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RAILROAD NOISE EXPOSURE MODEL (RYNEM)

VOLUME 3

RYNEM PROGRAMMING MANUAL

January 1982

U.S. Environmental Protection Agency
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16. Abstract (Limit: 200 words)

This volume describes the structure of the RYNEM and the model's program source code. It is not meant to teach the reader how to run the program. Execution of the model is described in Volume 2. It assumes the reader has digested the contents of Volume 1. The intended audience is the programmer who needs to maintain the program and make changes to the source code. A strong knowledge of standard IBM FORTRAN IV language is assumed.

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0.0 PRELIMINARIES

0.1 Scope of These Manuals

The present set of manuals, volumes 1-3, is meant to describe the Railyard Noise Exposure Model (RYNEM) in some detail. In the following, a brief description of each volume and its intended audience is presented.

Volume 1: General Description of the Model

This volume presents an overview of the model. The basic philosophy of the model is discussed and the relevant equations used in the computations are presented. This volume is written for those who need to know what the model is like. It does not go into detail of how each computation is done in the program, nor does it teach the user how to run the model. It presupposes some familiarity with the EPA noise terminology, as is covered by the "EPA Levels" document [1]. The reader is advised to peruse the Railroad Background document [2] for other terminology used without explanation.

Volume 2: User Manual

This volume presents a cookbook approach to the execution of the model. Its intended audience is those who will exercise the model. It assumes familiarity with volume 1, i.e., the user knows the quantities he inputs, and he knows the quantities printed out. For obvious reasons, the explanations incorporated in volume 1 are not repeated. While it does not presume expertise with the EPA IBM computer system, it does assume the user can follow the instructions presented in this volume to the letter. This point cannot be emphasized often enough. Contrary to popular opinion, a computer cannot think. It can only carry out the instructions given it exactly. As far as is known, the present program is bug-free. If an error occurs, the source most likely is in the input data or the job card.) Though the manual presents a short description of relevant commands in the appendix, the user is reminded that EPA changes its computer systems every so often, so that the instructions presented may be obsolete. The user is strongly advised to obtain a copy of the latest computer user guide and learn the necessary commands to make runs.

Volume 3: Programmer Manual

This volume describes all the nuts and bolts in the program code. It is not meant to teach the reader how to run the program. That is the job of volume 2. It assumes the reader has digested the contents of volume 1. No attempt has been provided to educate the reader as to what Ldn or LWP is. The intended audience is the programmer who needs to maintain the program and make changes in the code. A strong knowledge of standard IBM FORTRAN IV language is assumed.

The correct sequence of reading for a rank novice with no knowledge whatsoever of the EPA noise model methodology is as follows:

1. EPA Levels document - in which the terminology is introduced.
2. Railroad Background document - which describes what a railyard is, the noise sources inside, etc.

3. Volume 1 - what the model attempts to do.

4. Volume 2 - how to make the program grind out numbers.

5. Volume 3 - how the code achieves the aims of volume 1.

Volumes 2 and 3 are not necessary for the person who only wants to understand what RYNEM is about. Volume 2 is not necessary for the person who only wants to exercise the model. For the programmer who maintains the code and to whom job failures will be reported, an intimate knowledge of all three volumes is necessary.

References

[1] Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, 550/9-74-004, U.S. EPA, Washington, D.C., March 1974.

[2] Background Document for Proposed Revision to Rail Carrier Noise Emissions Regulation, 550/9-78-207, U.S. EPA, Washington, D.C., February 1979.

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0.2 General Introduction to the Model

The Railyard Noise Exposure Model (RYNEM) is a computer program designed to quantify the health/welfare impact due to railyard-generated noise on the general population. In this model, a railyard contains two causes of noise sources: stationary and moving. Some examples of stationary sources are master retarders (MR), inert retarders (IR), crane trucks (CT), goat trucks (GT), idling locomotives (IL), refrigerator cars (RC) and load tests (LT). Moving sources consist of switch engines (SE) and inbound (IB) and outbound (OB) trains. Each of these noise sources generates a noise level which can be measured at the railyard boundary (property line). Together, they combine to produce a higher noise level than each can produce on its own. Taking into account the hours of the day during which the noise sources are used, an averaged noise level, Ldn (for day-night weighting) can be computed at the railyard property line using the standard EPA methodology. Based on this Ldn value the general adverse response level weighted population (LWP), or equivalent number impacted (ENI) can be computed.

So far, this is standard practice of the EPA noise models. Whereas formerly, the EPA noise models would use some kind of "average" parameters to construct a model of an "average" yard and then scale up the LWP from this "average" yard to the total population of yards for the national impact, RYNEM does the scaling in a slightly different way. RYNEM considers that the LWP for the national population of railyards form a distribution with mean μ and variance σ^2. When random samples are taken from this distribution and their mean, $\hat{\mu}$, computed, the Weak Law of Large Numbers implies that the sample mean approaches the true mean of the population when the sample size is large, i.e., the sample mean μ is a good approximation of the true mean μ. If we scale up the sample mean LWP by the total number of yards in the population, we will obtain a good approximation to the total LWP due to all the yards, when our sample size is large enough. In this sense, RYNEM is a "statistical" model.

An estimate of the error involved in $\hat{\mu}$ can be obtained as follows:

The true variance of the population, σ^2, can be approximated by the sample variance:

$$S^2 = \sum_{i=1}^{n} \frac{(xi - \hat{\mu})^2}{n-1}$$

where xi are the individual LWP's
n is the sample size.

Let $xi \overset{iid}{\sim} f(\mu,\sigma^2) \quad i = 1, \ldots, n$
Then for

$$Z = \frac{Xi + \ldots + Xn}{n}$$

$$E(Z) = \mu$$

$$var(Z) = \frac{var(xi)}{n} = \frac{\sigma^2}{n}$$

Thus, the standard error of Z is $\frac{\sigma}{\sqrt{n}}$ or approximately $\frac{S}{\sqrt{n}}$.

Therefore, the error of the total LWP is approximately $\frac{SN}{\sqrt{n}}$ where N is the total number of railyards in the population.

1.0 INTRODUCTION

RYNEM, the Railyard Noise Exposure Model, is a computer program that calculates the health and welfare impact due to noise from railyards, the costs associated with noise abatement through construction of barrier walls, and the resulting health and welfare benefits. This manual is designed to be an in-depth discussion of the nuts and bolts of the program code. It presupposes general knowledge of the EPA noise models and a good command of FORTRAN.

The code was written in standard IBM FORTRAN IV (G1 version) for the EPA NCC IBM 370/168. The source code, load module and data base are stored in the NCC WYLBUR system. For more information about how to run the model, see volume 2, "RYNEM User Manual."

This manual is divided into the following sections:

- General outline of the model - a description of the model is presented from a programmer's point of view.
- Discussion of the computation procedures - the algorithms used in the program are explained.
- Flow charts, descriptions and listings of the code - Each of the subprograms are explained in greater detail than in the previous section.
- Interpretation of a sample output - a sample run is examined in detail.
- Dictionary of pertinent variables.

For a listing of the source file, the contents of the data base, and run time and storage requirement, the reader is referred to volume 2.

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2.0 GENERAL OUTLINE OF THE MODEL

Given a population of railyards in the United States, we would like to find the total noise impact. One way to tackle this problem is to consider the "average" yard, compute the noise impact and cost for this yard, and extrapolate these figures to the total population. This is the approach adopted by most of the EPA noise models, and it works so long as the distributions are reasonably smooth and the "average" parameters are chosen correctly. An alternative approach is to take a random sample from the total population, and estimate the means of various parameters of the total population by calculating the means of the respective parameters in the sample. If the underlying distributions are reasonably smooth, then by the law of large numbers, we can reasonably expect that for a sufficiently large N

$$\frac{N\hat{\mu}}{n} \text{ is close to } \mu \quad .$$

where μ is the true parameter

$\hat{\mu}$ is the estimate obtained from the sample

N is the total population size

n is the sample size

This is the philosophy adopted in RYNEM. A sample of railyards is selected at random. Each yard in the sample is examined individually. From data furnished by the Environmental Photographic Interpretation Center (EPIC), a model of the yard is constructed. Using the parameters of this yard, the noise impact and abatement costs are computed. The respective means of these quantities (over all yards in the sample) is used to estimate the respective means of the total population: and the total impact is just the sample mean multiplied by the number of yards in the total population.

The geometry of a sample yard as seen by the model is shown in Figure 1.

A number of approximations have been made in order to make the model tractable. In a real yard situation, several moving sources on different tracks may impact one receiving property area. The procedure for calculating the noise impact of such a case is complex. In the model, the tracks of each area are combined into one track at an equivalent distance from the property line. Furthermore, the moving source is approximated by an infinite line source; this is a close approximateion when the length of the track is longer than the distance from the track to the property line. The noise contours produced by these moving sources in the model are parallel to the property line (Figure 3).

In a real yard situation, several fixed sources may impact one receiving property area and be at differing distances from the property line. In the model, these fixed sources are placed at an equivalent distance from the property line. For ease of computation, the fixed sources regard the receiving property area as a segment of a circle; this is a close approximation when the length of the area is longer than the distance from the fixed source to the property line. This approximating technique works for fixed sources because the noise produced by fixed sources attenuates much faster than the noise produced by moving sources. The noise contours produced by the fixed sources enclose sections of annuli (Figure 4).

Fixed sources impacting one receiving area may not impact an adjacent area. They can impact an area on the other side of the tracks, however. Moving sources, whose noise contours are parallel to the tracks, will impact adjacent areas only if they are moving along the length of those adjacent areas.

The wall length, as constructed by the model, is the same as the length of the equivalent track (and the length of the area). Edge effects of the wall are assumed to be negligible. Since the receiving areas are often adjacent and the walls are joined together, assuming no edge effects in many cases seems reasonable.

When the moving sources and fixed sources are combined with the ambient the resulting noise contours are very complicated. From some preliminary calculations, it was decided that the Level Weighted Population (LWP) from the composite noise sources can be approximated by the sum of the LWP of the moving sources and the LWP of the fixed sources computed separately. The population exposed is taken to be the maximum of the population exposed due to the moving sources and that due to the fixed sources (to prevent double counting).

When noise attenuating barriers are erected, the attenuation for each source is different because of the differing source heights and source frequencies. So the attenuation of each source is computed separately. Then attenuated Ldn of each source is computed at the property line. Finally, the composite noise level is computed. Because of the prohibitively large number of calculations that would be required, it was decided to compute the barrier attenuation at the property line only, and it is assumed that the barrier attenuation beyond the property line is the same as at the property line, so that the attenuation beyond the property line is computed the same way as before inserting the barrier.

