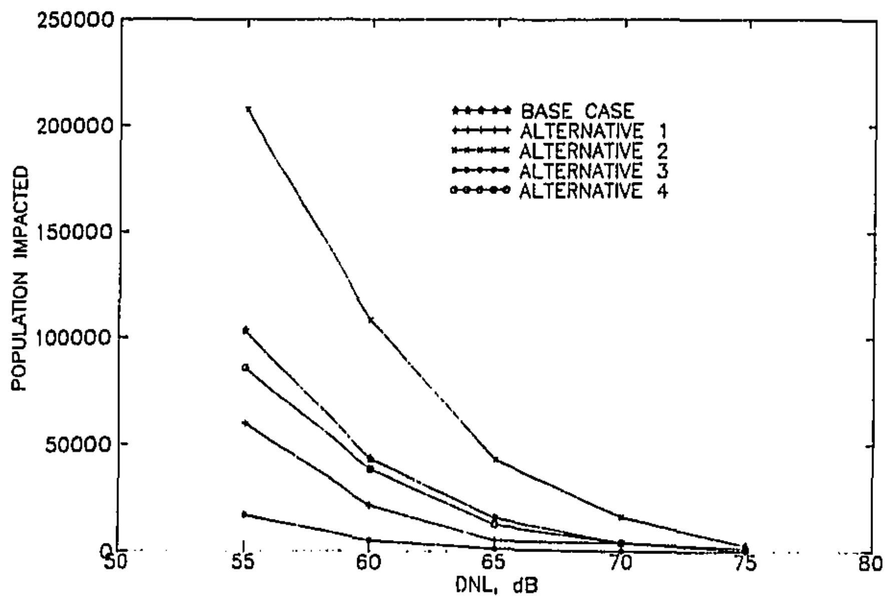


Figure 4-13. T.F. Green State Airport Airport (PVD): People Impacted by Levels Greater than DNL 55 dB.

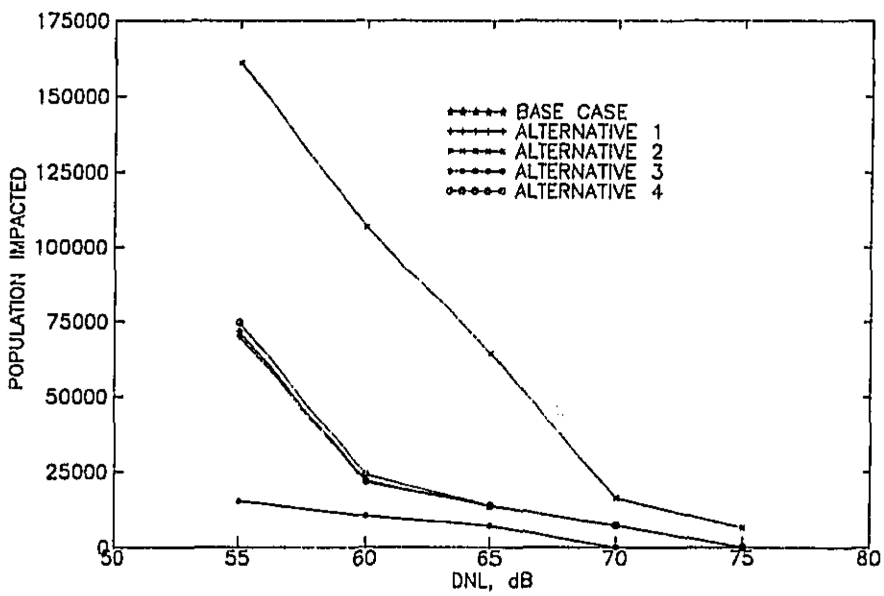


Figure 4-14. Palm Beach International Airport (PBI): People Impacted by Levels Greater than DNL 55 dB.

depending on the proportion of nighttime operations in each case; except for the very small contours at BDR, Alternative #1 produced reductions in areas and populations impacted at all airports and DNL contours.

- *Alternative #2 (increased nighttime operations):* Again because of the 10 dB nighttime penalty, the addition of nighttime operations at an airport should increase the extent of the DNL noise contours; Alternative #2 consistently produced larger areas and populations impacted at all airports.

- *Alternative #3 (all Stage 3 airplanes):* Airplanes certified to the Stage 3 noise standards are substantially quieter than the older, Stage 2 models, so that the conversion of all operations at an airport to Stage 3 models should decrease the extent of the DNL noise contours; with the exception of BDR, Alternative #3 consistently produced smaller areas and populations impacted.

- *Alternative #4 (changes in flight tracks):* This alternative was intended to take advantage of non-noise-sensitive areas, such as bodies of water, industrial developments, and major surface transportation rights-of-way around each airport, to minimize populations impacts, insofar as feasible; the noise contour areas were expected to remain essentially unchanged; in general, both expected results were found for the airports analyzed, although the results were not consistent; in several cases, the population counts increased by a small amount, depending on the ability to define flight tracks which were clearly advantageous over those already in use at those airport.

4.4 SEL Results

The results of the SEL analyses were not consistent with the changes in noise impacts that were expected. The areas of the contours of maximum SEL did not change for Alternatives #1 and #2, inasmuch as these contours are governed by the noisiest airplane operating at each airport, and the elimination or addition of nighttime operations did not affect that factor. Alternative #3, the substitution of only Stage 3 operations at each airport, produced a decrease in contour area, reflecting the operation of only quieter airplanes. Alternative #4, the changes in flight tracks, generally produced smaller SEL contours. These trends are tabulated in Table 4-3 (impacted areas) and Table 4-4 (impacted populations), and are presented graphically in Figures 4-15 through 4-28. The SEL contours are included in Appendix B.

On the other hand, the "people-incidents" counts did vary considerably, in somewhat unexpected ways. Since this measure of impact is a function of the number of airplane overflights above the specified SEL threshold multiplied by the exposed population, the results are most sensitive to those factors.

- *Alternative #1 (no nighttime operations):* The numbers of "people-incidents" computed for this alternative showed only slight changes, except within the highest SEL contour (105 dB). The slight changes probably result from the computational procedure, inasmuch as the number and mix of airplanes and their flight tracks did not change.

- *Alternative #2 (increased nighttime operations):* The number of "people-incidents" computed for this alternative increased as expected, consistent with the increase in numbers of flights represented by the added nighttime operations, with the exception of PBI for SELs above 95 dB; the reductions in "people-incidents" at PBI appear to be an anomaly, and probably are the result of computational errors.

- *Alternative #3 (all Stage 3 airplanes):* The SEL contour areas decreased in size as the result of substituting quieter airplanes at the airport, as expected; the reductions in areas and populations impacted are roughly of the same magnitudes as the reductions from the DNL analyses, especially beyond DNL 65 dB.

- *Alternative #4 (change in flight tracks):* The changes in SEL contour areas and population impacted do not follow any logical pattern.

Table 4-3

Summary of Areas Impacted by Levels Exceeding SEL 90 dB

Airport	Scenario	Impacted Areas, Square Miles Sound Exposure Level (SEL) Greater Than 90 dB	95 dB	100 dB	105 dB
LAX	BASE	77.1	37.3	24.1	12.9
	ALT #1	77.1 0%	37.3 0%	24.1 0%	12.9 0%
	ALT #2	77.1 0%	37.3 0%	24.1 0%	12.9 0%
	ALT #3	50.9 -34%	24.5 -34%	12.2 -49%	4.8 -63%
	ALT #4	77.1 0%	37.3 0%	24.1 0%	12.9 0%
BOS	BASE	134.0	60.8	35.5	15.3
	ALT #1	134.0 0%	60.8 0%	35.5 0%	15.3 0%
	ALT #2	134.0 0%	60.8 0%	35.5 0%	15.3 0%
	ALT #3	71.0 -47%	24.4 -60%	10.5 -70%	4.2 -73%
	ALT #4	NA	NA	NA	NA
BNA	BASE	101.5	51.2	29.8	10.2
	ALT #1	101.5 0%	51.2 0%	29.8 0%	10.2 0%
	ALT #2	101.5 0%	51.2 0%	29.8 0%	10.2 0%
	ALT #3	15.2 -85%	4.6 -91%	1.3 -96%	0.5 -95%
	ALT #4	92.2 -9%	46.8 -9%	27.4 -8%	9.6 -6%
FLL	BASE	70.7	36.3	18.3	5.0
	ALT #1	70.7 0%	36.3 0%	18.3 0%	5.0 0%
	ALT #2	70.7 0%	36.3 0%	18.3 0%	5.0 0%
	ALT #3	39.9 -44%	18.7 -48%	6.5 -64%	2.4 -52%
	ALT #4	56.0 -21%	31.5 -13%	17.0 -7%	4.6 -8%

NOTE: Percentages denote change relative to the base case.

Table 4-3 (Continued)

Airport	Scenario	Impacted Areas, Square Miles Sound Exposure Level (SEL) Greater Than 90 dB	95 dB	100 dB	105 dB
CVG	BASE	163.6	68.9	39.1	13.6
	ALT #1	163.6	68.9	39.1	13.6
		0%	0%	0%	0%
	ALT #2	163.6	68.9	39.1	13.6
		0%	0%	0%	0%
	ALT #3	92.7	39.7	17.7	6.2
		-43%	-42%	-55%	-54%
	ALT #4	149.0	66.5	38.1	13.5
		-9%	-3%	-3%	-1%
PVD	BASE	87.5	40.7	22.3	7.5
	ALT #1	87.5	40.7	22.3	7.5
		0%	0%	0%	0%
	ALT #2	87.5	40.7	22.3	7.5
		0%	0%	0%	0%
	ALT #3	10.0	3.0	0.8	0.1
		-89%	-93%	-96%	-99%
	ALT #4	63.6	30.2	17.1	6.1
		-27%	-26%	-23%	-19%
PBI	BASE	114.5	56.1	26.1	6.9
	ALT #1	114.5	56.1	26.1	6.9
		0%	0%	0%	0%
	ALT #2	114.5	56.1	26.1	6.9
		0%	0%	0%	0%
	ALT #3	37.5	16.0	4.2	1.7
		-67%	-71%	-84%	-75%
	ALT #4	92.1	45.8	21.5	6.2
		-20%	-18%	-18%	-10%
BDR	BASE	34.2	14.9	4.4	1.8
	ALT #1	34.2	14.9	4.4	1.8
		0%	0%	0%	0%
	ALT #2	89.1	42.0	23.7	8.1
		161%	182%	439%	350%
	ALT #3	34.2	14.9	4.4	1.8
		0%	0%	0%	0%
	ALT #4	18.9	10.4	4.1	1.8
		-45%	-30%	-7%	0%

Table 4-4

Summary of Populations Impacted by Levels Exceeding SEL 90 dB

Airport	Scenario	People Incidents (Persons Affected x No. of Ops.) Sound Exposure Level (SEL) Greater Than			
		90 dB	95 dB	100 dB	105 dB
LAX	BASE	18,598,096	4,453,152	843,060	69,920
	ALT #1	18,712,035	4,494,756	859,332	87,450
		1%	1%	2%	25%
	ALT #2	21,021,312	5,017,962	860,020	83,424
		13%	13%	2%	19%
	ALT #3	12,218,628	3,108,738	717,215	48,468
		-34%	-30%	-15%	-31%
	ALT #4	11,664,320	1,576,800	181,364	15,904
		-37%	-65%	-78%	-77%
BOS	BASE	5,155,660	1,711,904	626,640	55,120
	ALT #1	5,266,608	1,776,172	658,000	71,472
		2%	4%	5%	30%
	ALT #2	6,796,077	2,194,432	940,480	78,752
		32%	28%	50%	43%
	ALT #3	256,176	27,728	7,616	224
		-95%	-98%	-99%	-100%
	ALT #4	NA	NA	NA	NA
BNA	BASE	2,299,481	971,457	382,247	183,312
	ALT #1	2,242,668	968,943	377,191	187,806
		-2%	0%	-1%	2%
	ALT #2	3,452,023	1,386,961	596,873	281,929
		50%	43%	56%	54%
	ALT #3	1,146,323	353,253	195,840	0
		-50%	-64%	-49%	-100%
	ALT #4	2,329,083	975,580	389,555	178,080
		1%	0%	2%	-3%
FLL	BASE	2,048,320	974,688	358,768	17,248
	ALT #1	2,056,763	977,072	359,936	17248
		0%	0%	0%	0%
	ALT #2	2,440,800	1,199,376	485,200	51,744
		19%	23%	35%	200%
	ALT #3	814,976	308,768	51,040	11,088
		-60%	-68%	-86%	-36%
	ALT #4	2,064,352	964,128	358,768	41,568
		1%	-1%	0%	141%

NOTE: Percentages denote change relative to the base case.

Table 4-4 (Continued)

Airport	Scenario	People Incidents (Persons Affected x No. of Ops.) Sound Exposure Level (SEL) Greater Than			
		90 dB	95 dB	100 dB	105 dB
CVG	BASE	1,200,522	398,784	151,246	23,297
	ALT #1	1,251,671 4%	422,549 6%	156,424 3%	25,769 11%
	ALT #2	1,901,842 58%	555,859 39%	213,253 41%	30,607 31%
	ALT #3	299,731 -75%	20,109 -95%	2,829 -98%	0 -100%
	ALT #4	1,235,099 3%	406,578 2%	151,774 0%	23,405 0%
PVD	BASE	1,129,696	524,928	196,208	69,104
	ALT #1	1,144,416 1%	524,896 0%	194,320 -1%	67,776 -2%
	ALT #2	1,662,176 47%	738,720 41%	290,304 48%	89,824 30%
	ALT #3	175,920 -84%	34,944 -93%	10,752 -95%	0 -100%
	ALT #4	1,051,659 -7%	488,136 -7%	184,082 -6%	76,037 10%
PBI	BASE	2,212,459	970,105	395,131	134,037
	ALT #1	2,212,559 0%	972,397 0%	396,277 0%	135,183 1%
	ALT #2	2,686,540 21%	861,821 -11%	265,928 -33%	62,539 -53%
	ALT #3	586,329 -73%	237,698 -75%	90,203 -77%	7,413 -94%
	ALT #4	2,236,472 1%	1,005,437 4%	446,871 13%	184,814 38%
BDR	BASE	87,584	10,720	4,288	4,288
	ALT #1	84,584 -3%	10,720 0%	4,288 0%	4,288 0%
	ALT #2	364,082 316%	118,816 1008%	70,528 1545%	8,576 100%
	ALT #3	87,584 0%	10,720 0%	4,288 0%	4,288 0%
	ALT #4	30,016 -66%	10,720 0%	6,432 50%	4,288 0%

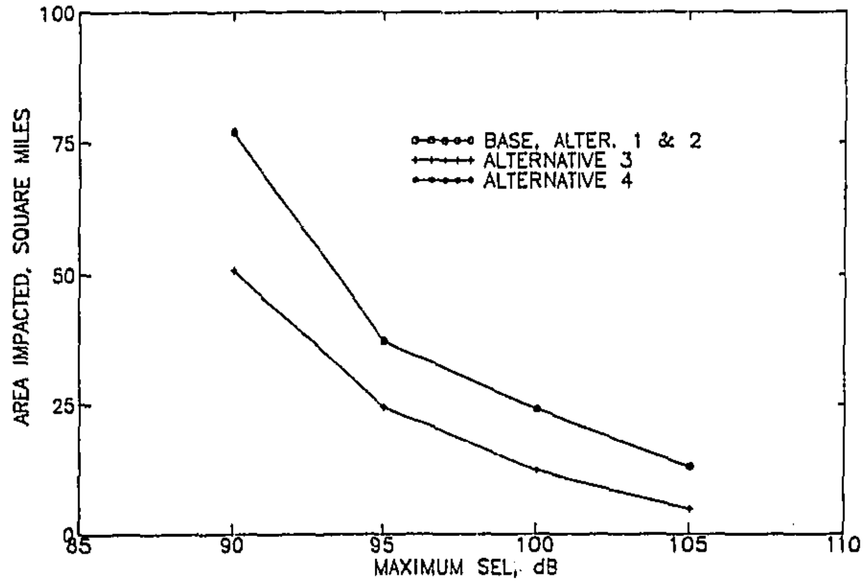


Figure 4-15. Los Angeles International Airport (LAX): Area Impacted by Levels Greater than SEL 90 dB.

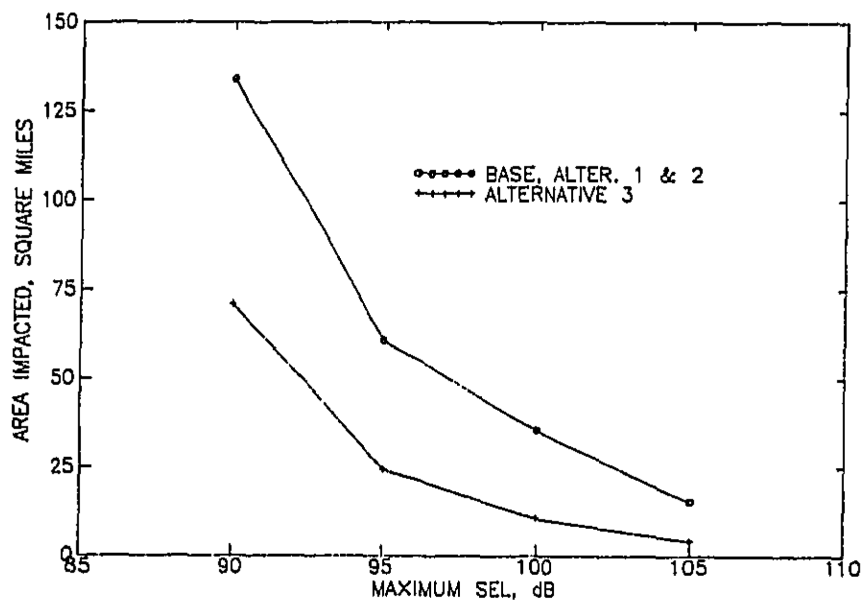


Figure 4-16. Boston Logan International Airport (BOS): Area Impacted by Levels Greater than SEL 90 dB.

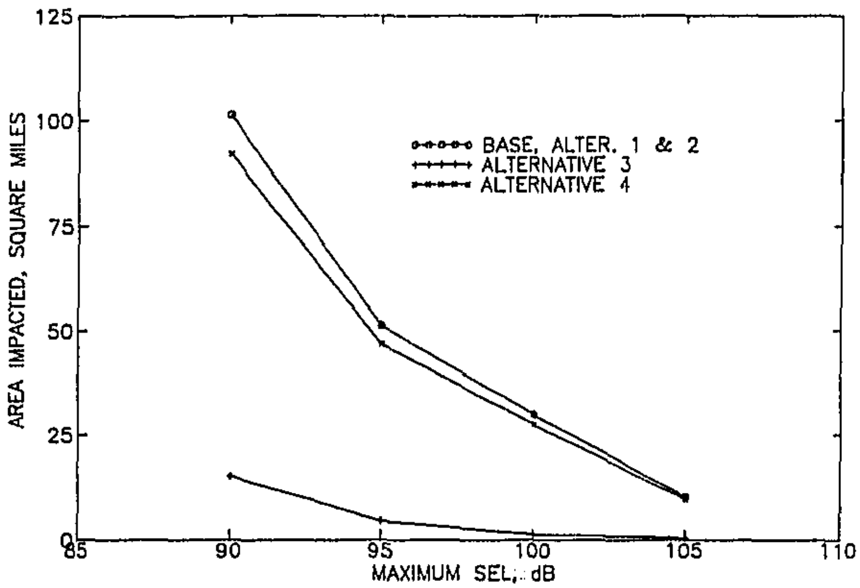


Figure 4-17. Nashville International Airport (BNA): Area Impacted by Levels Greater than SEL 90 dB.

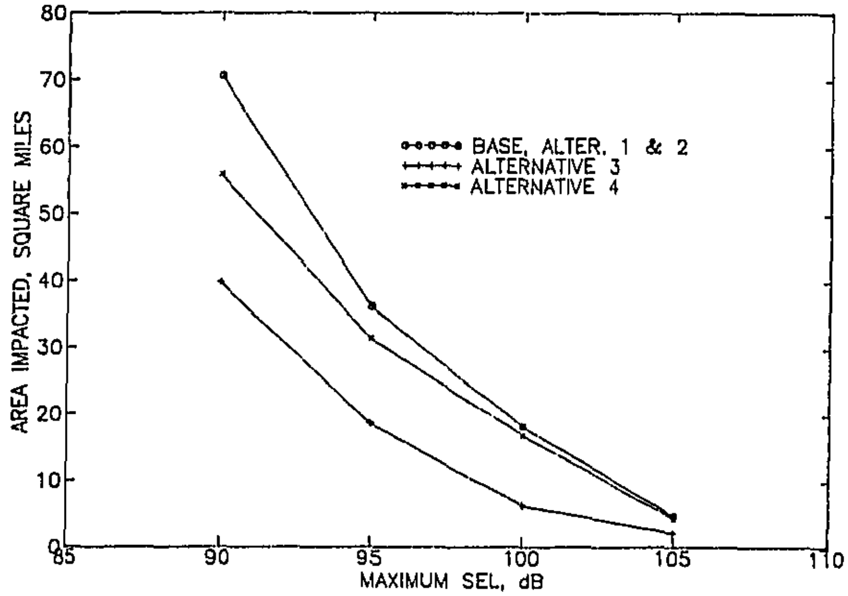


Figure 4-18. Fort Lauderdale International Airport (FLL): Area Impacted by Levels Greater than SEL 90 dB.

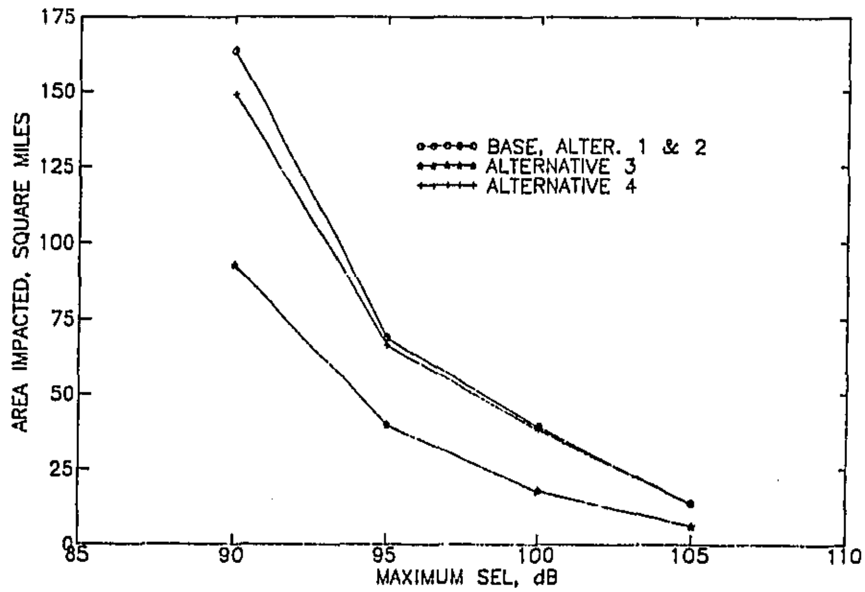


Figure 4-19. Cincinnati International Airport (CVG): Area Impacted by Levels Greater than SEL 90 dB.

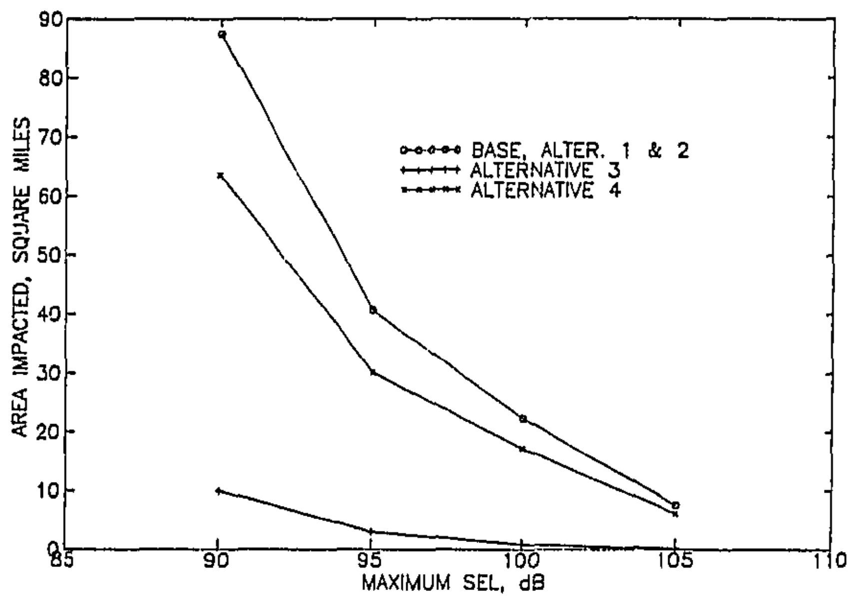


Figure 4-20. T.F. Green State Airport Airport (PVD): Area Impacted by Levels Greater than SEL 90 dB.

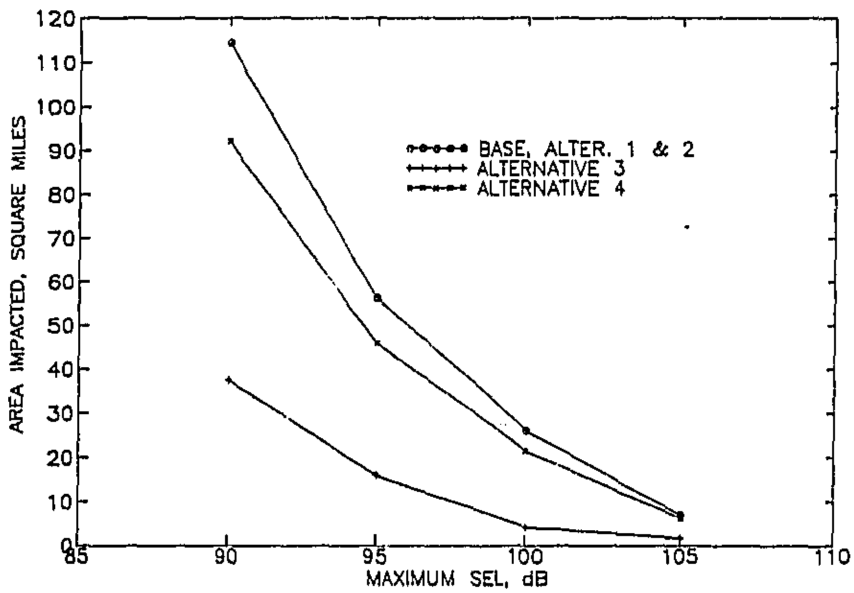


Figure 4-21. Palm Beach International Airport (PBI): Area Impacted by Levels Greater than SEL 90 dB.

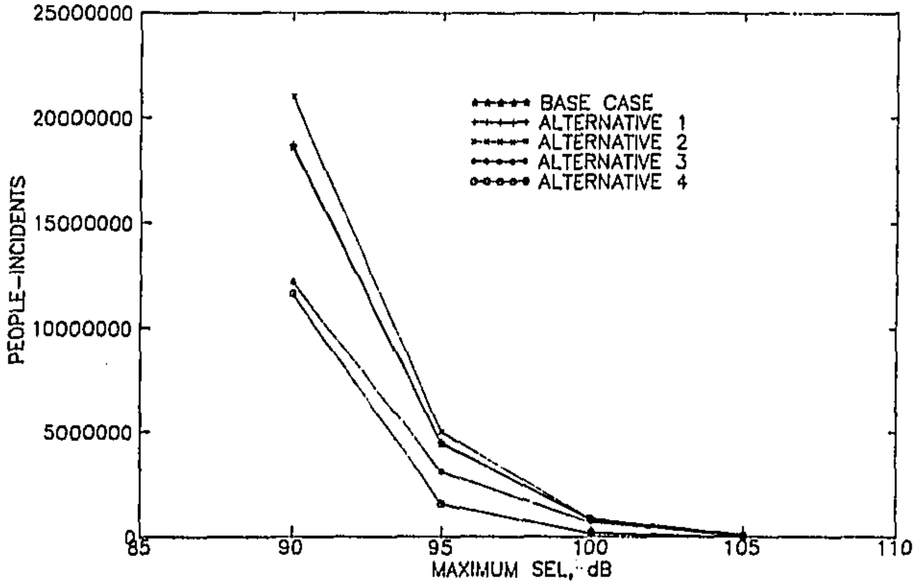


Figure 4-22. Los Angeles International Airport (LAX): "People-Incidents" for Levels Greater than SEL 90 dB.

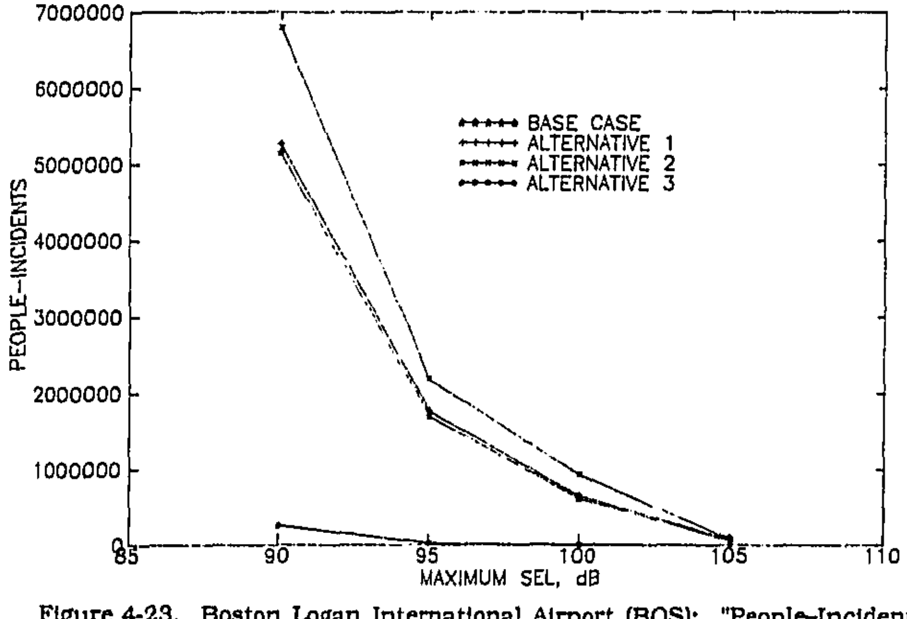


Figure 4-23. Boston Logan International Airport (BOS): "People-Incidents" for Levels Greater than SEL 90 dB.

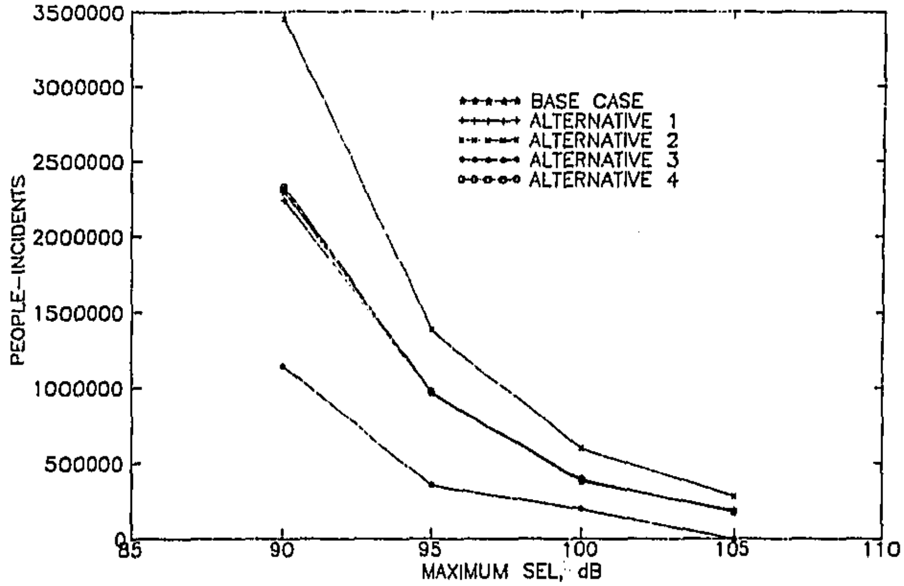


Figure 4-24. Nashville International Airport (BNA): "People-Incidents" for Levels Greater than SEL 90 dB.

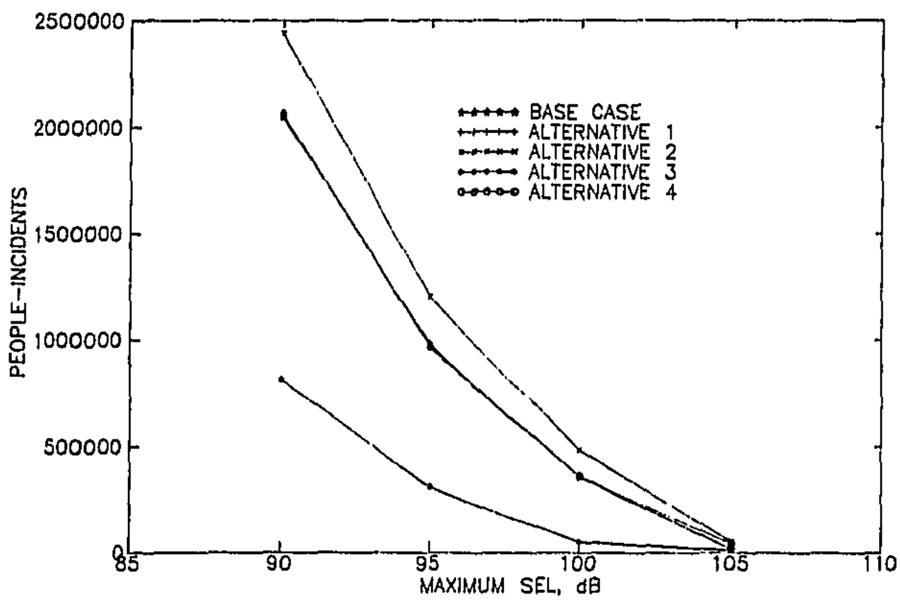


Figure 4-25. Fort Lauderdale International Airport (FLL): "People-Incidents" for Levels Greater than SEL 90 dB.

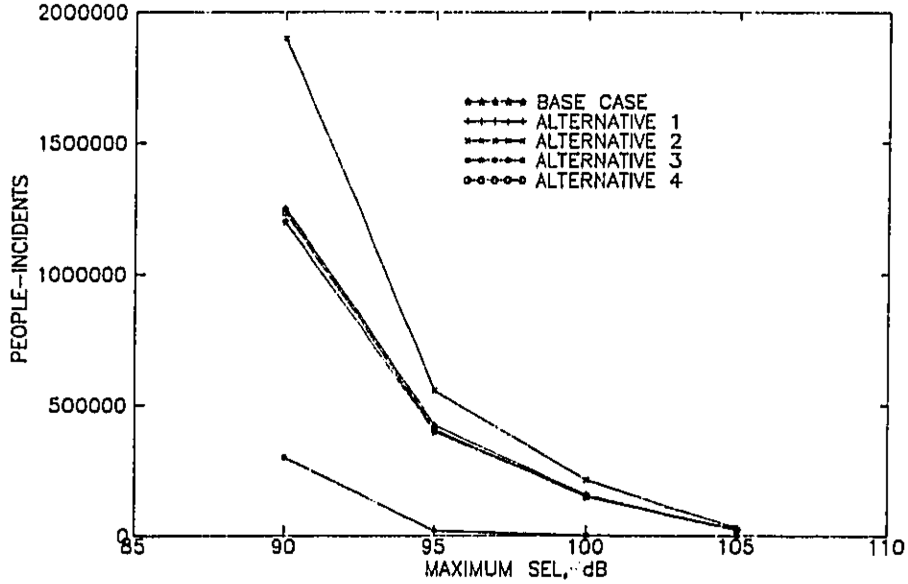


Figure 4-26. Cincinnati International Airport (CVG): "People–Incidents" for Levels Greater than SEL 90 dB.

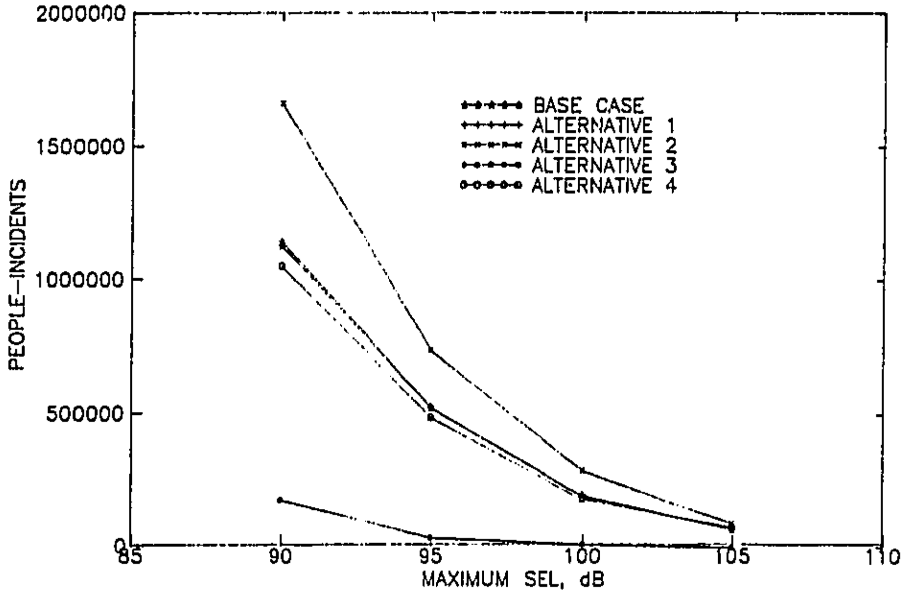


Figure 4-27. T.F. Green State Airport (PVD): "People–Incidents" for Levels Greater than SEL 90 dB.