So, the procedure of the model is reduced to·

1. Pick a random yard
2. Divide the residential region into separate rectangular areas
3. Pick a receiving property area
4. Find out which sources impact that area
5. Determine the equivalent distances for the moving and fixed sources
6. Compute Population Exposed (PE) LWP
7. Build a wall that meets the regulated level
8. Compute PE, LWP, ΔLWP and the cost of the wall
9. Repeat steps 7 and 8 until the regulation levels being examined are exhausted
10. Repeat steps 3 to 9 until all areas are exhausted
11. Repeat steps 1 to 10 until all the yards in the sample are exhausted

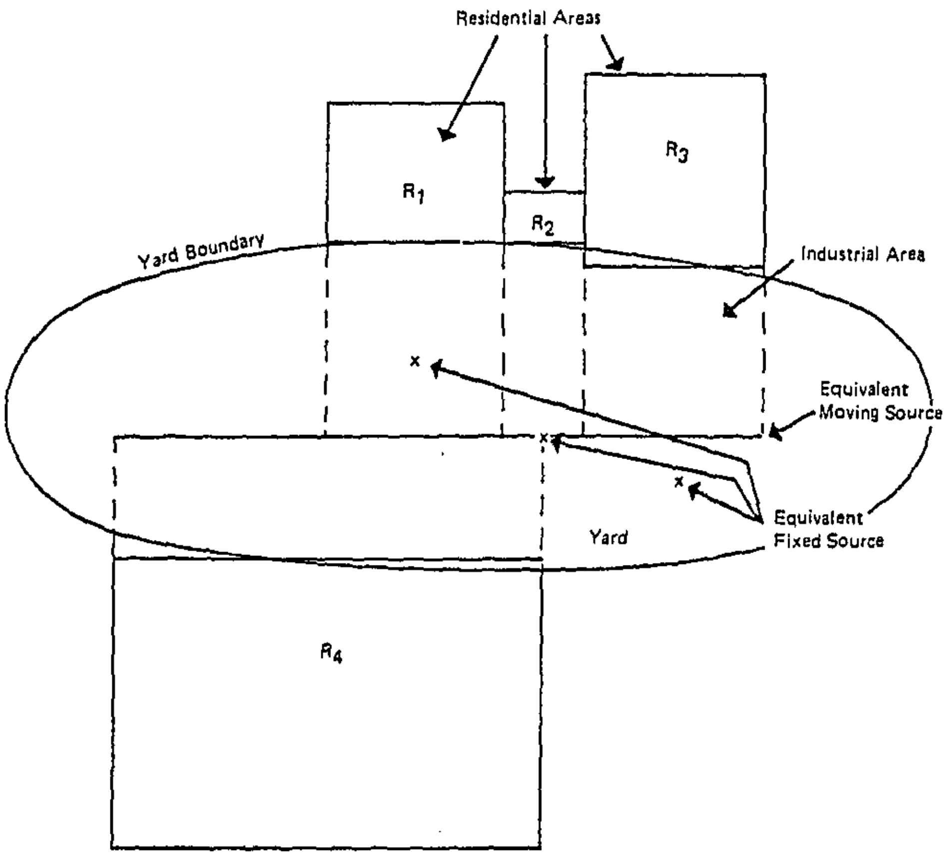


Figure 1. Geometry of yard.

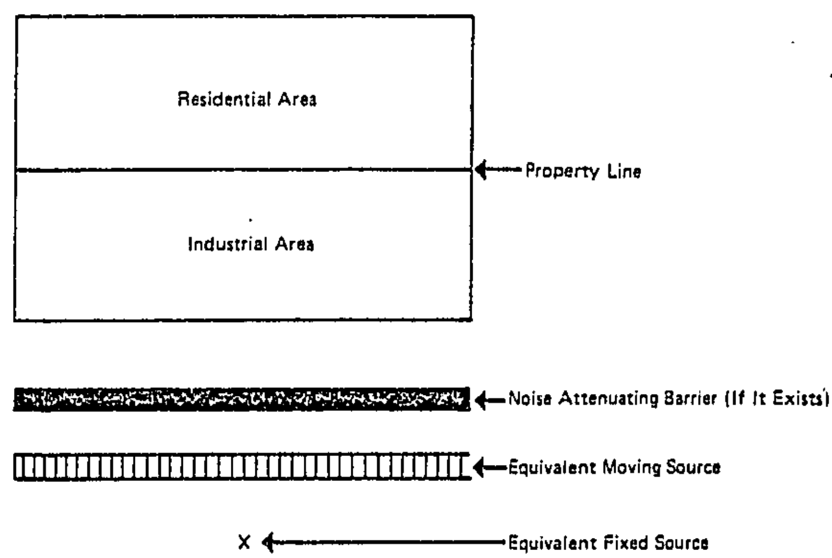


Figure 2. Geometry of area.

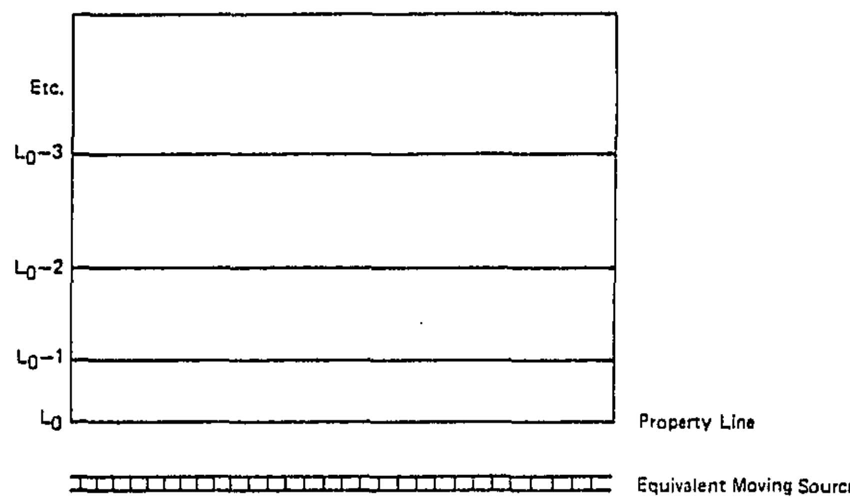


Figure 3. Noise contours of moving sources.

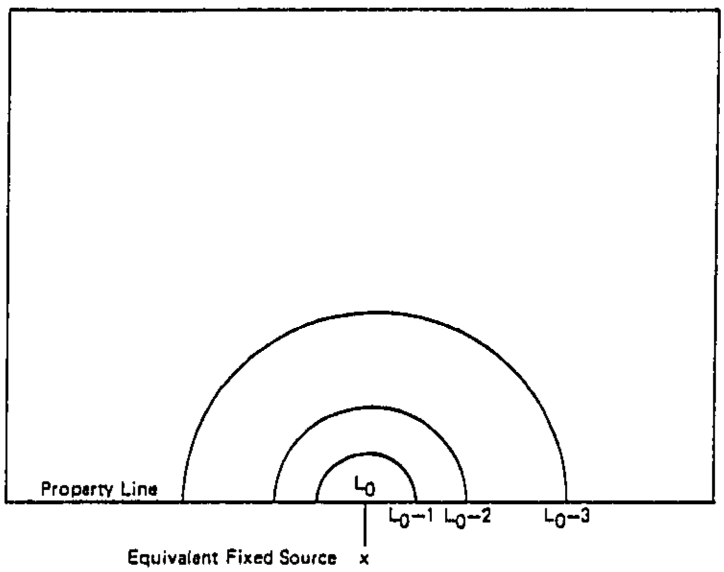


Figure 4. Noise contours of fixed sources

3.0 COMPUTATION PROCEDURES

The following consists of a series of notes on various computation procedures in the code. The order of the notes is roughly the same as the order of the flow of control in the main program. They are designed to supplement the descriptions given in the next section. In general, only non-trivial, important points of interest which are not treated in detail in Section 4 are presented here. Procedures about input/output are generally obvious and hence are not presented here.

3.1 Background Noise

The background noise is computed according to the 100 sites equation

$$L_{BG} = 10 \log_{10} (p) + 22$$

where p is the population density in people/sq mile.

If $L_{BG} > 54$ dB, L_{BG} is set to 54 dB in Ldn computations.

3.2 NYDC (LEV, IT)

NYDC is the number of yards of type IT which are already in compliance with regulation level LEV. If the number of areas in the yard is zero, that means no area is impacted by the noise, so the yard is in compliance with all regulation levels.

3.3 Ldn Levels

ALMS is the composite Ldn of all the moving sources at property line

ALFS is the composite Ldn of all the fixed sources at property line

ALALL is the composite Ldn of the moving and fixed sources at property line

BLALL is the composite Ldn of all noise sources and the background noise at property line

3.4 Impact

Noise impact is computed separately for moving sources and fixed sources. For the baseline case, LEV100 is used to compute the Ldn at 100 feet for each source impacting the area. Then LEVBD is used to compute the Ldn of each source at the property line. The moving sources are combined with the ambient to give a composite line source and impact is computed by determining the distances to each of the 1-dB bands in the standard way. This procedure continues until a level of 55 dB is reached or the limit of the area (i.e., WIDTH) is reached. A similar thing is done with the fixed sources. The LWP of the area is the sum of these two LWP's, and the population exposed is the maximum of the two PE's to prevent double counting.

IMPACT computes PE and LWP in the following 1-dB bands:

L_0 to L_0'

L_0' to $L_0'-1$

$L_0'-1$ to $L_0'-2$

.
.
.

$L_0'-n$ to L_W

where L_0 is the Ldn at property line

L_0' is the largest integer smaller than L_0

L_w is 55 dB or the composite level at the far edge of area, whichever is larger.

n is the largest integer such that $L_0' - n > L_w$

For the LWP computation in the 1-dB band, the noise level in the 1-dB band is approximated by the mean of the two levels associated with the dB band. For the 3-dB band computation, PE and LWP are just the sums of the PE and LWP of the 1-dB bands which fall into the 3-dB band respectively.

The excess wall attenuation at the property line for each source is computed separately. The noise levels are then combined at the property line and propagated as before.

3.5 NA(IL)

NA is the number of areas in the yard that can meet regulation level IL by building a wall.

3.6 IC(IL)

IC is the number of areas that can meet regulation level IL <u>without</u> building a wall, i.e., the number of areas in the yard that are already in compliance with regulation level IL. Note that IC $\leq$ NA.

3.7 IWALL

IWALL is a dummy index in a do-loop. It represents the height of the wall from 5 to 30 feet. Note that if the regulation noise levels are too close together, a wall which complies with level IL may also comply with level IL+1. But the way the code was written, the program will not recognize this fact, and it will blithely add one extra foot to the wall and deduce that a 1-foot-higher wall is required to meet the regulation. So always examine the composite level and compare it to the regulation level.

3.8 Residential Attenuation

The rule for excess residential attenuation is as follows: if industrial attenuation (ATTIND) > 0, then residential attentuation (ATTRES) is set to ATTRES/2; if there is no wall blocking line of sight, the attenuation for the group of sources (moving or fixed) is ATTRES; if the wall does block line of sight, the attenuation for the group of sources is ATTRES/2. A switch (IWSM, IWSF for moving and fixed sources, respectively) is used to determine if the wall is tall enough to block line of sight.

4.0 FLOW CHARTS, DESCRIPTIONS AND LISTINGS OF THE CODE

The program consists of the following subprograms:

MAIN PROGRAM
FUNCTION SUM
FUNCTION DIFF
FUNCTION HEIGHT
FUNCTION WATT
SUBROUTINE LEVELS
SUBROUTINE LEV100
SUBROUTINE LEVBD
SUBROUTINE NEWTON
FUNCTION FFP
FUNCTION AREA
SUBROUTINE IMPACT
SUBROUTINE OUTPUT

The above order is the order of the subprograms in the code. In the following, the descriptions of the subprograms are placed in the same order.

4.1 Main Program

ARGUMENTS: None

PURPOSE: Perform input/output and call on the subprograms to do the calculations

The input data for the main program consist of the estimated number of active railyards in the United States, and the linear cost ($/ft) associated with noise barriers (walls) at the railyard boundary. These constants are listed in Tables 1 and 2. The main program flow chart is shown in Figure 5, and the computer code is presented in Table 3.

DATA:

IT	NUM
1	44
2	51
3	29
4	476
5	346
6	130
7	838
8	1779

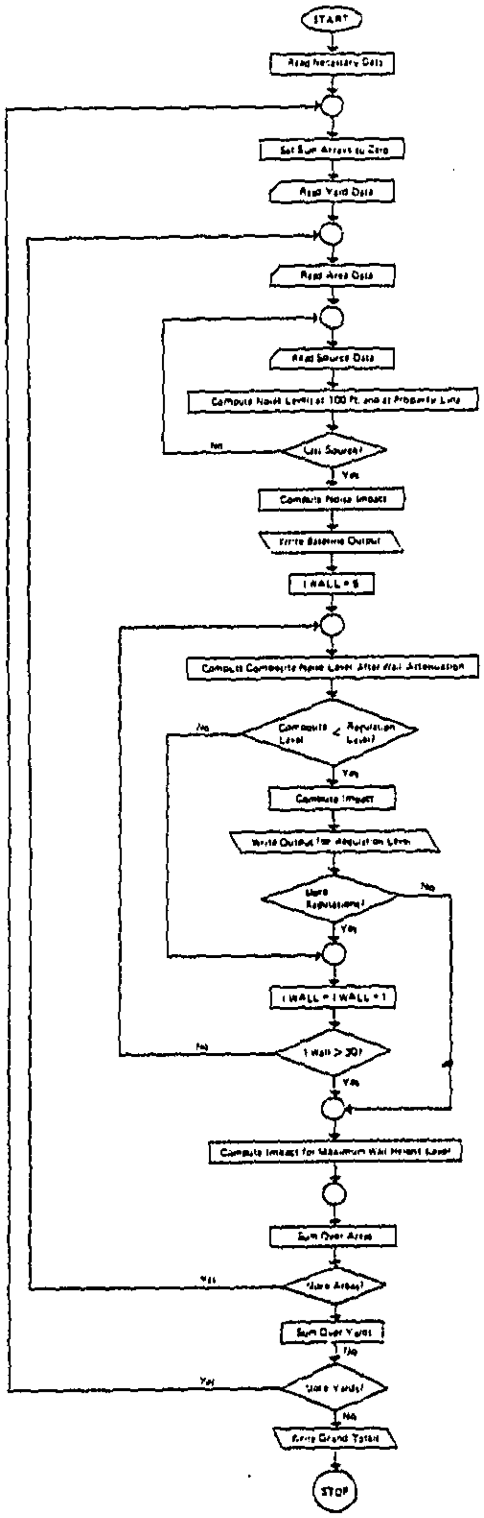
IT = Railyard Type and Traffic Rate Category

NUM = Number of railyards of each type (Estimated active yards in the United States)

Table 1. Table of values of NUM (IT), the total number of yards of each type in the United States.

IWALL (FT)	WCOST ($/FT)	IWALL (FT)	WCOST ($/FT)	IWALL (FT)	WCOST $/FT)
5	27	14	80.8	23	134.6
6	32	15	88	24	140.8
7	37	16	93.6	25	147
8	42	17	99.2	26	153
9	47	18	104.8	27	159
10	52	19	110.4	28	165
11	59.2	20	116	29	171
12	66.4	21	122.2	30	177
13	73.6	22	128.4		

Table 2. Values of WCOST (IWALL). The cost ($/linear ft) of building a wall of height IWALL.