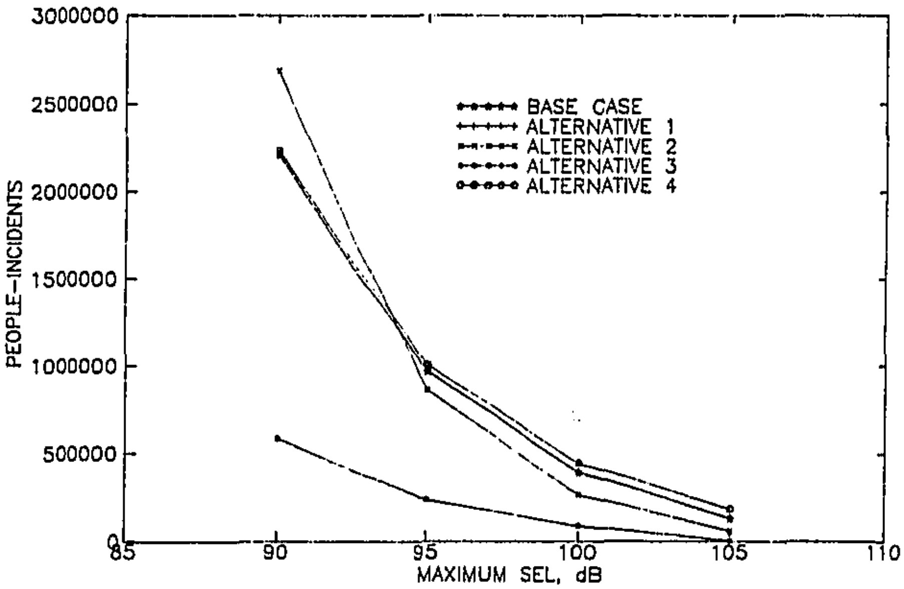


Figure 4-28. Palm Beach International Airport (PBI): "People-Incidents" for Levels Greater than SEL 90 dB.

5.0 COMPARATIVE DNL/SEL ANALYSIS

In order to compare the results of this analysis, the DNL and SEL impact matrices of the previous section have been reproduced side by side in Table 5-1 (impacted areas) and Table 5-2 (impacted populations).

The purpose of this analysis was to determine if the use of a noise metric based on a single-event noise level, such as Sound Exposure Level, would provide a more sensitive measure of noise impacts than does the Day-Night Average Sound Level currently used to represent noise impact and compatible land use around airports. This issue is most pertinent for DNLs below 65 dB, the level which is considered to be normally compatible with residential use. As a means of determining the relative efficacy of these two noise metrics, each was used to compare the changes in noise impacts at seven airports, and in turn compared with the intuitive changes in those impacts which should be expected. Table 5-3 summarizes these comparisons for noise levels below DNL 65 dB.

Examining each alternative in turn, the elimination of nighttime operations at each of the airports (Alternative #1) would be expected to provide a moderate reduction in noise impacts around those airports. This change is reflected in the results of the DNL analysis, with reductions varying from 2 percent at PBI to 57 percent at CVG. The SEL analyses provide changes which vary from a reduction of 2 percent to an increase of 6 percent, although no changes would be expected because the number and mix of airplanes did not vary for this alternative. The minor changes calculated result from the rounding down of fractional operations in the software used. Certainly, the SEL analysis does not provide a very sensitive measure of the expected changes.

The addition of nighttime operations at each of the airports (Alternative #2) was expected to add moderate to large impacts, depending on the numbers of nighttime operations already there. The DNL analyses provided increases in impacts varying from 13 percent to 185 percent among the seven airports shown. The SEL analyses provided changes in impacts varying from a decrease of 11 percent to an increase of 58 percent. Again, the DNL provides the expected changes, and is more sensitive to those changes.

Table 5-1

Summary of Areas Impacted by
Levels Exceeding DNL 55 dB and SEL 90 dB

Air-port	Scenario	Impacted Areas, Square Miles Day-Night Average Sound Level (DNL) Greater Than:					Impacted Areas, Square Miles Sound Exposure Level (SEL) Greater Than:			
		55 dB	60 dB	65 dB	70 dB	75 dB	90 dB	95 dB	100 dB	105 dB
LAX	BASE	183.5	77.0	32.5	16.1	9.1	77.1	37.3	24.1	12.9
	ALT #1	115.3	48.8	22.0	11.9	6.5	77.1	37.3	24.1	12.9
		-37%	-37%	-32%	-26%	-29%	0%	0%	0%	0%
	ALT #2	279.2	118.2	46.9	21.9	11.4	77.1	37.3	24.1	12.9
		52%	54%	44%	36%	25%	0%	0%	0%	0%
	ALT #3	78.5	33.3	13.8	6.7	2.2	50.9	24.5	12.2	4.8
		-57%	-57%	-58%	-58%	-76%	-34%	-34%	-49%	-63%
	ALT #4	181.1	77.0	32.6	16.2	8.8	77.1	37.3	24.1	12.9
		-1%	0%	0%	1%	-3%	0%	0%	0%	0%
BOS	BASE	119.8	58.1	28.0	11.9	4.4	134	60.8	35.5	15.3
	ALT #1	86.8	42.4	20.3	8.0	3.0	134	60.8	35.5	15.3
		-28%	-27%	-28%	-33%	-32%	0%	0%	0%	0%
	ALT #2	246.1	106.7	52.0	26.0	10.5	134	60.8	35.5	15.3
		105%	84%	86%	118%	139%	0%	0%	0%	0%
	ALT #3	29.5	10.6	4.2	2.1	1.0	71	24.4	10.5	4.2
		-75%	-82%	-85%	-82%	-77%	-47%	-60%	-70%	-73%
	ALT #4	NA	NA	NA	NA	NA	NA	NA	NA	NA
BNA	BASE	71.3	35.9	15.9	5.3	1.9	101.5	51.2	29.8	10.2
	ALT #1	62.2	31.7	13.8	4.8	1.7	101.5	51.2	29.8	10.2
		-13%	-12%	-13%	-9%	-11%	0%	0%	0%	0%
	ALT #2	222.2	99.8	49.3	25.8	9.9	101.5	51.2	29.8	10.2
		212%	178%	210%	387%	421%	0%	0%	0%	0%
	ALT #3	16.8	6.4	2.6	1.2	0.4	15.2	4.6	1.3	0.5
		-76%	-82%	-84%	-77%	-79%	-85%	-91%	-96%	-95%
	ALT #4	66.9	35.5	16.3	5.3	2.0	92.2	46.8	27.4	9.6
		-6%	-1%	3%	0%	5%	-9%	-9%	-8%	-6%
FLL	BASE	26.8	14.4	8.0	3.6	1.4	70.7	36.3	18.3	5
	ALT #1	22.0	11.9	6.4	2.6	1.0	70.7	36.3	18.3	5
		-18%	-17%	-20%	-28%	-29%	0%	0%	0%	0%
	ALT #2	44.4	25.0	14.4	7.8	3.6	70.7	36.3	18.3	5
		66%	74%	80%	117%	157%	0%	0%	0%	0%
	ALT #3	14.8	7.1	3.0	1.3	0.7	39.9	18.7	6.5	2.4
		-45%	-51%	-63%	-64%	-50%	-44%	-48%	-64%	-52%
	ALT #4	25.4	14.2	8.2	3.7	1.3	56	31.5	17	4.6
		-5%	-1%	3%	3%	-7%	-21%	-13%	-7%	-8%

NOTE: Percentages denote change relative to the base case.

Table 5-1 (Continued)

Air-port	Scenario	Impacted Areas, Square Miles Day-Night Average Sound Level (DNL) Greater Than:					Impacted Areas, Square Miles Sound Exposure Level (SEL) Greater Than:			
		55 dB	60 dB	65 dB	70 dB	75 dB	90 dB	95 dB	100 dB	105 dB
CVG	BASE	129.4	54.7	25.1	10.5	4.1	163.6	68.9	39.1	13.6
	ALT #1	65.2	30.7	13.5	5.3	2.1	163.6	68.9	39.1	13.6
		-50%	-44%	-46%	-50%	-49%	0%	0%	0%	0%
	ALT #2	245.7	118.8	54.6	27.9	10.9	163.6	68.9	39.1	13.6
		90%	117%	118%	166%	166%	0%	0%	0%	0%
	ALT #3	34.0	13.2	4.9	2.3	0.7	92.7	39.7	17.7	6.2
		-74%	-76%	-80%	-78%	-83%	-43%	-42%	-55%	-54%
	ALT #4	130.3	53.9	25.2	10.6	4.1	149	66.5	38.1	13.5
		1%	-1%	0%	1%	0%	-9%	-3%	-3%	-1%
PVD	BASE	39.1	16.9	6.3	2.2	0.7	87.5	40.7	22.3	7.5
	ALT #1	24.5	9.3	3.3	1.1	0.4	87.5	40.7	22.3	7.5
		-37%	-45%	-48%	-50%	-43%	0%	0%	0%	0%
	ALT #2	84.4	40.9	19.4	7.3	2.4	87.5	40.7	22.3	7.5
		116%	142%	208%	232%	243%	0%	0%	0%	0%
	ALT #3	7.4	2.6	0.9	0.3	0.1	10	3	0.8	0.1
		-81%	-85%	-86%	-86%	-86%	-89%	-93%	-96%	-99%
	ALT #4	36.6	17.3	6.7	2.2	0.8	63.6	30.2	17.1	6.1
		-6%	2%	6%	0%	14%	-27%	-26%	-23%	-19%
PBI	BASE	37.4	17.8	7.6	2.9	1.1	114.5	56.1	26.1	6.9
	ALT #1	36.7	17.4	7.5	2.9	1.1	114.5	56.1	26.1	6.9
		-2%	-2%	-1%	0%	0%	0%	0%	0%	0%
	ALT #2	182.3	81.7	39.2	19.0	8.1	114.5	56.1	26.1	6.9
		387%	359%	416%	555%	636%	0%	0%	0%	0%
	ALT #3	13.1	5.5	2.3	1.0	0.5	37.5	16	4.2	1.7
		-65%	-69%	-70%	-66%	-55%	-67%	-71%	-84%	-75%
	ALT #4	37.5	17.8	7.9	3.0	1.1	92.1	45.8	21.5	6.2
		0%	0%	4%	3%	0%	-20%	-18%	-18%	-10%
BDR	BASE	4.3	1.8	0.7	0.3	0.1	34.2	14.9	4.4	1.8
	ALT #1	4.1	1.7	0.7	0.3	0.1	34.2	14.9	4.4	1.8
		-5%	-6%	0%	0%	0%	0%	0%	0%	0%
	ALT #2	62.9	31.8	15.3	5.9	2.0	89.1	42	23.7	8.1
		1363%	1667%	2086%	1867%	1900%	161%	182%	439%	350%
	ALT #3	4.3	1.8	0.7	0.3	0.1	34.2	14.9	4.4	1.8
		0%	0%	0%	0%	0%	0%	0%	0%	0%
	ALT #4	4.8	1.8	0.7	0.3	0.1	18.9	10.4	4.1	1.8
		12%	0%	0%	0%	0%	-45%	-30%	-7%	0%

Table 5-2

Summary of Populations Impacted by
Levels Exceeding DNL 55 dB and SEL 90 dB

Air-port	Scenario	Impacted Populations					People-Incidents (Persons Affected x No. of Ops.)			
		Day-Night Average Sound Level (DNL) Greater Than					Sound Exposure Level (SEL) Greater Than			
		55 dB	60 dB	65 dB	70 dB	75 dB	90 dB	95 dB	100 dB	105 dB
LAX	BASE	482,325	263,354	99,594	38,416	13,504	18,598,096	4,453,152	843,060	69,920
	ALT #1	385,612	185,484	71,034	38,416	0	18,712,035	4,494,756	859,332	87,450
		-20%	-30%	-29%	0%	-100%	1%	1%	2%	25%
	ALT #2	545,526	342,572	140,908	60,474	13,504	21,021,312	5,017,962	860,020	83,424
		13%	30%	41%	57%	0%	13%	13%	2%	19%
	ALT #3	304,280	172,822	59,162	38,416	13,504	12,218,628	3,108,738	717,215	48,468
		-37%	-34%	-41%	0%	0%	-34%	-30%	-15%	-31%
	ALT #4	412,698	247,818	86,090	24,912	0	11,664,320	1,576,800	181,364	15,904
		-14%	-6%	-14%	-35%	-100%	-37%	-65%	-78%	-77%
BOS	BASE	246,080	111,840	60,064	4,496	0	5,155,660	1,711,904	626,640	55,120
	ALT #1	188,326	73,670	24,448	2,400	224	5,266,608	1,776,172	658,000	71,472
		-23%	-34%	-59%	-47%	---	2%	4%	5%	30%
	ALT #2	376,521	220,656	86,432	59,840	4,272	6,796,077	2,194,432	940,480	78,752
		53%	97%	44%	1231%	---	32%	28%	50%	43%
	ALT #3	49,600	12,112	224	224	0	256,176	27,728	7,616	224
		-80%	-89%	-100%	-95%	0%	-95%	-98%	-99%	-100%
	ALT #4	NA	NA	NA	NA	NA	NA	NA	NA	NA
BNA	BASE	81,008	50,896	28,512	2,499	0	2,299,481	971,457	382,247	183,312
	ALT #1	72,174	45,940	21,529	2,499	0	2,242,668	968,943	377,191	187,806
		-11%	-10%	-24%	0%	0%	-2%	0%	-1%	2%
	ALT #2	144,523	102,062	64,495	37,702	13,568	3,452,023	1,386,961	596,873	281,929
		78%	101%	126%	1409%	---	50%	43%	56%	54%
	ALT #3	36,935	1,950	0	0	0	1,146,323	353,253	195,840	0
		-54%	-96%	-100%	-100%	0%	-50%	-64%	-49%	-100%
	ALT #4	85,195	50,524	28,668	2,499	0	2,329,083	975,580	389,555	178,080
		5%	-1%	1%	0%	0%	1%	0%	2%	-3%

NOTE: Percentages denote change relative to the base case.

Table 5-2 (Continued)

Air-port	Scenario	Impacted Populations Day-Night Average Sound Level (DNL) Greater Than 55 dB	60 dB	65 dB	70 dB	75 dB	People-Incidents (Persons Affected x No. of Ops.) Sound Exposure Level (SEL) Greater Than 90 dB	95 dB	100 dB	105 dB
FFL	BASE	52,064	30,944	19,344	12,144	0	2,048,320	974,688	358,768	17,248
	ALT #1	47,408	28,512	14,576	2,480	0	2,056,763	977,072	359,936	17,248
		-9%	-8%	-25%	-80%	0%	0%	0%	0%	0%
	ALT #2	69,864	48,776	27,312	14,576	12,144	2,440,800	1,199,376	485,200	51,744
		34%	58%	41%	20%	–	19%	23%	35%	200%
	ALT #3	34,556	18,188	9,644	0	0	814,976	308,768	51,040	11,088
		-34%	-41%	-50%	-100%	0%	-60%	-68%	-86%	-36%
	ALT #4	46,384	30,944	19,344	12,144	0	2,064,352	964,128	358,768	41,568
		-11%	0%	0%	0%	0%	1%	-1%	0%	141%
CVG	BASE	94,592	39,994	11,901	4,455	608	1,200,522	398,784	151,246	23,297
	ALT #1	45,371	17,307	4,867	814	304	1,251,671	422,549	156,424	25,769
		-52%	-57%	-59%	-82%	-50%	4%	6%	3%	11%
	ALT #2	260,060	114,009	40,043	15,971	4,656	1,901,842	555,859	213,253	30,607
		175%	185%	236%	258%	666%	58%	39%	41%	31%
	ALT #3	28,707	9,176	3,387	716	0	299,731	20,109	2,829	0
		-70%	-77%	-72%	-84%	-100%	-75%	-95%	-98%	-100%
	ALT #4	95,786	36,899	12,733	4,455	608	1,235,099	406,578	151,774	23,405
		1%	-8%	7%	0%	0%	3%	2%	0%	0%
PVD	BASE	103,392	43,408	15,696	4,032	1,344	1,129,696	524,928	196,208	69,104
	ALT #1	60,064	21,552	5,376	4,032	0	1,144,416	524,896	194,320	67,776
		-42%	-50%	-66%	0%	-100%	1%	0%	-1%	-2%
	ALT #2	207,680	108,368	42,912	16,000	2,688	1,662,176	738,720	290,304	89,824
		101%	150%	173%	297%	100%	47%	41%	48%	30%
	ALT #3	17,040	5,376	1,344	0	0	175,920	34,944	10,752	0
		-84%	-88%	-91%	-100%	-100%	-84%	-93%	-95%	-100%
	ALT #4	85,964	38,544	12,672	4,032	1,344	1,051,659	488,136	184,082	76,037
		-17%	-11%	-19%	0%	0%	-7%	-7%	-6%	10%

Table 5-2 (Continued)

Air-port	Scenario	Impacted Populations Day-Night Average Sound Level (DNL) Greater Than					People-Incidents (Persons Affected x No. of Ops.) Sound Exposure Level (SEL) Greater Than			
		55 dB	60 dB	65 dB	70 dB	75 dB	90 dB	95 dB	100 dB	105 dB
PBI	BASE	71,653	22,147	13,910	7,368	41	2,212,459	970,105	395,131	134,037
	ALT #1	70,040	21,699	13,910	7,368	41	2,212,559	972,397	396,277	135,183
		-2%	-2%	0%	0%	0%	0%	0%	0%	1%
	ALT #2	160,975	106,784	64,363	16,472	6,541	2,686,540	861,821	265,928	62,539
		125%	382%	363%	124%	15854%	21%	-11%	-33%	-53%
	ALT #3	15,335	10,549	7,200	41	0	586,329	237,698	90,203	7,413
		-79%	-52%	-48%	-99%	-100%	-73%	-75%	-77%	-94%
	ALT #4	74,652	24,100	13,910	7,368	41	2,236,472	1,005,437	446,871	184,814
		4%	9%	0%	0%	0%	1%	4%	13%	38%
BDR	BASE	2,144	2,144	0	0	0	87,584	10,720	4,288	4,288
	ALT #1	2,144	2,144	0	0	0	84,584	10,720	4,288	4,288
		0%	0%	0%	0%	0%	-3%	0%	0%	0%
	ALT #2	140,436	67,360	11,072	2,144	0	364,082	118,816	70,528	8,576
		6450%	3042%	—	—	0%	316%	1008%	1545%	100%
	ALT #3	2,144	2,144	0	0	0	87,584	10,720	4,288	4,288
		0%	0%	0%	0%	0%	0%	0%	0%	0%
	ALT #4	3,216	2,144	0	0	0	30,016	10,720	6,432	4,288
		50%	0%	0%	0%	0%	-66%	0%	50%	0%

Table 5-3

Comparative Changes in Population Impact
Using DNL and SEL (Relative to Base Case)

Scenario	Airport	People Impacted DNL Greater Than:			People-Incidents SEL Greater Than:		
		55 dB	60 dB	65 dB	90 dB	95 dB	100 dB
Alternative #1: Moderate Decrease Expected	LAX	-20%	-30%	-29%	1%	1%	2%
	BOS	-23%	-34%	-59%	2%	4%	5%
	BNA	-11%	-10%	-24%	-2%	0%	-1%
	FLL	-9%	-8%	-25%	0%	0%	0%
	CVG	-52%	-57%	-59%	4%	6%	3%
	PVD	-42%	-50%	-66%	1%	0%	-1%
	PBI	-2%	-2%	0%	0%	0%	0%
Alternative #2: Moderate to Significant Increase Expected	LAX	13%	30%	41%	13%	13%	2%
	BOS	53%	97%	44%	32%	28%	50%
	BNA	78%	101%	126%	50%	43%	56%
	FLL	34%	58%	41%	19%	23%	35%
	CVG	175%	185%	236%	58%	39%	41%
	PVD	101%	150%	173%	47%	41%	48%
Alternative #3: Significant Decrease Expected	LAX	-37%	-34%	-41%	-34%	-30%	-15%
	BOS	-80%	-89%	-100%	-95%	-98%	-99%
	BNA	-54%	-96%	-100%	-50%	-64%	-49%
	FLL	-34%	-41%	-50%	-60%	-68%	-86%
	CVG	-70%	-77%	-72%	-75%	-95%	-98%
	PVD	-84%	-88%	-91%	-84%	-93%	-95%
	PBI	-79%	-52%	-48%	-73%	-75%	-77%
Alternative #4: Small Decrease Expected	LAX	-14%	-6%	-14%	-37%	-65%	-78%
	BNA	5%	-1%	1%	1%	0%	2%
	FLL	-11%	0%	0%	1%	-1%	0%
	CVG	1%	-8%	7%	3%	2%	0%
	PVD	-17%	-11%	-19%	-7%	-7%	-6%
	PBI	4%	9%	0%	1%	4%	13%

The elimination of the older, noisier Stage 2 airplanes at each of the airports (Alternative #3) was expected to provide a significant reduction in noise impacts around those facilities. The DNL analyses provided reductions varying from 34 percent to 96 percent in the population impacted around the seven airports shown. The SEL analyses provided similar reductions varying from 30 percent to 98 percent in the people-incidents computed. The two metrics appear to provide a similar degree of comparative change and sensitivity for this alternative.

Finally, adopting different flight tracks around each airport (Alternative #4) was expected to achieve small reductions in noise impacts there. The DNL analyses provided changes varying from an increase of 17 percent to a reduction of 9 percent in population impacted. The SEL analyses provided changes which varied from an increase of 3 percent to a reduction of 65 percent. The two metrics appear to provide a similar degree of comparative change, although the SEL appears to provide more sensitivity to those changes.

Table 5-4 presents the same comparison of impacted areas calculated for the four alternatives at the seven airports. In general, the same observations as those noted above for the impacted populations hold true here.

One other comparison was performed between the DNL and SEL representations. Since the DNL measure includes a 10 decibel nighttime weighting for flights between the hours of 2200 and 0700, it is inherently more sensitive to changes in nighttime operations. Alternatives #1 and #2 were designed to identify this characteristic. The calculation of SEL "people–incidents" did not include any such weighting. To achieve this comparison, the SEL "people–incidents" were also calculated using a similar nighttime penalty by multiplying the nighttime operations by a factor of 10. Table 5-5 presents these results. Figures 5-1 and 5-2 plot the corresponding changes for each alternative, relative to the base case.

The changes from the base case as measured in population exposed to DNL and SEL "weighted people–incidents" appear to correlate reasonably well. A first-order, least-squares regression provides the following relationship between

Table 5-4

Comparative Changes in Impacted Areas
Using DNL and SEL (Relative to Base Case)

Scenario	Airport	Impacted Areas DNL Greater Than:			Impacted Areas SEL Greater Than:		
		55 dB	60 dB	65 dB	90 dB	95 dB	100 dB
Alternative #1: Moderate Decrease Expected	LAX	-37%	-37%	-32%	0%	0%	0%
	BOS	-28%	-27%	-28%	0%	0%	0%
	BNA	-13%	-12%	-13%	0%	0%	0%
	FLL	-18%	-17%	-20%	0%	0%	0%
	CVG	-50%	-44%	-46%	0%	0%	0%
	PVD	-37%	-45%	-48%	0%	0%	0%
	PBI	-2%	-2%	-1%	0%	0%	0%
Alternative #2: Moderate to Significant Increase Expected	LAX	52%	54%	44%	0%	0%	0%
	BOS	105%	84%	86%	0%	0%	0%
	BNA	212%	178%	210%	0%	0%	0%
	FLL	66%	74%	80%	0%	0%	0%
	CVG	90%	117%	118%	0%	0%	0%
	PVD	116%	142%	208%	0%	0%	0%
Alternative #3: Significant Decrease Expected	LAX	-57%	-57%	-58%	-34%	-34%	-49%
	BOS	-75%	-82%	-85%	-47%	-60%	-70%
	BNA	-76%	-82%	-84%	-85%	-91%	-96%
	FLL	-45%	-51%	-63%	-44%	-48%	-64%
	CVG	-74%	-76%	-80%	-43%	-42%	-55%
	PVD	-81%	-85%	-86%	-89%	-93%	-96%
	PBI	-65%	-69%	-70%	-67%	-71%	-84%
Alternative #4: Small Decrease Expected	LAX	-1%	0%	0%	0%	0%	0%
	BNA	-6%	-1%	3%	-9%	-9%	-8%
	FLL	-5%	-1%	3%	-21%	-13%	-7%
	CVG	1%	-1%	0%	-9%	-3%	-3%
	PVD	-6%	2%	6%	-27%	-26%	-23%
	PBI	0%	0%	4%	-20%	-18%	-18%

Table 5-5

Comparative Changes in People Impacted
Using DNL and SEL (Relative to Base Case):
Nighttime Penalty Imposed on People-Incidents

Scenario	Airport	People Impacted DNL Greater Than:			Weighted People-Incidents SEL Greater Than:		
		55 dB	60 dB	65 dB	90 dB	95 dB	100 dB
Alternative #1: Moderate Decrease Expected	LAX	-20%	-30%	-29%	-34%	-36%	-4%
	BOS	-23%	-34%	-59%	-37%	-36%	-29%
	BNA	-11%	-10%	-24%	-16%	-12%	-19%
	FLL	-9%	-8%	-25%	-30%	-29%	-31%
	CVG	-52%	-57%	-59%	-56%	-55%	-55%
	PVD	-42%	-50%	-66%	-48%	-47%	-42%
	PBI	-2%	-2%	0%	-2%	0%	0%
Alternative #2: Moderate to Significant Increase Expected	LAX	13%	30%	41%	86%	75%	54%
	BOS	53%	97%	44%	197%	174%	338%
	BNA	78%	101%	126%	467%	448%	503%
	FLL	34%	58%	41%	133%	162%	242%
	CVG	175%	185%	236%	272%	215%	232%
	PVD	101%	150%	173%	262%	248%	319%
Alternative #3: Significant Decrease Expected	LAX	-37%	-34%	-41%	-34%	-28%	-6%
	BOS	-80%	-89%	-100%	-95%	-99%	-99%
	BNA	-54%	-96%	-100%	-50%	-62%	-58%
	FLL	-34%	-41%	-50%	-66%	-78%	-90%
	CVG	-70%	-77%	-72%	-76%	-98%	-99%
	PVD	-84%	-88%	-91%	-80%	-92%	-90%
	PBI	-79%	-52%	-48%	-74%	-75%	-77%
Alternative #4: Small Decrease Expected	LAX	-14%	-6%	-14%	-34%	-80%	3%
	BNA	5%	-1%	1%	1%	0%	2%
	FLL	-11%	0%	0%	1%	-1%	0%
	CVG	1%	-8%	7%	3%	1%	0%
	PVD	-17%	-11%	-19%	-2%	-4%	-4%
	PBI	4%	9%	0%	1%	4%	13%

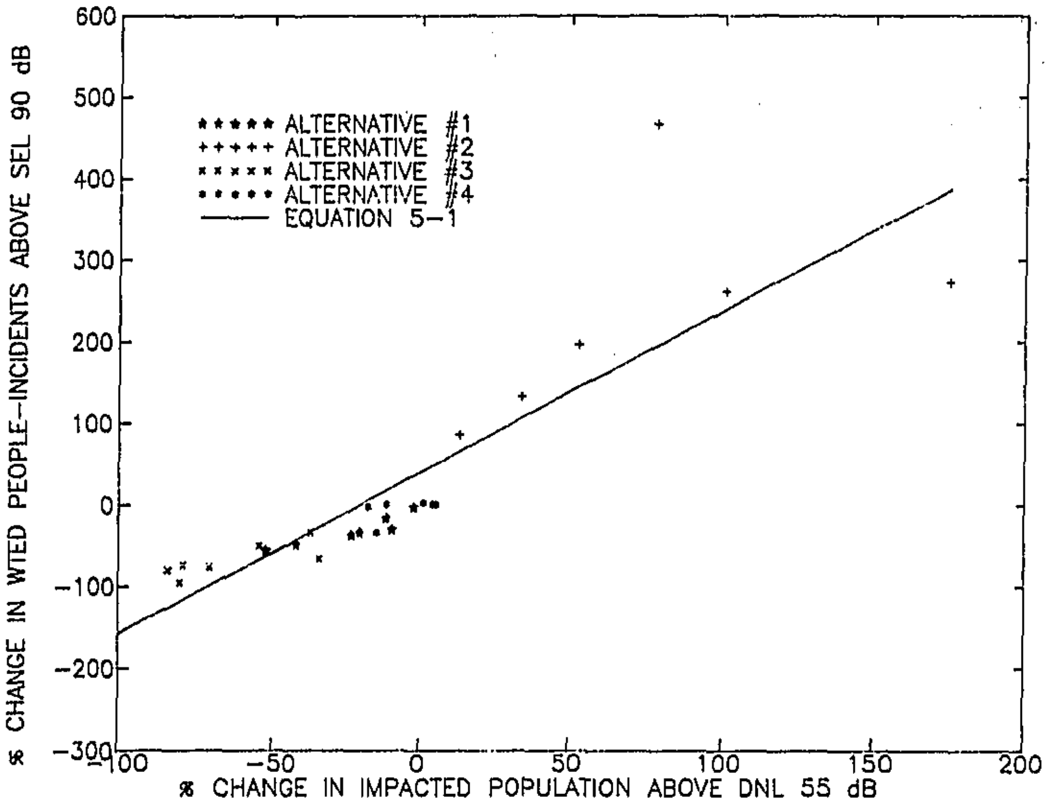


Figure 5-1. Comparative Changes in Impact Relative to Base Case – DNL Greater Than 55 dB, SEL Greater Than 90 dB.

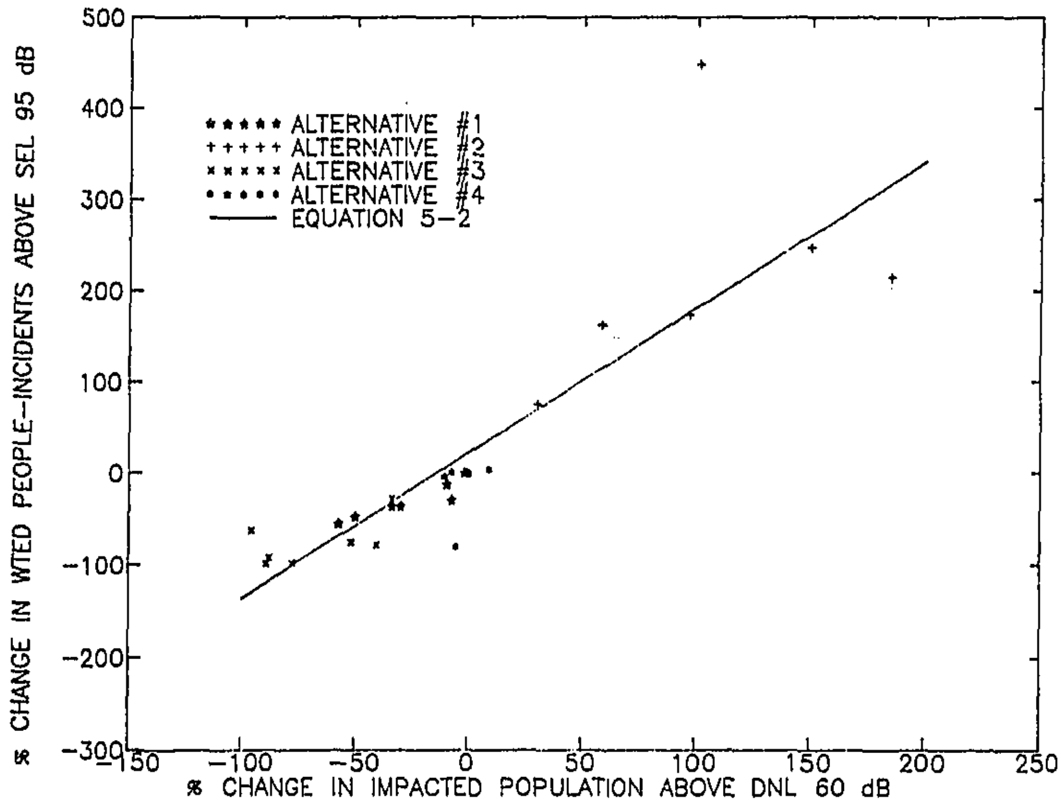


Figure 5-2. Comparative Changes in Impact Relative to Base Case – DNL Greater Than 60 dB, SEL Greater Than 95 dB.

people exposed to a DNL above 55 dB and "weighted people-incidents" for SEL greater than 90 dB:

$$\Delta_{SEL} = 39.8 + 1.98 \times \Delta_{DNL}, \quad dB \qquad (5\text{-}1)$$

(correlation coefficient = 0.864)

where Δ_{SEL} = percent change in "weighted people-incidents" relative to the base case;

Δ_{DNL} = percent change in impacted populations relative to the base case.

The same relationship for people exposed to a DNL above 60 dB and "weighted people-incidents" for SEL above 95 dB is:

$$\Delta_{SEL} = 23.0 + 1.59 \times \Delta_{DNL}, \quad dB \qquad (5\text{-}2)$$

(correlation coefficient = 0.868)

In effect, the determination of either measure of noise impact should provide a reasonably accurate determination of the other.

6.0 CONCLUSIONS

In general, the changes which are obtained from the DNL analysis reflect the expected changes in noise impacts around the airports used here. The changes obtained from the SEL analysis are not consistent with the expected changes unless a nighttime weighting factor is incorporated in the definition of "weighted people-incidents". This is to be expected, since the SEL values are determined by the loudest airplanes in operation. Thus, for example, in changing nighttime operations to an equal number of daytime operations, there would be no change in the SEL results unless a nighttime weighting factor were used.

With a 10 dB nighttime weighting applied, the two measures of populations exposed above a certain DNL value and "weighted people-incidents" above a similar SEL value appear to correlate reasonably well. In other words, neither measure would appear to be superior to the other in terms of sensitivity to changes in noise exposure. There appears to be no real benefit in adopting an SEL-based metric in lieu of the currently accepted DNL.

From a more conceptual viewpoint, it would appear that the DNL measure is more representative of the noise exposure in communities than the SEL measure. The DNL measure essentially includes all of the noise energy generated by aircraft operations in the communities around the airport, considering both the total noise made by each aircraft passby and the number of those events. The SEL measure depends only on the number of times that aircraft noise exceeds a specific SEL in the communities, and does not consider how much higher those noise levels may actually be. Thus the SEL-based measure actually "short-changes" the real amount of noise exposure. As a second comment, the large numbers of "people-incidents" determined with the SEL-based measure may be unduly alarming and misleading to many communities. For example, the "people-incidents" above an SEL of 90 dB at LAX are 18,600,000. A number of this magnitude could easily be misinterpreted, and certainly appears to represent more people than actually live reasonably close to this airport.

7.0 REFERENCES

1. Schultz, T.J., "Synthesis of Social Surveys on Noise Annoyance", *J. Acoust. Soc. Am.*, *64*, 377-405.

2. "Sound Level Descriptors for Determination of Compatible Land Use", American National Standard ANSI S3.23-1980.

3. "Guidelines for Considering Noise in Land-Use Planning and Control", Federal Interagency Committee on Urban Noise, June 1980.

4. Advisory Circular 1050.1D, "Policies and Procedures for Considering Environmental Impacts", FAA, December 5, 1986.

5. "Updating a Dosage-Effect Relationship for the Prevalence of Annoyance Due to General Transportation Noise", *J. Acoust. Soc. Am.*, *89*, 221-233.

6. "The National Airport Noise Impact Model and Its Applications to Regulatory Alternatives", Report FAA EE-88-3, July 1987.

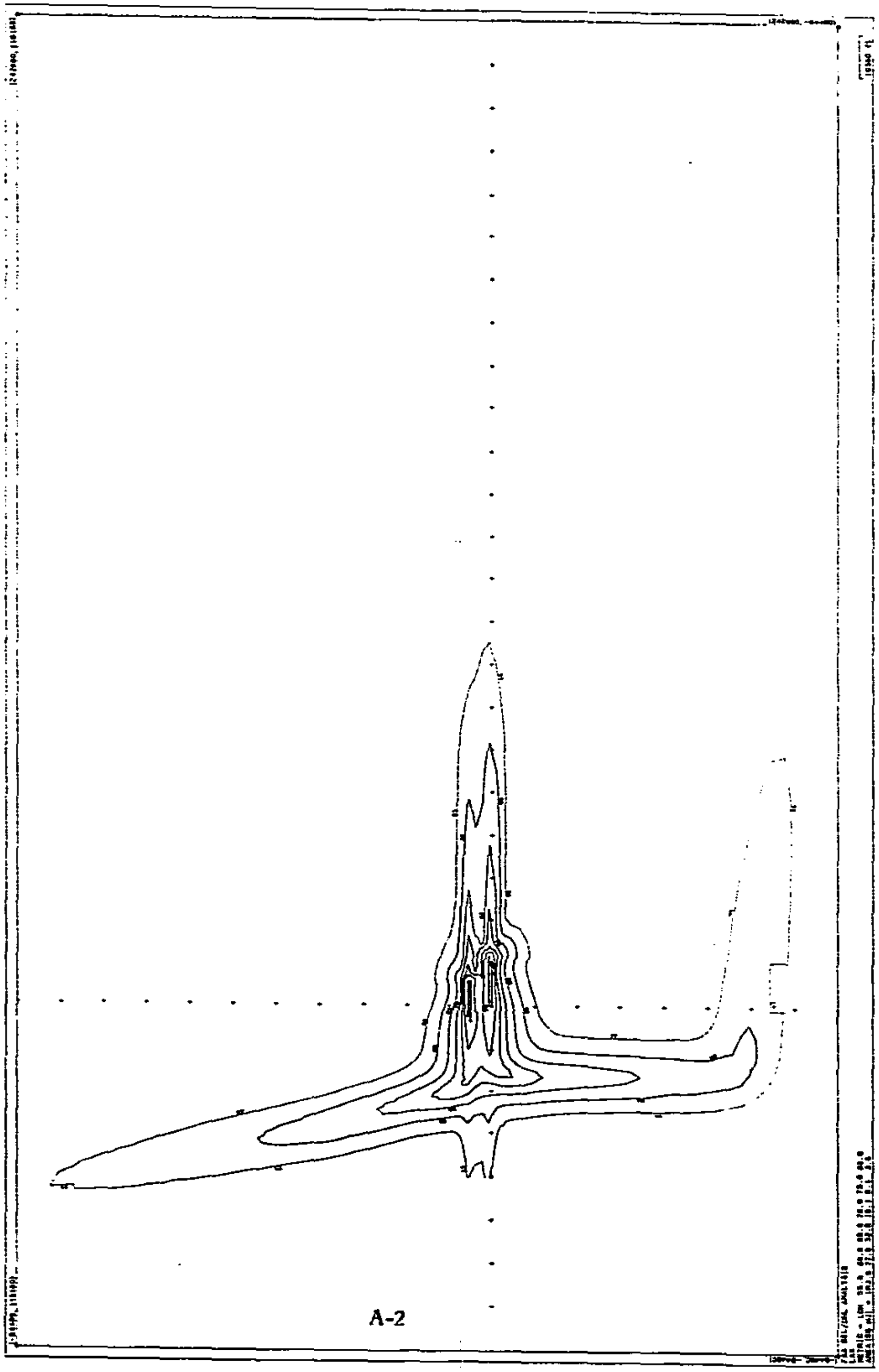
APPENDIX A

DNL Contour Plots for All Candidate Airports (All Scenarios)

NOTE 1: Most of the Contour Plots in this appendix were generated on "C" or "D" size paper. In reducing these to the 8.5 x 11-inch format, some degradation in the quality of the plots may have occurred in some cases.

NOTE 2: There is no contour plot for BDR-Alternative #3 (All Stage 3 Aircraft). BDR is currently served only by Stage 3 aircraft, so the contours for the Base Case are sufficient.

NOTE 3: There is no contour plot for BOS-Alternative #4 (Flight Tracks). This has been explained in Section 2.3.



CORRECTION!

THE PREVIOUS DOCUMENT(S) MAY HAVE BEEN FILMED INCORRECTLY . . .

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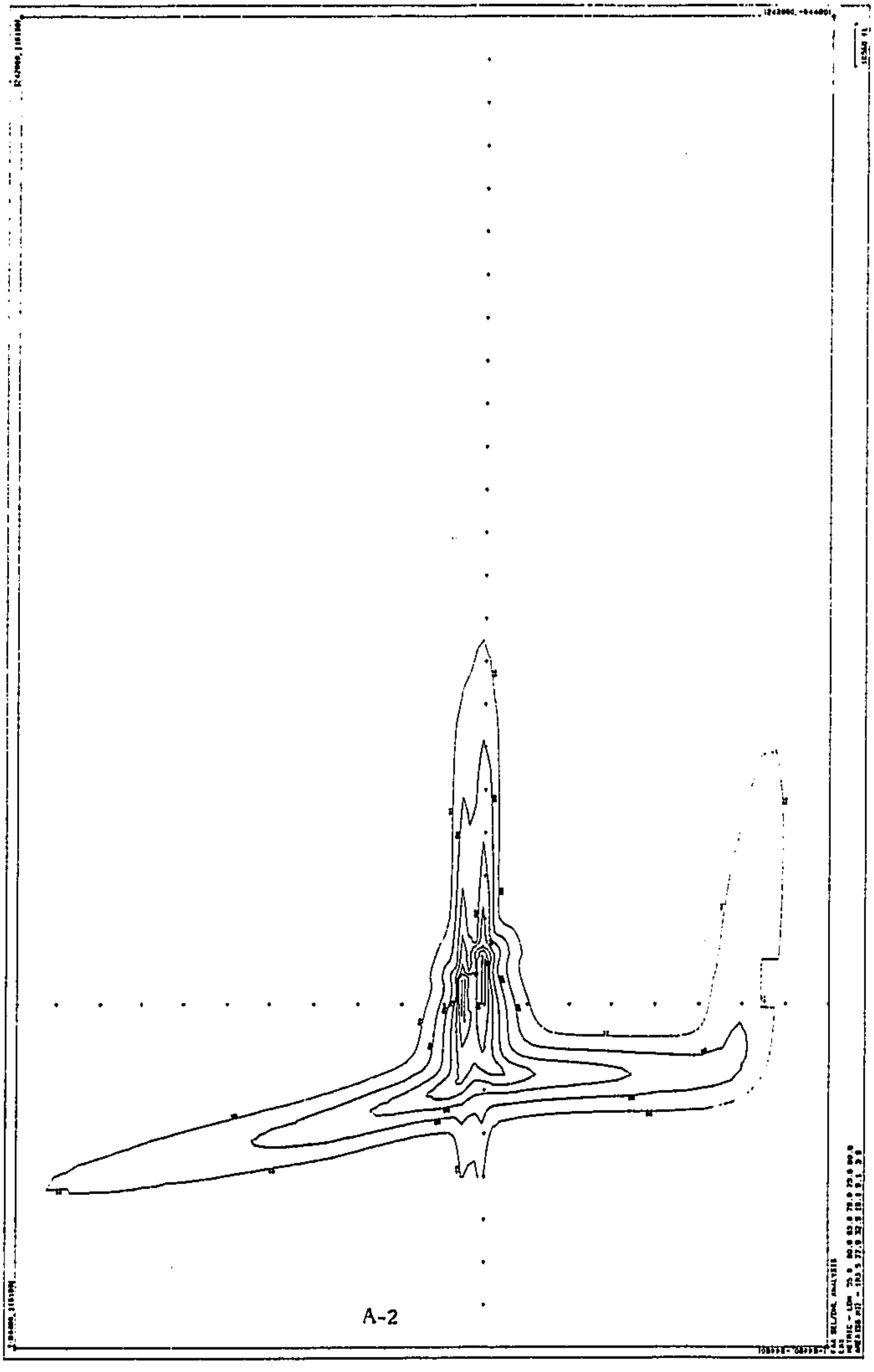
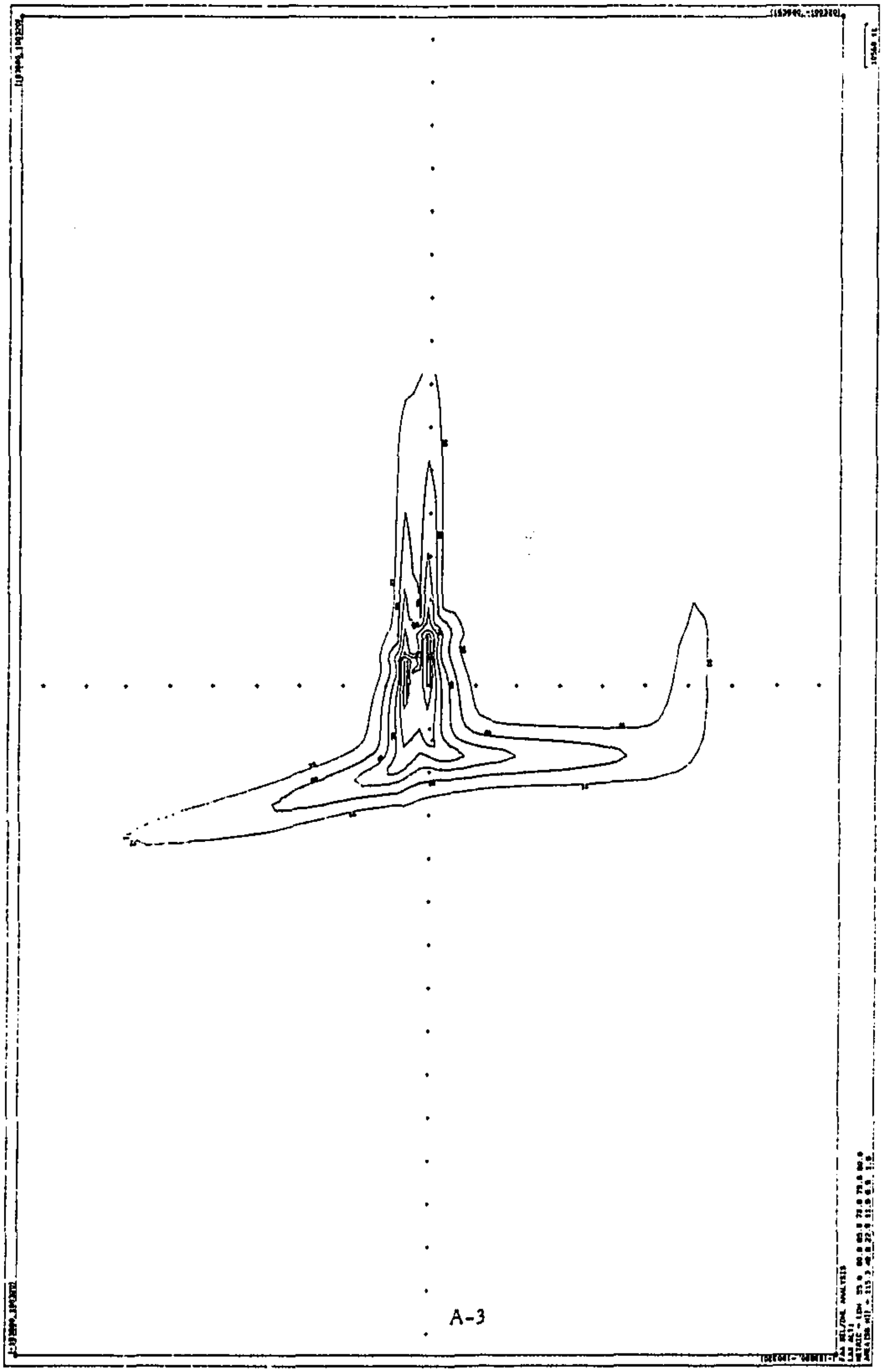
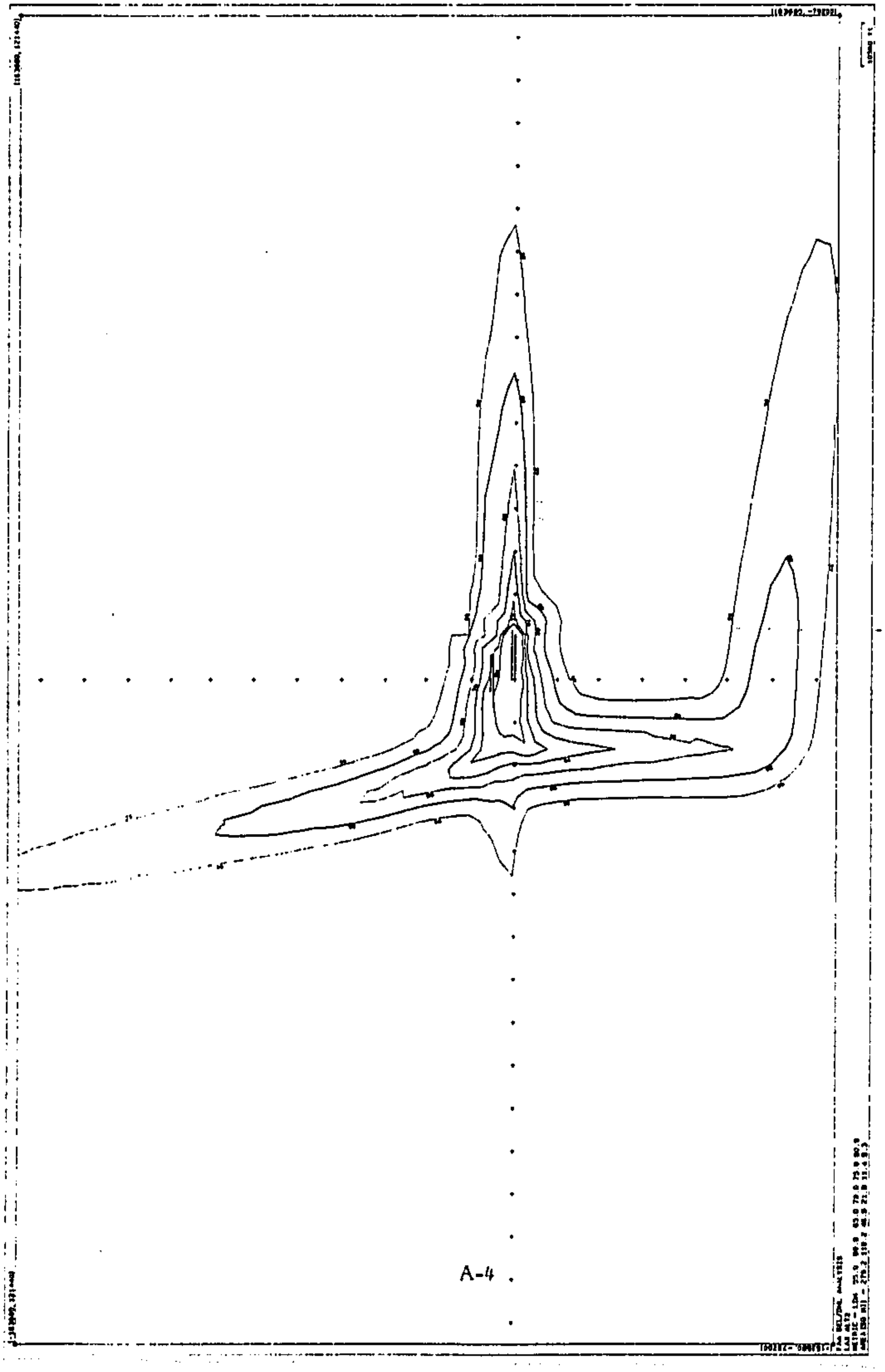
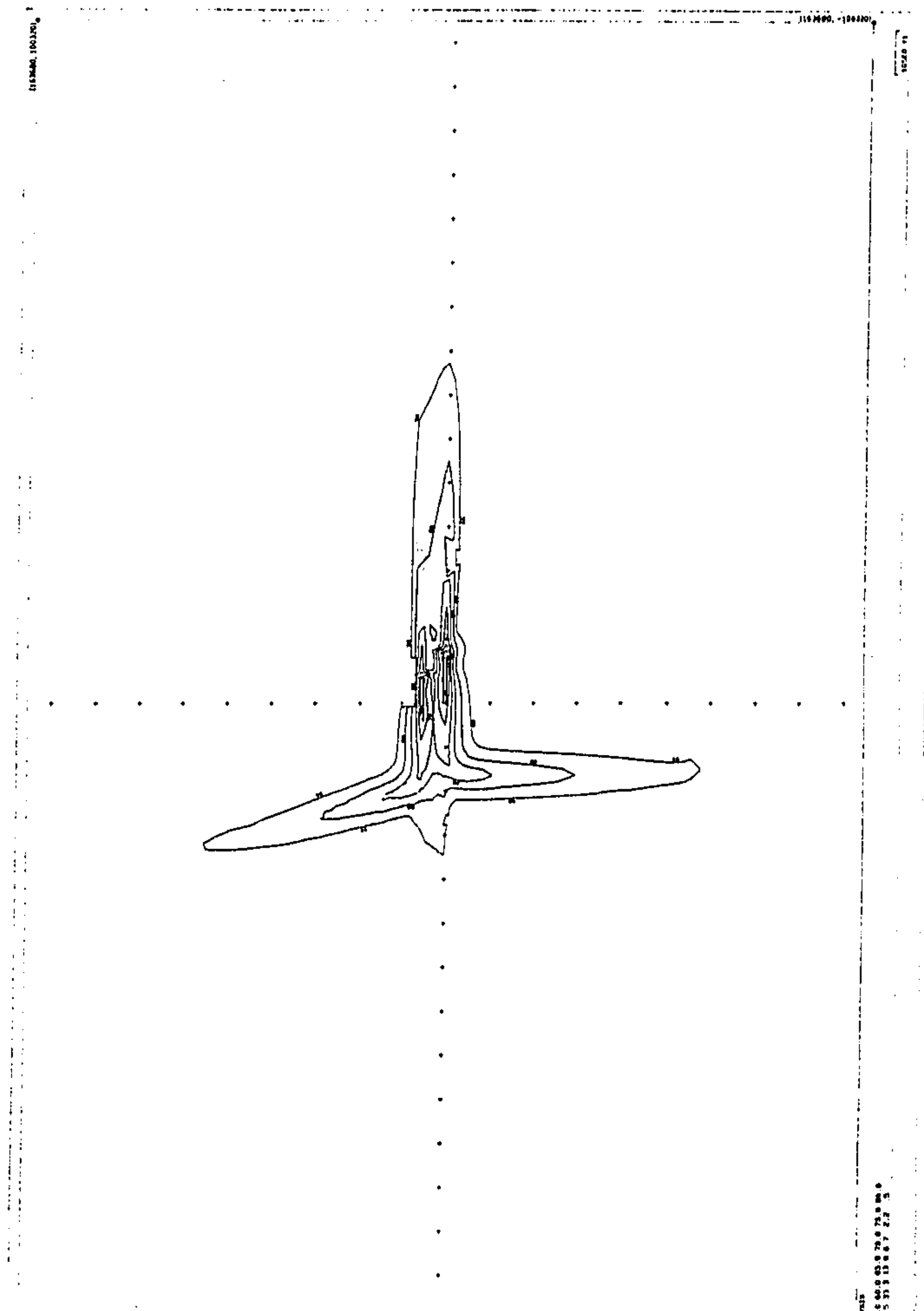
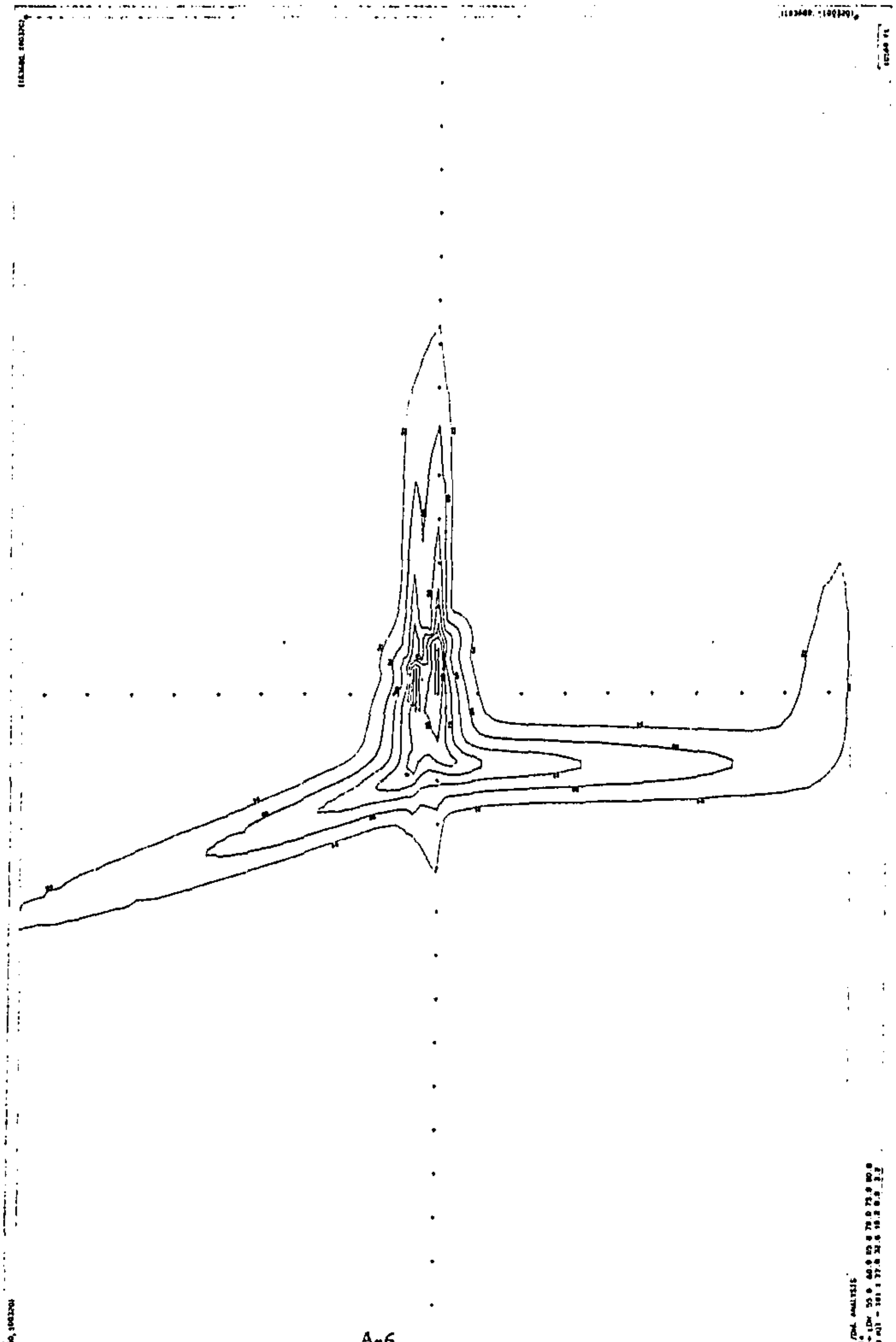
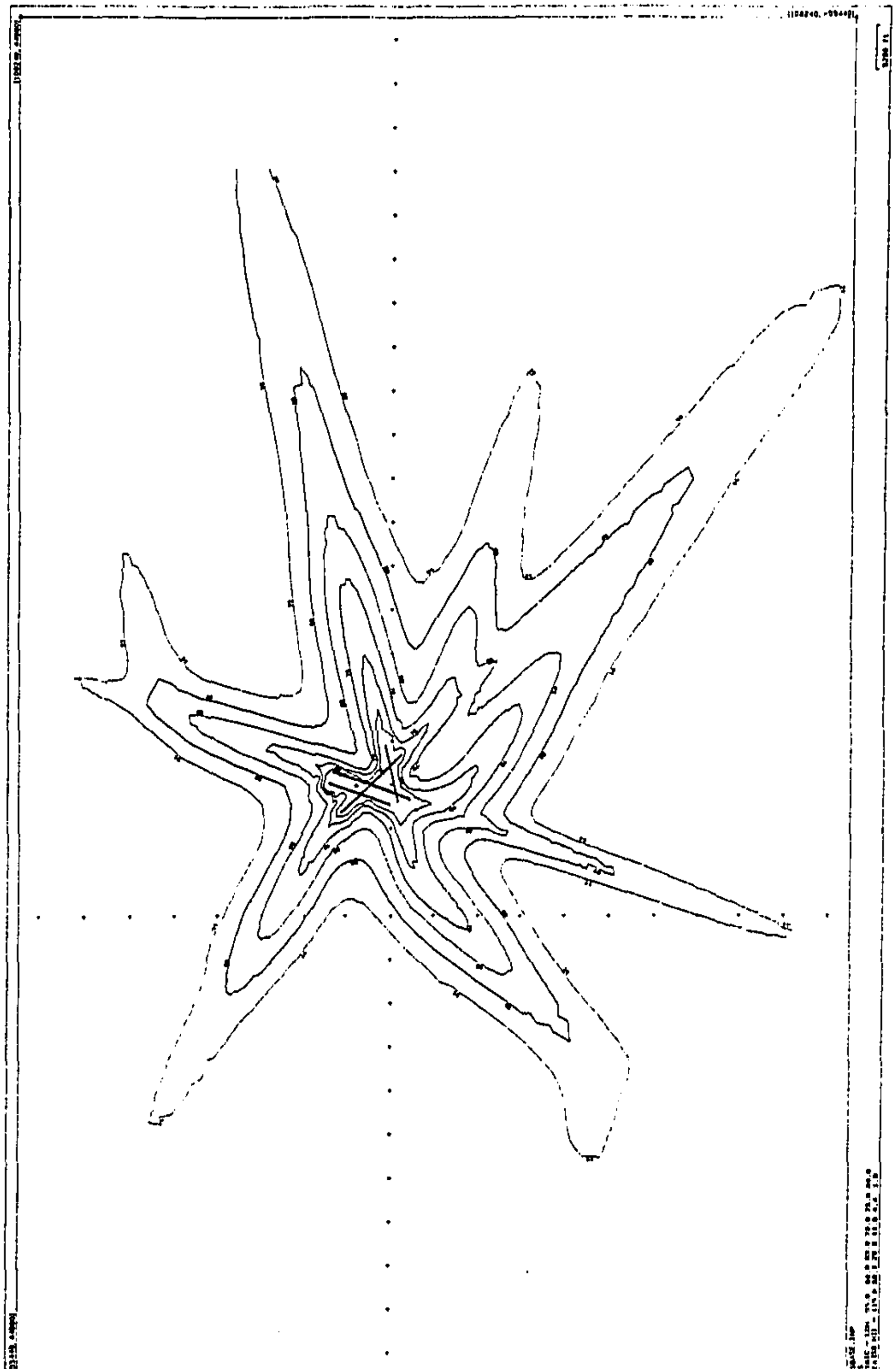


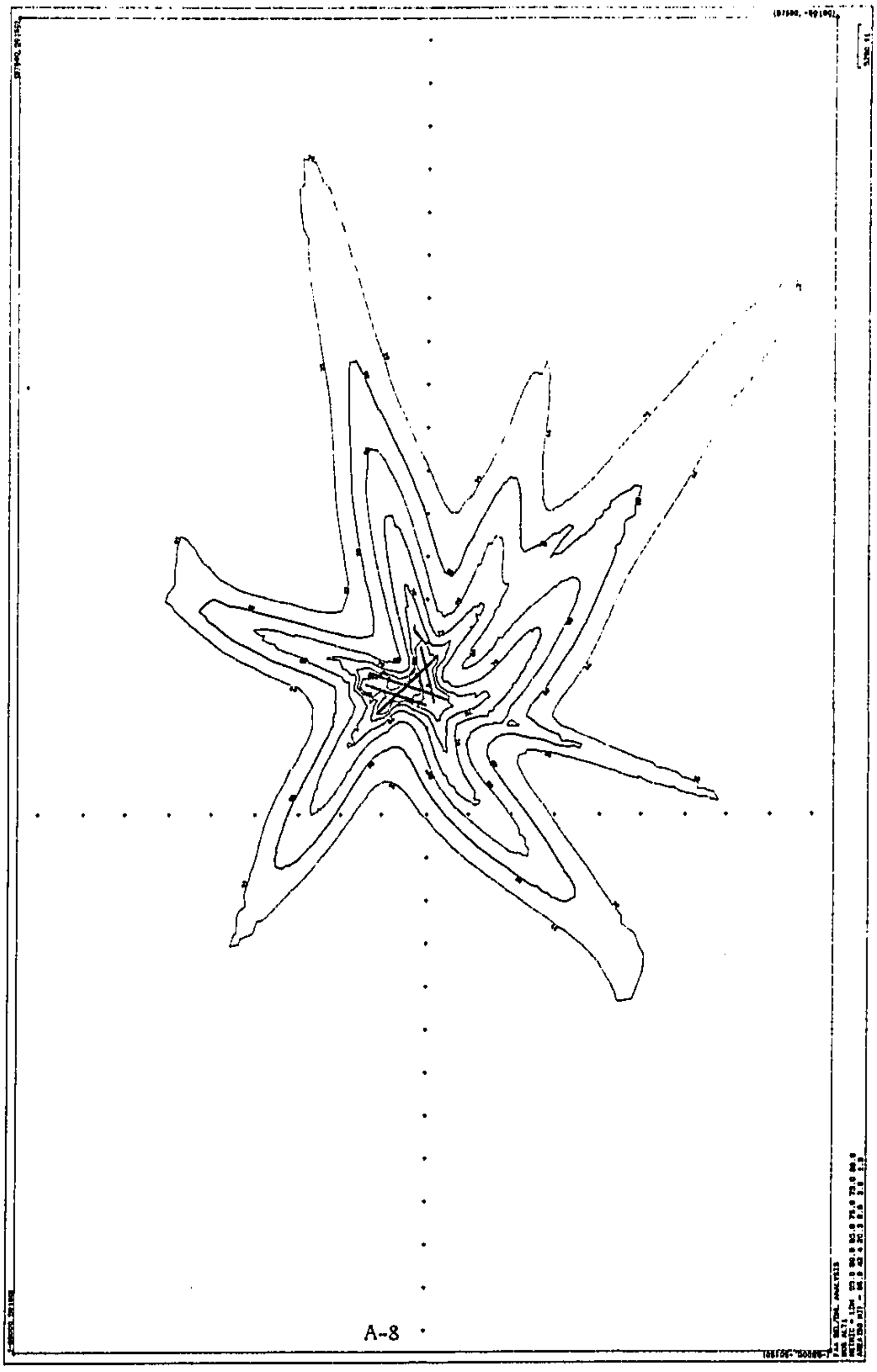


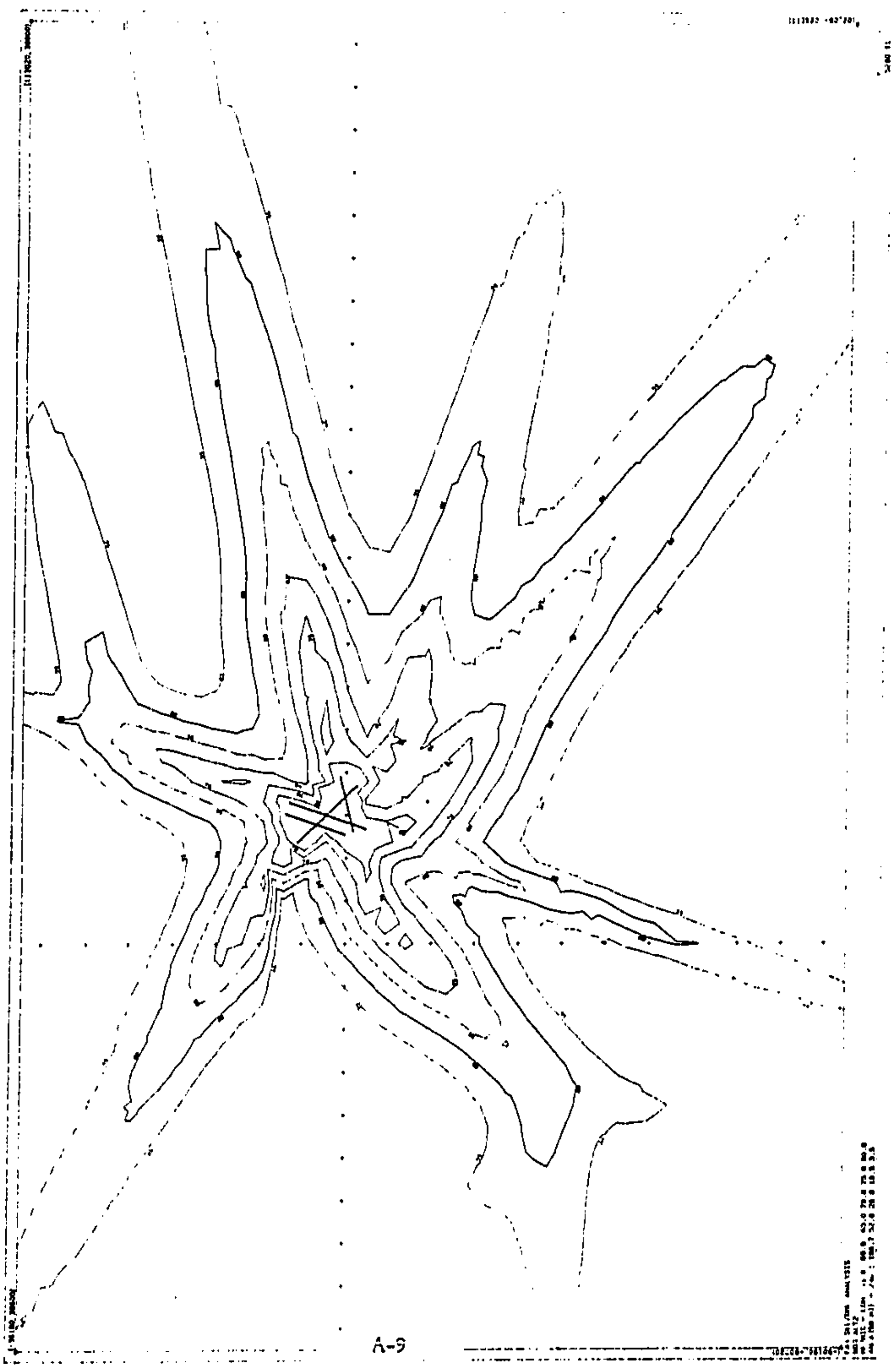


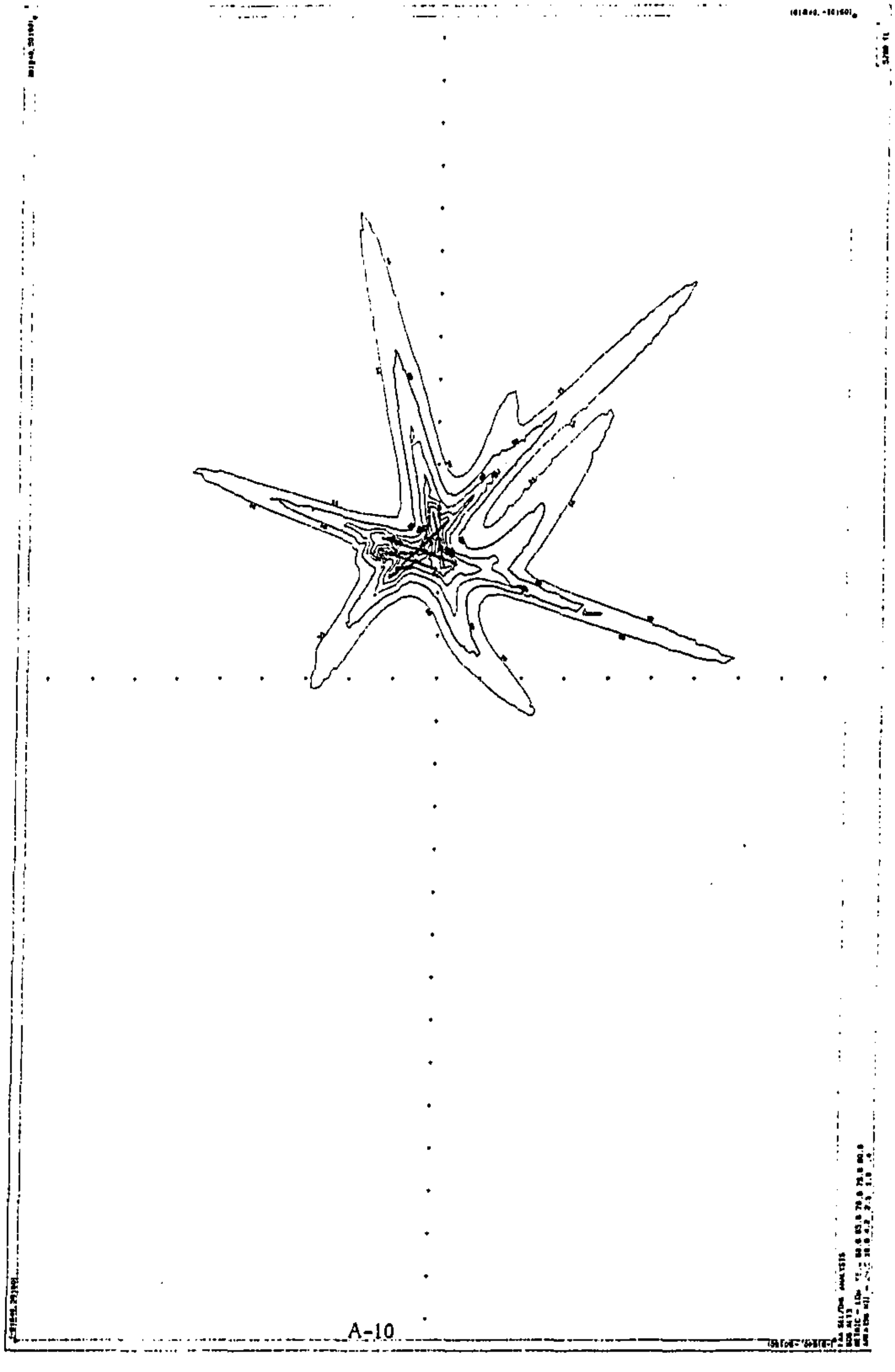


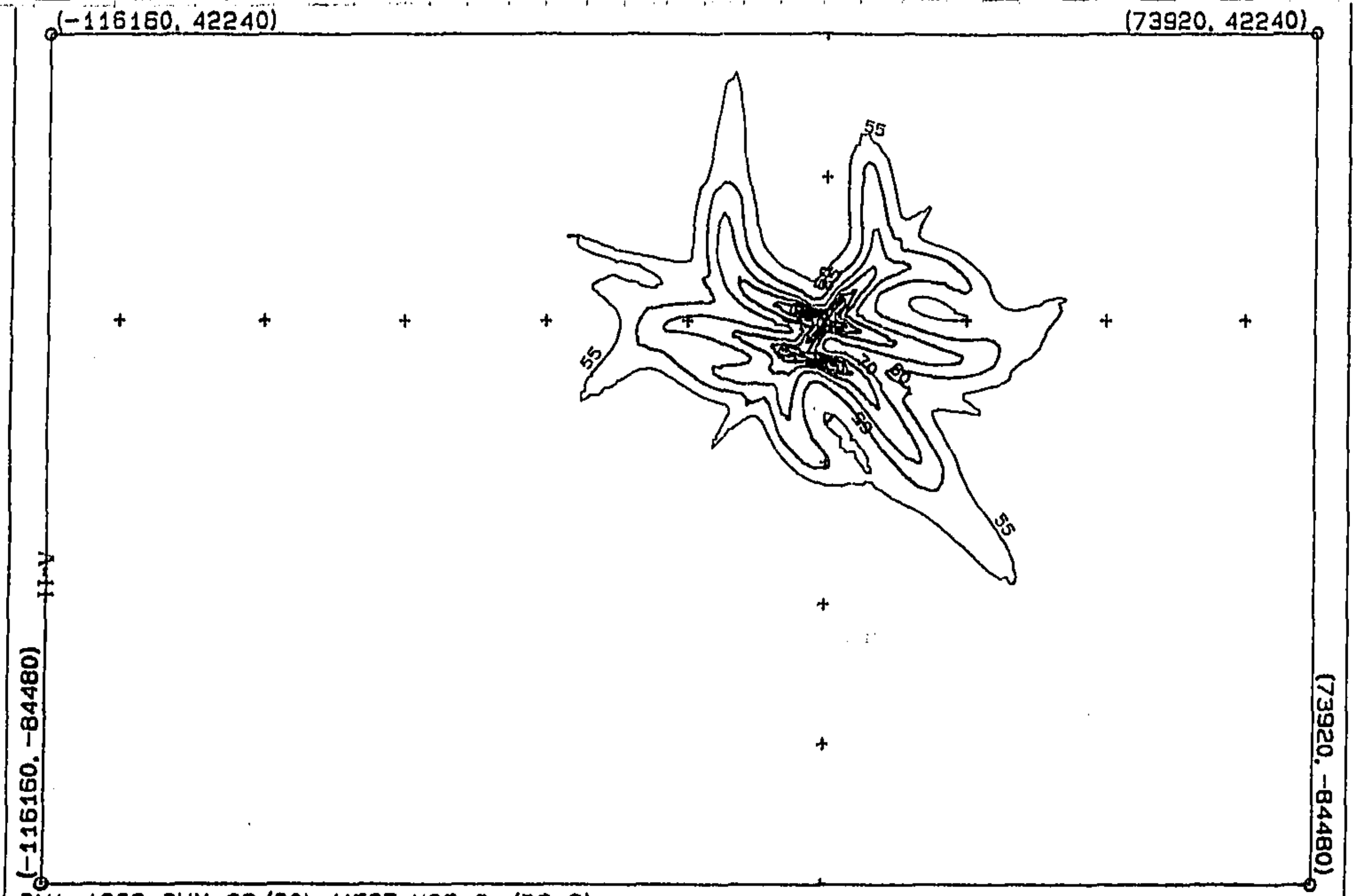




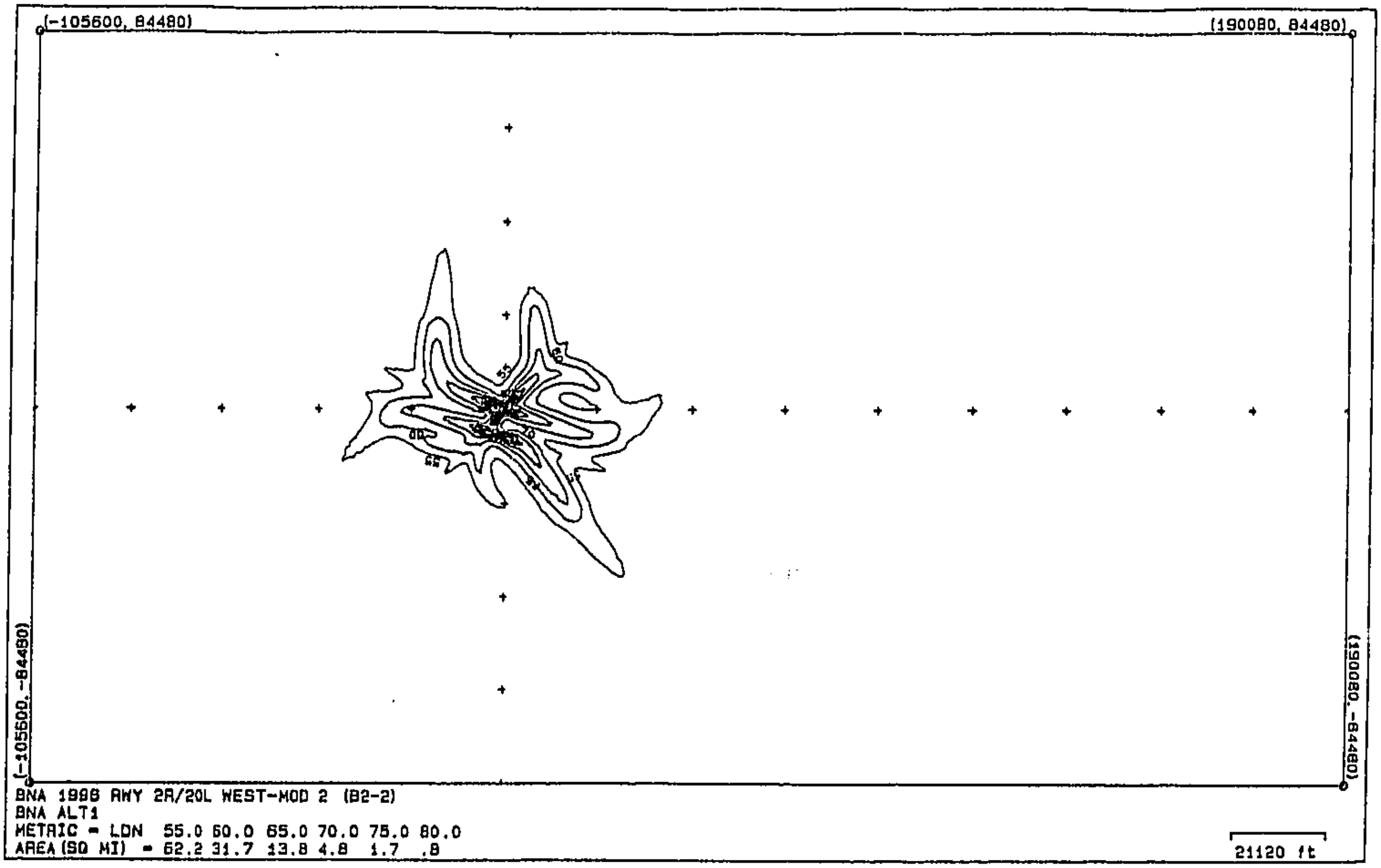








BNA 1996 RWY 2R/20L WEST-MOD 2 (B2-2)
NASHVILLE METRO AIRPORT
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 71.3 35.9 15.9 5.3 1.9 .9