 Figures . MAIN Program Flow Chart

Table 3. RYNEM MAIN Program

```
C***************************************************************************
C
C       PROGRAM:    RM80N3
C
C       DATE:       10/21/80
C
C       FUNCTION:   H/W COMPUTATION IN 1 DB BANDS, OUTPUT IN 3 DB BANDS,
C                   BARRIER ATTENTION AND COST, PROJECTION TO TOTAL POPULATION.
C
C
C***************************************************************************
C
C         COMMON STATEMENTS
C
      COMMON/B1/DB,DNMOV,DNFIX,ATTIND,ALENG,WIDTH,IWALL
      COMMON/B2/ATTM(10),ATTF(10),SMDN(7,10),SMEQ(7,10),SMMAX(7,10),
     2 SFDN(7,10),SFEQ(7,10),SFMAX(7,10),NMOV,NFIX
      COMMON/B3/SLDN,SEQ,SMAX,ED,EN,H1,H2,H3,U1,U2,U3
      COMMON/B4/PE,ENI,BLALL,ALMS,ALFS,ALBG,POPU
      COMMON/B5/LREG(7),ISM(10),ISF(10),ALEV(7),PEA(7),ENIA(7),
     2 DENIA(7),COSTA(7),IW(7)
      COMMON/B8/PEDB(10),ENIDB(10),DBB(10)
C
C         DIMENSION STATEMENTS
C
      DIMENSIONPEYD(7),ENIYD(7),DENIYD(7),COSTYD(7)
      DIMENSIONPEYT(7,8),ENIYT(7,8),DENIYT(7,8),COSTYT(7,8)
      DIMENSIONYDTYPE(4,8),NAMEYD(10),IHMMIN(10),IHFMIN(10),NYD(8)
      DIMENSIONWCOST(30),NUM(8),NAMEA(2),NA(7),IC(7),NYDC(7,8)
      DIMENSIONHPE(7),HENI(7),HDENI(7),HCOST(7),NYDCH(7)
      DIMENSIONPEYDB(10),ENIYDB(10),PETDB(10,8),ENITDB(10,8),
     2 RDBB(2,10)
C
C         DATA STATEMENTS
C
      DATAPETDB,ENITDB/160*0./
      DATANPE,NENI/'PE','ENI'/
      DATANUM/44,51,29,476,346,130,838,1779/
      DATAPEYT,ENIYT,DENIYT,COSTYT/224*0./
      DATANYD,NYDC/64*0/
      DATAWCOST/4*0.,27.,32.,37.,42.,47.,52.,59.2,66.4,73.6,
     2 80.8,88.,93.6,99.2,104.8,110.4,116.,122.2,128.4,134.6,140.8,
     3 147.,153.,159.,165.,171.,177./
C
C         READ NECESSARY DATA
C
      READ(5,1)((YDTYPE(I,IT),I=1,4),IT=1,8)
 1    FORMAT(4A4)
      READ(5,39)(DBB(I),I=1,10)
 39   FORMAT(10F3.0)
      READ(5,40)((RDBB(J,I),J=1,2),I=1,10)
 40   FORMAT(2A4)
      READ(5,1)LREG(1),LREG(7)
      READ(5,30)(LREG(LEV),LEV=2,6)
 30   FORMAT(5I3)
      WRITE(6,33)(LREG(LEV),LEV=2,6)
 33   FORMAT('1REGULATED LEVELS ARE',5I5)
```

```
      READ(5,30)IP
C
C        LOOP FOR EACH YARD
C
1000  CONTINUE
C
C        ZERO SUM ARRAYS FOR YARD
C
      DO1001LEV=1,7
      PEYD(LEV)=0.
      ENIYD(LEV)=0.
      DENIYD(LEV)=0.
      COSTYD(LEV)=0.
      NA(LEV)=0
      IC(LEV)=0
1001  CONTINUE
      DO4001I=1,10
      PEYDB(I)=0.
      ENIYDB(I)=0.
4001  CONTINUE
      READ(5,2,END=9999)(NAMEYD(I),I=1,10),IT,POP,PU,NAREAS
2     FORMAT(10A4,I5,2F10.0,I5)
      POPU=POP/PU
      ALBG=10.*ALOG10(POP)+22.
      IF(IP.GT.1)WRITE(6,3)(NAMEYD(I),I=1,10),(YDTYPE(I,IT),I=1,4)
3     FORMAT('1',10A4,1X,4A4)
      IF(IP.GT.1)WRITE(6,4)POP,PU,POPU,ALBG,NAREAS
4     FORMAT('0',T6,'POP DEN',T15,'USAGE',T26,'EFF POP',T35,'BKGD',T43,
     2 '# AREAS'//F12.1,F7.2,3X,F10.1,F6.1,3X,I6)
      IF(NAREAS.NE.0)GOTO2111
      DO2112LEV=2,6
      NYDC(LEV,IT)=NYDC(LEV,IT)+1
2112  CONTINUE
      GOTO2000
2111  CONTINUE
C
C        SET BACKGROUND NOISE LEVEL
C
      IF(ALBG.GT.54.)ALBG=54.
C
C        LOOP FOR EACH AREA
C
      DO1010IAREA=1,NAREAS
C
C        ZERO SUM ARRAYS FOR AREA
C
      DO1011LEV=1,7
      PEA(LEV)=0.
      ENIA(LEV)=0.
      DENIA(LEV)=0.
      COSTA(LEV)=0.
      IW(LEV)=0
1011  CONTINUE
      ALMS=0.
      ALFS=0.
      READ(5,5)(NAMEA(I),I=1,2),ALENG,WIDTH,DB,ATTIND,ATTRES,DNMOV,
     2 DNFIX,NMOV,NFIX
5     FORMAT(A1,A4,3F10.0,2F5.0,2F10.0,2I5)
```

```
      IF(IP.EQ.3)WRITE(6,7)(NAMEA(I),I=1,2),ALENG,WIDTH,DB,ATTIND,
     2 ATTRES,DNMOV,DNFIX,NMOV,NFIX
      FORMAT('0',T5,'AREA',T11,'LENGTH',T19,'WIDTH',T27,'DB',
     2 T33,'DI',T37,'DR',T41,'DNM',T47,'DNF',T54,'NMS',T59,'NFS'/
     3 '0',T5,A1,A4,3F7.0,2F4.0,2F6.0,2I5)
      IF(NMOV.EQ.0)GOTO1020
C
C        LOOP FOR MOVING SOURCES
C
      DO1021IMOV=1,NMOV
      READ(5,6)ISM(IMOV),ED,EN
6     FORMAT(I5,8F7.0)
C
C        COMPUTE NOISE LEVEL AT 100FT & AT PROPERTY LINE FOR EACH MOVING SOURCE
C
      CALLLEV100(ISM(IMOV),IT)
      CALLLEVBD(ISM(IMOV))
      SMDN(1,IMOV)=SLDN
      SMEQ(1,IMOV)=SEQ
      SMMAX(1,IMOV)=SMAX
      ALMS=SUM(ALMS,SLDN)
      IHMMIN(IMOV)=HEIGHT(ISM(IMOV))+.5
      ATTM(IMOV)=0.
1021  CONTINUE
1020  CONTINUE
      IF(NFIX.EQ.0)GOTO1022
C
C        LOOP FOR FIXED SOURCES
C
      DO1023IFIX=1,NFIX
      READ(5,6)ISF(IFIX),ED,EN,H1,H2,H3,U1,U2,U3
C
C        COMPUTE NOISE LEVEL AT 100FT & AT PROPERTY LINE FOR EACH FIXED SOURCE
C
      CALLLEV100(ISF(IFIX),IT)
      CALLLEVBD(ISF(IFIX))
      SFDN(1,IFIX)=SLDN
      SFEQ(1,IFIX)=SEQ
      SFMAX(1,IFIX)=SMAX
      ALFS=SUM(ALFS,SLDN)
      IHFMIN(IFIX)=HEIGHT(ISF(IFIX))+.5
      ATTF(IFIX)=0.
1023  CONTINUE
1022  CONTINUE
C
C        SUM ALL NOISE LEVELS
C
      ALALL=SUM(ALMS,ALFS)
      BLALL=SUM(ALALL,ALBG)
      ALEV(1)=BLALL
C
C        PUT IN EXCESS RESIDENTIAL ATTENUATION
C        IF THERE IS AN INTERVENING INDUSTRIAL AREA, RESIDENTIAL
C        ATTENUATION IS HALVED
C
      IF(ATTIND.GT.0.)ATTRES=ATTRES/2.
      ALMS=ALMS-ATTRES
      ALFS=ALFS-ATTRES
```

```
C
C         COMPUTE NOISE H/W IMPACT
C
      CALLIMPACT
      PEA(1)=PE
      ENIA(1)=ENI
      DO4002I=1,10
      PEYDB(I)=PEYDB(I)+PEDB(I)
      ENIYDB(I)=ENIYDB(I)+ENIDB(I)
      PETDB(I,IT)=PETDB(I,IT)+PEDB(I)
      ENITDB(I,IT)=ENITDB(I,IT)+ENIDB(I)
 4002 CONTINUE
      IF(IP.NE.3)GOTO4003
      WRITE(6,41)
 41   FORMAT('0    DB BANDS FOR BASELINE')
      WRITE(6,42)((RDBB(J,I),J=1,2),I=1,10)
 42   FORMAT('0',T11,10(2A4,2X)/)
      WRITE(6,43)NPE,(PEDB(I),I=1,10)
 43   FORMAT(1X,A4,1X,10(1PE10.2))
      WRITE(6,43)NENI,(ENIDB(I),I=1,10)
      CALLOUTPUT(1)
 4003 CONTINUE
      NA(1)=NA(1)+1
      IF(BLALL.GT.55.)GOTO2020
      DO2021IL=2,6
      NA(IL)=NA(IL)+1
      IC(IL)=IC(IL)+1
 2021 CONTINUE
      GOTO1030
 2020 CONTINUE
C
C         LOOP FOR THE FIVE REGULATION LEVELS
C
      DO1031LEV=2,6
      IF(BLALL.GT.FLOAT(LREG(LEV)))GOTO1032
      NA(LEV)=NA(LEV)+1
      IC(LEV)=IC(LEV)+1
 1031 CONTINUE
      IWALL=0
      GOTO1050
 1032 CONTINUE
      IF(LEV.EQ.2)GOTO1033
      LEV1=LEV-1
      DO1034I=2,LEV1
      PEA(I)=PEA(1)
      ENIA(I)=ENIA(1)
 1034 CONTINUE
 1033 CONTINUE
C
C         BUILD WALL FROM 5FT TO 30FT
C
      DO1040IWALL=5,30
      ALMS=0.
      ALFS=0.
      IWSM=0
      IWSF=0
      IF(NMOV.EQ.0)GOTO1041
C
```

```
C        COMPUTE BARRIER ATTENUATION FOR EACH MOVING SOURCE INDIVIDUALLY
C
      DO1042IMOV=1,NMOV
      ATTM(IMOV)=0.
      IF(IHMMIN(IMOV).LE.IWALL)ATTM(IMOV)=WATT(ISM(IMOV))
      IF(IHMMIN(IMOV).LE.IWALL)IWSM=1
      SLDN=SMDN(1,IMOV)-ATTM(IMOV)
      ALMS=SUM(ALMS,SLDN)
 1042 CONTINUE
 1041 CONTINUE
      IF(NFIX.EQ.0)GOTO1043
C
C        COMPUTE BARRIER ATTENUATION FOR EACH FIXED SOURCE INDIVIDUALLY
C
      DO1044IFIX=1,NFIX
      ATTF(IFIX)=0.
      IF(IHFMIN(IFIX).LE.IWALL)ATTF(IFIX)=WATT(ISF(IFIX))
      IF(IHFMIN(IFIX).LE.IWALL)IWSF=1
      SLDN=SFDN(1,IFIX)-ATTF(IFIX)
      ALFS=SUM(ALFS,SLDN)
 1044 CONTINUE
 1043 CONTINUE
      ALALL=SUM(ALMS,ALFS)
      BLALL=SUM(ALALL,ALBG)
C
C        IF THE WALL BLOCKS LINE OF SIGHT, USE ONLY HALF THE EXCESS
C        RESIDENTIAL ATTENUATION
C
      ALMS=ALMS-ATTRES/2.
      ALFS=ALFS-ATTRES/2.
      IF(IWSM.EQ.0)ALMS=ALMS-ATTRES/2.
      IF(IWSF.EQ.0)ALFS=ALFS-ATTRES/2.
      IF(BLALL.GT.FLOAT(LREG(LEV)))GOTO1040
      CALLIMPACT
      ALEV(LEV)=BLALL
      PEA(LEV)=PE
      ENIA(LEV)=ENI
      DENIA(LEV)=ENIA(1)-ENI
      COSTA(LEV)=ALENG*WCOST(IWALL)
      IW(LEV)=IWALL
      CALLLEVELS(LEV)
      NA(LEV)=NA(LEV)+1
      IF(IP.EQ.3)CALLOUTPUT(LEV)
      LEV=LEV+1
      IF(LEV.GT.6)GOTO1050
 1040 CONTINUE
 1050 CONTINUE
C
C        MAXIMUM WALL LEVEL
C
      CALLIMPACT
      ALEV(7)=BLALL
      PEA(7)=PE
      ENIA(7)=ENI
      DENIA(7)=ENIA(1)-ENI
      IWALL=MINO(IWALL,30)
      NA(7)=NA(7)+1
      COSTA(7)=0.
```

```
      IW(7)=IWALL
      IF(IWALL.NE.0)COSTA(7)=ALENG*WCOST(IWALL)
      CALLLEVELS(7)
      IF(IP.EQ.3)CALLOUTPUT(7)
      IF(LEV.GT.6)GOTO2011
      DO2010IL=LEV,6
      BLALL=FLOAT(LREG(IL))
      ALMS=DIFF(BLALL,ALBG)-3.01-ATTRES/2.
      ALFS=ALMS
      CALLIMPACT
      PEA(IL)=PE
      ENIA(IL)=ENI
      DENIA(IL)=ENIA(1)-ENI
      COSTA(IL)=COSTA(7)
 2010 CONTINUE
 2011 CONTINUE
C
C        SUM OVER AREAS
C
      DO1051LEV=1,7
      PEYD(LEV)=PEYD(LEV)+PEA(LEV)
      ENIYD(LEV)=ENIYD(LEV)+ENIA(LEV)
      DENIYD(LEV)=DENIYD(LEV)+DENIA(LEV)
      COSTYD(LEV)=COSTYD(LEV)+COSTA(LEV)
 1051 CONTINUE
 1030 CONTINUE
 1010 CONTINUE
C
C        SUM OVER YARDS FOR EACH YARD TYPE
C
      DO1052LEV=1,7
      PEYT(LEV,IT)=PEYT(LEV,IT)+PEYD(LEV)
      ENIYT(LEV,IT)=ENIYT(LEV,IT)+ENIYD(LEV)
      DENIYT(LEV,IT)=DENIYT(LEV,IT)+DENIYD(LEV)
      COSTYT(LEV,IT)=COSTYT(LEV,IT)+COSTYD(LEV)
 1052 CONTINUE
      DO1081LEV=2,6
      J=IC(LEV)/NAREAS
      NYDC(LEV,IT)=NYDC(LEV,IT)+J
 1081 CONTINUE
      IF(IP.EQ.1)GOTO2000
C
C        PRINT TOTALS FOR YARD
C
      WRITE(6,34)
 34   FORMAT('OTOTALS FOR YARD')
      WRITE(6,41)
      WRITE(6,42)((RDBB(J,I),J=1,2),I=1,10)
      WRITE(6,43)NPE,(PEYDB(I),I=1,10)
      WRITE(6,43)NENI,(ENIYDB(I),I=1,10)
      WRITE(6,11)
 11   FORMAT('0','LEVEL',4X,'PE',8X,'ENI',6X,'DENI',6X,'COST',
     2 6X,'NA',8X,'IC'/)
      WRITE(6,12)LREG(1),PEYD(1),ENIYD(1),DENIYD(1),COSTYD(1),
     2 NA(1)
 12   FORMAT(1X,A4,4(1PE10.2),I6)
      DO1092LEV=2,6
      J=IC(LEV)/NAREAS
```

```
      WRITE(6,13)LREG(LEV),PEYD(LEV),ENIYD(LEV),DENIYD(LEV),COSTYD(LEV),
     2 NA(LEV),J
 3    FORMAT(1X,I4,4(1PE10.2),2(I6,4X))
1092  CONTINUE
      WRITE(6,12)LREG(7),PEYD(7),ENIYD(7),DENIYD(7),COSTYD(7),NA(7)
2000  CONTINUE
      NYD(IT)=NYD(IT)+1
C
C        GO TO NEXT YARD
C
      GOTO1000
9999  CONTINUE
C
C        GRAND TOTALS AND PROJECTIONS
C
      WRITE(6,20)
20    FORMAT('1GRAND TOTAL FOR ALL YARDS'/'0',T28,'SAMPLE',T70,
     2 'PROJECTED'/'0',10X,2('# YD',4X,'PE',8X,'ENI',6X,'DENI',6X,
     3 'COST',3X),3X,'# IC')
      DO1091IT=1,8
      WRITE(6,21)(YDTYPE(I,IT),I=1,4)
21    FORMAT('0',4A4/)
      FACTOR=0.
      IF(NYD(IT).NE.0)FACTOR=FLOAT(NUM(IT))/NYD(IT)
      DO1082LEV=1,7
      APE=FACTOR*PEYT(LEV,IT)
      AENI=FACTOR*ENIYT(LEV,IT)
      ADENI=FACTOR*DENIYT(LEV,IT)
      ACOST=FACTOR*COSTYT(LEV,IT)
      IF(LEV.EQ.1.OR.LEV.EQ.7)WRITE(6,22)LREG(LEV),NYD(IT),PEYT(LEV,IT),
     2 ENIYT(LEV,IT),DENIYT(LEV,IT),COSTYT(LEV,IT),NUM(IT),APE,
     3 AENI,ADENI,ACOST
22    FORMAT(4X,A4,I6,4(1PE10.2),I6,4(1PE10.2))
      IF(LEV.NE.1.AND.LEV.NE.7)WRITE(6,23)LREG(LEV),NYD(IT),
     2 PEYT(LEV,IT),ENIYT(LEV,IT),DENIYT(LEV,IT),COSTYT(LEV,IT),
     3 NUM(IT),APE,AENI,ADENI,ACOST,NYDC(LEV,IT)
23    FORMAT(6X,I2,I6,4(1PE10.2),I6,4(1PE10.2),I6)
1082  CONTINUE
1091  CONTINUE
      NYH=0
      NUMH=0
      DO3000LEV=1,7
      NYDCH(LEV)=0
      HPE(LEV)=0.
      HENI(LEV)=0.
      HDENI(LEV)=0.
      HCOST(LEV)=0.
3000  CONTINUE
      DO3001IT=1,3
      NYH=NYH+NYD(IT)
      NUMH=NUMH+NUM(IT)
      DO3001LEV=1,7
      NYDCH(LEV)=NYDCH(LEV)+NYDC(LEV,IT)
      HPE(LEV)=HPE(LEV)+PEYT(LEV,IT)
      HENI(LEV)=HENI(LEV)+ENIYT(LEV,IT)
      HDENI(LEV)=HDENI(LEV)+DENIYT(LEV,IT)
      HCOST(LEV)=HCOST(LEV)+COSTYT(LEV,IT)
3001  CONTINUE
```

```
      WRITE(6,50)
50    FORMAT('OHUMP YARDS--ALL VOLUMES'/)
      FACTOR=0.
      IF(NYH.NE.0)FACTOR=FLOAT(NUMH)/NYH
      DO3002LEV=1,7
      APE=FACTOR*HPE(LEV)
      AENI=FACTOR*HENI(LEV)
      ADENI=FACTOR*HDENI(LEV)
      ACOST=FACTOR*HCOST(LEV)
      IF(LEV.EQ.1.OR.LEV.EQ.7)WRITE(6,22)LREG(LEV),NYH,HPE(LEV),
     2 HENI(LEV),HDENI(LEV),HCOST(LEV),NUMH,APE,
     3 AENI,ADENI,ACOST
      IF(LEV.NE.1.AND.LEV.NE.7)WRITE(6,23)LREG(LEV),NYH,
     2 HPE(LEV),HENI(LEV),HDENI(LEV),HCOST(LEV),
     3 NUMH,APE,AENI,ADENI,ACOST,NYDCH(LEV)
3002  CONTINUE
      NYF=0
      NUMF=0
      DO3100LEV=1,7
      NYDCH(LEV)=0
      HPE(LEV)=0.
      HENI(LEV)=0.
      HDENI(LEV)=0.
      HCOST(LEV)=0.
3100  CONTINUE
      DO3101IT=4,6
      NYF=NYF+NYD(IT)
      NUMF=NUMF+NUM(IT)
      DO3101LEV=1,7
      NYDCH(LEV)=NYDCH(LEV)+NYDC(LEV,IT)
      HPE(LEV)=HPE(LEV)+PEYT(LEV,IT)
      HENI(LEV)=HENI(LEV)+ENIYT(LEV,IT)
      HDENI(LEV)=HDENI(LEV)+DENIYT(LEV,IT)
      HCOST(LEV)=HCOST(LEV)+COSTYT(LEV,IT)
3101  CONTINUE
      WRITE(6,51)
51    FORMAT('OFLAT YARDS--ALL VOLUMES'/)
      FACTOR=0.
      IF(NYF.NE.0)FACTOR=FLOAT(NUMF)/NYF
      DO3102LEV=1,7
      APE=FACTOR*HPE(LEV)
      AENI=FACTOR*HENI(LEV)
      ADENI=FACTOR*HDENI(LEV)
      ACOST=FACTOR*HCOST(LEV)
      IF(LEV.EQ.1.OR.LEV.EQ.7)WRITE(6,22)LREG(LEV),NYF,HPE(LEV),
     2 HENI(LEV),HDENI(LEV),HCOST(LEV),NUMF,APE,
     3 AENI,ADENI,ACOST
      IF(LEV.NE.1.AND.LEV.NE.7)WRITE(6,23)LREG(LEV),NYF,
     2 HPE(LEV),HENI(LEV),HDENI(LEV),HCOST(LEV),
     3 NUMF,APE,AENI,ADENI,ACOST,NYDCH(LEV)
3102  CONTINUE
      WRITE(6,41)
      WRITE(6,42)((RDBB(J,I),J=1,2),I=1,10)
      DO4004IT=1,8
      WRITE(6,21)(YDTYPE(I,IT),I=1,4)
      WRITE(6,44)
44    FORMAT(' SAMPLE')
      WRITE(6,43)NPE,(PETDB(I,IT),I=1,10)
```

```
      WRITE(6,43)NENI,(ENITDB(I,IT),I=1,10)
      FACTOR=0.
      IF(NYD(IT).NE.0)FACTOR=FLOAT(NUM(IT))/NYD(IT)
      DO4005I=1,10
      PEDB(I)=PETDB(I,IT)*FACTOR
      ENIDB(I)=ENITDB(I,IT)*FACTOR
4005  CONTINUE
      WRITE(6,45)
45    FORMAT(' PROJECTED')
      WRITE(6,43)NPE,(PEDB(I),I=1,10)
      WRITE(6,43)NENI,(ENIDB(I),I=1,10)
4004  CONTINUE
      DO4006I=1,10
      PEDB(I)=0.
      ENIDB(I)=0.
4006  CONTINUE
      DO4007IT=1,3
      DO4007I=1,10
      PEDB(I)=PEDB(I)+PETDB(I,IT)
      ENIDB(I)=ENIDB(I)+ENITDB(I,IT)
4007  CONTINUE
      WRITE(6,50)
      WRITE(6,44)
      WRITE(6,43)NPE,(PEDB(I),I=1,10)
      WRITE(6,43)NENI,(ENIDB(I),I=1,10)
      FACTOR=0.
      IF(NYH.NE.0)FACTOR=FLOAT(NUMH)/NYH
      DO4008I=1,10
      PEDB(I)=PEDB(I)*FACTOR
      ENIDB(I)=ENIDB(I)*FACTOR
4008  CONTINUE
      WRITE(6,45)
      WRITE(6,43)NPE,(PEDB(I),I=1,10)
      WRITE(6,43)NENI,(ENIDB(I),I=1,10)
      DO4009I=1,10
      PEDB(I)=0.
      ENIDB(I)=0.
4009  CONTINUE
      DO4010IT=4,6
      DO4010I=1,10
      PEDB(I)=PEDB(I)+PETDB(I,IT)
      ENIDB(I)=ENIDB(I)+ENITDB(I,IT)
4010  CONTINUE
      WRITE(6,51)
      WRITE(6,44)
      WRITE(6,43)NPE,(PEDB(I),I=1,10)
      WRITE(6,43)NENI,(ENIDB(I),I=1,10)
      FACTOR=0.
      IF(NYF.NE.0)FACTOR=FLOAT(NUMF)/NYF
      DO4011I=1,10
      PEDB(I)=PEDB(I)*FACTOR
      ENIDB(I)=ENIDB(I)*FACTOR
4011  CONTINUE
      WRITE(6,45)
      WRITE(6,43)NPE,(PEDB(I),I=1,10)
      WRITE(6,43)NENI,(ENIDB(I),I=1,10)
      STOP
      END
```

4.2 Function SUM (AL1, AL2)

ARGUMENTS:	AL1	noise level 1
	AL2	noise level 2

PURPOSE: To compute the composite noise level of AL1 and AL2.

The flow chart for this function is shown in Figure 6, and the computer code is given in Table 4.

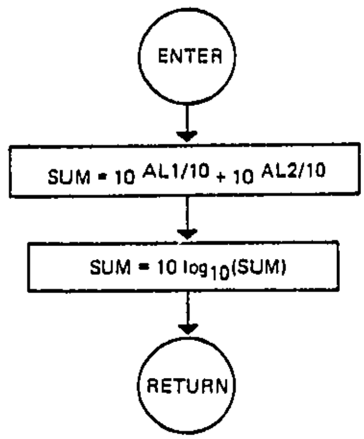


Figure 6. Function SUM Flow Chart

```
      ADD 2 NOISE LEVELS LOGARITHMIICALLY

      FUNCTIONSUM(AL1,AL2)
      SUM=10.**(AL1/10.)+10.**(AL2/10.)
      SUM=10.*ALOG10(SUM)
      RETURN
      END
```

Table 4. Function SUM Computer Code

4.3 Function DIFF (AL1, AL2)

ARGUMENTS:	AL1	noise level 1
	AL2	noise level 2

PURPOSE: To compute the noise level, which when combined with AL2, gives the noise level AL1.

The flow chart for this function is shown in Figure 7, and the computer code is listed in Table 5.

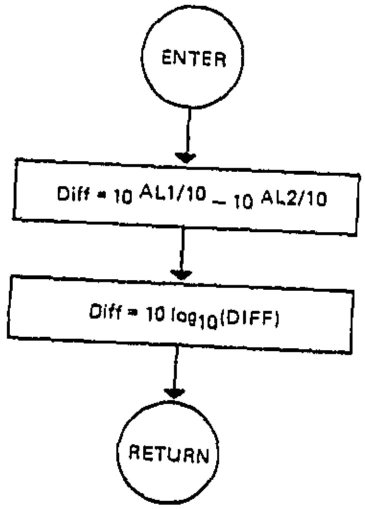


Figure 7. Function DIFF Flow Chart .

```
   SUBTRACT 2ND NOISE LEVEL FROM 1ST NOISE LEVEL

FUNCTIONDIFF(AL1,AL2)
DIFF=10.**(AL1/10.)-10.**(AL2/10.)
DIFF=10.*ALOG10(DIFF)
RETURN
END
```

Table 5. Function DIFF Computer Code

4.4 Function HEIGHT (IS)

ARGUMENTS: IS noise source

PURPOSE: To compute the minimum wall height necessary to block line of sight from property line to the noise source to determine whether there is any diffraction effect from the wall. If the distance from the property line to the wall is less than 50 ft, it is set to 50 ft.

DESCRIPTION: With the notation in Figure 11, using similar triangles, we obtain the relation

$$\frac{\text{HEIGHT} - 5}{\text{DB}} = \frac{\text{HS} - 5}{\text{DN}}$$

or

$$\text{HEIGHT} = (\text{HS}-5)\,\frac{\text{DB}}{\text{DN}} + 5$$

Diffraction effects are considered to be negligible when the wall height is less than the minimum wall height (HEIGHT). The property line, for the purposes of diffraction computation, is assumed to be at least 50 ft from the wall (i.e., it cannot be located right behind the wall).

DATA: The input data required consist of heights for each source type. These constants are listed in Table 6.

The geometrical relationships are shown in figure 8, the subroutine flow chart is shown in Figure 9, and the computer code is listed in Table 7.

RECEIVER HEIGHT 5 FT

IS	HS(IS)	IS	HS(IS)	IS	(HS(IS)
1	10	6	10	11	8
2	10	7	10	12	8
3	10	8	3	13	10
4	10	9	1	14	8
5	10	10	1	15	15

Table 6. Values of HS(IS) for Each Source (IS)

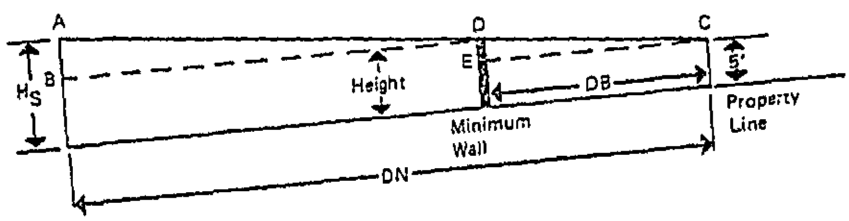


Figure 8. Geometry of wall, source and receiver

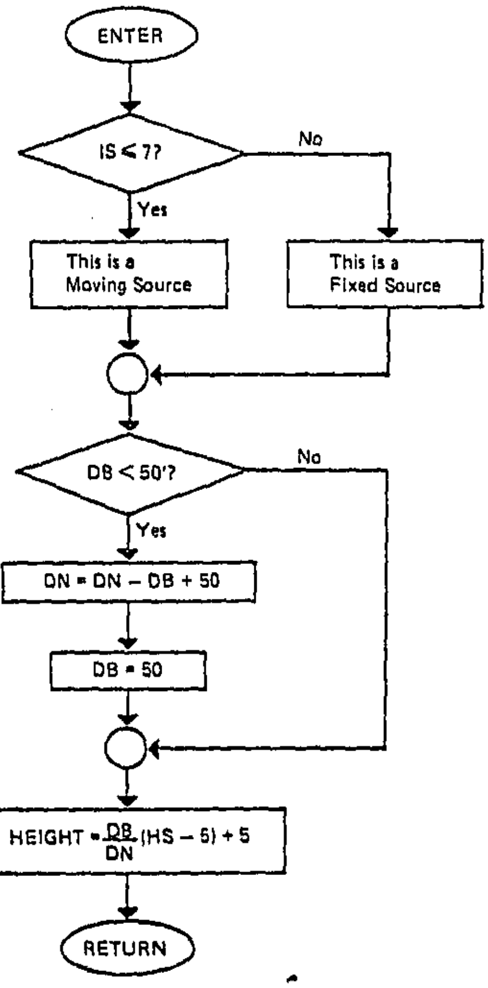


Figure 9. Function HEIGHT Flow Chart

```
C     COMPUTE HEIGHT OF WALL TO BLOCK LINE OF SIGHT FOR EACH SOURCE
C
      FUNCTIONHEIGHT(IS)
      COMMON/B1/DB,DNMOV,DNFIX,ATTIND,ALENG,WIDTH,IWALL
      DIMENSIONHS(15)
      DATAHS/7*10.,3.,2*1.,2*8.,10.,8.,15./
      DBU=DB
      IF(IS.LE.7)DNU=DNMOV
      IF(IS.GT.7)DNU=DNFIX
C
C     IF DISTANCE OF WALL TO PROPERTY LINE < 50FT, SET TO 50FT
C
      IF(DB.LT.50.)DNU=DNU-DB+50.
      IF(DB.LT.50.)DBU=50.
      HEIGHT=DBU/DNU*(HS(IS)-5.)+5.
      RETURN
      END
```

Table 7. Function HEIGHT Computer Code

4.5 Function WATT (IS)

ARGUMENTS: IS noise source

PURPOSE: To compute the excess noise attenuation for noise source IS from the wall.