BNA 1986 RWY 2R/20L WEST-MOD 2 (B2-2)
BNA ALT1
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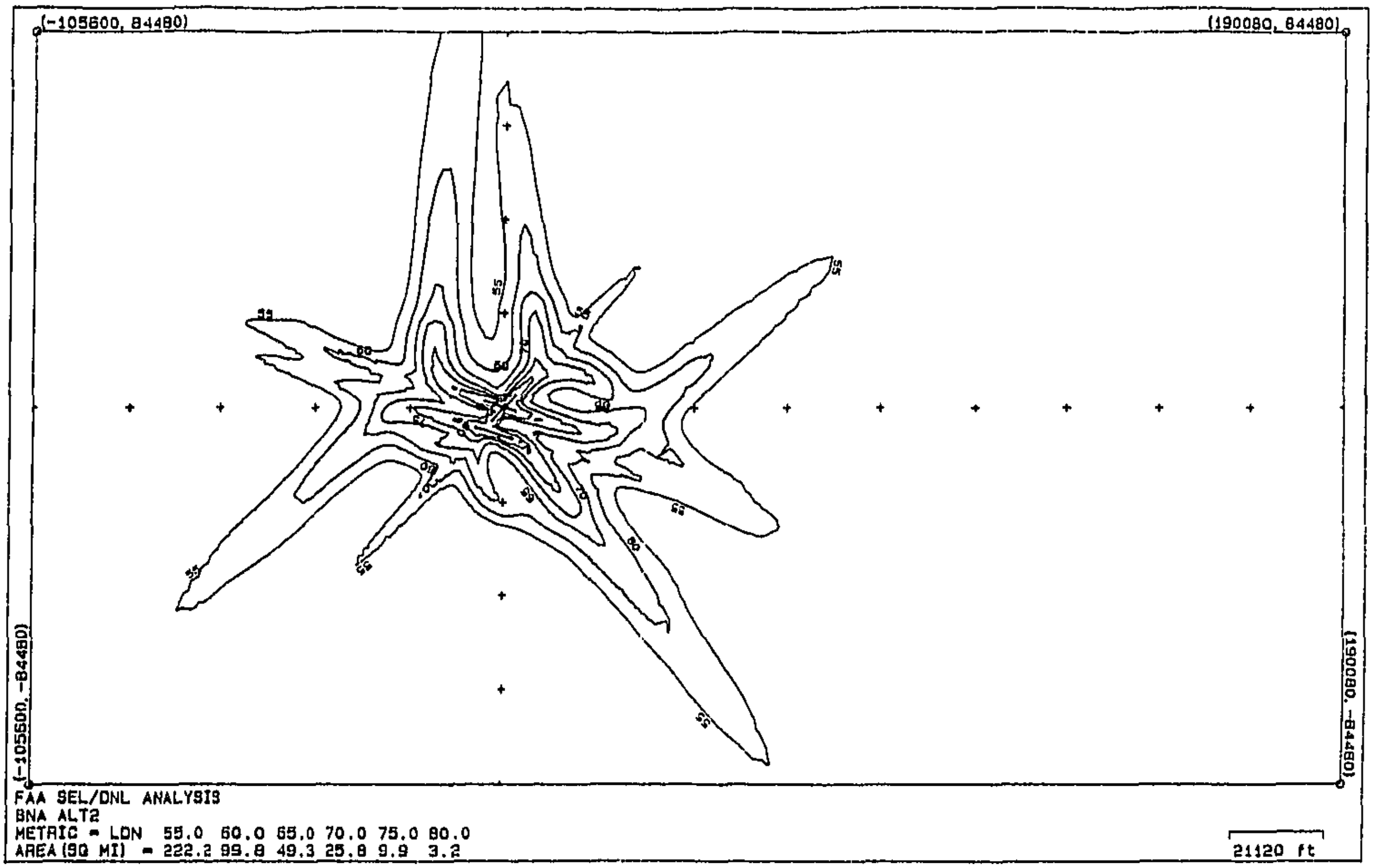
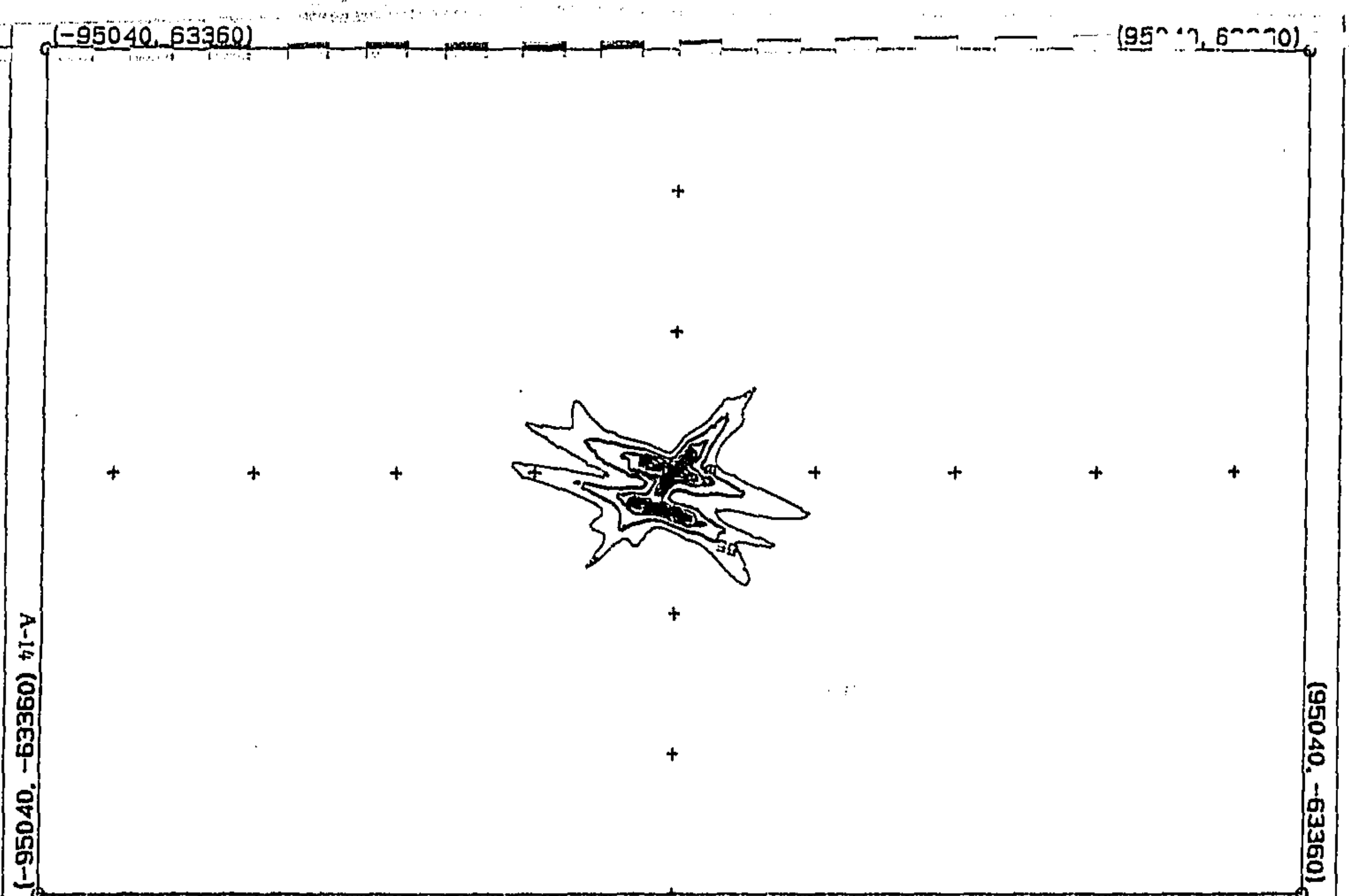
AREA (SQ MI) = 62.2 31.7 13.8 4.8 1.7 .8


(-105600, 84480)
(190080, 84480)
(-105600, -84480)
(190080, -84480)
55
60
65
70
75
FAA SEL/DNL ANALYSIS
BNA ALT2
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 222.2 99.8 49.3 25.8 9.9 3.2
21120 ft



FAA SEL/DNL ANALYSIS
BNA ALT3
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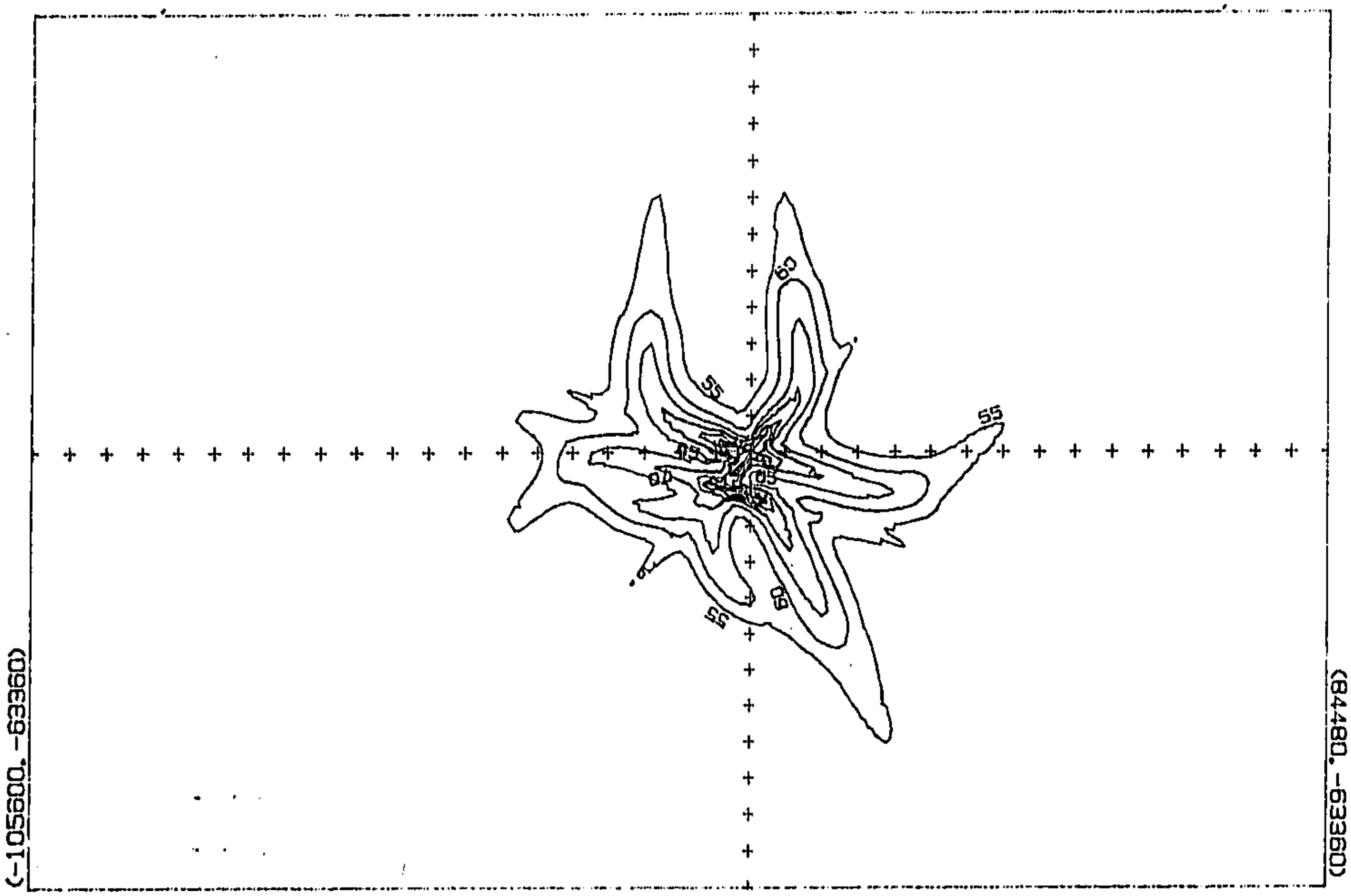
AREA (SQ MI) = 16.8 6.4 2.6 1.2 .4 .1

21120 ft



FAA SEL/DNL ANALYSIS
BNA ALT4
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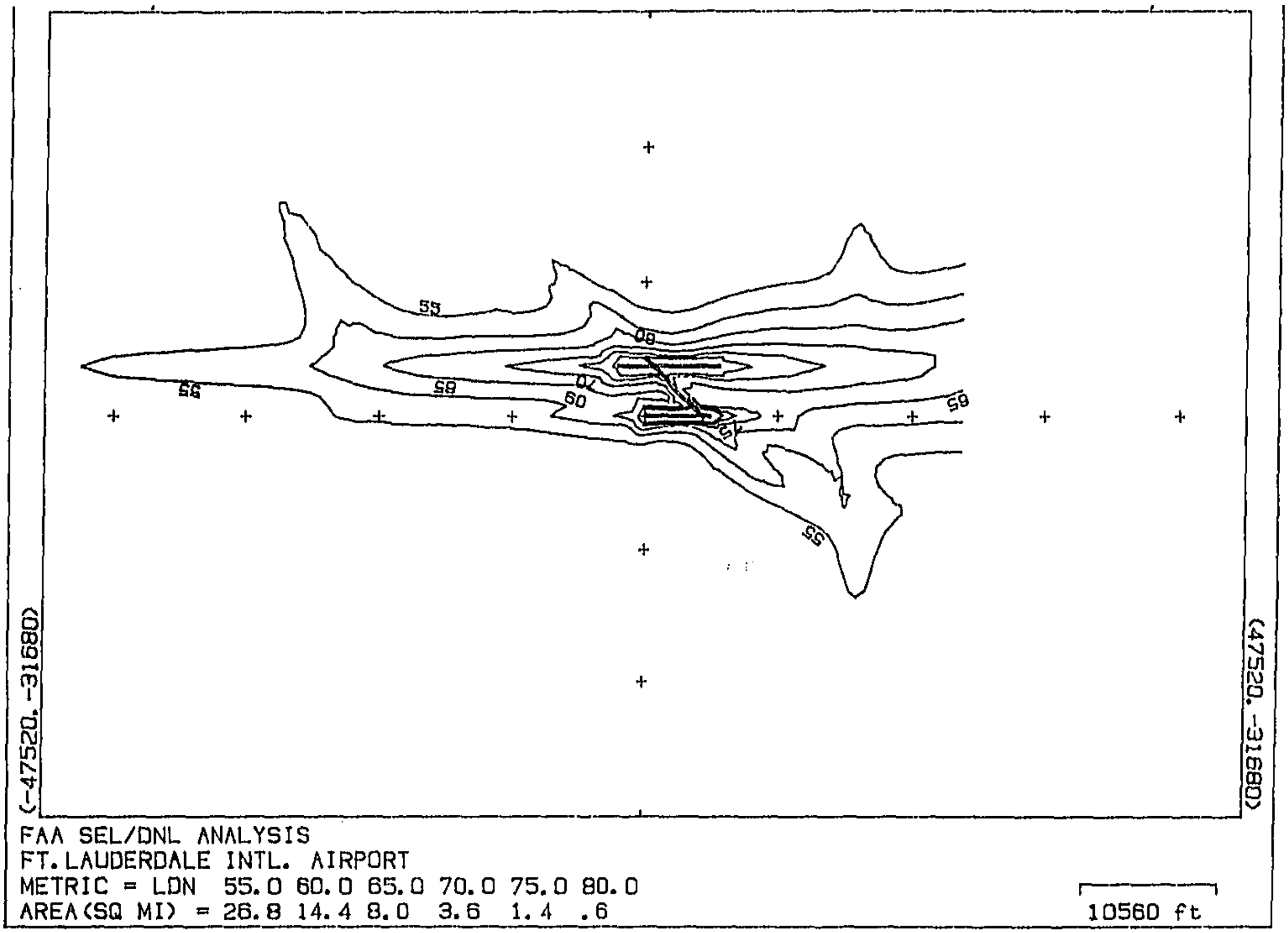
AREA(SQ MI) = 66.9 35.5 16.3 5.3 2.0 .8

21120 ft



55
60
65
70
(-47520. -31680)
(47520. -31680)
FAA SEL/DNL ANALYSIS
FT. LAUDERDALE INTL. AIRPORT
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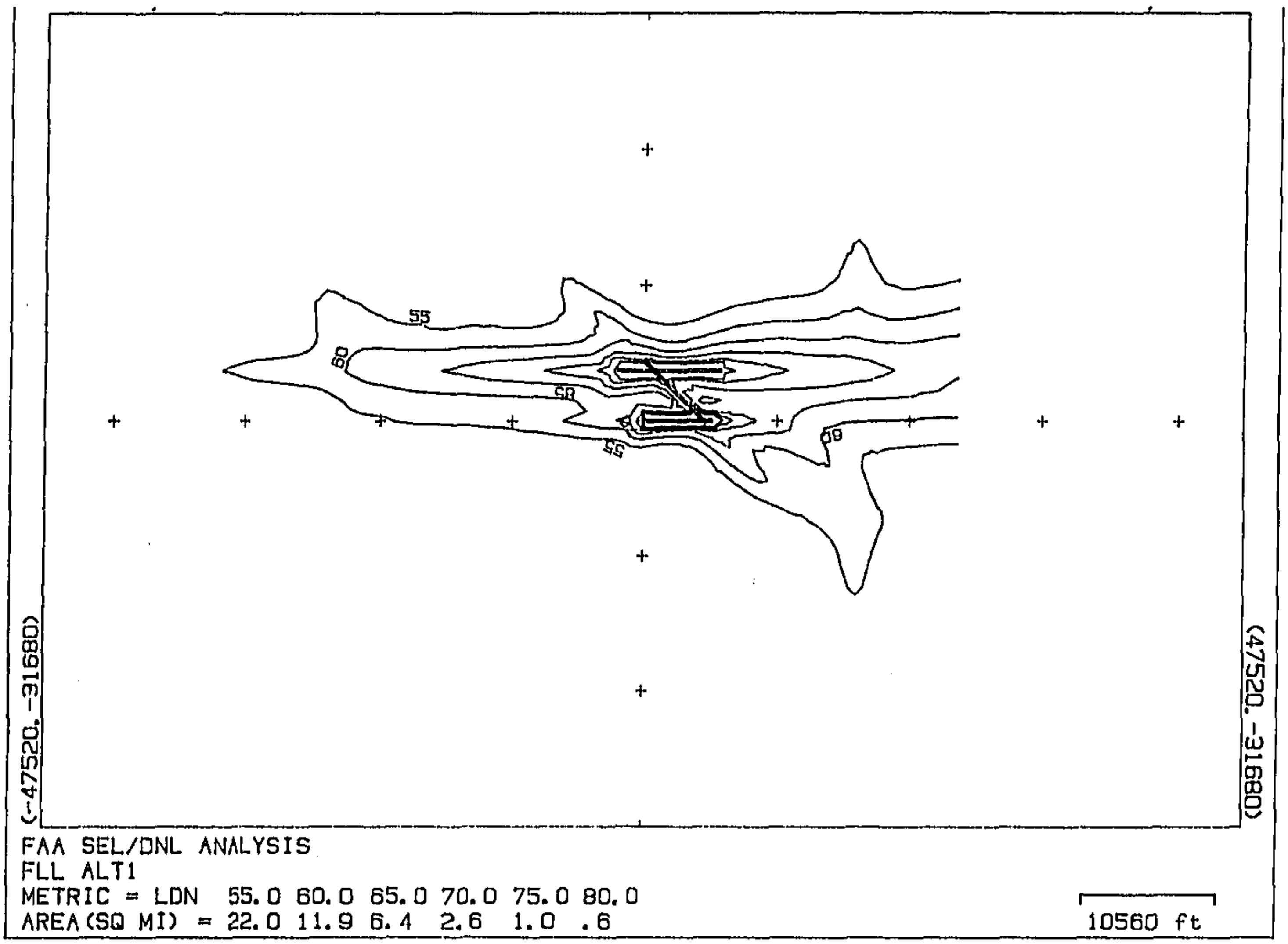
AREA (SQ MI) = 26.8 14.4 8.0 3.6 1.4 .6
10560 ft


(-47520, -31680)
(47520, -31680)
55
60
FAA SEL/DNL ANALYSIS
FLL ALT1
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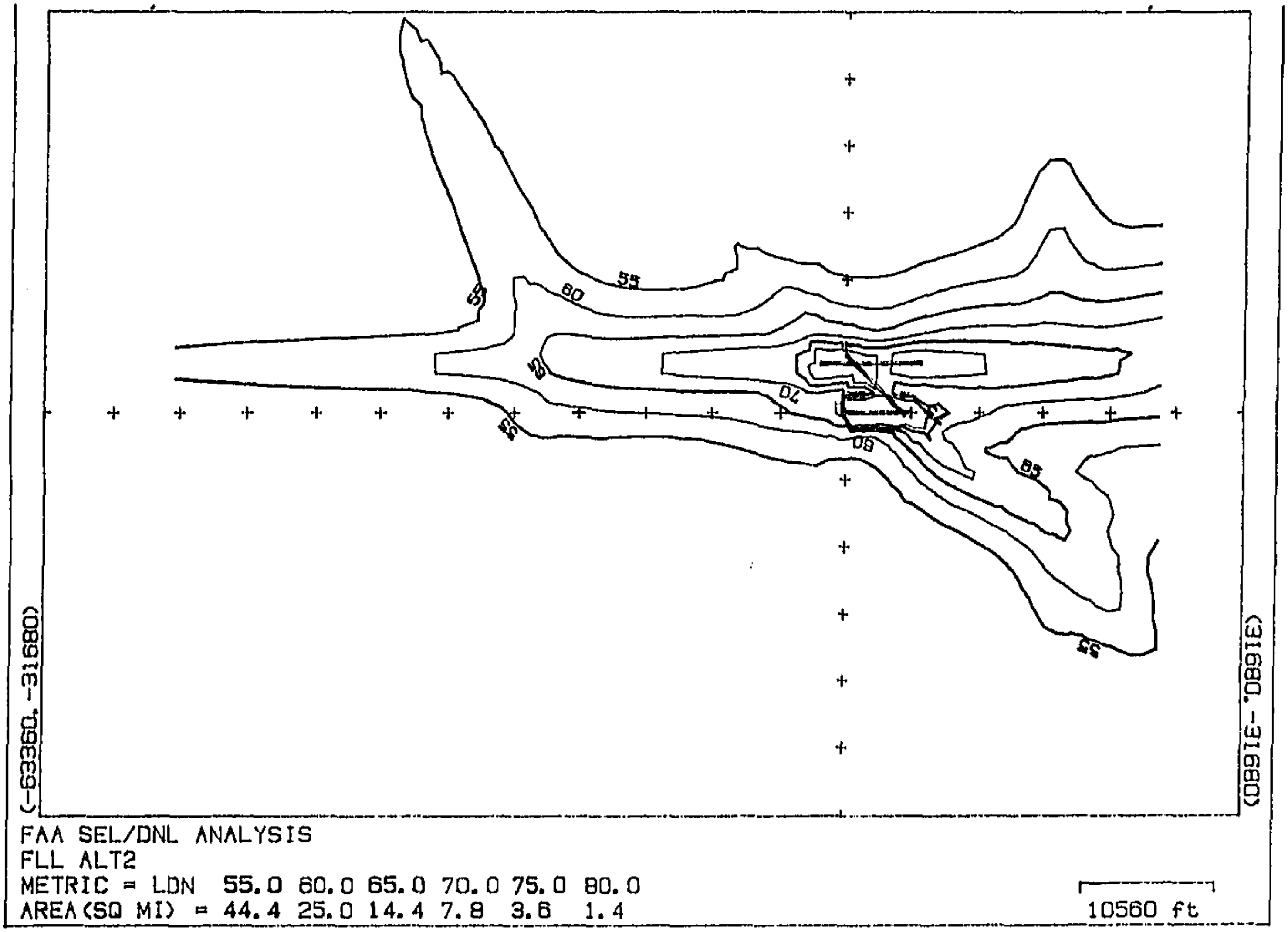
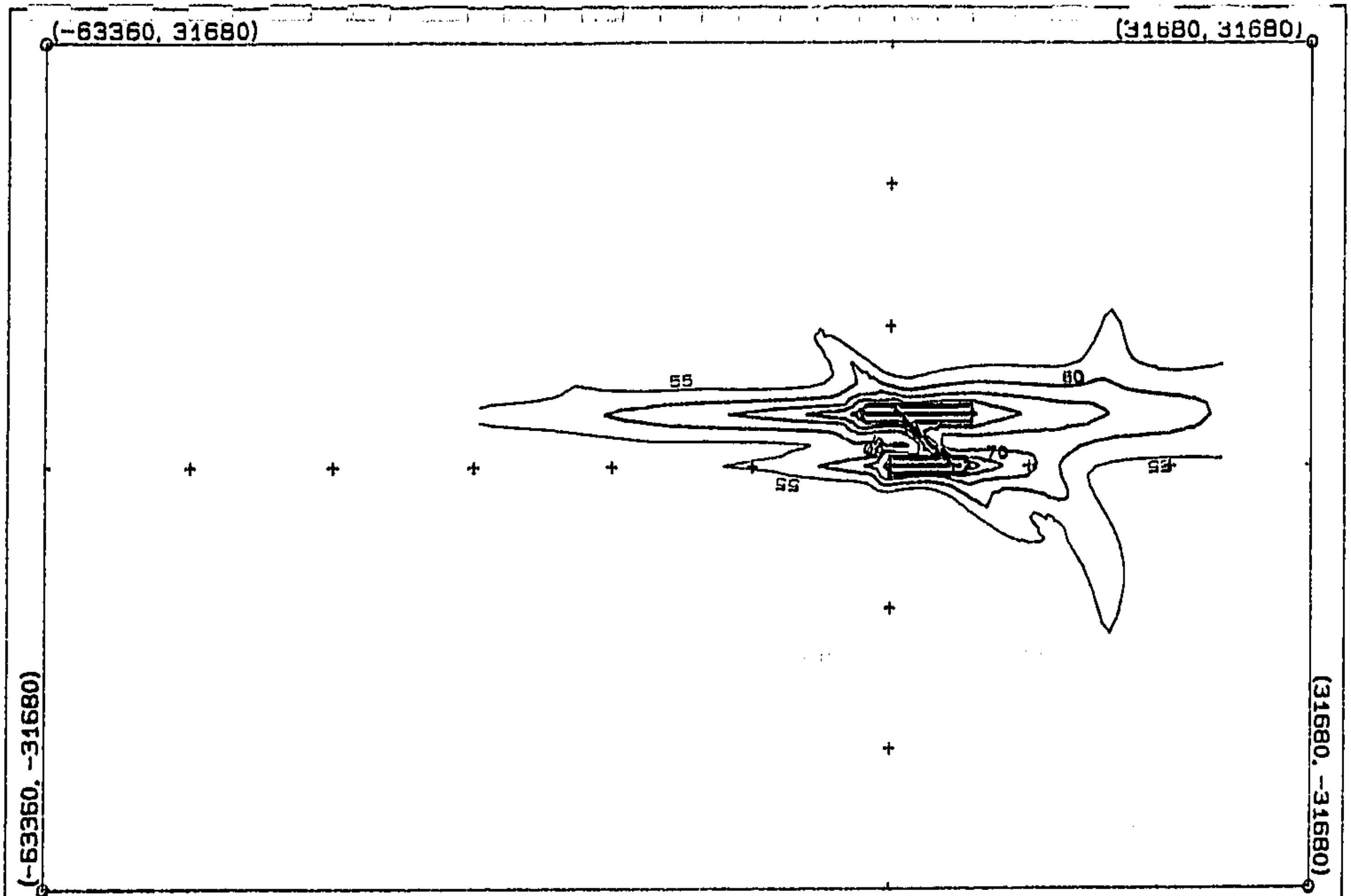
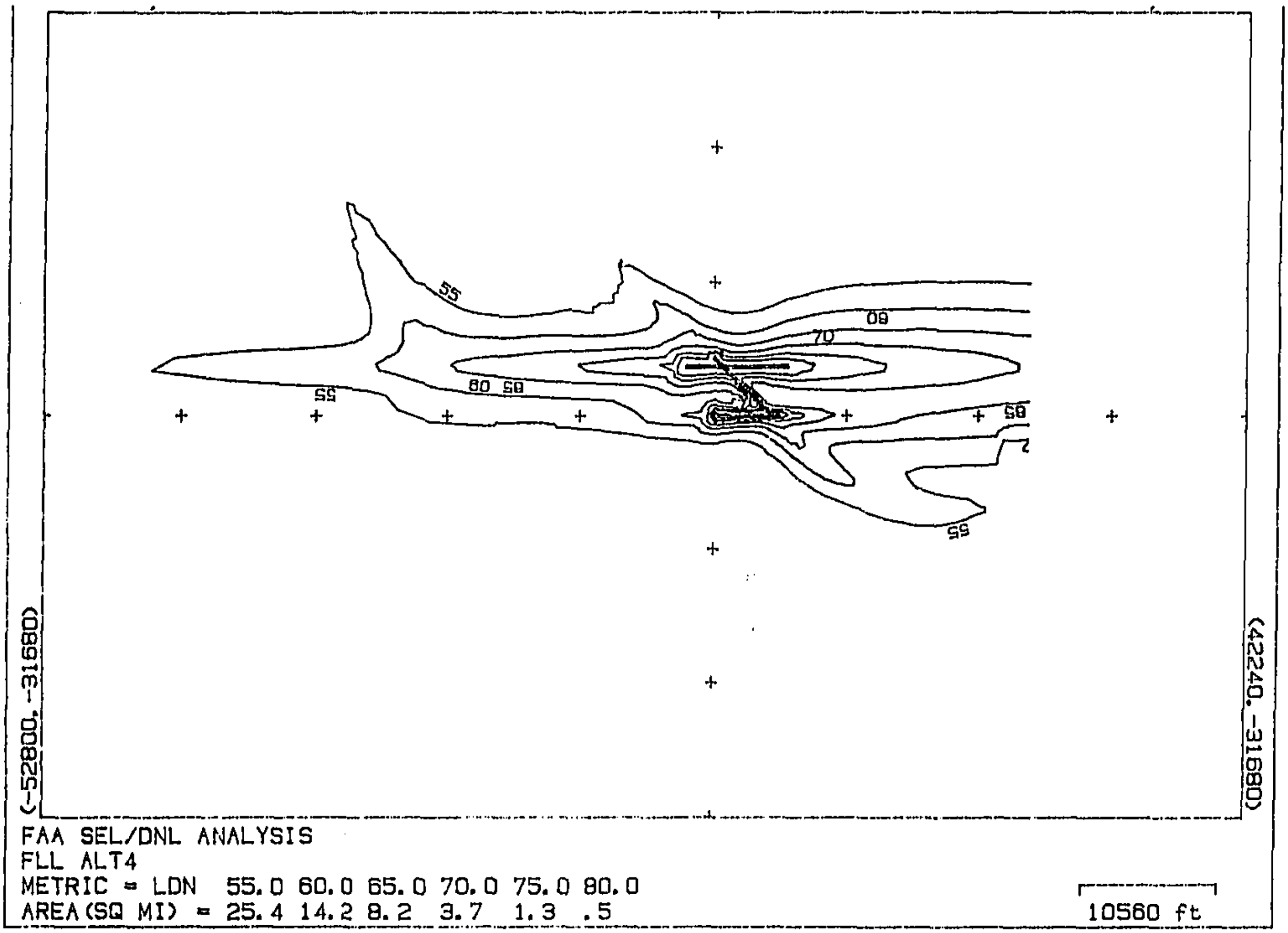
AREA(SQ MI) = 22.0 11.9 6.4 2.6 1.0 .6
10560 ft


(-63360, -31680)
(31680, -31680)
55
60
65
70
80
FAA SEL/DNL ANALYSIS
FLL ALT2
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA(SQ MI) = 44.4 25.0 14.4 7.8 3.6 1.4
10560 ft



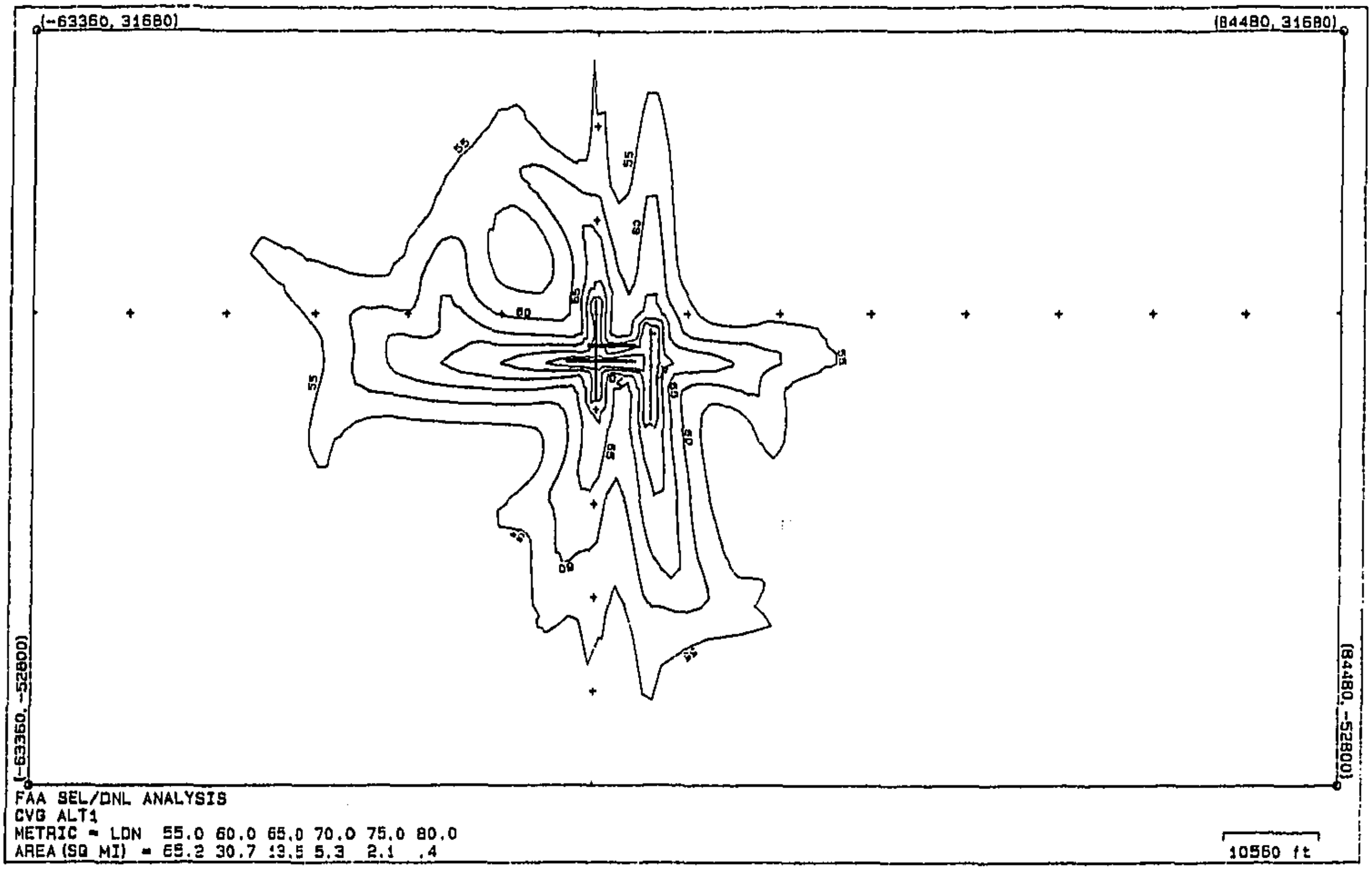
FAA SEL/DNL ANALYSIS
FLL ALT3
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 14.8 7.1 3.0 1.3 .7 .5