DESCRIPTION: The excess noise attenuation due to the erection of a barrier is computed using Maekawa's equation. With the notation in Figure 14, if DB <50 ft, DB is set to 50 ft.

δ = A+B−C, the path length difference. The wall attenuation is given by

$$WATT = 5+10 \log_{10} \frac{\sqrt{2\pi N}}{\tanh \sqrt{2\pi N}}$$

where

$$N = \frac{2\delta}{\lambda}$$

λ = wave length of noise source

$$= \frac{c}{f} = \frac{1117}{f}$$

where c = speed of sound in air

f = frequency of noise source = FREQ(IS)

DATA: The input data consist of the predominant sound frequency for each type of noise source, as listed in Table 8.

The geometrical relationships are shown in Figure 10. The calculation flow chart is given in Figure 11, and the corresponding computer code is listed in Table 9.

IS	FREQ(IS)	IS	FREQ(IS)	IS	FREQ(IS)
1	550	6	550	11	550
2	550	7	550	12	550
3	550	8	1250	13	125
4	550	9	2500	14	1250
5	550	10	2500	15	550

Table 8. Values of FREQ(IS) for Each Source Type

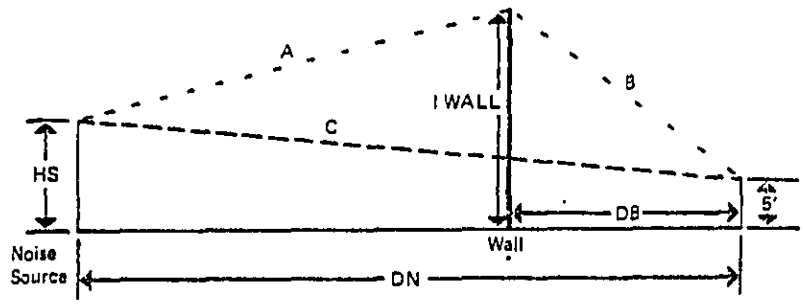


Figure 10. Geometry for barrier attenuation calculations

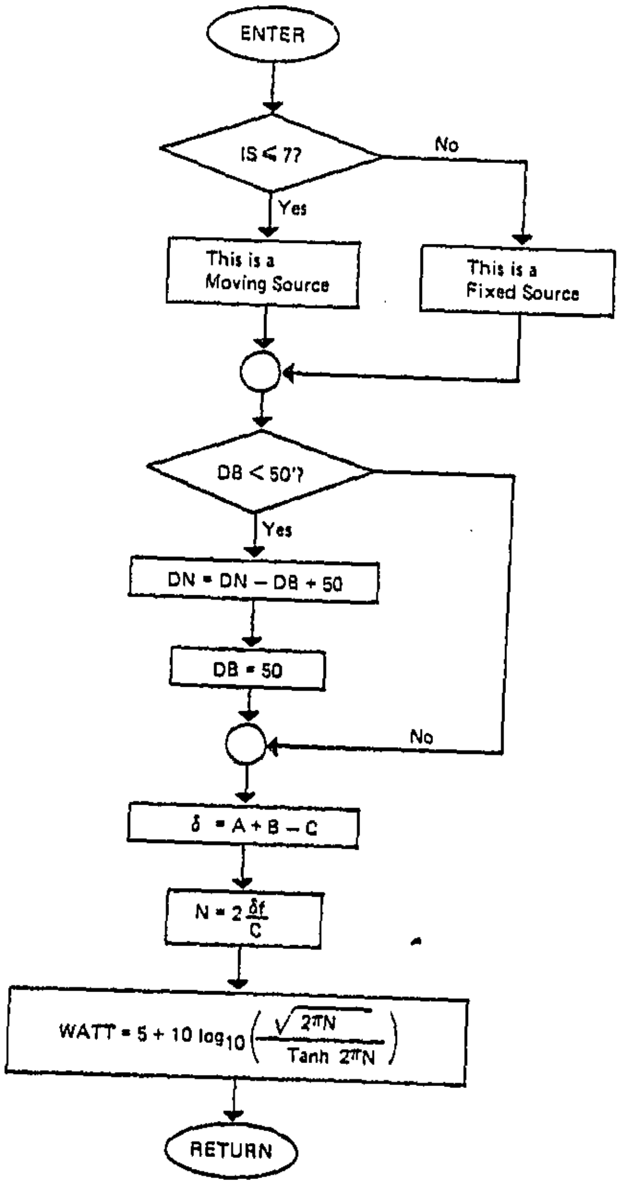


Figure 11, Function WATT Flow Chart

```
      COMPUTE BARRIER ATTENUATION FOR EACH SOURCE
   FUNCTIONWATT(IS)
   COMMON/B1/DB,DNMOV,DNFIX,ATTIND,ALENG,WIDTH,IWALL
   DIMENSIONHS(15),FREQ(15)
   DATAHS/7*10.,3.,2*1.,2*8.,10.,8.,15./
   DATAFREQ/7*550.,1250.,2*2500.,2*550.,125.,1250.,550./
   DBU=DB
   IF(IS.LE.7)DNU=DNMOV
   IF(IS.GT.7)DNU=DNFIX

      IF DISTANCE OF WALL TO PROPERTY LINE < 50FT, SET TO 50FT

   IF(DB.LT.50.)DNU=DNU-DB+50.
   IF(DB.LT.50.)DBU=50.
   A=SQRT((IWALL-HS(IS))**2+(DNU-DBU)**2)
   B=SQRT((IWALL-5.)**2+DBU**2)
   C=SQRT((HS(IS)-5.)**2+DNU**2)
   DELTA=A+B-C
   IF(DELTA.LE.0.)WATT=5.
   IF(DELTA.LE.0.)RETURN
   FREN=2.*DELTA*FREQ(IS)/1117.
   Q=SQRT(2.*3.141592654*FREN)
   WATT=5.+10.*ALOG10(Q/TANH(Q))
   RETURN
   END
```

Table 9. Function WATT Computer Code

4.6 Subroutine LEVELS (LEV)

ARGUMENTS: LEV level

(i.e., 1 = baseline

2-6 = regulation levels 1-5 respectively

7 = maximum height wall level)

PURPOSE: To compute L_{dn}, L_{eq}, L_{max} for each noise source at the property line after excess barrier attenuation has been subtracted.

The flow chart for this calculation subroutine is shown in Figure 12, and the computer code is listed in Table 10.

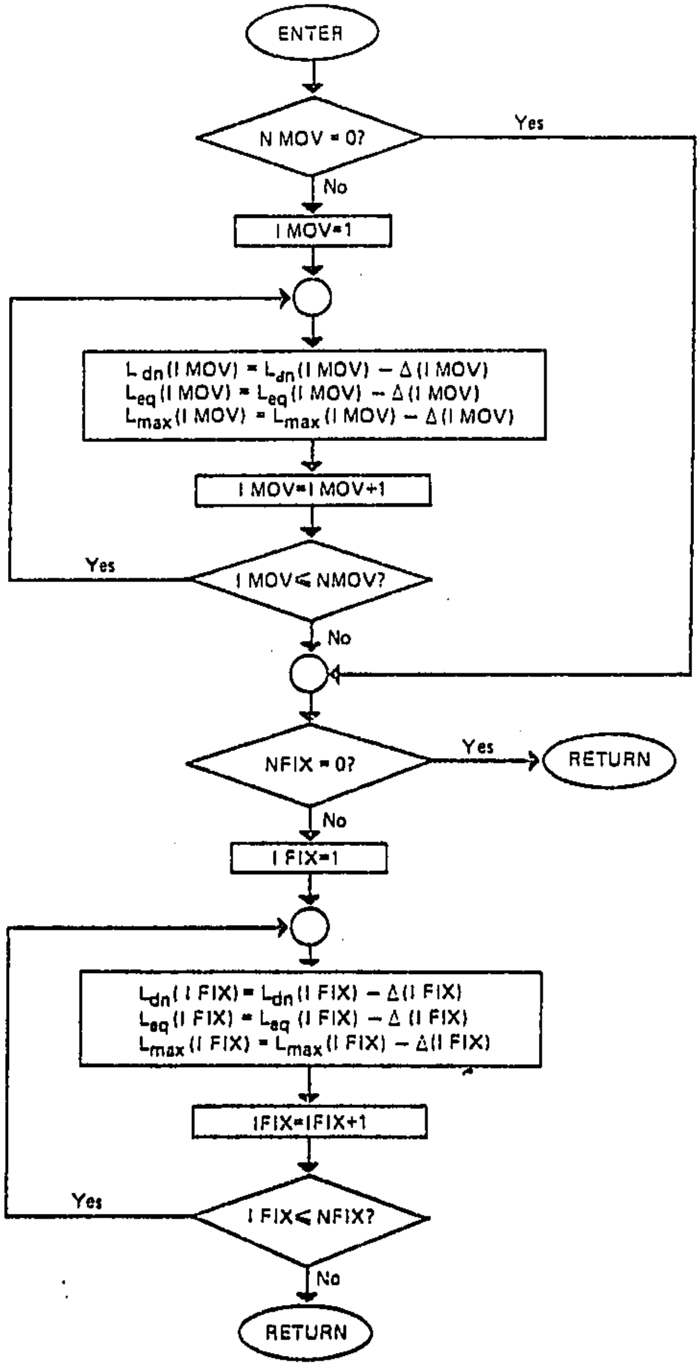


Figure 12. Subroutine LEVELS Flow Chart

```
C         COMPUTE LDN, LEQ, LMAX AT PROPERTY LINE WITH WALL ATTENUATION
      SUBROUTINELEVELS(LEV)
      COMMON/B2/ATTM(10),ATTF(10),SMDN(7,10),SMEQ(7,10),SMMAX(7,10),
     2 SFDN(7,10),SFEQ(7,10),SFMAX(7,10),NMOV,NFIX
      IF(NMOV.EQ.0)GOTO1001
      DO1002IMOV=1,NMOV
      SMDN(LEV,IMOV)=SMDN(1,IMOV)-ATTM(IMOV)
      SMEQ(LEV,IMOV)=SMEQ(1,IMOV)-ATTM(IMOV)
      SMMAX(LEV,IMOV)=SMMAX(1,IMOV)-ATTM(IMOV)
 1002 CONTINUE
 1001 CONTINUE
      IF(NFIX.EQ.0)RETURN
      DO1003IFIX=1,NFIX
      SFDN(LEV,IFIX)=SFDN(1,IFIX)-ATTF(IFIX)
      SFEQ(LEV,IFIX)=SFEQ(1,IFIX)-ATTF(IFIX)
      SFMAX(LEV,IFIX)=SFMAX(1,IFIX)-ATTF(IFIX)
 1003 CONTINUE
      RETURN
      END
```

Table 10. Subroutine LEVELS Computer Code

4.7 Subroutine LEV100 (IS,IT)

ARGUMENTS: IS noise source

IT yard type

PURPOSE: To compute L_{dn}, L_{eq}, L_{max} of noise source at 100 ft.