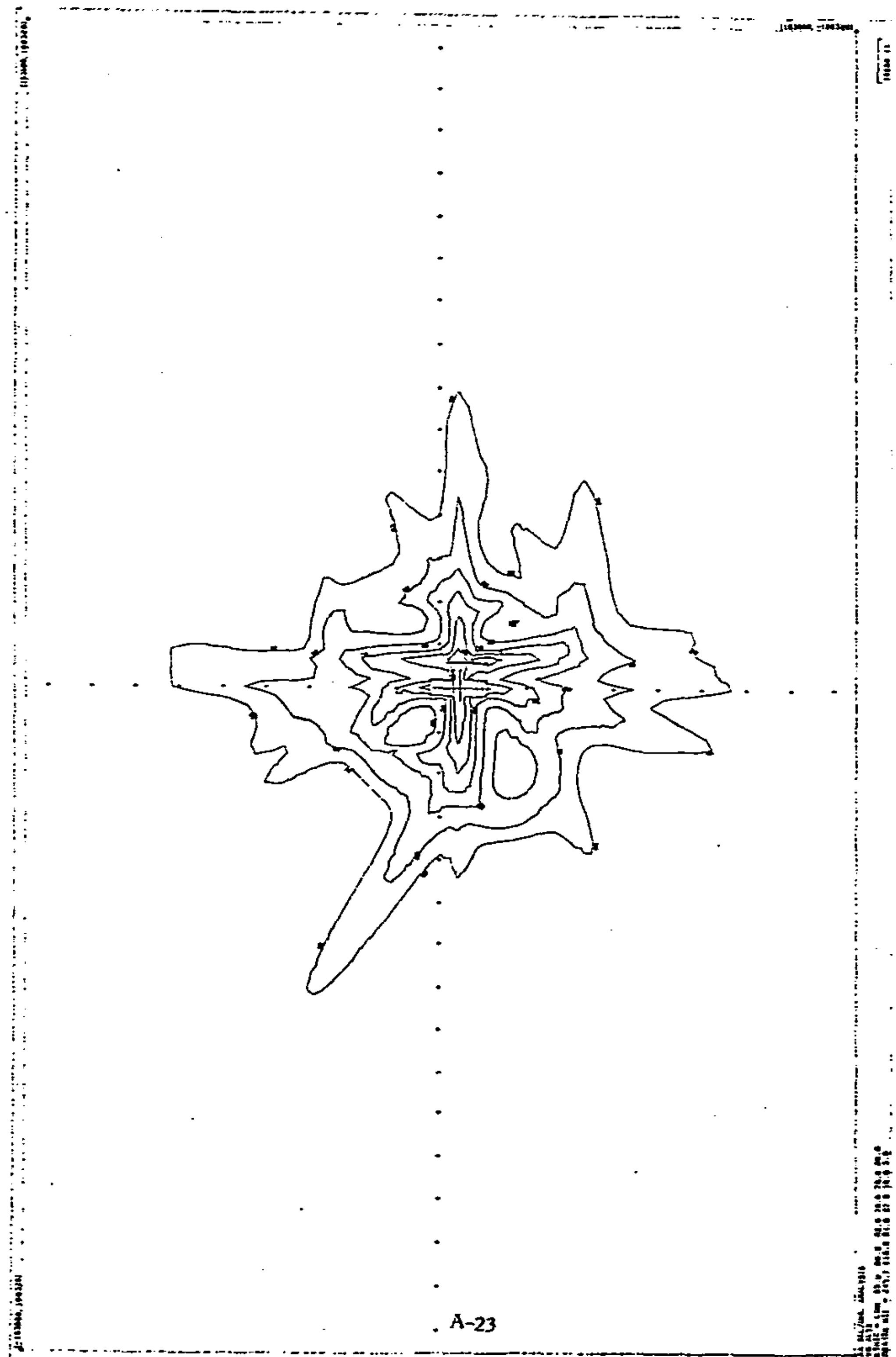
10560 ft

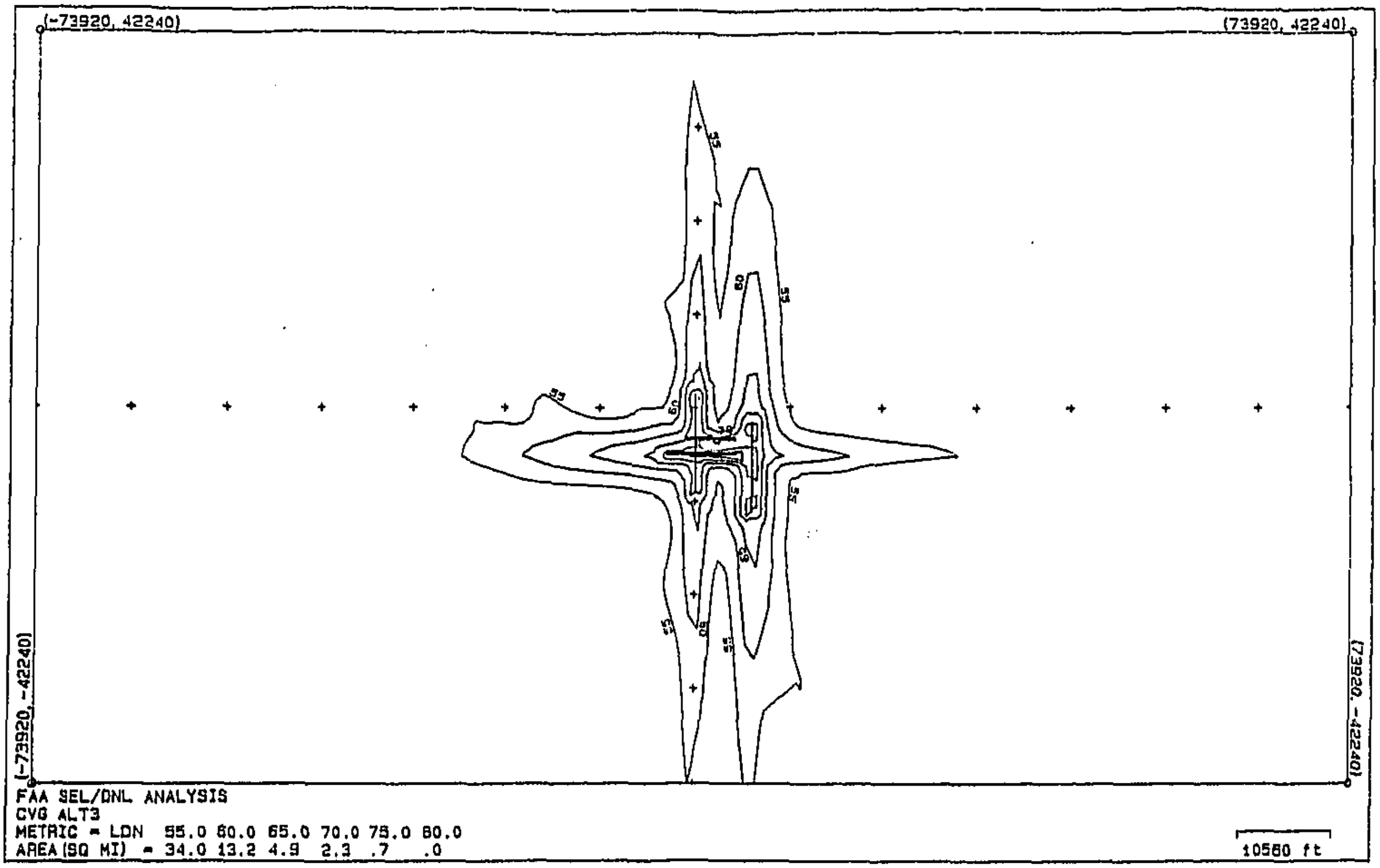

55
60
70
65
80
(-52800,-31680)
(42240,-31680)
FAA SEL/DNL ANALYSIS
FLL ALT4
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA(SQ MI) = 25.4 14.2 8.2 3.7 1.3 .5
10560 ft

FAA SEL/DNL ANALYSIS
CINCINNATI INTERNATIONAL AIRPORT
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 129.4 54.7 25.1 10.5 4.1 1.3

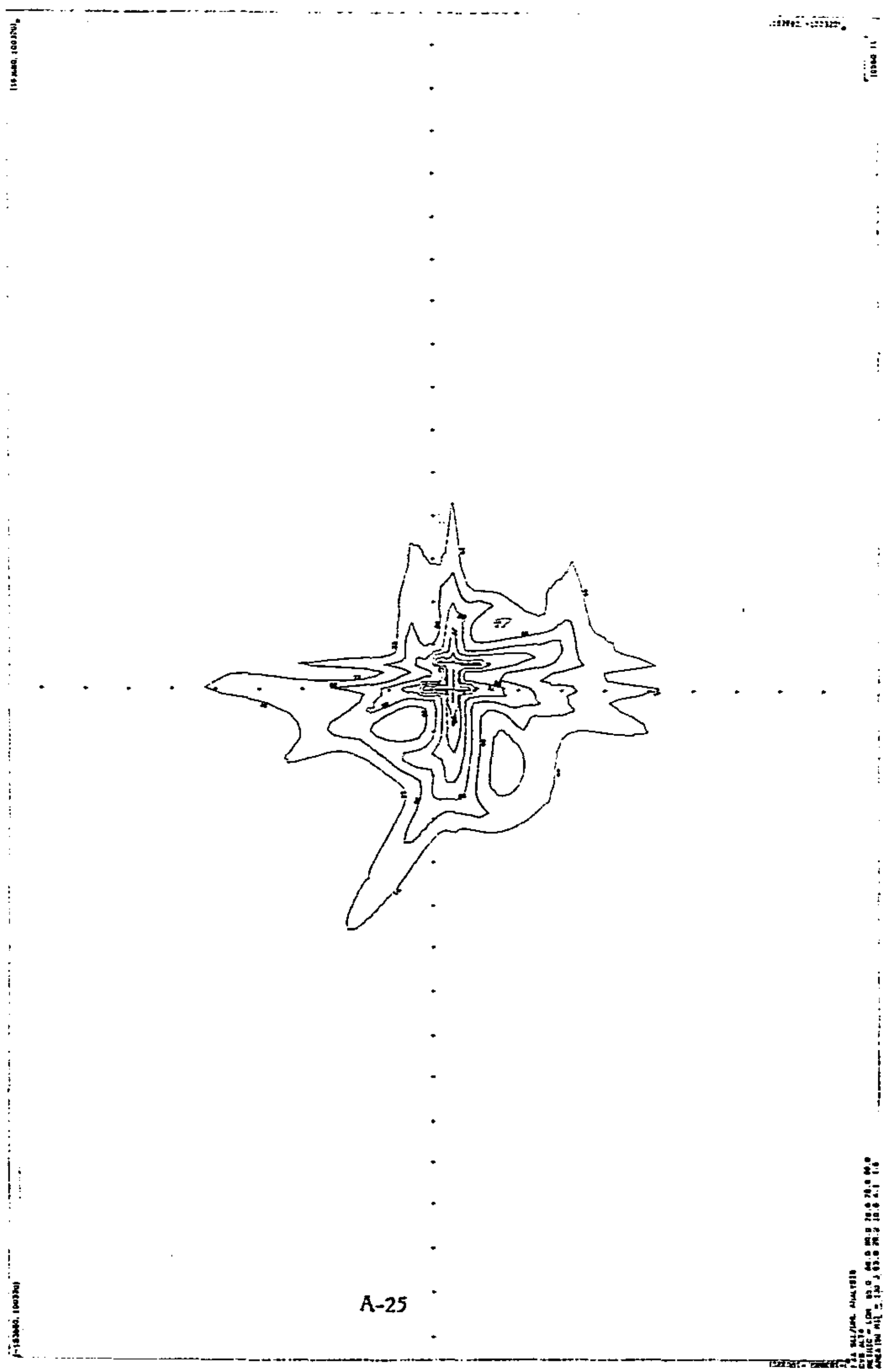
10560 ft

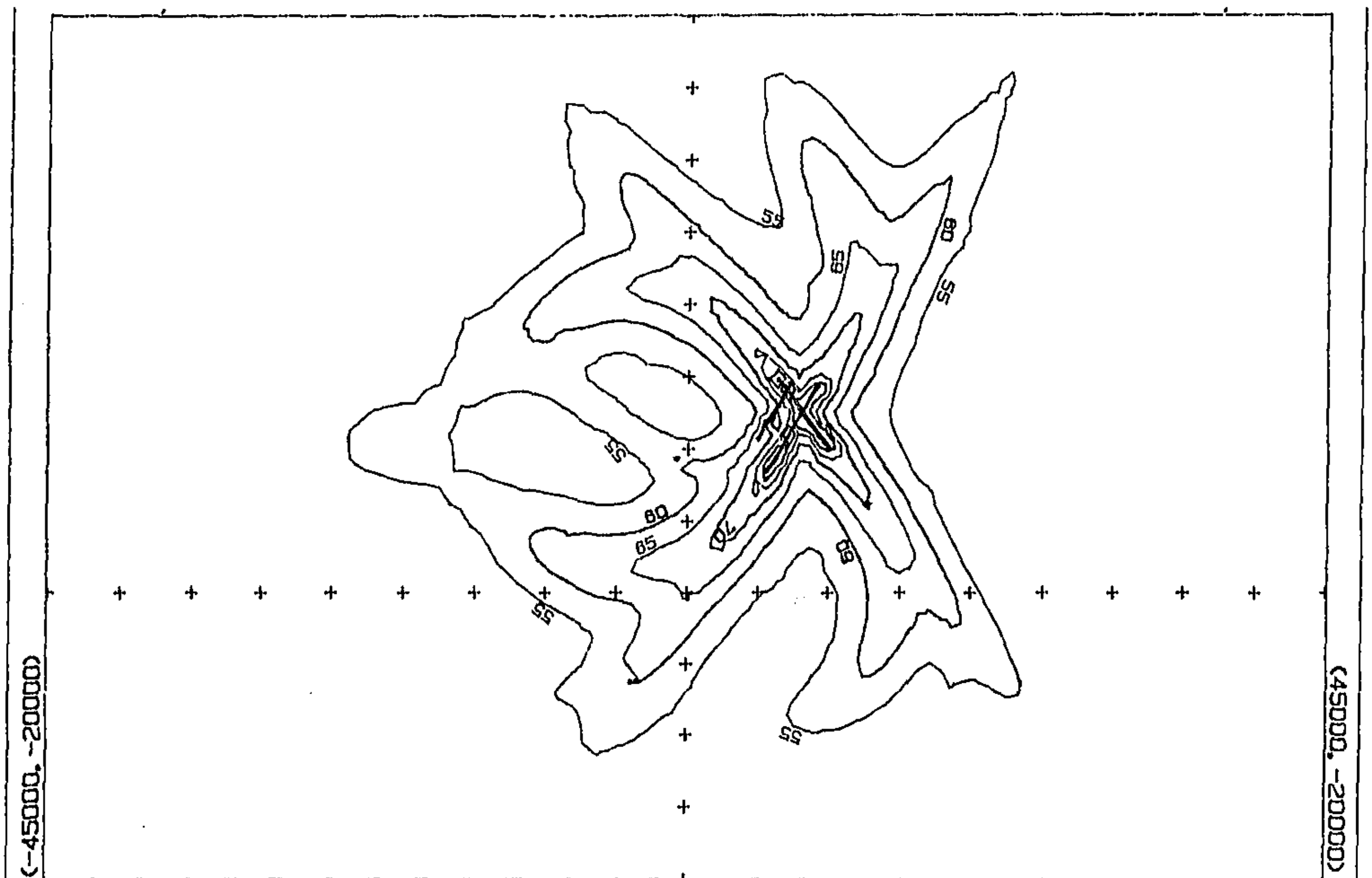

(-63360, 31680)
(84480, 31680)
(-63360, -52800)
(84480, -52800)
55
60
65
70
FAA SEL/DNL ANALYSIS
CVG ALT1
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 65.2 30.7 13.5 5.3 2.1 .4
10560 ft





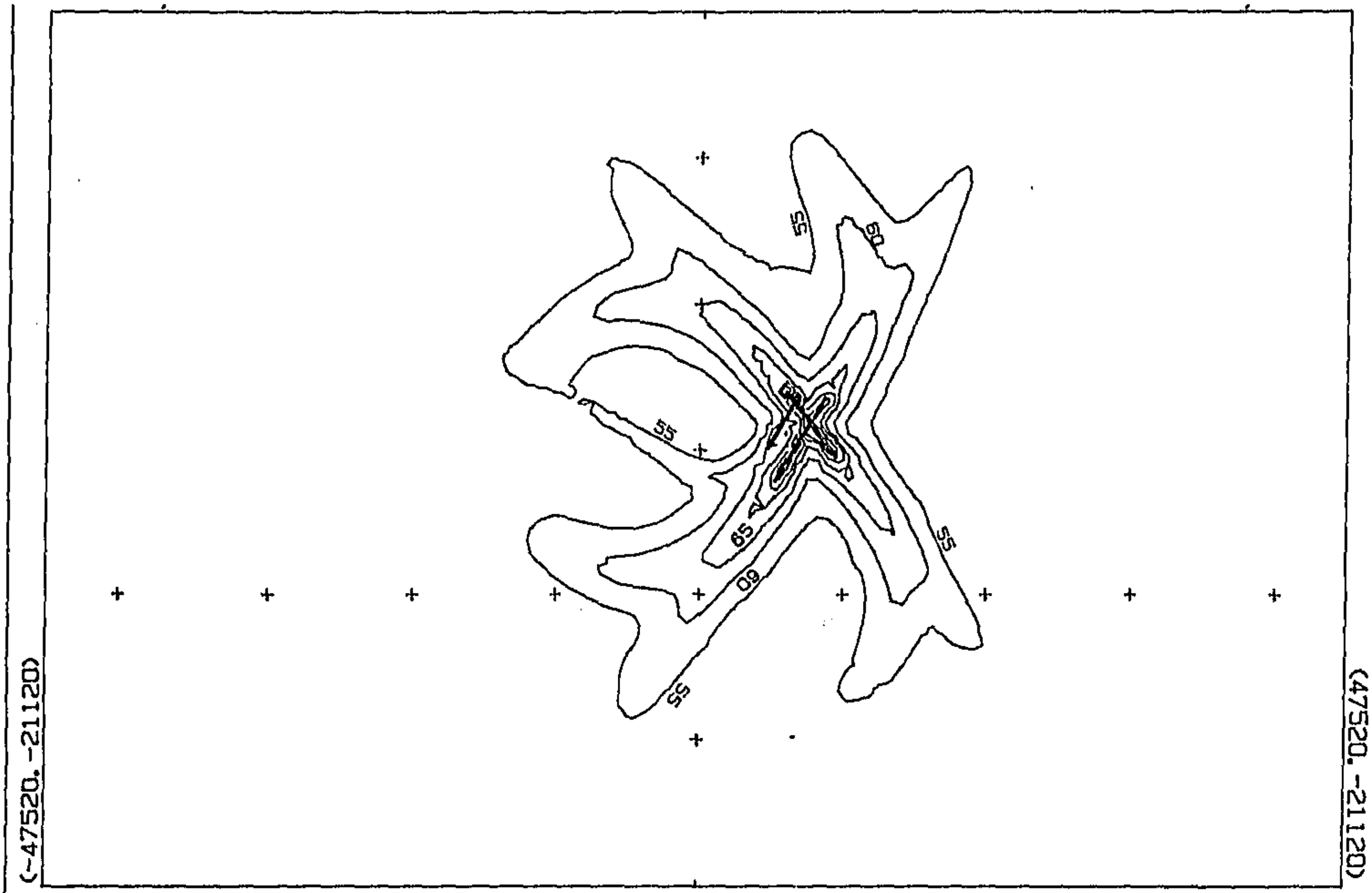
(-73920, 42240)
(73920, 42240)
(-73920, -42240)
(73920, -42240)
55
60
65
FAA SEL/DNL ANALYSIS
CVG ALT3
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA(SQ MI) = 34.0 13.2 4.9 2.3 .7 .0
10560 ft





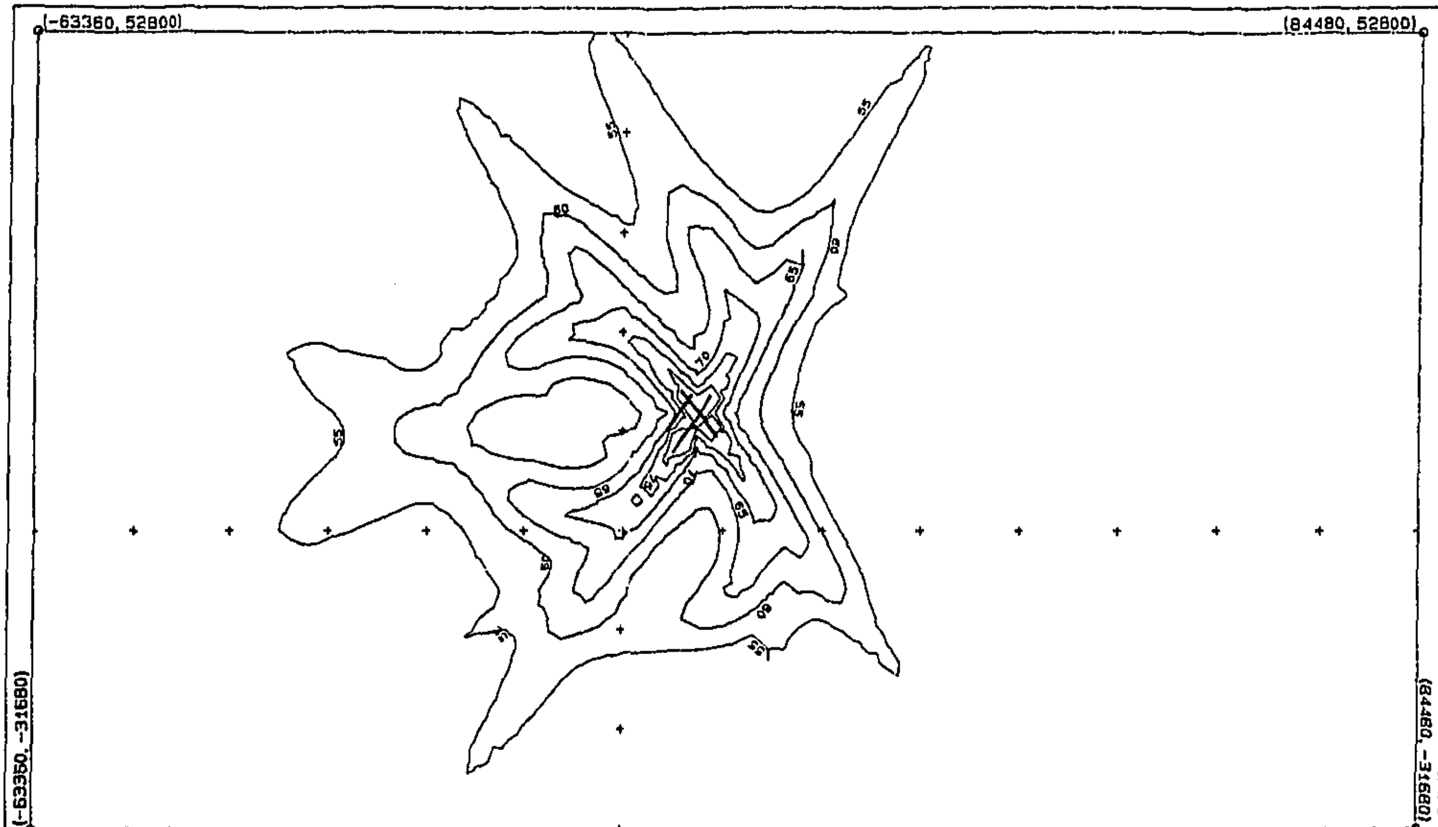
BASELINE 1989 OPS - ALL AIRCRAFT OPERATIONS
PVD
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 39.1 16.9 6.3 2.2 .7 .3

10000 ft

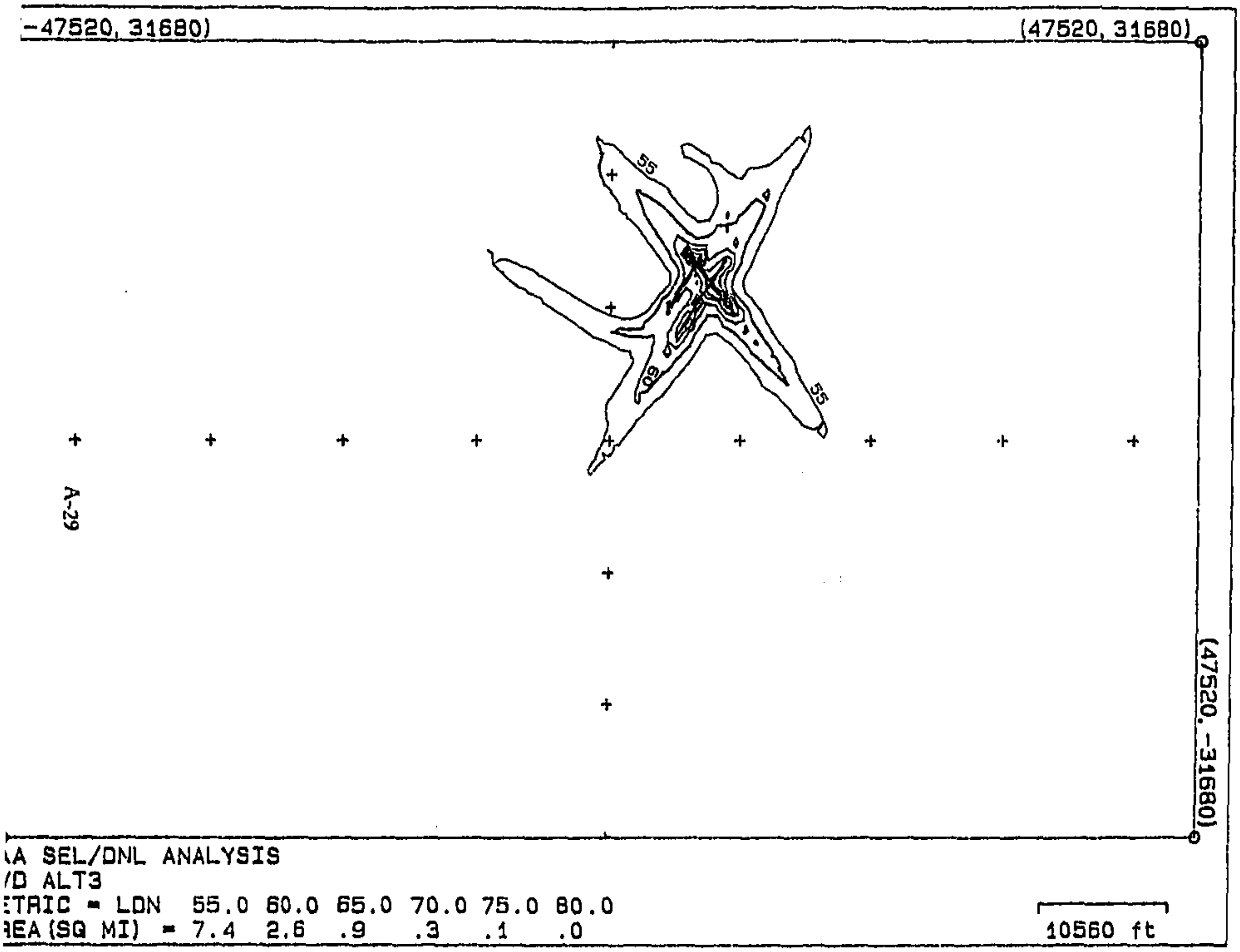


PVD ALT1
PVD
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA(SQ MI) = 24.5 9.3 3.3 1.1 .4 .1

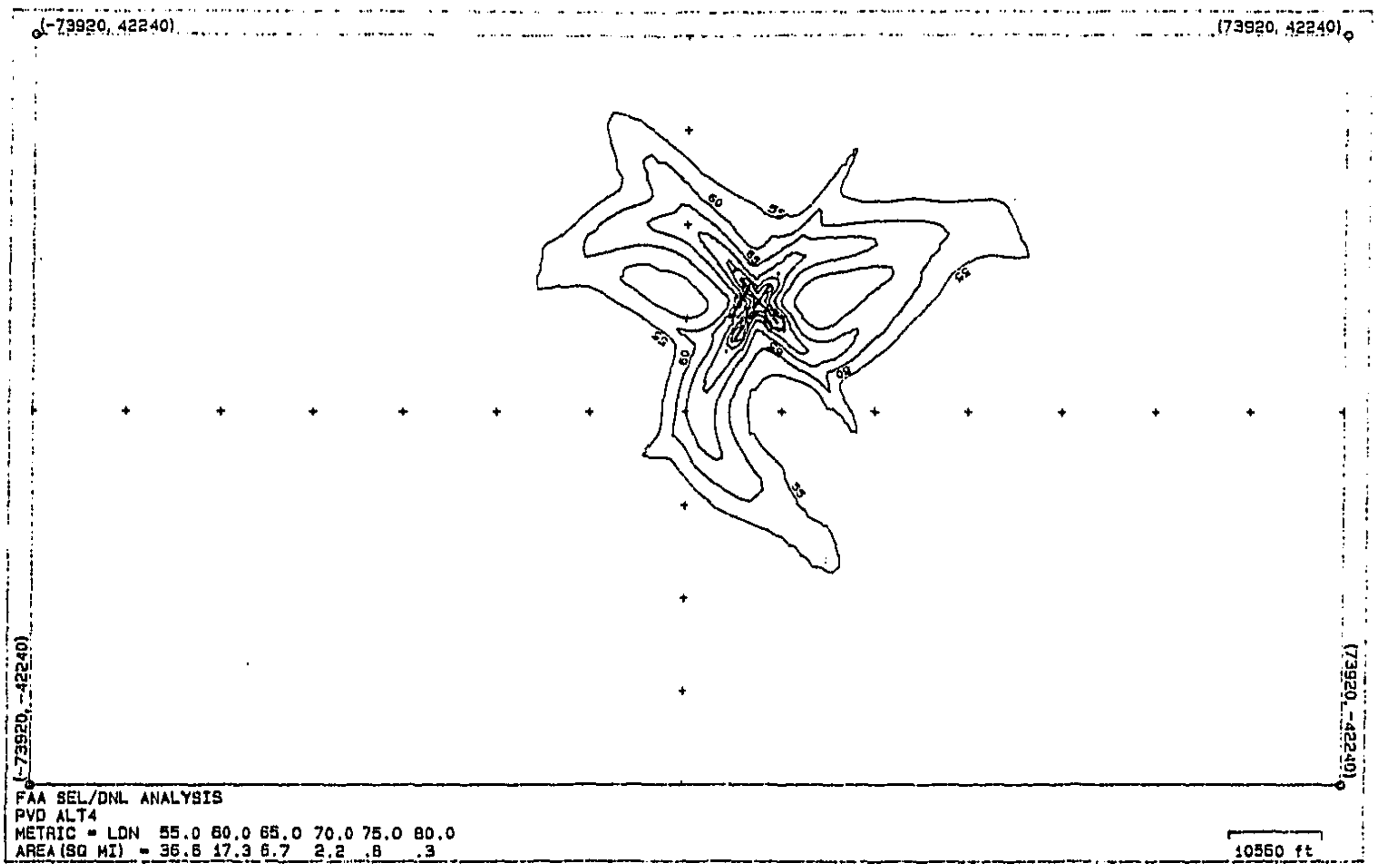
10560 ft

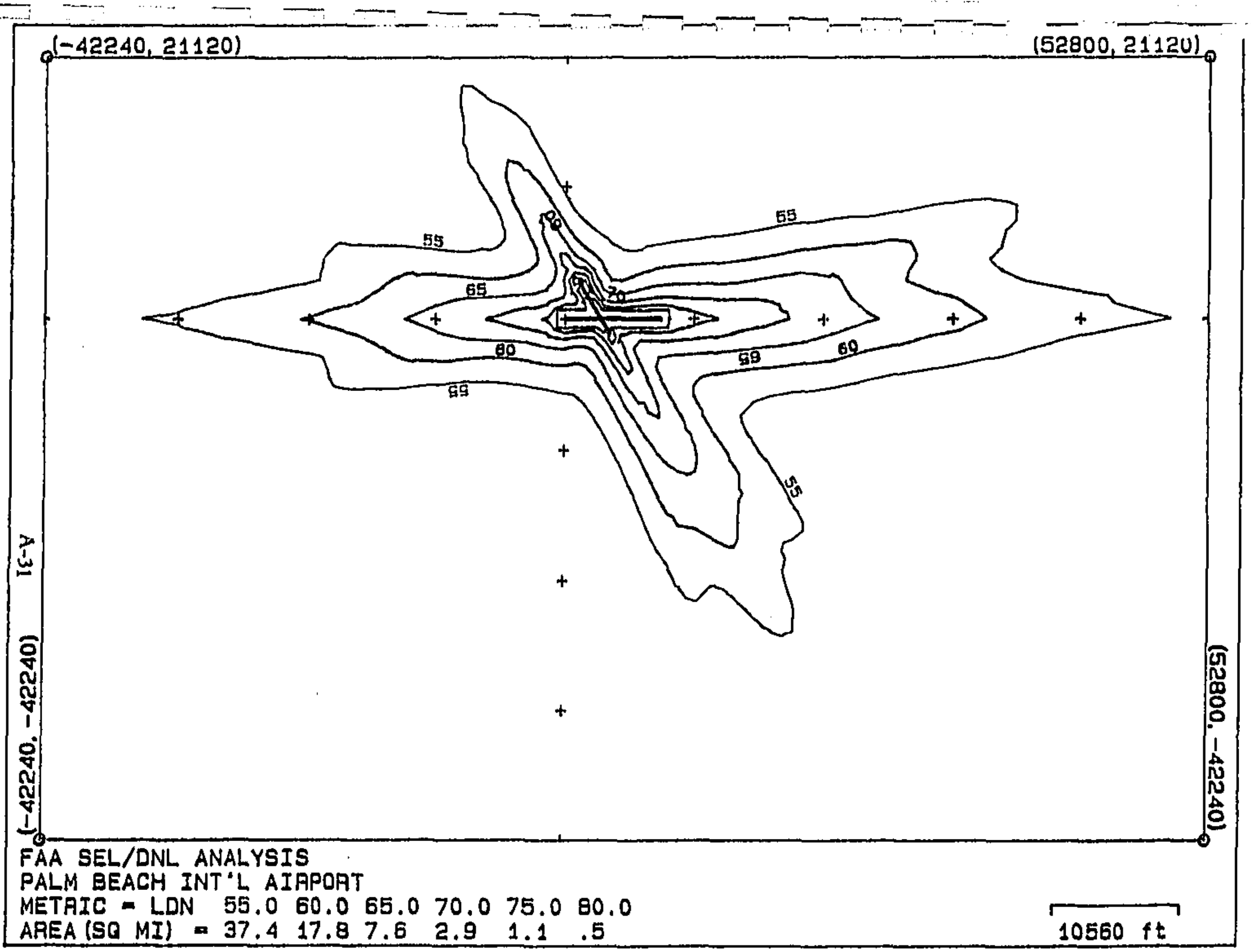


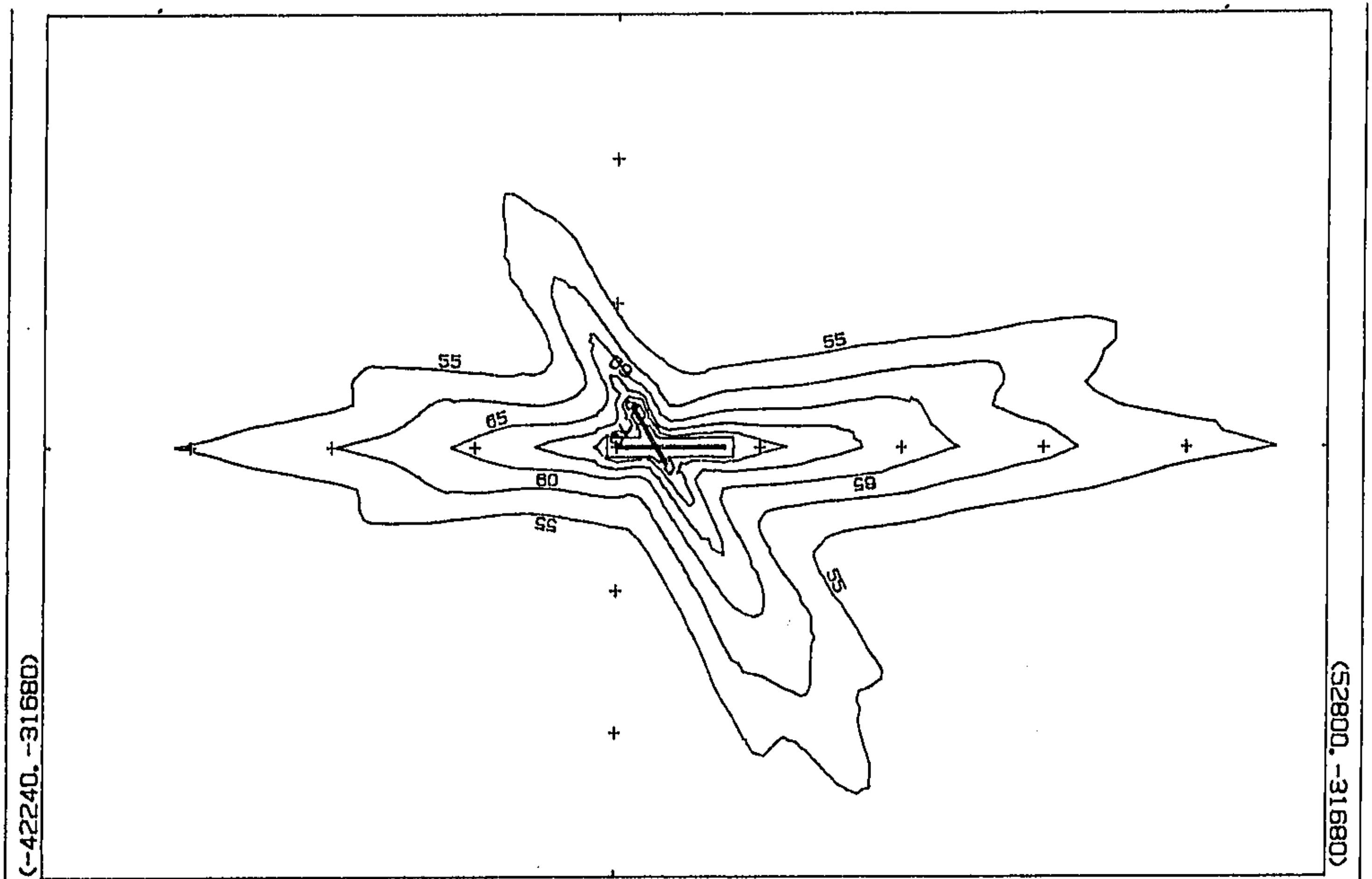
BASELINE 1989 OPS - ALL AIRCRAFT OPERATIONS
PVD ALT2
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 84.4 40.9 19.4 7.3 2.4 .7



-47520, 31680)
(47520, 31680)
(47520, -31680)
55
60
55
A SEL/DNL ANALYSIS
/D ALT3
ETRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
REA (SQ MI) = 7.4 2.6 .9 .3 .1 .0
10560 ft

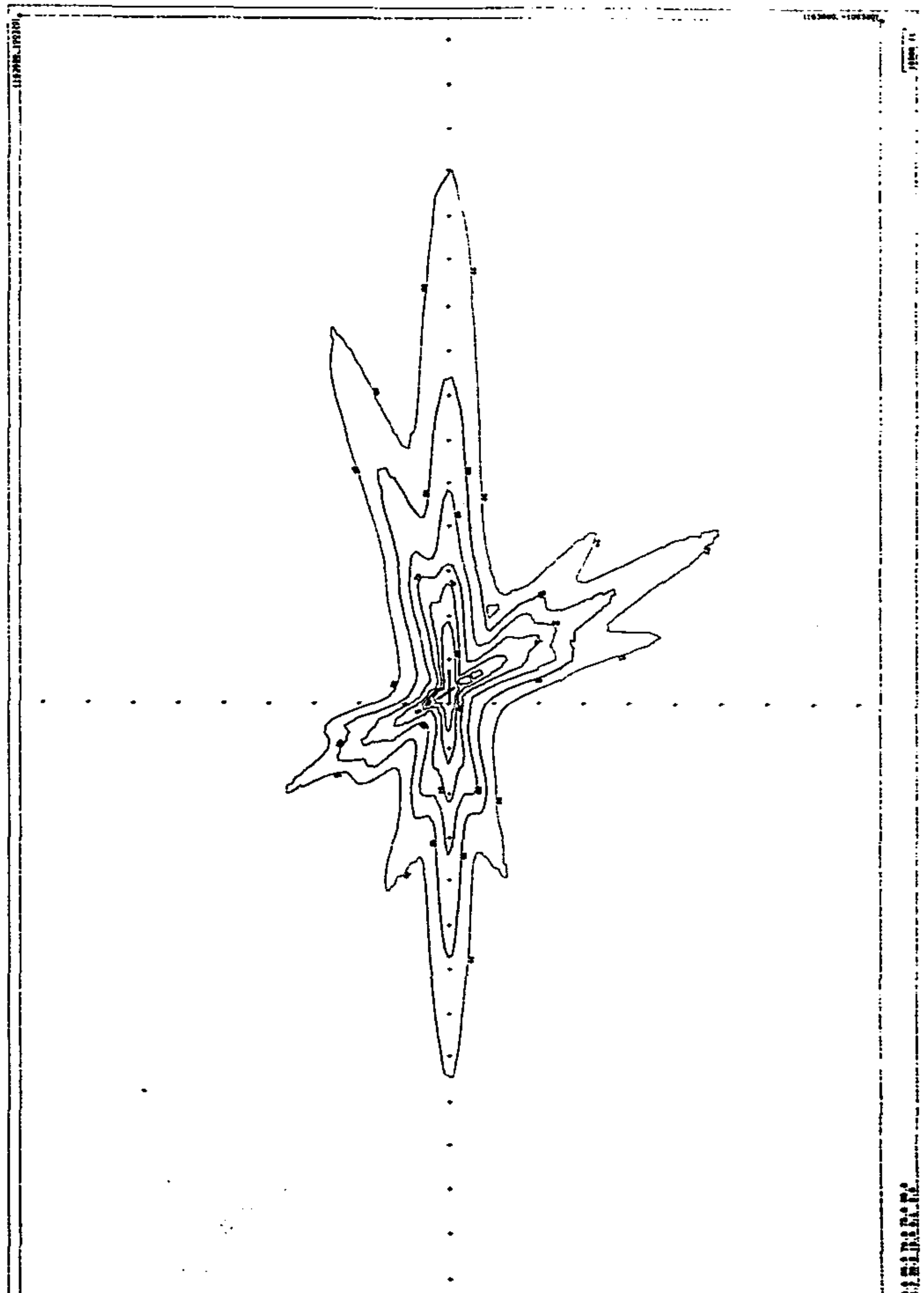

(-73920, 42240)
(73920, 42240)
(-73920, -42240)
(73920, -42240)
FAA SEL/DNL ANALYSIS
PVD ALT4
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 36.6 17.3 6.7 2.2 .8 .3
10560 ft

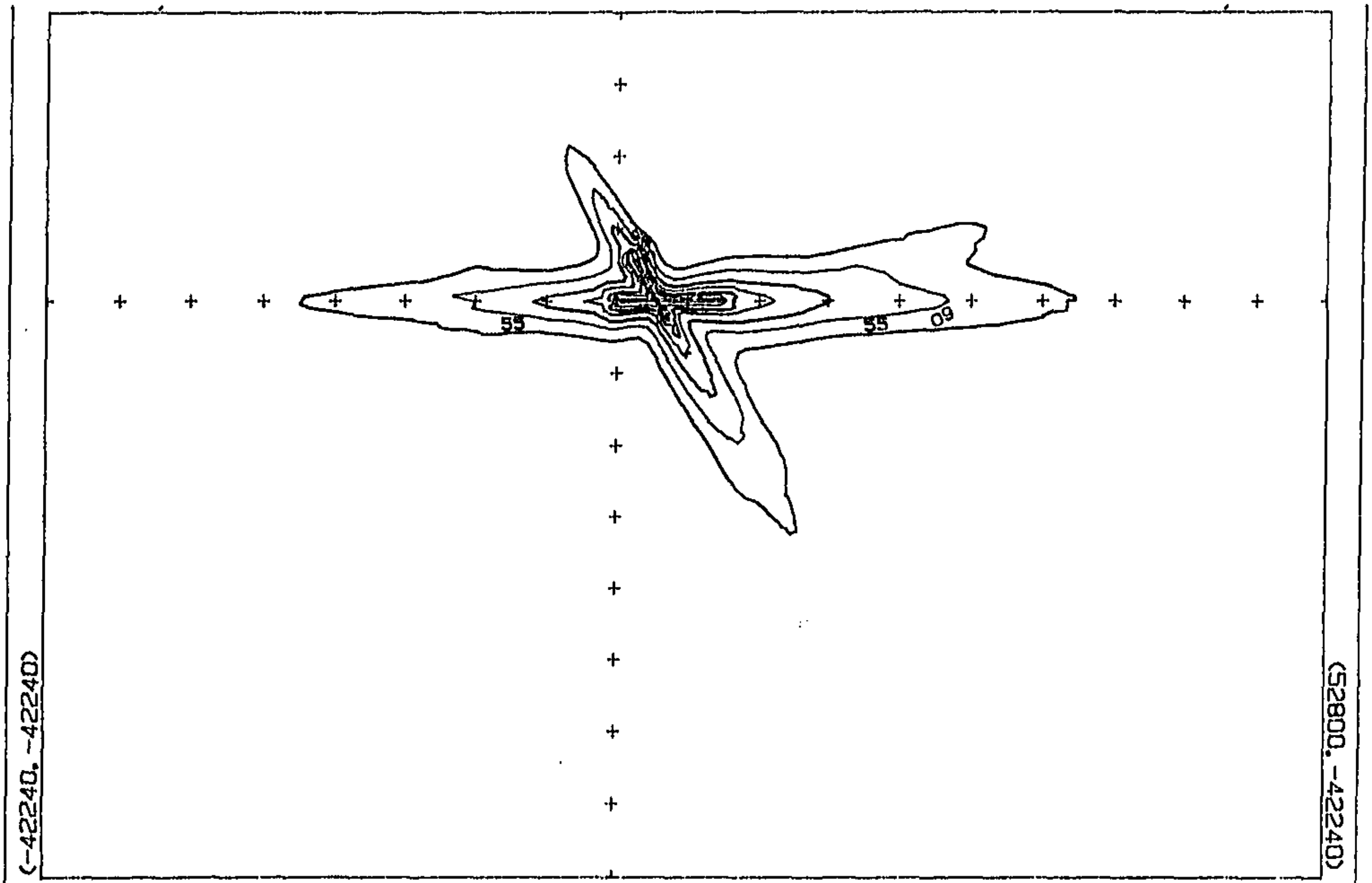

(-42240, 21120)
(52800, 21120)
(-42240, -42240)
(52800, -42240)
55
60
65
70
FAA SEL/DNL ANALYSIS
PALM BEACH INT'L AIRPORT
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 37.4 17.8 7.6 2.9 1.1 .5
10560 ft



FAA SEL/DNL ANALYSIS
PBI ALT1
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA(SQ MI) = 36.7 17.4 7.5 2.9 1.1 .5

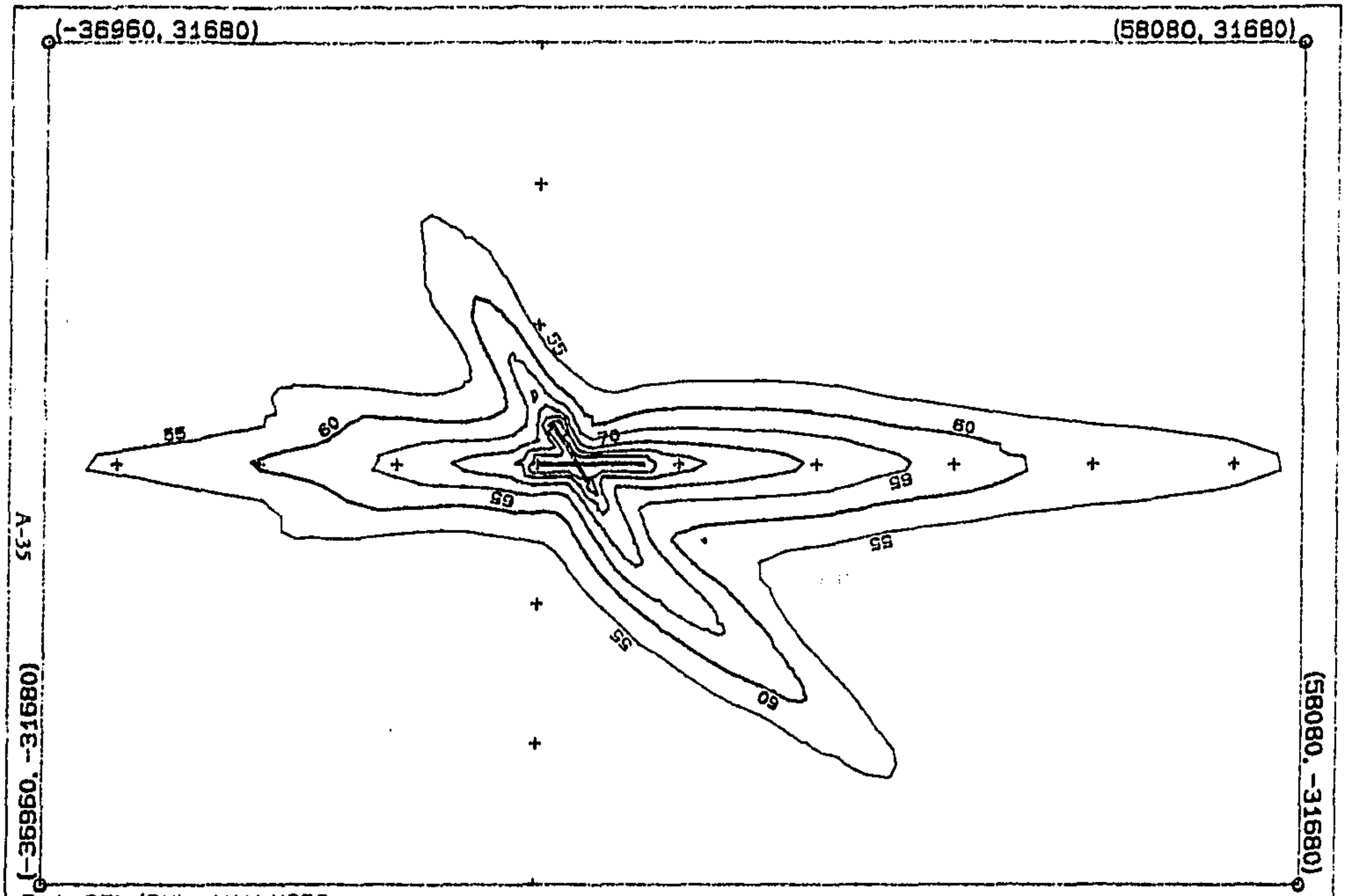
10560 ft





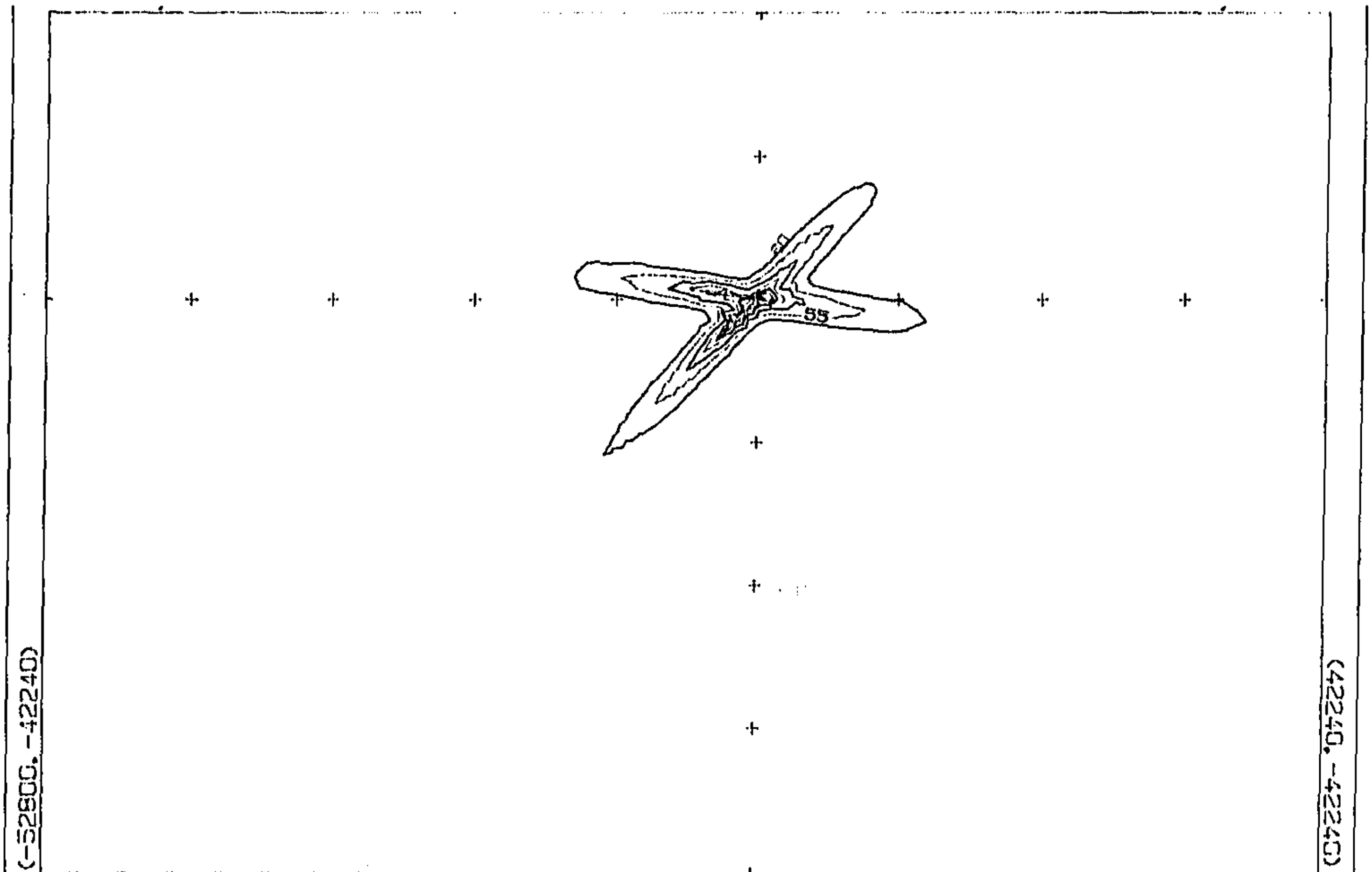
FAA SEL/DNL ANALYSIS
PBI ALT3
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA(SQ MI) = 13.1 5.5 2.3 1.0 .5 .2

10560 ft



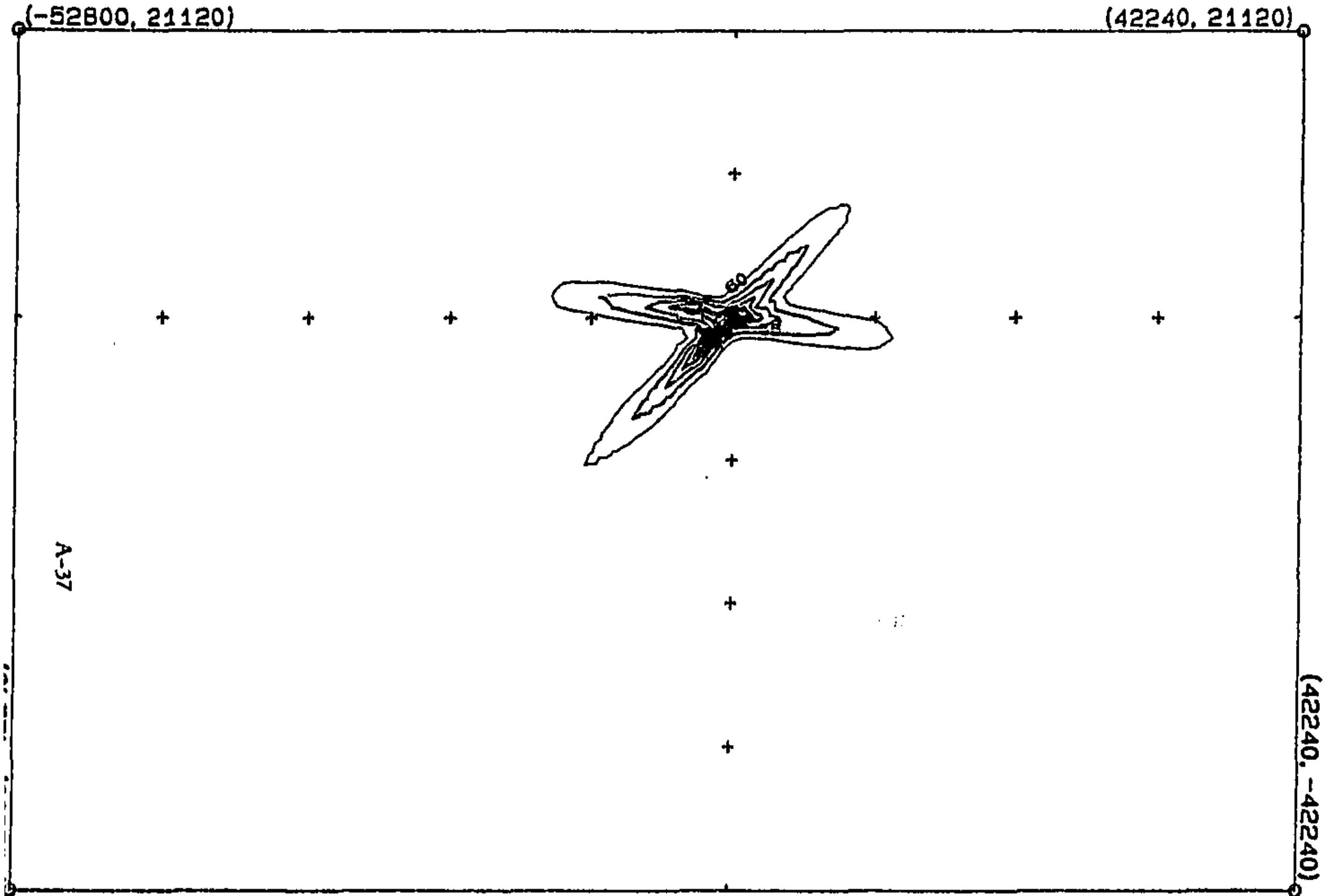
FAA SEL/DNL ANALYSIS
PBI ALT4
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 37.5 17.8 7.9 3.0 1.1 .5

10560 ft



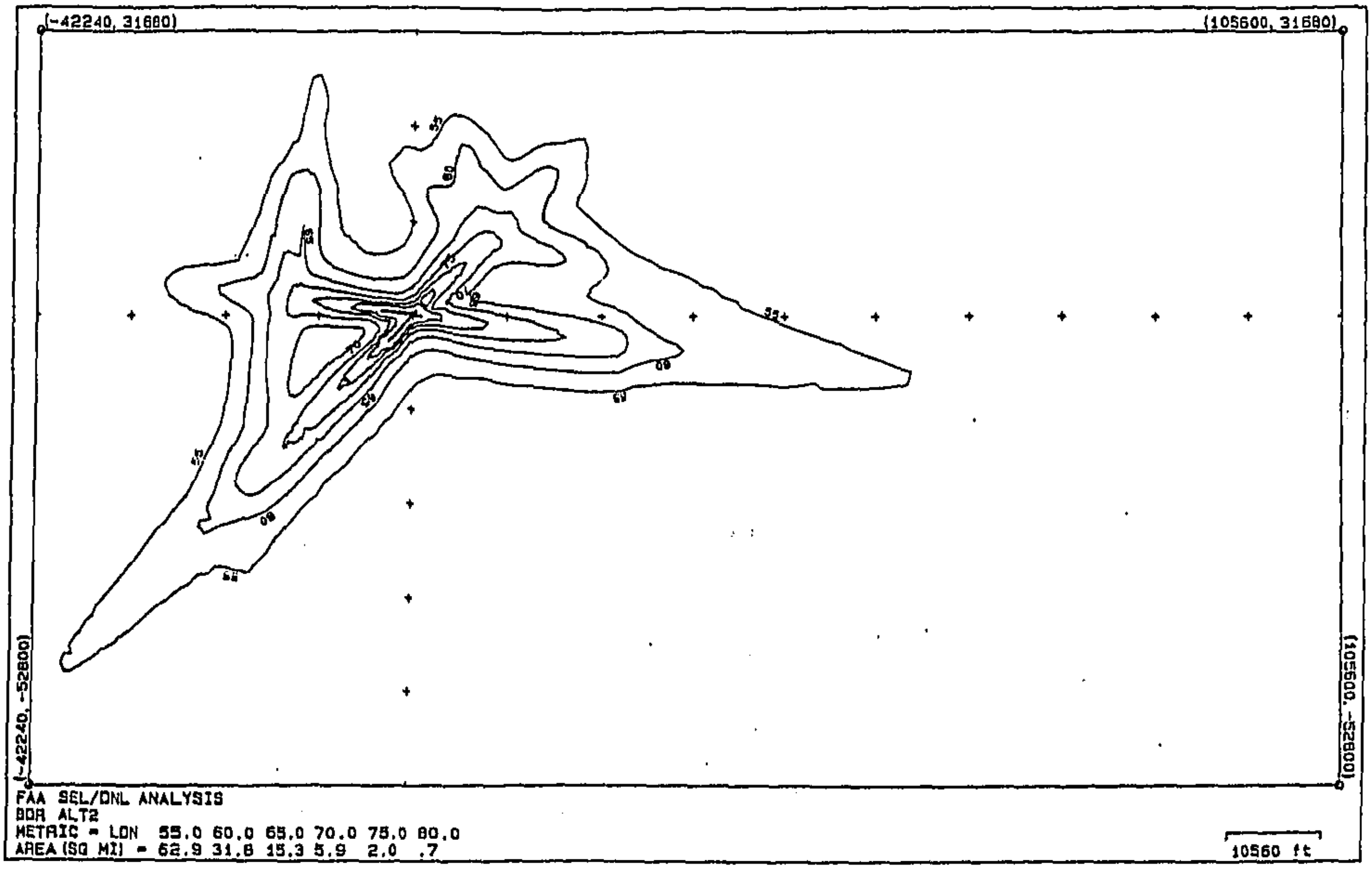
FAA SEL/DNL ANALYSIS
SIKORSKY MEMORIAL AIRPORT
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 4.3 1.8 .7 .3 .1 .0

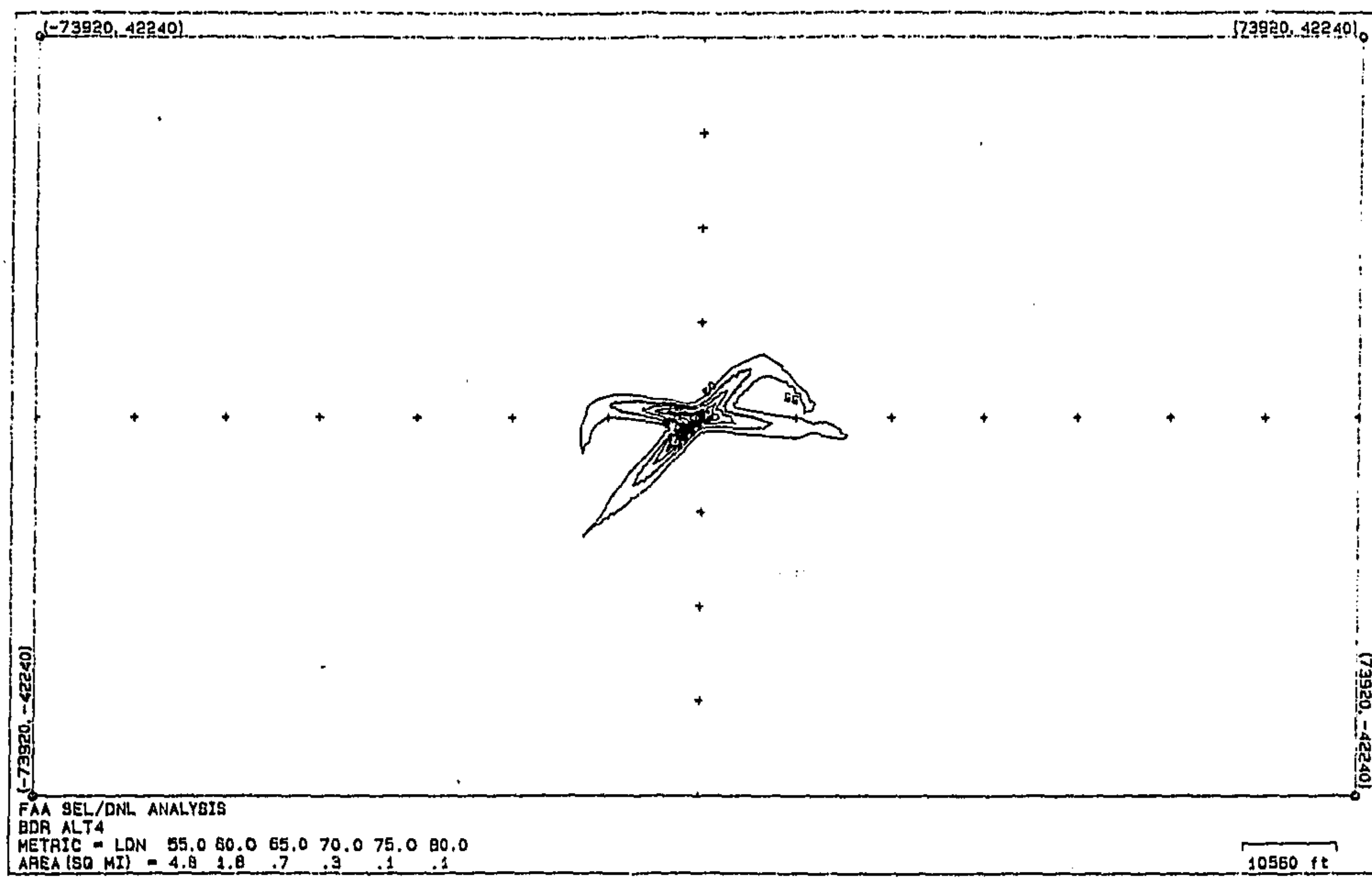
10560 ft



AA SEL/DNL ANALYSIS
DR ALT1
ETRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
REA (SQ MI) = 4.1 1.7 .7 .3 .1 .0

10560 ft


(-42240, 31680)
(105600, 31680)
(-42240, -52800)
(105600, -52800)
FAA SEL/DNL ANALYSIS
BDR ALT2
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 62.9 31.8 15.3 5.9 2.0 .7
10560 ft


(-73920, 42240)
(73920, 42240)
(-73920, -42240)
(73920, -42240)
FAA SEL/DNL ANALYSIS
BDR ALT4
METRIC = LDN 55.0 60.0 65.0 70.0 75.0 80.0
AREA (SQ MI) = 4.8 1.8 .7 .3 .1 .1
10560 ft

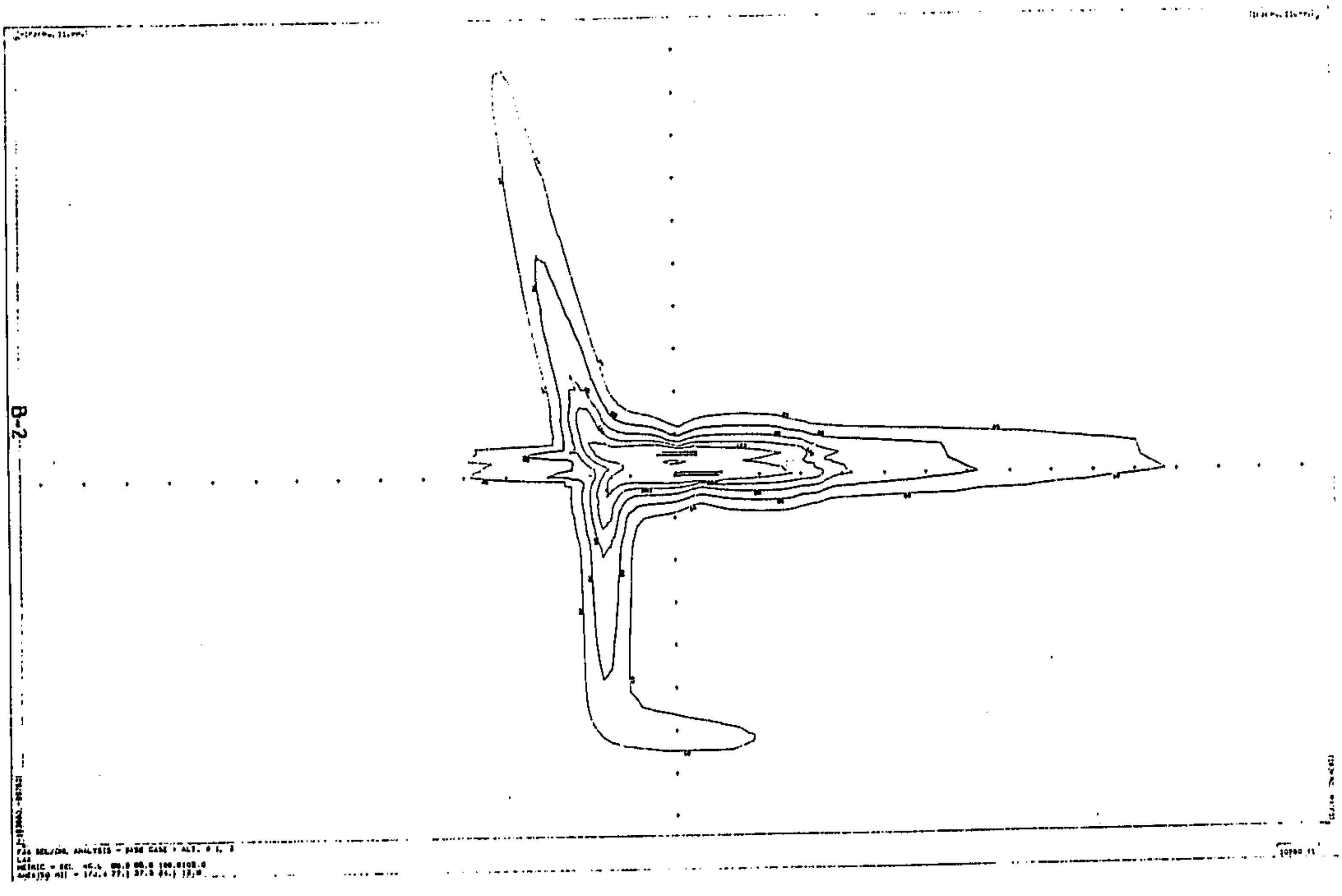
APPENDIX B

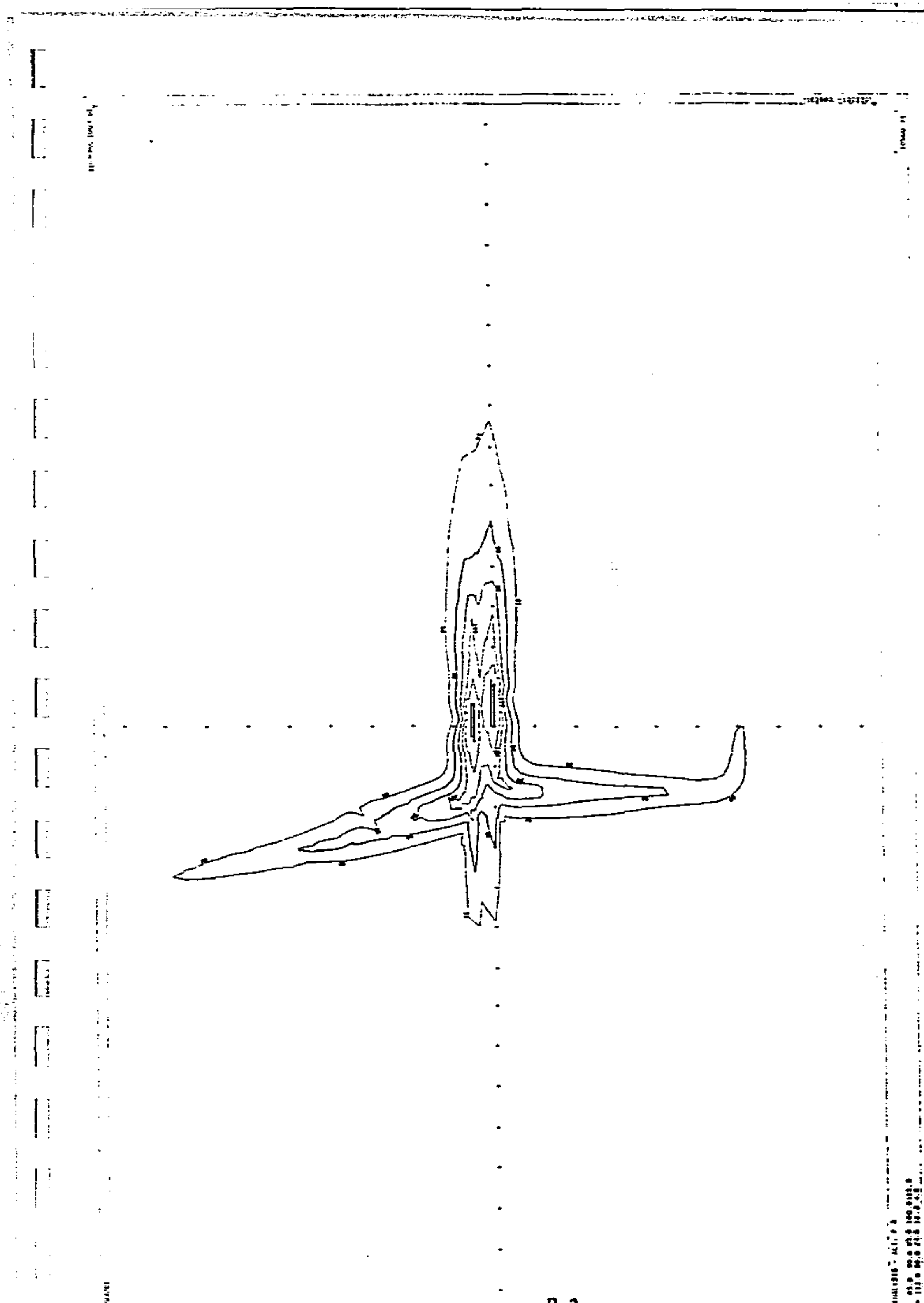
SEL Contour Plots for All Candidate Airports (All Scenarios)

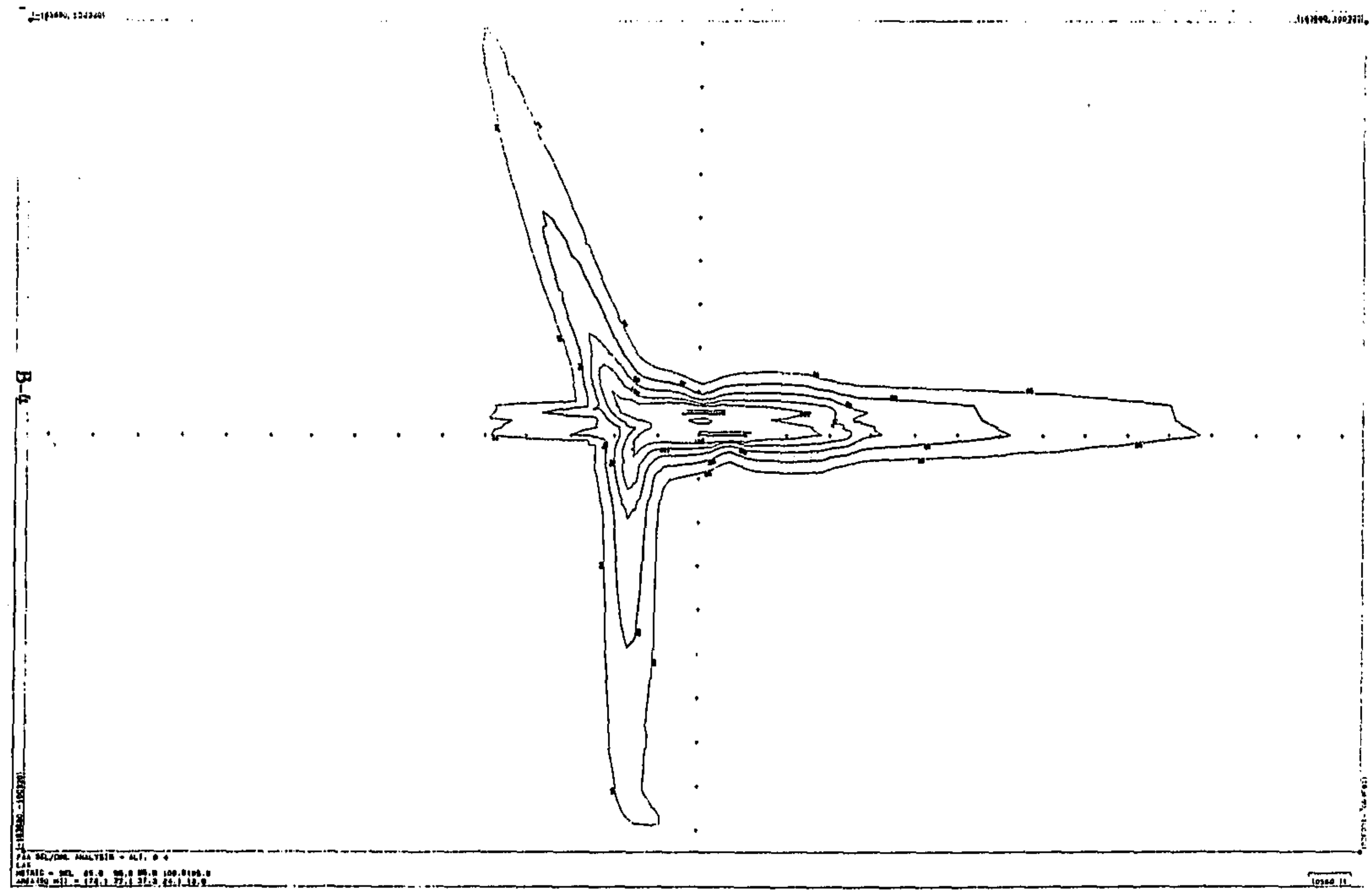
NOTE 1: Most of the Contour Plots in this appendix were generated on "C" or "D" size paper. In reducing these to the 8.5 x 11-inch format, some degradation in the quality of the plots may have occurred in some cases.