DESCRIPTION: Using the general noise source equation for noise sources 1-12, at 100 ft

$$L_{dn} = SEL - 49.4 + 10 \log_{10} \left\{ \frac{(N_d + 10\ N_n)\ \ N_p N_s P_e N_l}{N_v} \right\}$$

$$L_{eq} = SEL - 47.3 + 10 \log_{10} \left\{ \frac{\text{Max}\ (N_d, N_n)\ N_p N_s P_e N_l}{N_v} \right\}$$

$$L_{max} = L_m + 10 \log_{10} (N_l)$$

where
SEL = single event noise level
L_m = maximum level
N_d = number of daytime events
N_n = number of nighttime events
N_p = number of passbys
N_s = number of events per source
P_e = event probability
N_l = number of sources in group
N_v = number of virtual sources

For noise sources 13-15 at 100 ft

$$L_{dn} = SEL - 13.8 + 10 \log_{10} [H_1U_1 + H_2U_2 + H_3U_3]$$

$$L_{eq} = SEL + 10 \log_{10} [\max (U_1, U_2, U_3)]$$

$$L_{max} = L_m + 10 \log_{10} [\max (U_1, U_2, U_3)]$$

where H_1, H_2, H_3 = number of hours source operating first, second, third shifts respectively

U_1, U_2, U_3 = number of sources operating first, second, third shifts respectively

For flat classification yards, there are four locations for car impacts (IS = 8), instead of two as in the other yards. So the noise level of each source is reduced by 3 dB. For industrial and small industrial yards, inbound trains (IS = 5) have only one locomotive instead of 3 as in the other yards. So the noise level is scaled down by 4.771 dB.

DATA: The required input data is listed in Table 11.

IS	SEL	L_m	N_p	N_s	P_e	N_1	N_v
1	95	90	2	1	1	1	1
2	94	90	2	1	1	1	1
3	94	90	2	1	1	1	1
4	94	90	1	1	1	1	1
5	95	90	1	1	1	3	1
6	95	90	1	1	1	3	1
7	95	90	1	1	1	1	1
8	95	99	1	1	0.5	1	2
9	108	111	1	2	0.5	1	1
10	90	93	1	1	0.85	1	1
11	106.5	82	1	4	1	1	1
12	94.5	83	1	2	1	1	1
13	66	66	1	1	1	1	1
14	67	73	1	1	1	1	1
15	75	78	1	1	1	1	1

Table 11. Values for SEL, L_m, N_p, N_s, P_e, N_1, N_v. for Each Source Type

The flow chart for this subroutine is shown in Figure 13.

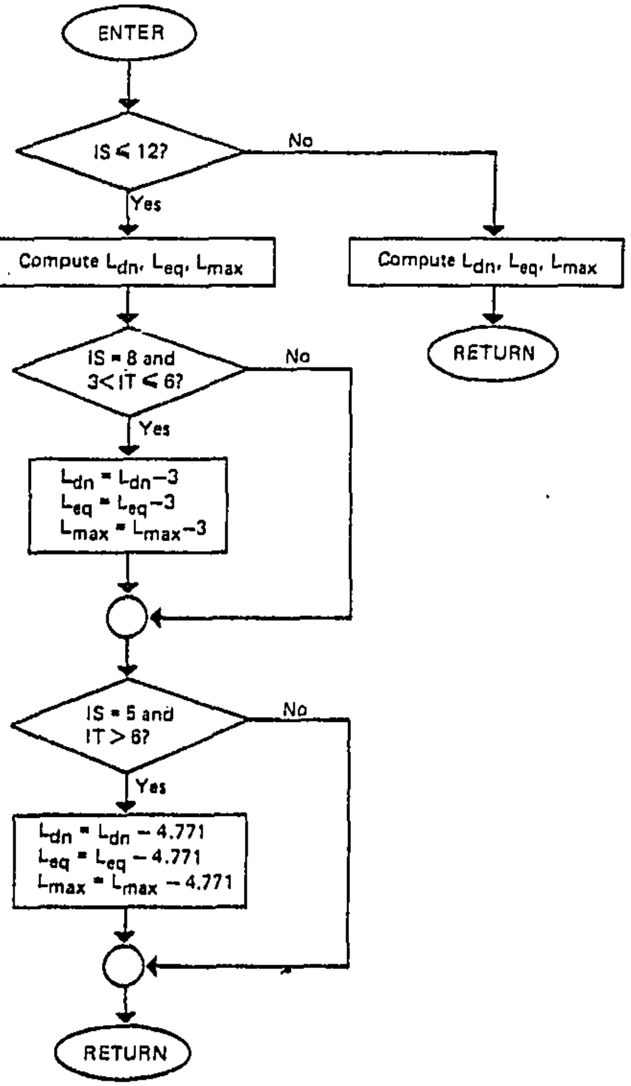


Figure 13. Subroutine LEV100 Flow Chart

```
C
C         COMPUTE BASELINE LDN, LEQ, LMAX FOR EACH SOURCE AT 100FT
C
      SUBROUTINELEV100(IS,IT)
      COMMON/B3/SLDN,SEQ,SMAX,ED,EN,H1,H2,H3,U1,U2,U3
      DIMENSIONS100(15),SM(15),NP(15),NES(15),EP(15),NL(15),
     2 NV(15)
      DATAS100/95.,3*94.,3*95.,94.,108.,90.,106.5,94.5,66.,
     2 67.,75./
      DATASM/7*90.,99.,111.,93.,83.,82.,66.,
     2 73.,78./
      DATANP/4*2,11*1/
      DATANES/8*1,2,1,4,2,3*1/
      DATAEP/7*1.,2*.5,.85,5*1./
      DATANL/4*1,2*3,9*1/
      DATANV/7*1,2,7*1/
      SLDN=0.
      SEQ=0.
      SMAX=0.
      IF(IS.GT.12)GOTO1001
      IF(ED.LE.0..AND.EN.LE.0.)RETURN
      SLDN=S100(IS)-49.4+10.*ALOG10((ED+10.*EN)*NP(IS)*NES(IS)*
     2 EP(IS)*NL(IS)/NV(IS))
      SEQ=S100(IS)-47.3+10.*ALOG10(AMAX1(ED,EN)*NP(IS)*NES(IS)*
     2 EP(IS)*NL(IS)/NV(IS))
      SMAX=SM(IS)+10.*ALOG10(FLOAT(NL(IS)))
      IF(IT.GT.6.OR.IT.LE.3.OR.IS.NE.8)GOTO1002
      SLDN=SLDN-3.01
      SEQ=SEQ-3.01
      SMAX=SMAX-3.01
      RETURN
 1002 CONTINUE
      IF(IS.NE.5.OR.IT.LE.6)RETURN
      SLDN=SLDN-4.771
      SEQ=SEQ-4.771
      SMAX=SMAX-4.771
      RETURN
 1001 CONTINUE
      IF((H1.LE.0..OR.U1.LE.0.).AND.(H2.LE.0..OR.U2.LE.0.).AND.
     2 (H3.LE.0..OR.U2.LE.0.))RETURN
      SLDN=S100(IS)-13.8+10.*ALOG10(H1*U1+H2*U2+H3*U3*10.)
      UX=AMAX1(U1,U2,U3)
      SEQ=S100(IS)+10.*ALOG10(UX)
      SMAX=SM(IS)+10.*ALOG10(UX)
      RETURN
      END
```

Table 12. Subroutine LEV100 Computer Code

4.8 Subroutine LEVBD (IS)

ARGUMENTS: IS noise source

PURPOSE: To compute L_{dn}, L_{eq}, L_{max} at property line, taking into effect point or line source attenuation, excess air and ground attenuation, and excess attenuation due to intervening industrial structures.

DESCRIPTION:

$$\Delta = \Delta_I + \alpha_g \text{ (DN-100)} + 10 \text{ N } \log_{10} \frac{DN}{100}$$

where Δ = total attenuation

Δ_I = attenuation due to intervening industrial area

α_g = excess air and ground attenuation

DN = distance from source to property line

N = noise attenuation coefficient

$= \begin{cases} 1 \text{ for moving sources} \\ 2 \text{ for fixed sources} \end{cases}$

In the case of master retarders, if L_{max} > 83 dB at property line, L_{max} is set to 83 dB at property line. L_{dn} and L_{eq} are adjusted to reflect that fact.

DATA: The required input data is listed in Table 13.

IS	ALPHAG(IS)	IS	ALPHAG(IS)	IS	ALPHAG(IS)
1	0.001	6	0.002	11	0.002
2	0.001	7	0.002	12	0.002
3	0.001	8	0.005	13	0.0025
4	0.001	9	0.01	14	0.0035
5	0.002	10	0.01	15	0.002

Table 13. Values of ALPHAG(IS) for Each Source Type

The flowchart for LEVBD is shown in Figure 14, and the computer code is listed in Table 14.

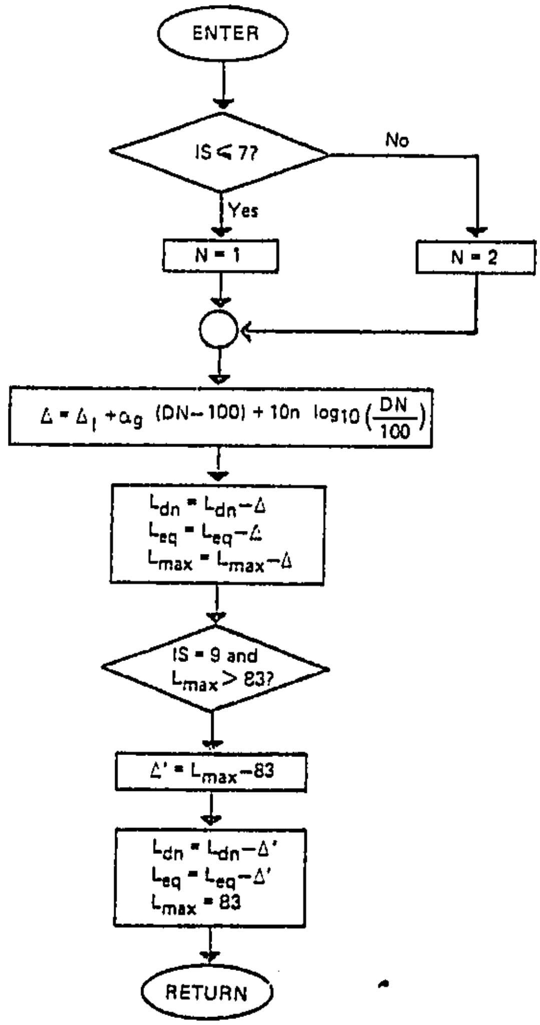


Figure 14. Subroutine LEVBD Flow Chart

```
      COMPUTE BASELINE LDN, LEQ, LMAX AT PROPERTY LINE FOR EACH SOURCE

   SUBROUTINELEVBD(IS)
   COMMON/B1/DB,DNMOV,DNFIX,ATTIND,ALENG,WIDTH,IWALL
   COMMON/B3/SLDN,SEQ,SMAX,ED,EN,H1,H2,H3,U1,U2,U3
   DIMENSIONALPHAG(15)
   DATAALPHAG/4*.001,3*.002,.005,2*.01,2*.002,.0025,
  2 .0035,.002/
   IF(SLDN.LE.0.)RETURN
   IF(IS.LE.7)DN=DNMOV
   IF(IS.LE.7)NATT=1
   IF(IS.GT.7)DN=DNFIX
   IF(IS.GT.7)NATT=2
   ATT=ATTIND+ALPHAG(IS)*(DN-100.)+10.*NATT*ALOG10(DN/100.)
   SLDN=SLDN-ATT
   SEQ=SEQ-ATT
   SMAX=SMAX-ATT
   IF(IS.NE.9)RETURN
   IF(SMAX.LE.83.)RETURN

      IF MR > 83DB AT PROPERTY LINE, SET TO 83DB

   ATT=SMAX-83.
   SLDN=SLDN-ATT
   SEQ=SEQ-ATT
   SMAX=83.
   RETURN
   END
```

Table 14. Subroutine LEVBD Computer Code

4.9 Subroutine NEWTON (D,NATT)

ARGUMENTS:	D	On input: initial distance to start iteration On output: distance from source to the Δ noise contour
	NATT	Noise alternative coefficient 1 for moving sources 2 for fixed sources
PURPOSE	To compute the distance from noise source to the noise contours Δ(d) by using Newton's method of finding roots to algebraic equations by iteration.	
DESCRIPTION:	To find the root of $F(d) = 0$ using Newton's method, approximate d by	

$$d = d_0 - \frac{F(d_0)}{F'(d_0)}$$

and iterate. Stop when $d-d_0 < 1$.