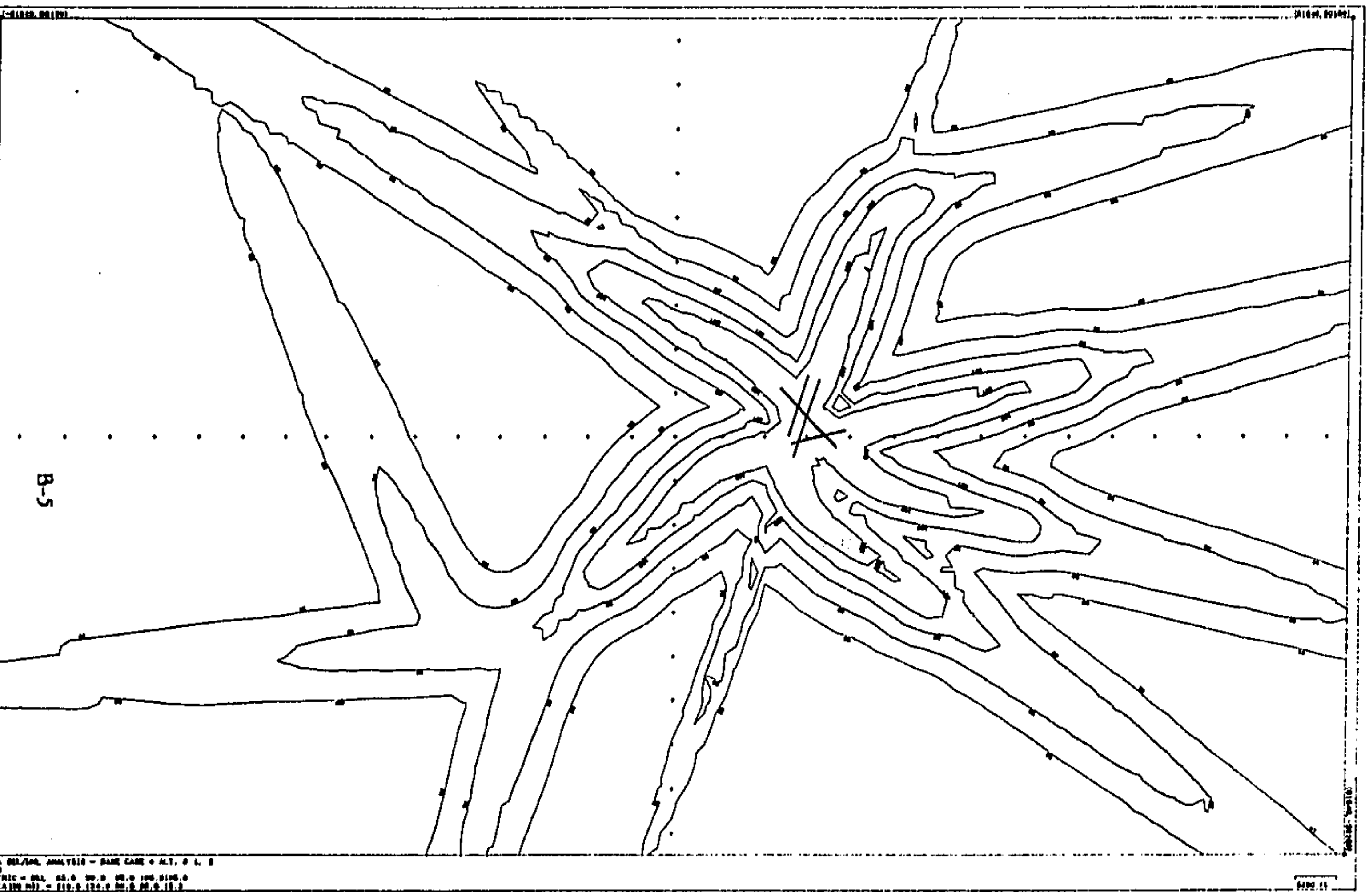
NOTE 2: Since the metric being considered is Maximum SEL, the Base Case, Alternative #1, and Alternative #2 will have identical SEL contours. The exception is BDR, which has identical contours for the Base Case, Alternative #1, and Alternative #3.

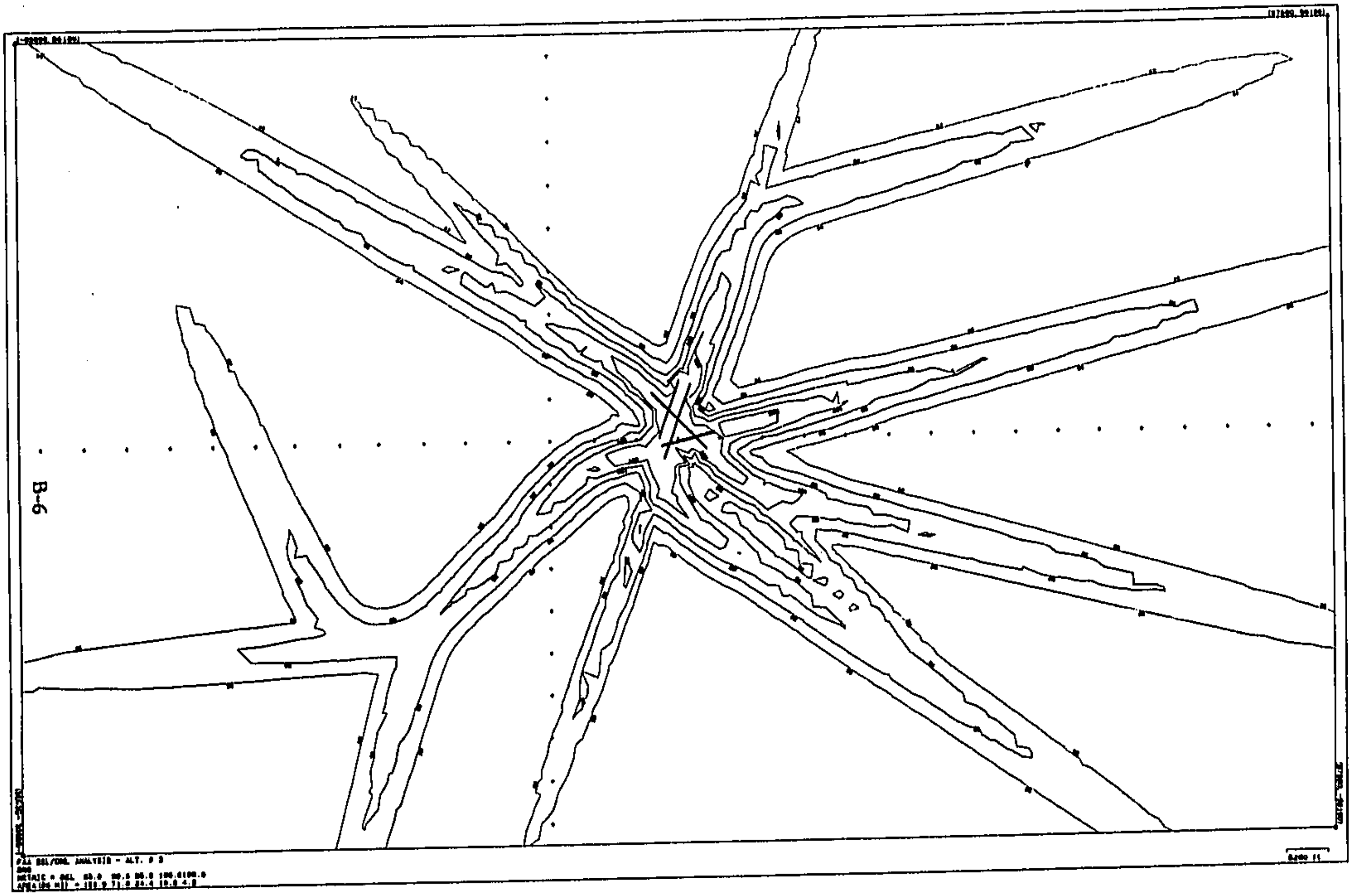
NOTE 3: There is no contour plot for BOS-Alternative #4 (Flight Tracks). This has been explained in Section 2.3.

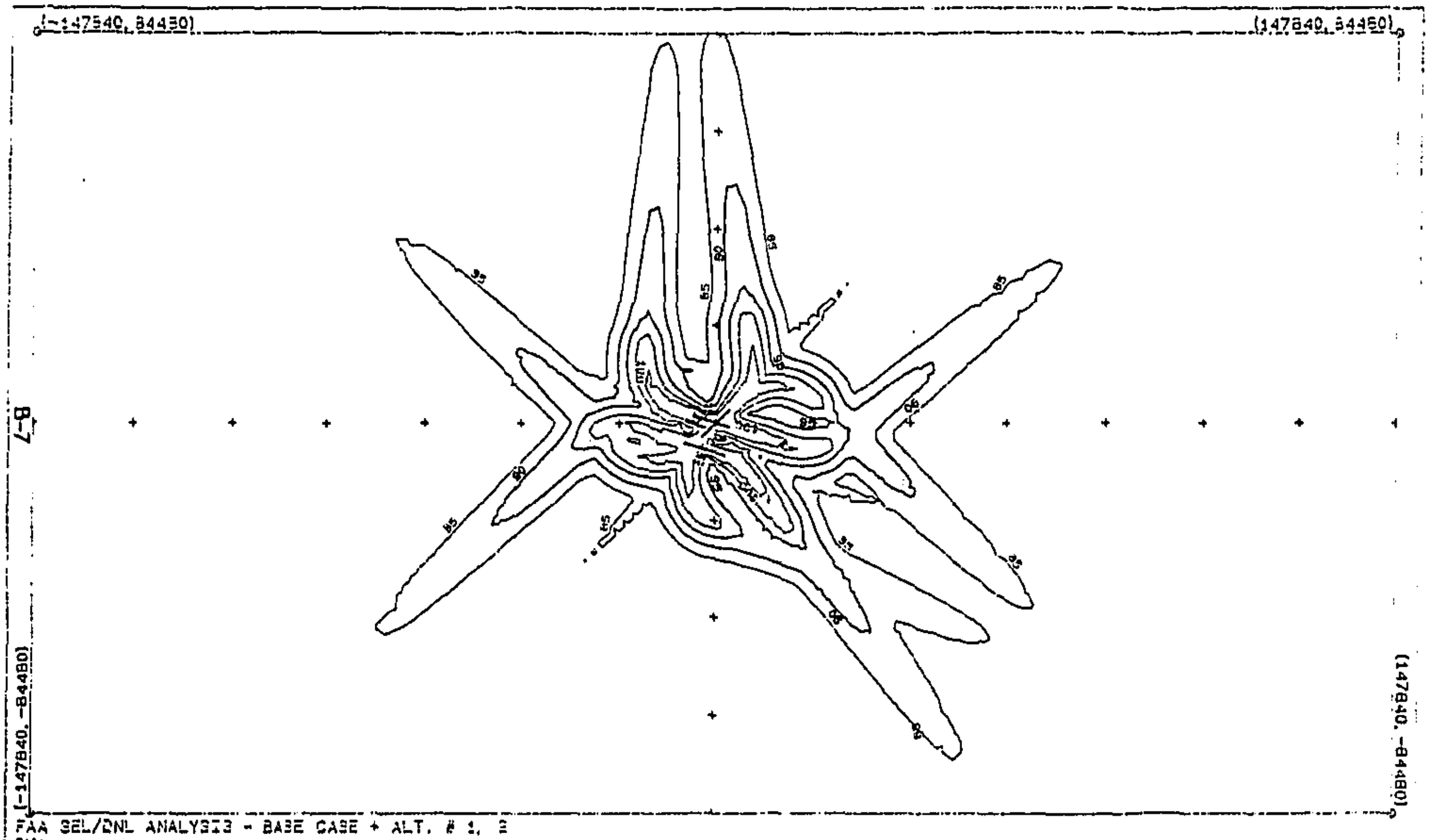






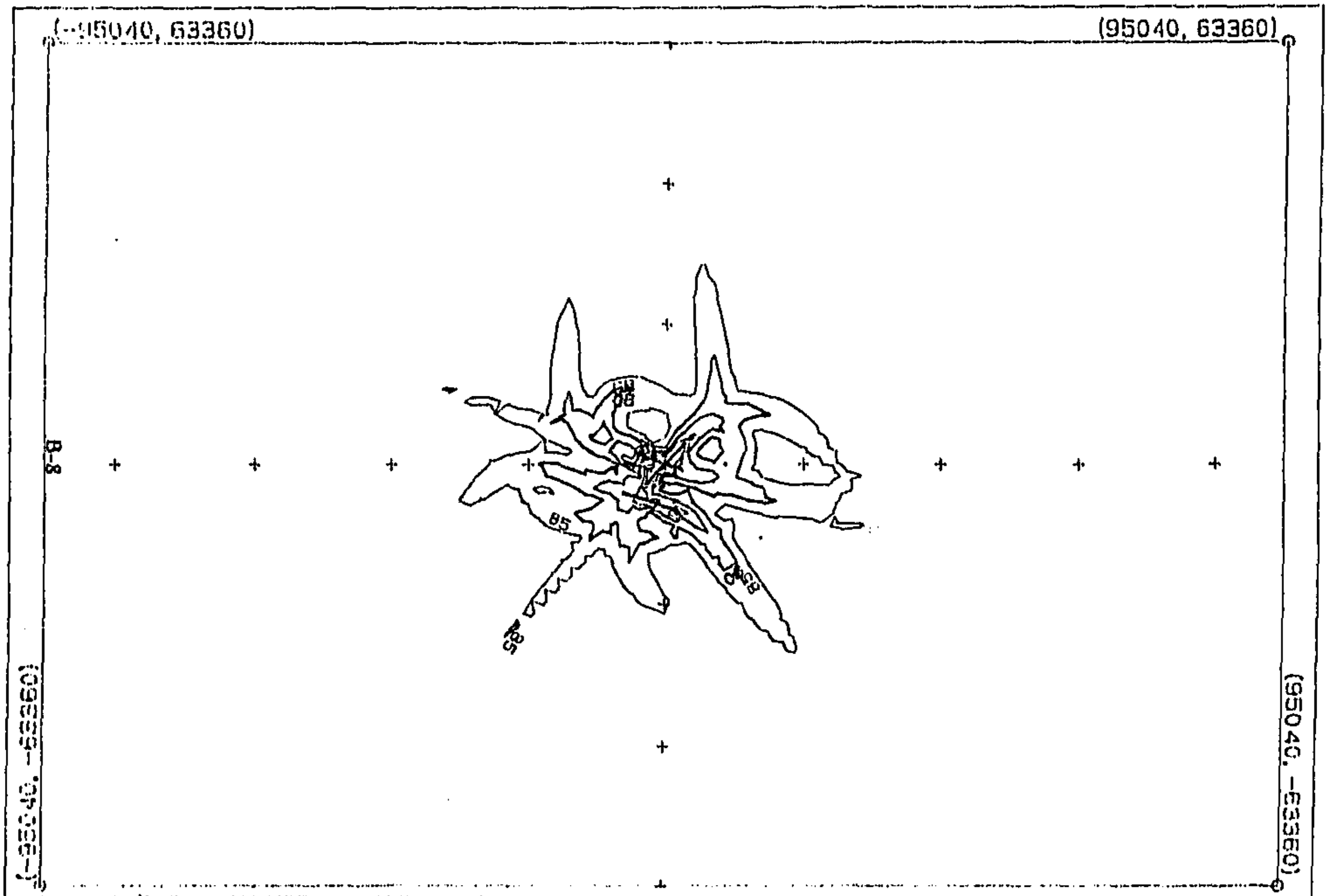




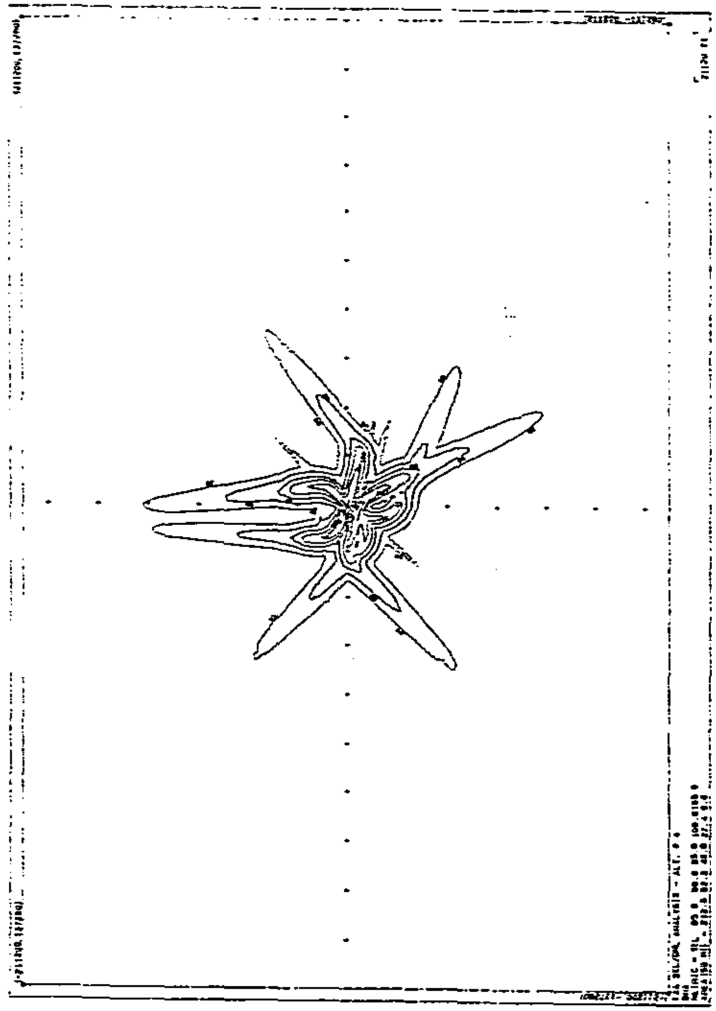


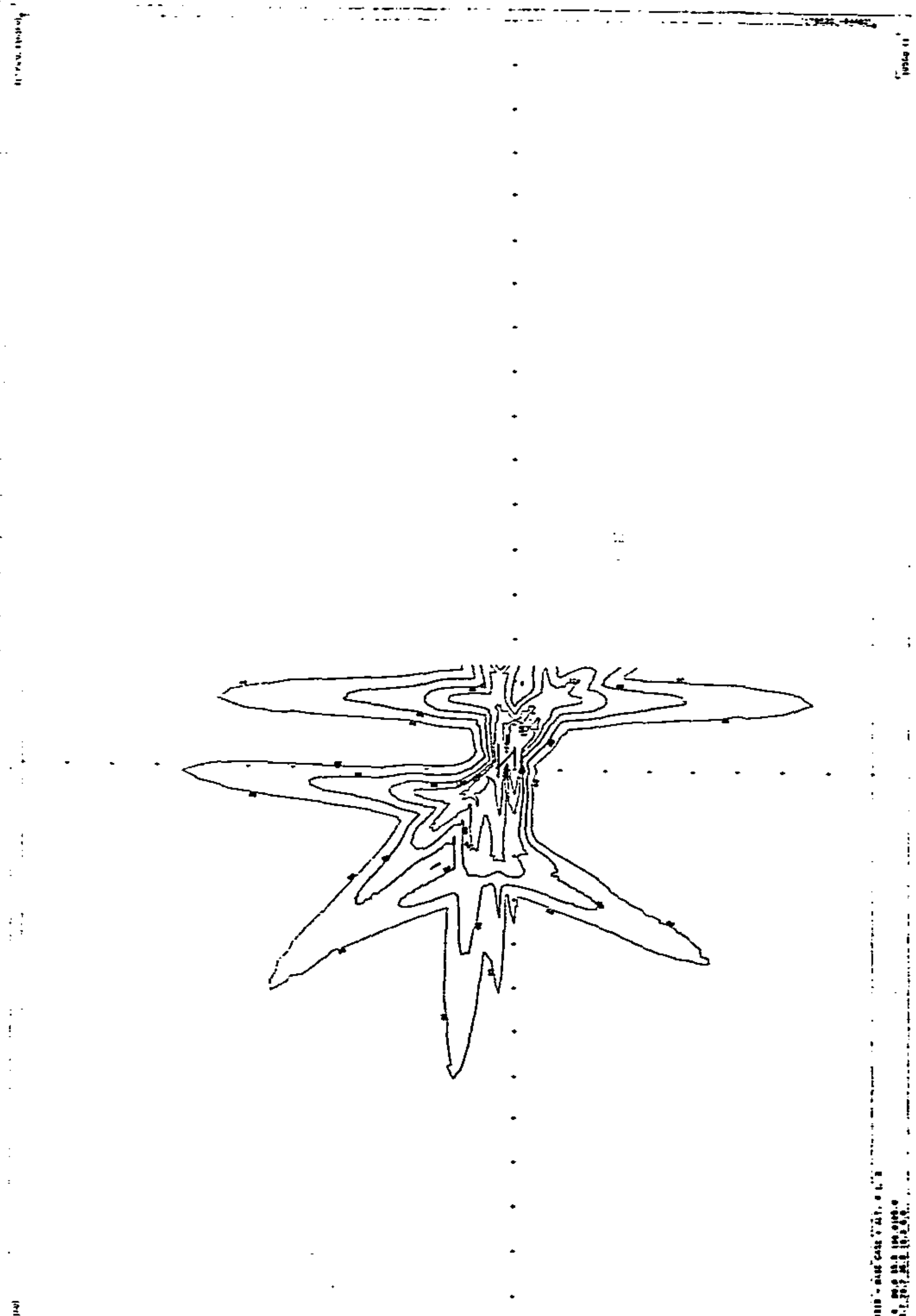
FAA SEL/DNL ANALYSIS - BASE CASE + ALT. # 1, 2
BNA
METRIC = SEL 85.0 90.0 95.0 100.0 105.0
AREA (SQ MI) = 229.7 101.5 51.2 29.5 10.2

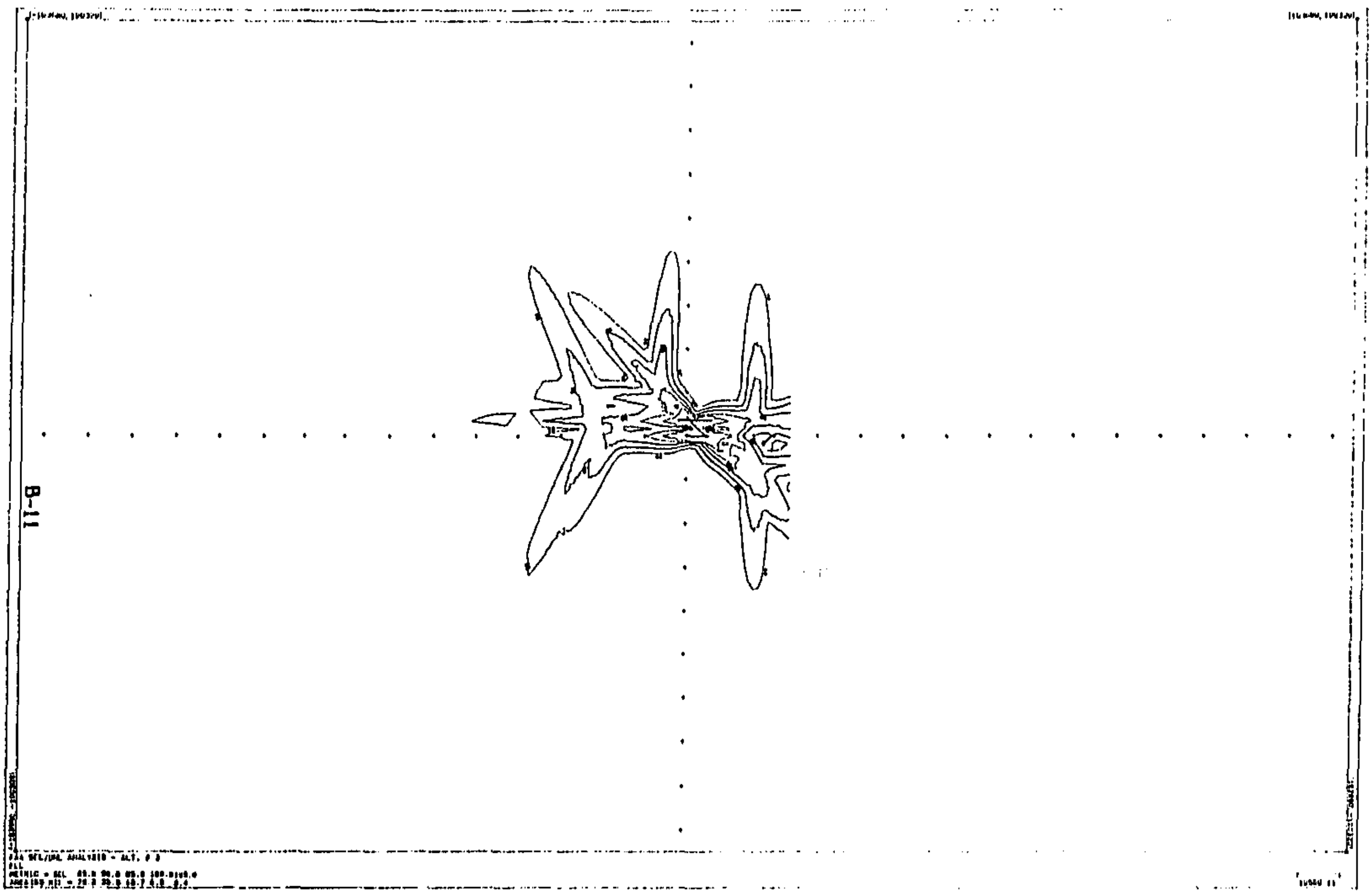
21120 ft

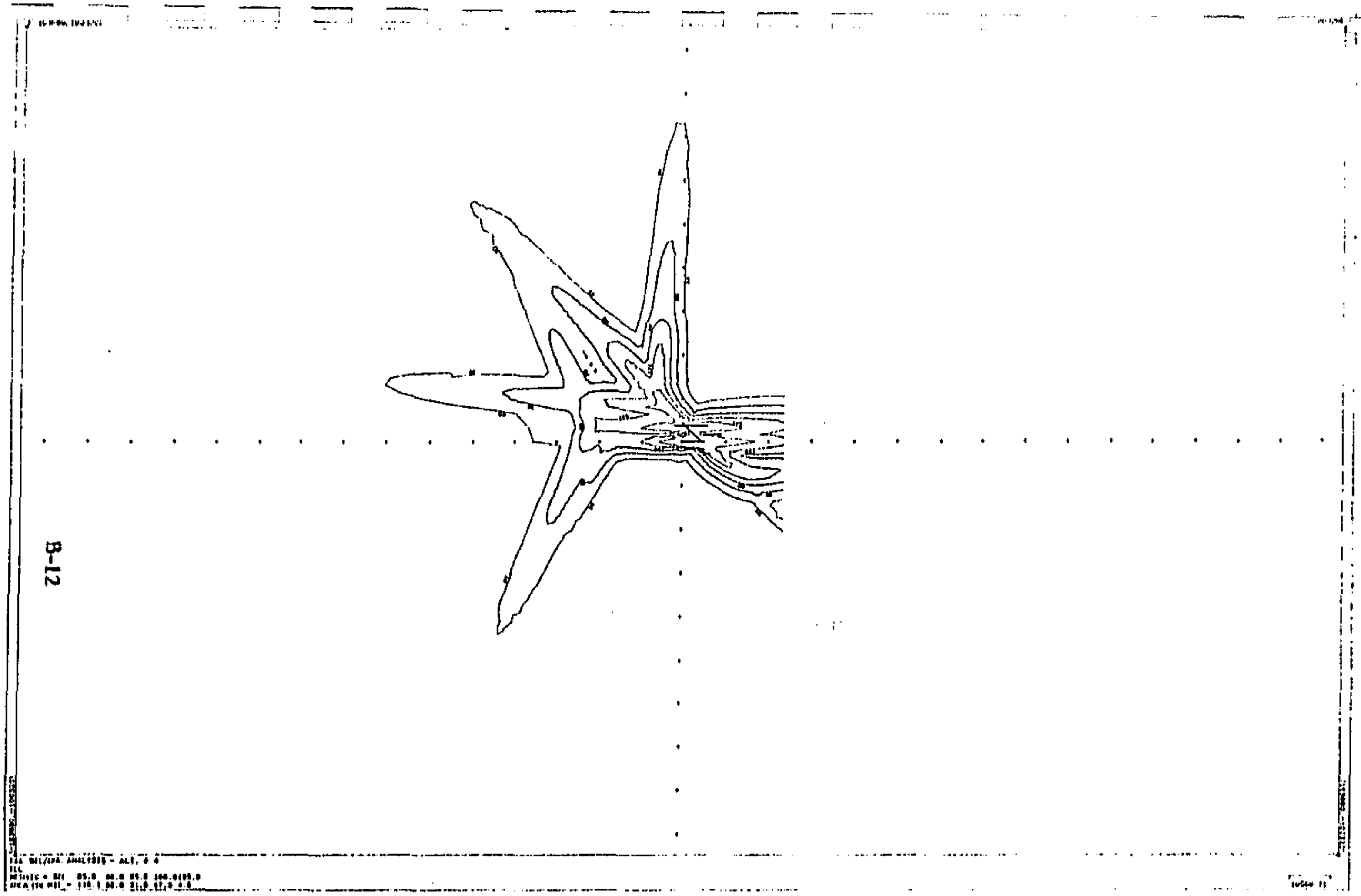


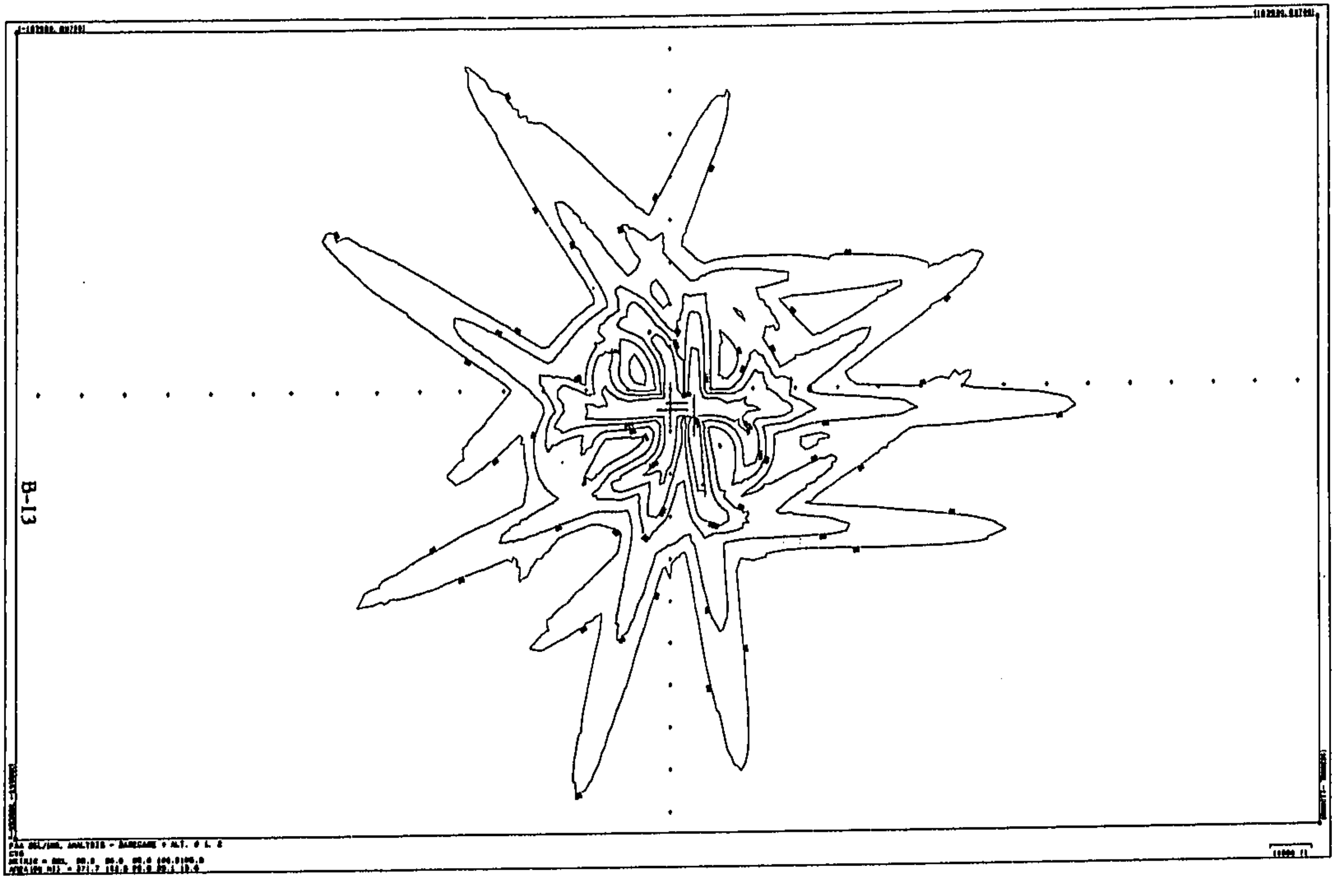
FAA SEL/DNL ANALYSIS - ALT. # 3
BNA
METRIC = SEL 85.0 90.0 95.0 100.0105.0
AREA (SQ MI) = 44.7 15.2 4.6 1.3 .5

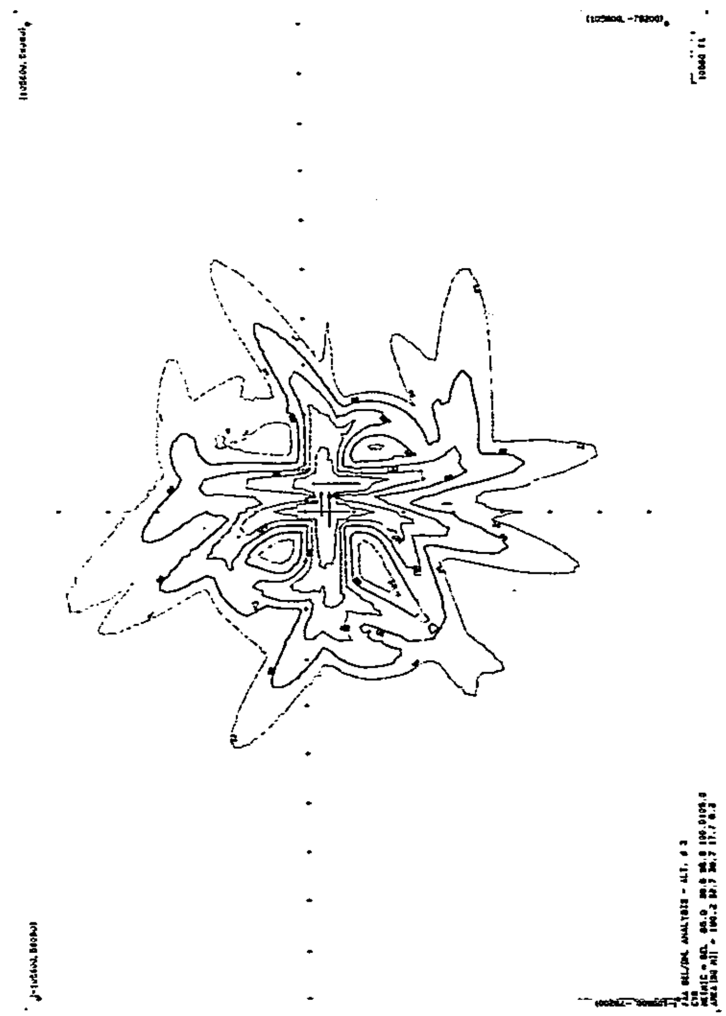


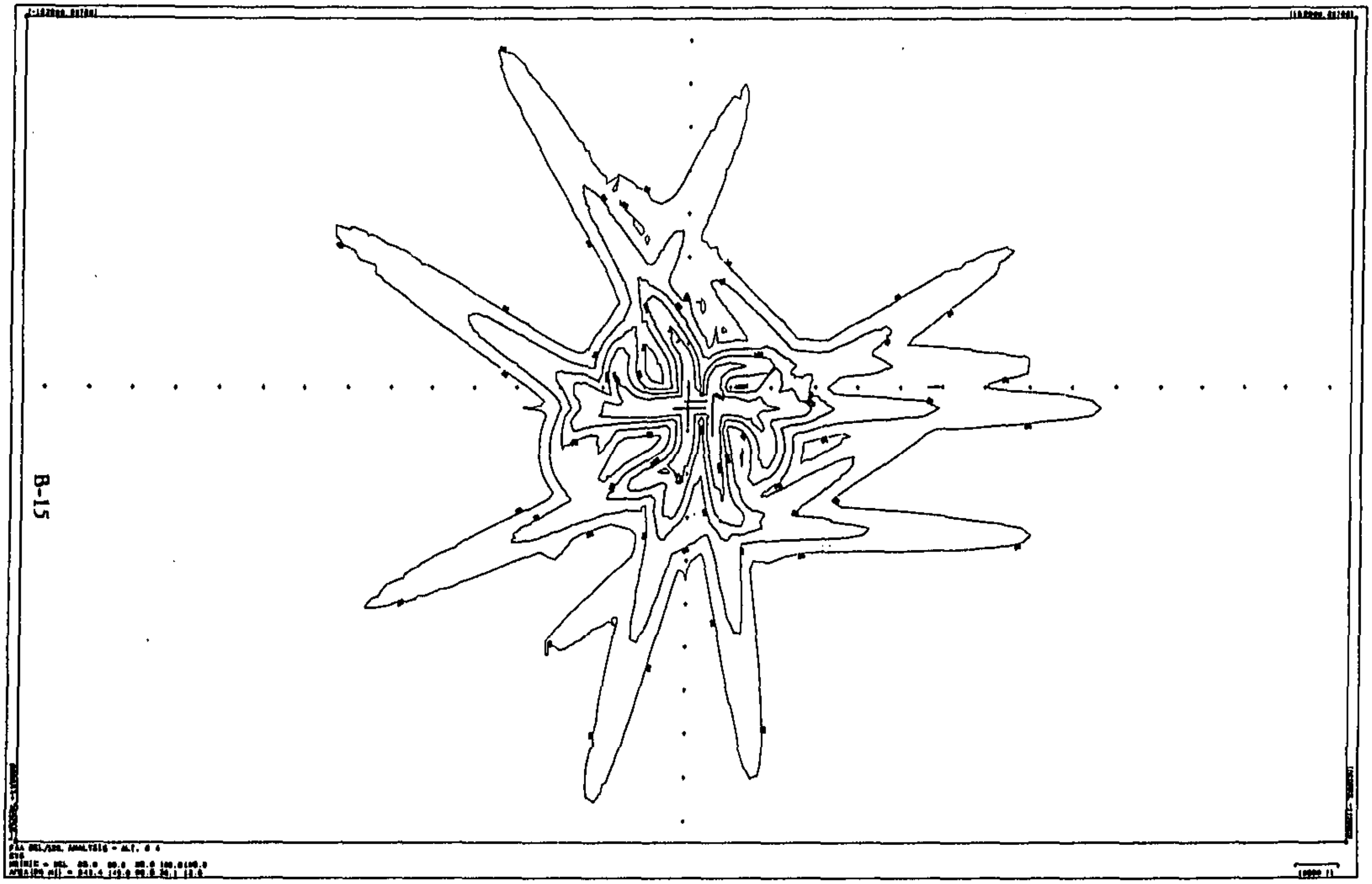


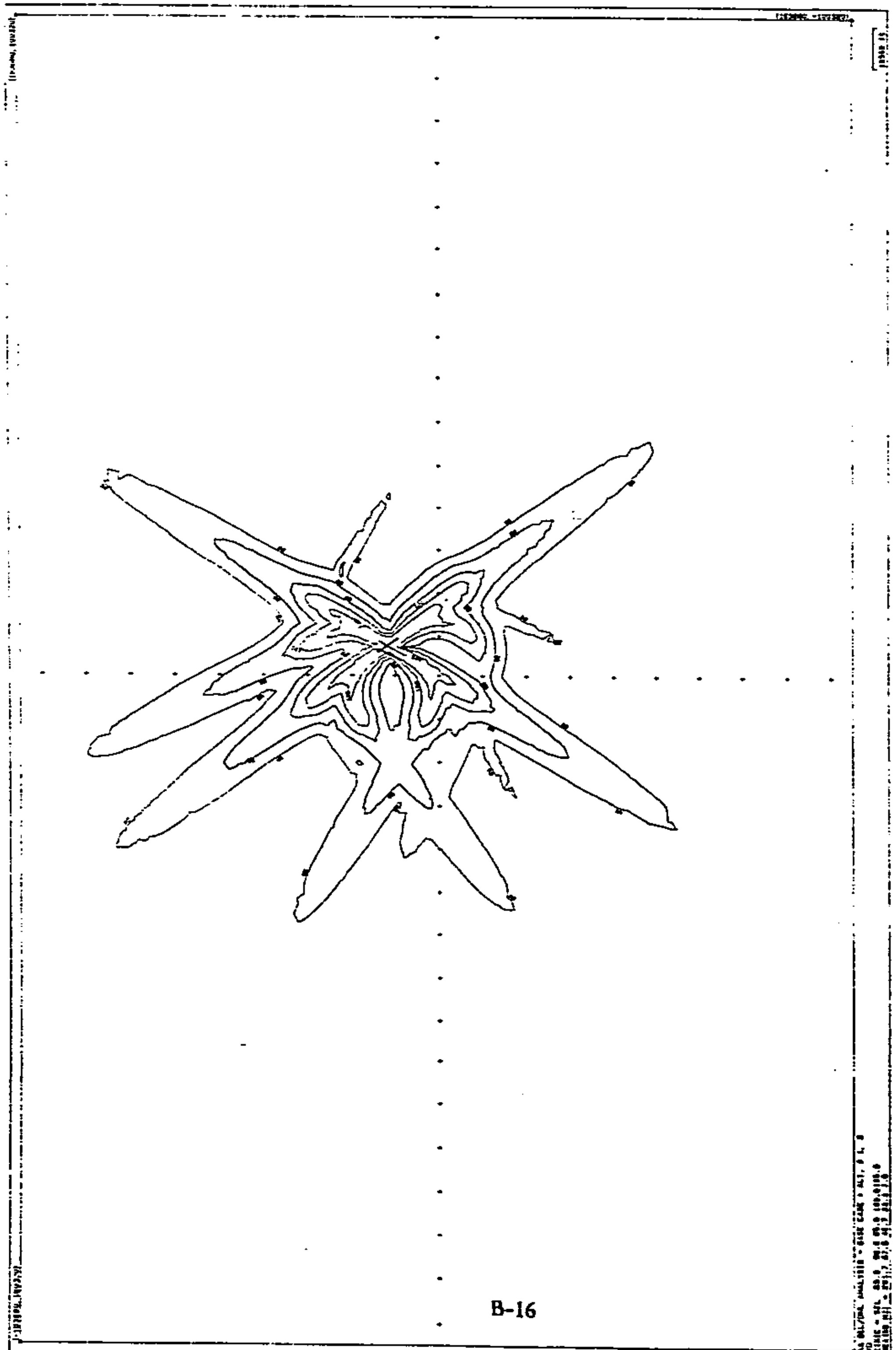


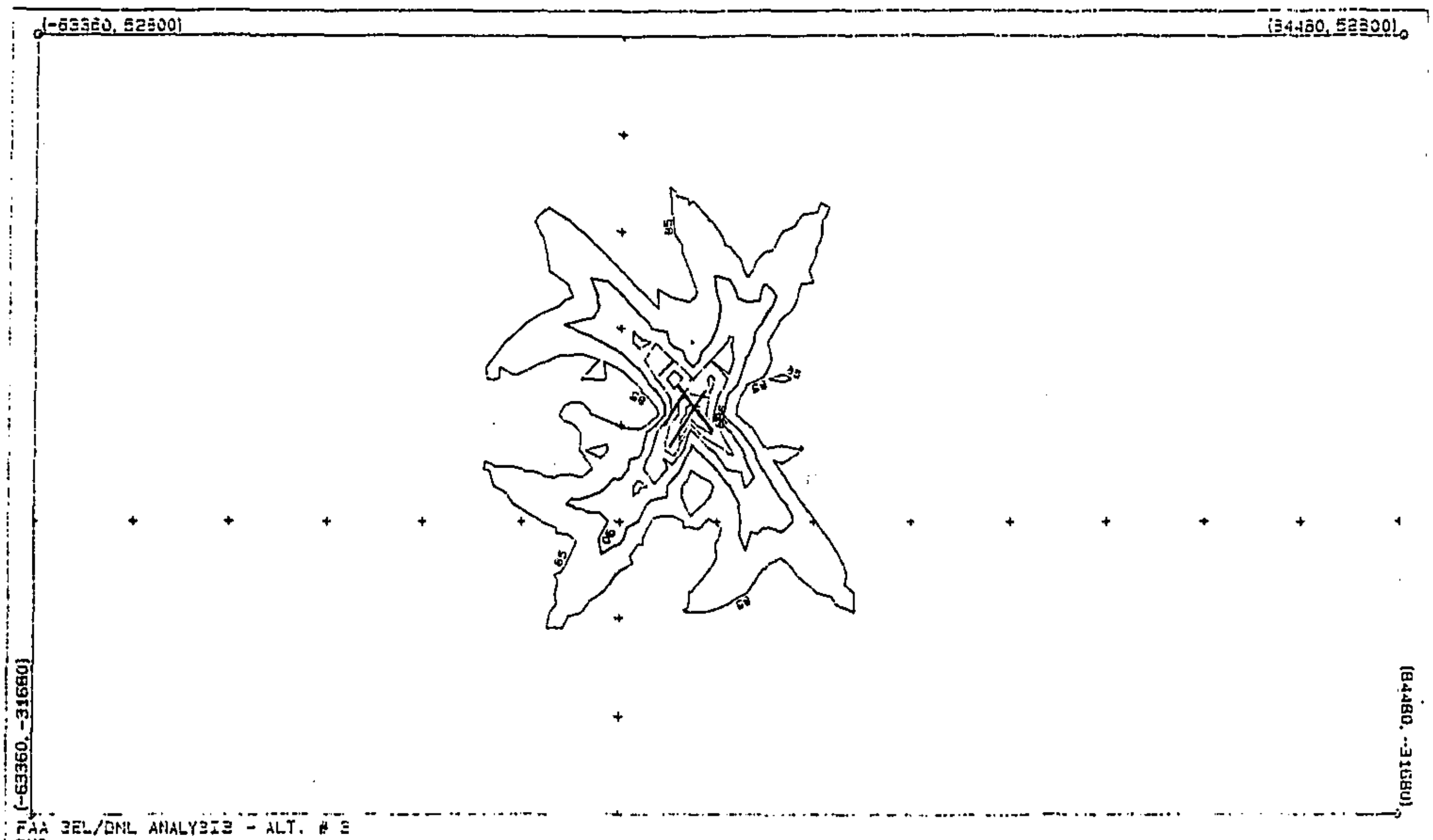




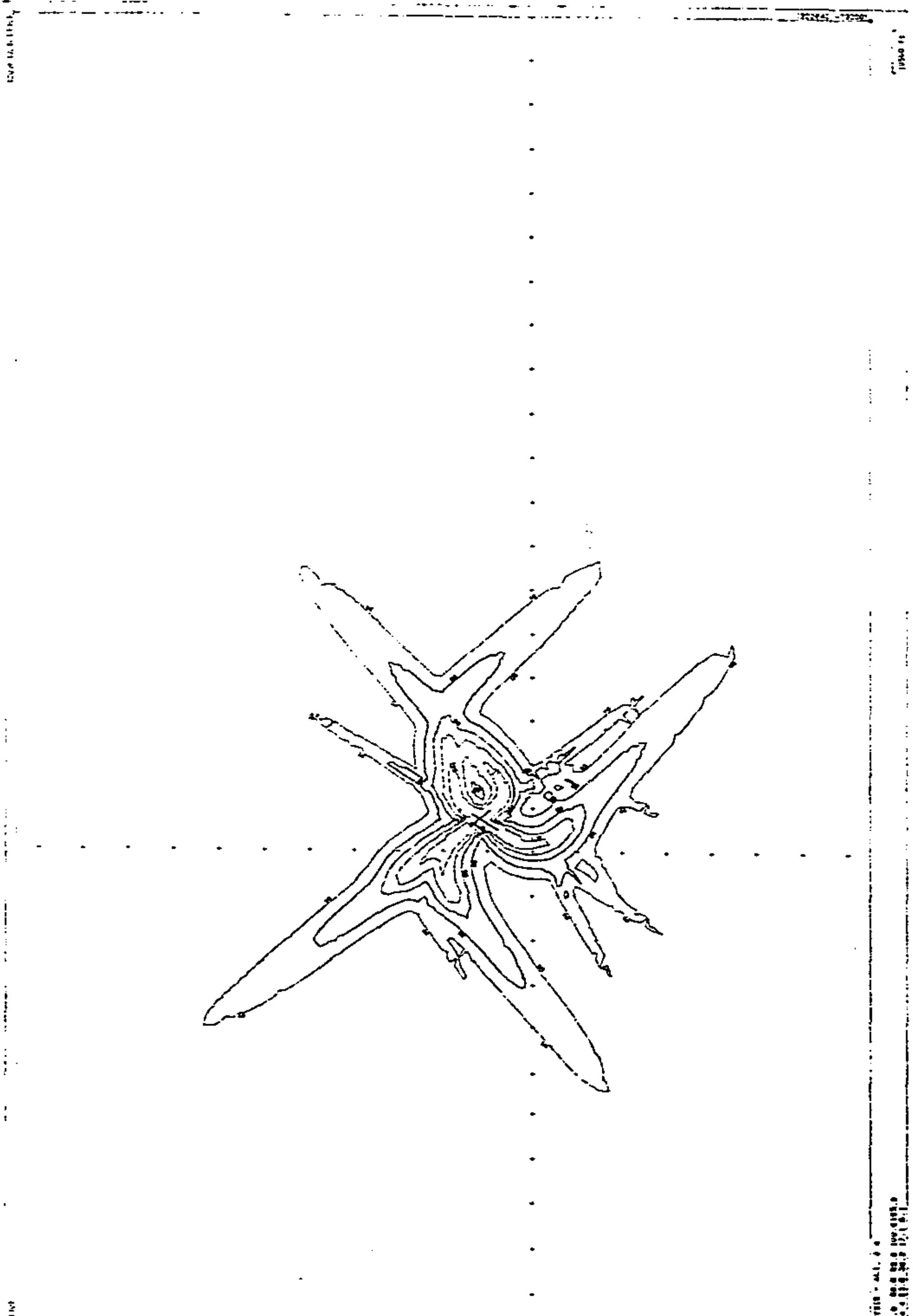

SEL/DNL ANALYSIS - ALT. # 3

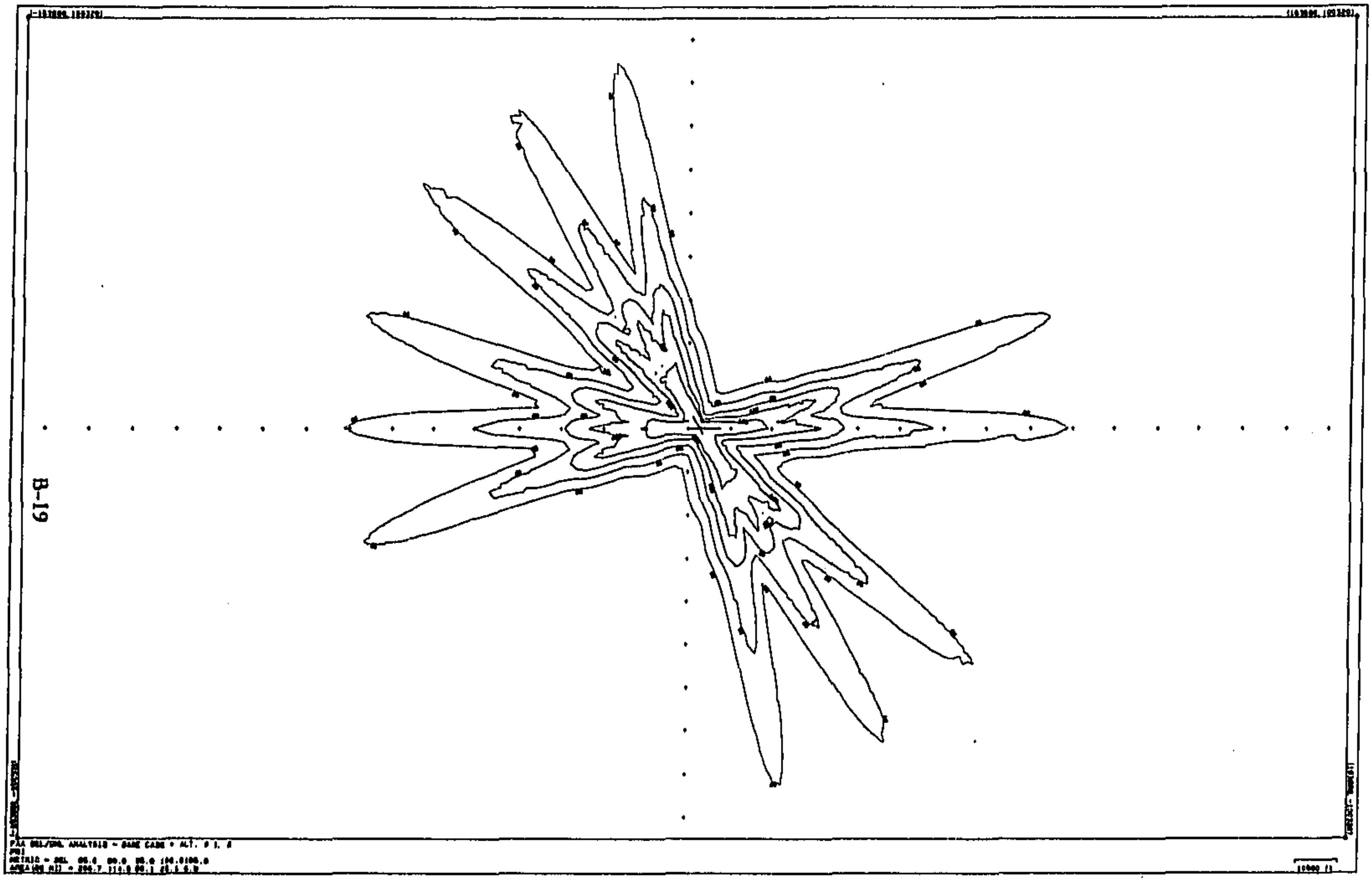


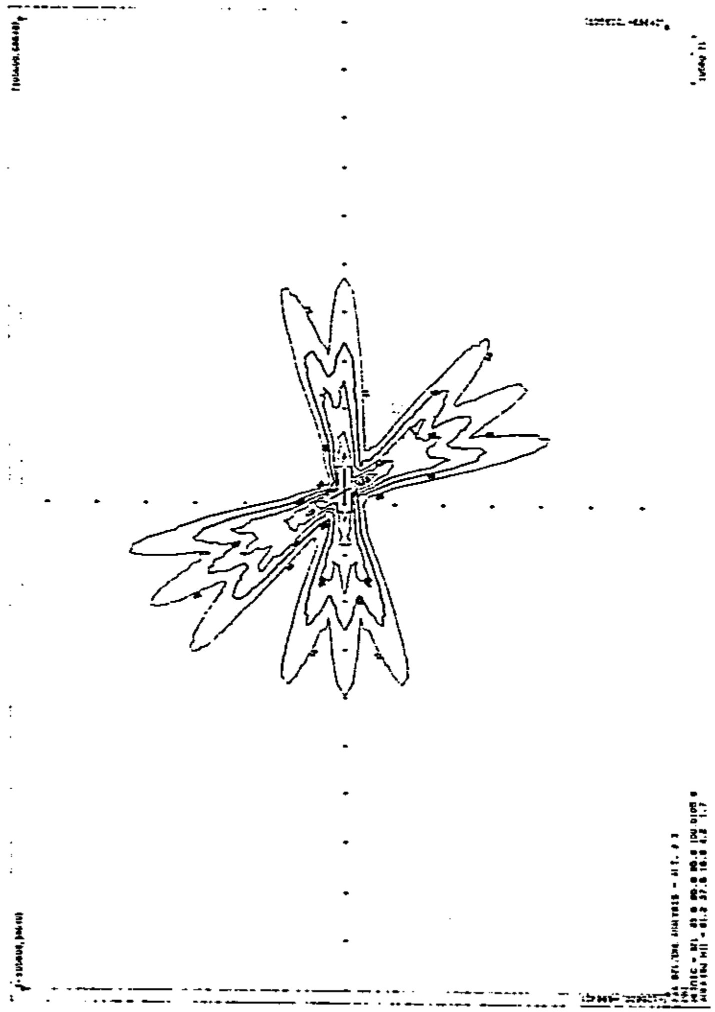


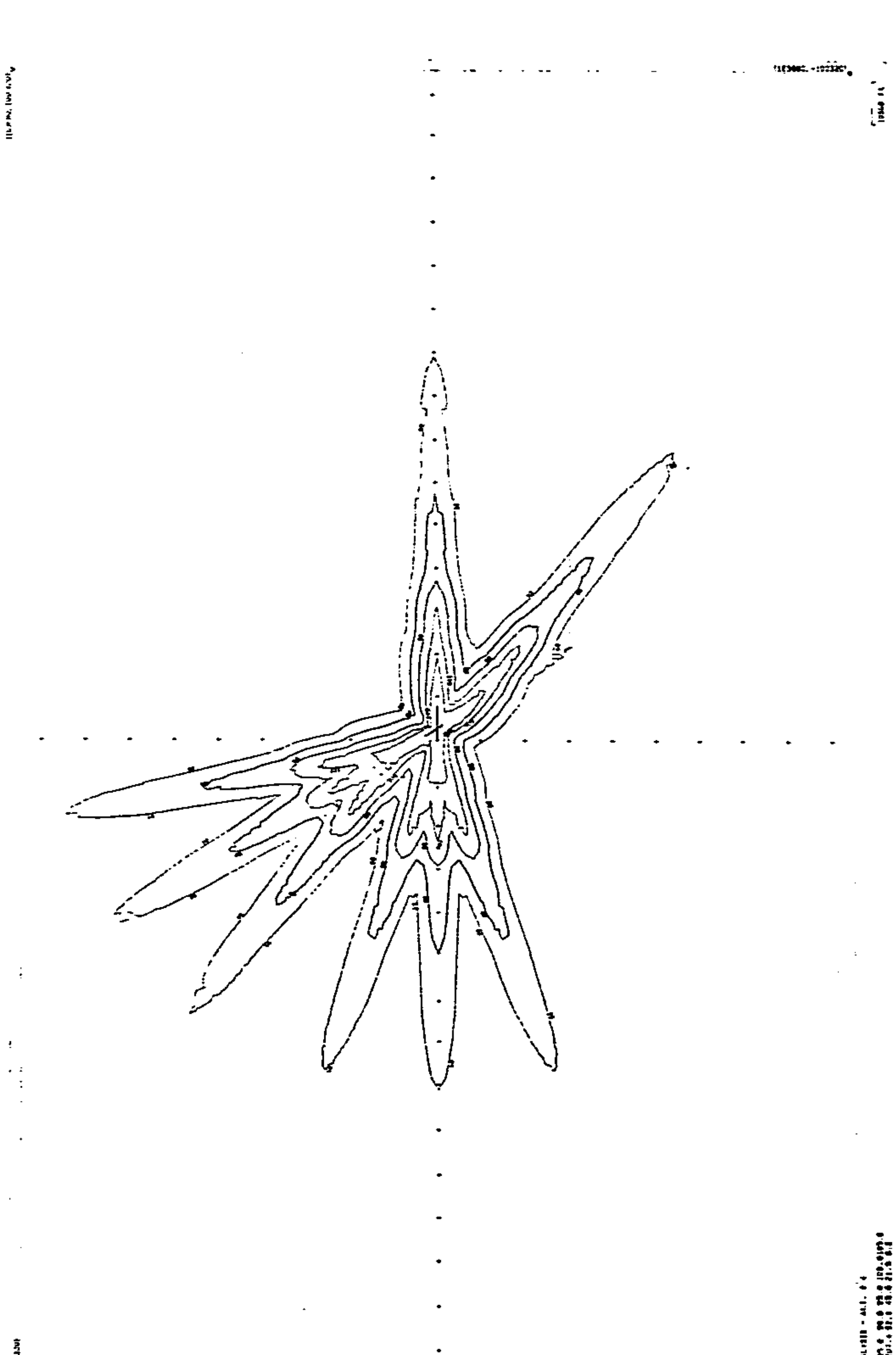


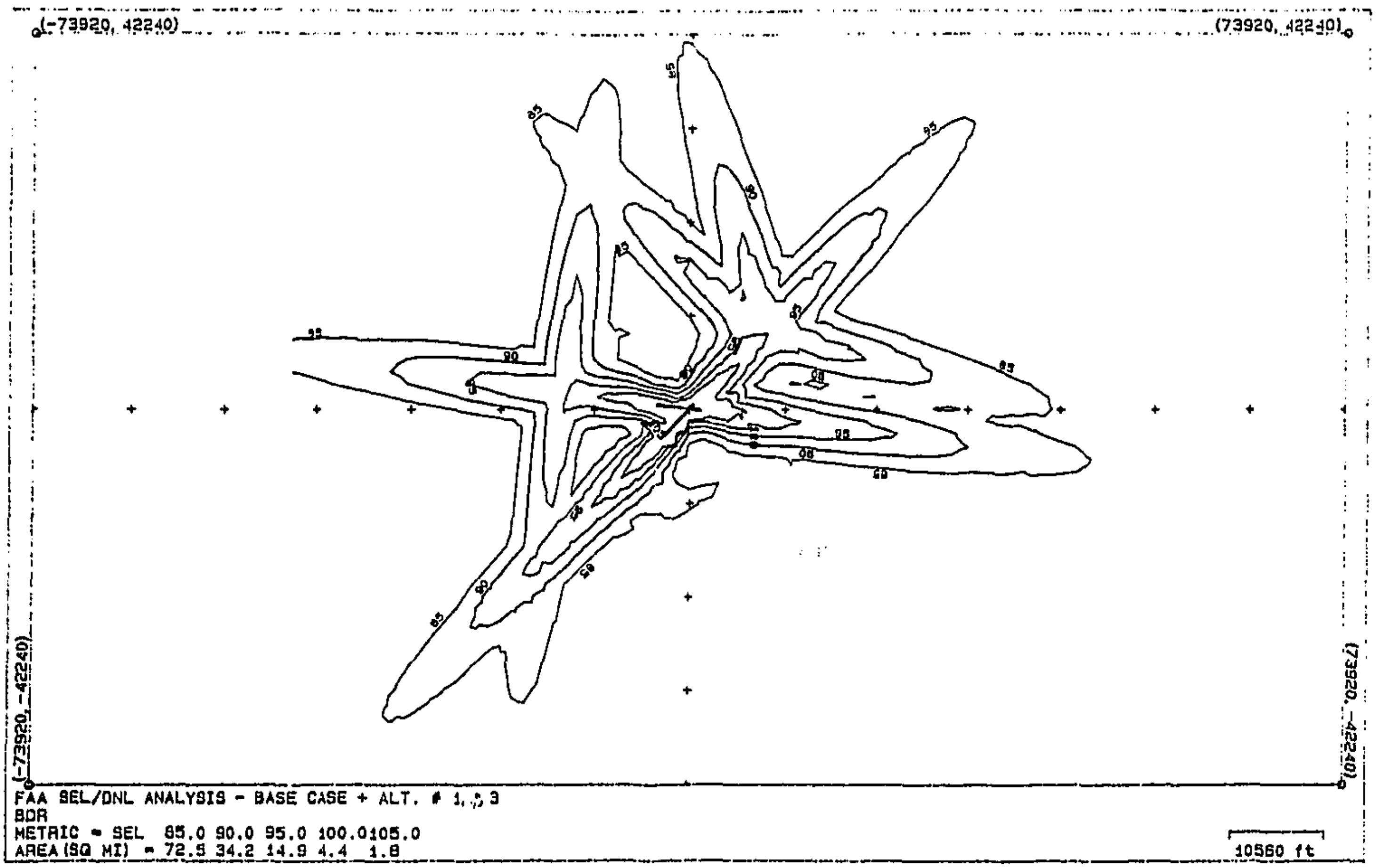
FAA SEL/DNL ANALYSIS - ALT. # 2
PVD
METRIC = SEL 85.0 90.0 95.0 100.0 105.0
AREA (SQ MI) = 31.4 10.0 3.0 .8 .1



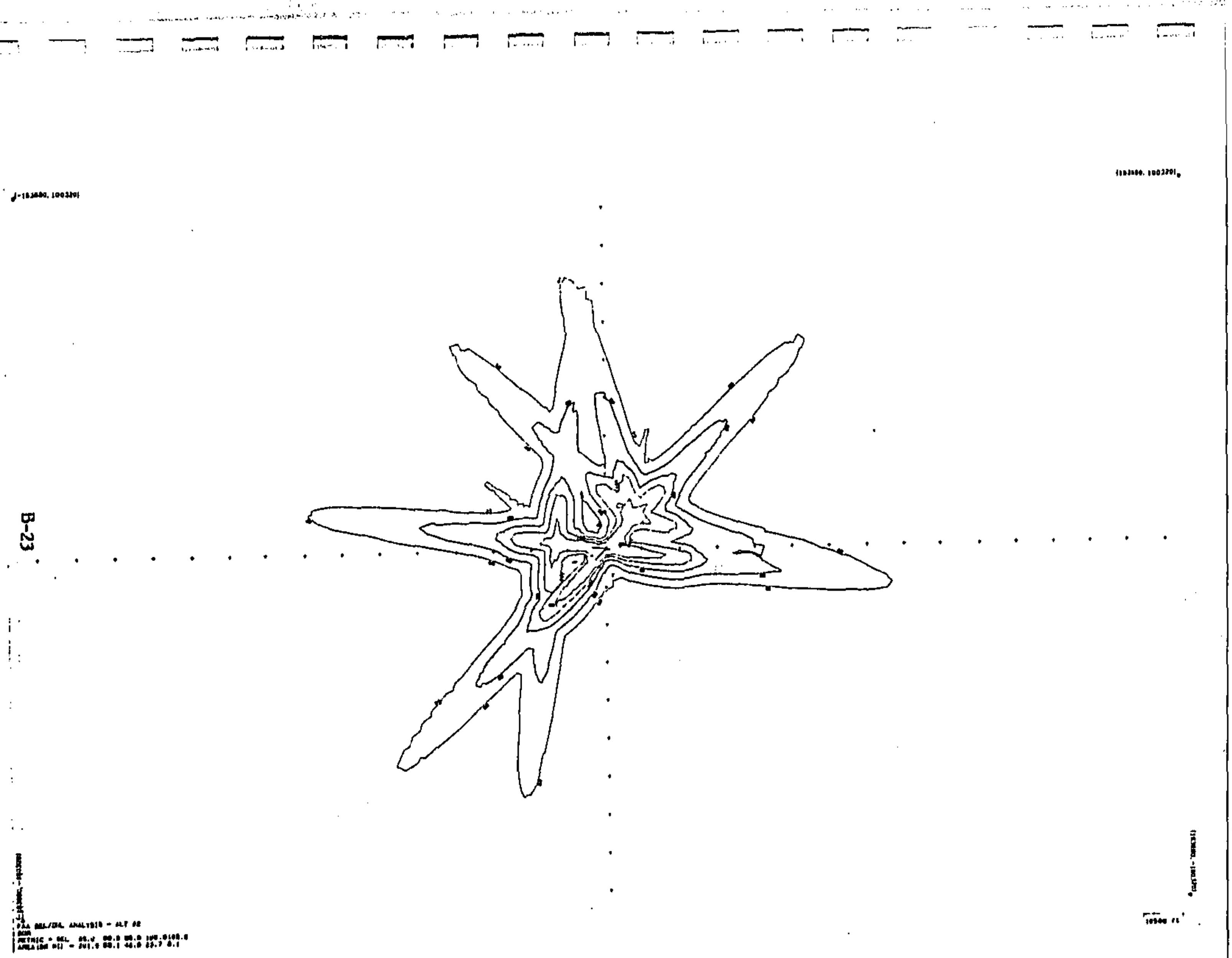


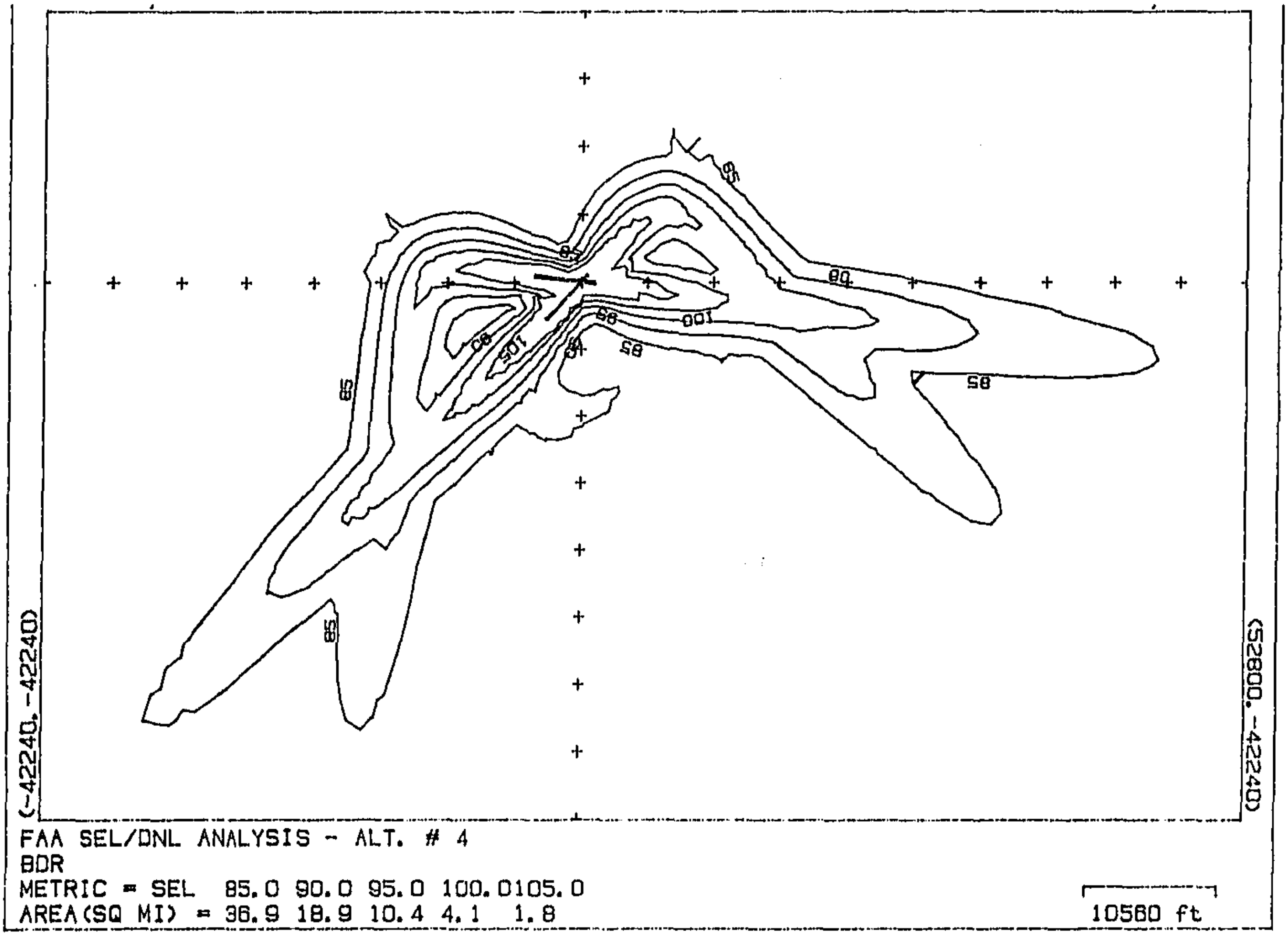






FAA SEL/DNL ANALYSIS - BASE CASE + ALT. # 1, 3
BDR
METRIC = SEL 85.0 90.0 95.0 100.0105.0
AREA (SQ MI) = 72.5 34.2 14.9 4.4 1.8




(-42240. -42240)
(52800. -42240)
85
90
95
100
105
FAA SEL/DNL ANALYSIS - ALT. # 4
BDR
METRIC = SEL 85.0 90.0 95.0 100.0105.0
AREA(SQ MI) = 36.9 18.9 10.4 4.1 1.8
10560 ft