The flow chart for NEWTON is shown in Figure 15, and the computer code is listed in Table 15.

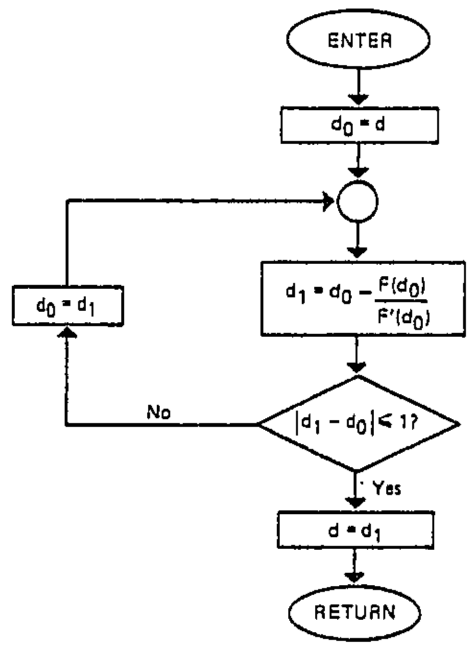


Figure 15. Subroutine NEWTON Flow Chart

```
      FIND ROOT OF ALGEBRAIC EQUATION USING NEWTON'S METHOD
      SUBROUTINENEWTON(D,NATT)
      D0=D
1001  CONTINUE
      D1=D0-FFP(D0,NATT)
      X=ABS(D1-D0)
      IF(X.GT.1.)D0=D1
      IF(X.GT.1.)GOTO1001
      D=D1
      RETURN
      END
```

Table 15. Subroutine NEWTON Computer Code

4.10 Function FFP(D,NATT)

ARGUMENTS: D — Distance from source to noise contour Δ

NATT — Noise attenuation coefficient
- 1 for moving sources
- 2 for fixed sources

PURPOSE:

$$FFP(d) = \frac{F(d)}{F'(d)}$$

is used in subroutine NEWTON.

DESCRIPTION: Given attenuation Δ, we want to find d such that F(d) = 0. FFP computes the ratio

$$\frac{F(d)}{F'(d)}$$

to be used in NEWTON to compute d(Δ).

$$F(d) = 10n \log_{10} \left(\frac{d}{DN}\right) + \alpha\,(d-DN) - \Delta$$

$$F'(d) = \frac{10n}{(\log 10)d} + \alpha$$

where
- n = noise attenuation coefficient = NATT
- α = excess air and ground attenuation
- DN = distance from noise source to property line
- Δ = total noise attenuation
- d = distance from noise source to noise contour Δ

DATA: The required input data are listed in Table 16.

	α
moving sources	0.002
fixed sources	0.005

Table 16. Values for α for Source Groups

The flow chart is shown in Figure 16, and the computer code is listed in Table 17.

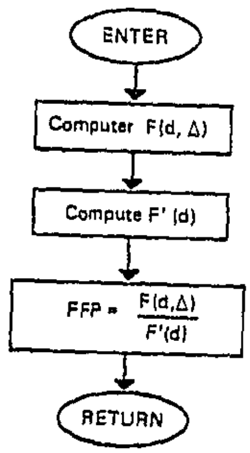


Figure 16. Function FFP Flow Chart

```
C     NOISE ATTENUATION FUNCTION (OF DISTANCE) FOR NEWTON
C
      FUNCTIONFFP(D,NATT)
      COMMON/B6/DN,AF,ATT
      F=10.*NATT*ALOG10(D/DN)+AF*(D-DN)-ATT
      FP=10.*NATT/ALOG(10.)/D+AF
      FFP=F/FP
      RETURN
      END
```

Table 17. Function FFP Computer Code

4.11 Function AREA (NATT)

ARGUMENTS: NATT noise attenuation coefficient
{1 for moving sources
{2 for fixed sources

PURPOSE: To compute the area between two noise contours.

DESCRIPTION: For moving sources, the area of impact is rectangular. See Figure 24. For fixed sources, the area is a section of an annulus. See Figure 25

$$\text{area } BB'CC = (\text{sector } ABC - \Delta ABC) - (\text{sector } AB'C' - \Delta AB'C')$$

$$= {d_2}^2 \cos^{-1}\left(\frac{DN}{d_2}\right) - DN\sqrt{d_2^2 - DN^2}$$

$$- \left[{d_1}^2 \cos^{-1}\left(\frac{DN}{d_1}\right) - DN\sqrt{d_1^2 - DN^2}\right]$$

Diagrams of the impact areas are shown in Figures 17 and 18. The calculation flow chart is shown in Figure 19, and the computer code is listed in Table 18.

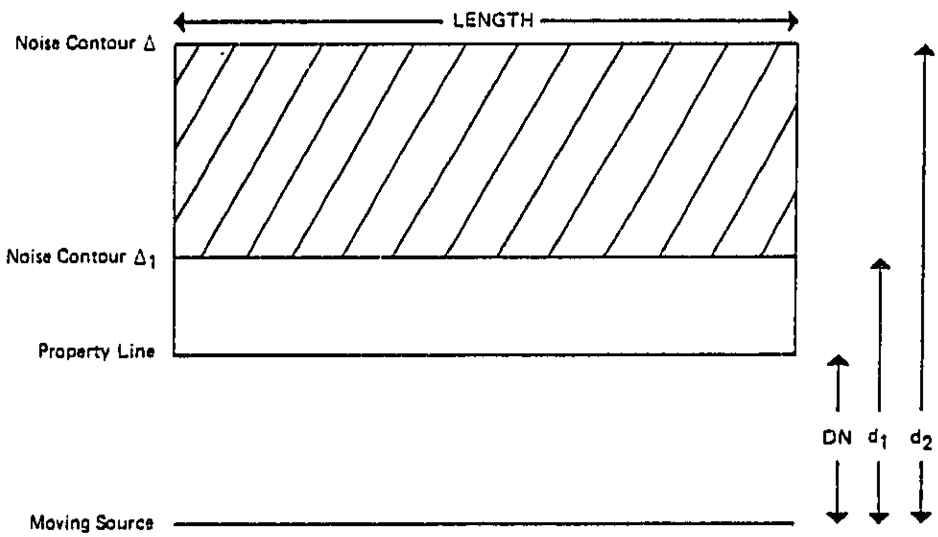


Figure 17. Noise contours for moving sources

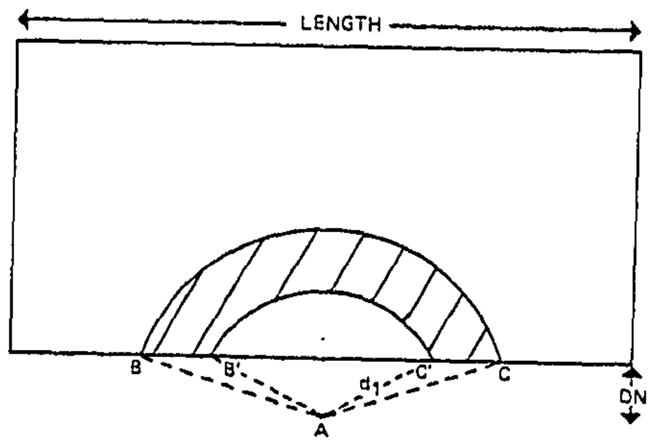


Figure 18. Noise contours for fixed sources

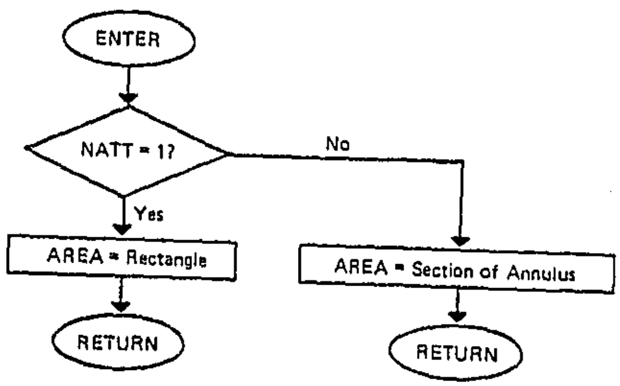


Figure 19. Function AREA Flow Chart

```
C
C        AREA INSIDE DB BAND
C
      FUNCTIONAREA(NATT)
      COMMON/B1/DB,DNMOV,DNFIX,ATTIND,ALENG,WIDTH,IWALL
      COMMON/B7/D1,D2
      SEG(D)=D**2*ACOS(DNFIX/D)-DNFIX*SQRT(D**2-DNFIX**2)
      GOTO(1001,1002),NATT
 1001 CONTINUE
C
C        FOR MOVING SOURCES, AREA IS A RECTANGLE
C
      AREA=(D2-D1)*ALENG
      RETURN
 1002 CONTINUE
C
C        FOR FIXED SOURCES, AREA IS PART OF AN ANNULUS
C
      AREA=SEG(D2)-SEG(D1)
      RETURN
      END
```

Table 18. Function AREA Computer Code

4.12 Subroutine IMPACT

ARGUMENTS: None.

PURPOSE: To compute the noise impact (PE, LWP) in 1-dB bands and 3-dB bands from all the noise sources.

DESCRIPTION: Compute the impact from moving and fixed sources separately, using 1-dB bands. Sum these into 3 dB bands for the 3-dB band output.

Total LWP = LWP (moving source) + LWP (fixed source).

Total PE = Max [PE (moving sources), PE (fixed sources)].

ALGORITHM:

Given noise level at property line (L_0), check for noise level at the end of residential region (L_w). L_w is set to be the maximum of L_w and 55. (So, if $L_w < 55$, impact computation stops at 55. If $L_w > 55$, impact computation stops at the boundary of the residential area.)

Take the largest integer smaller than L_0 (L). Compute d (L_0-L) using Newton's method

PE = Population living inside the noise contours L_0,L

$$LWP = \frac{\left(\frac{L_0 + L}{2}\right) - 55}{20} (PE)$$

Let $L_0 = L$

$L = L-1$

Continue until $L < L_w$ (if $L < L_w$, set $L = L_w$).

The flow chart is shown in Figure 20, and the computer code is listed in Table 19.

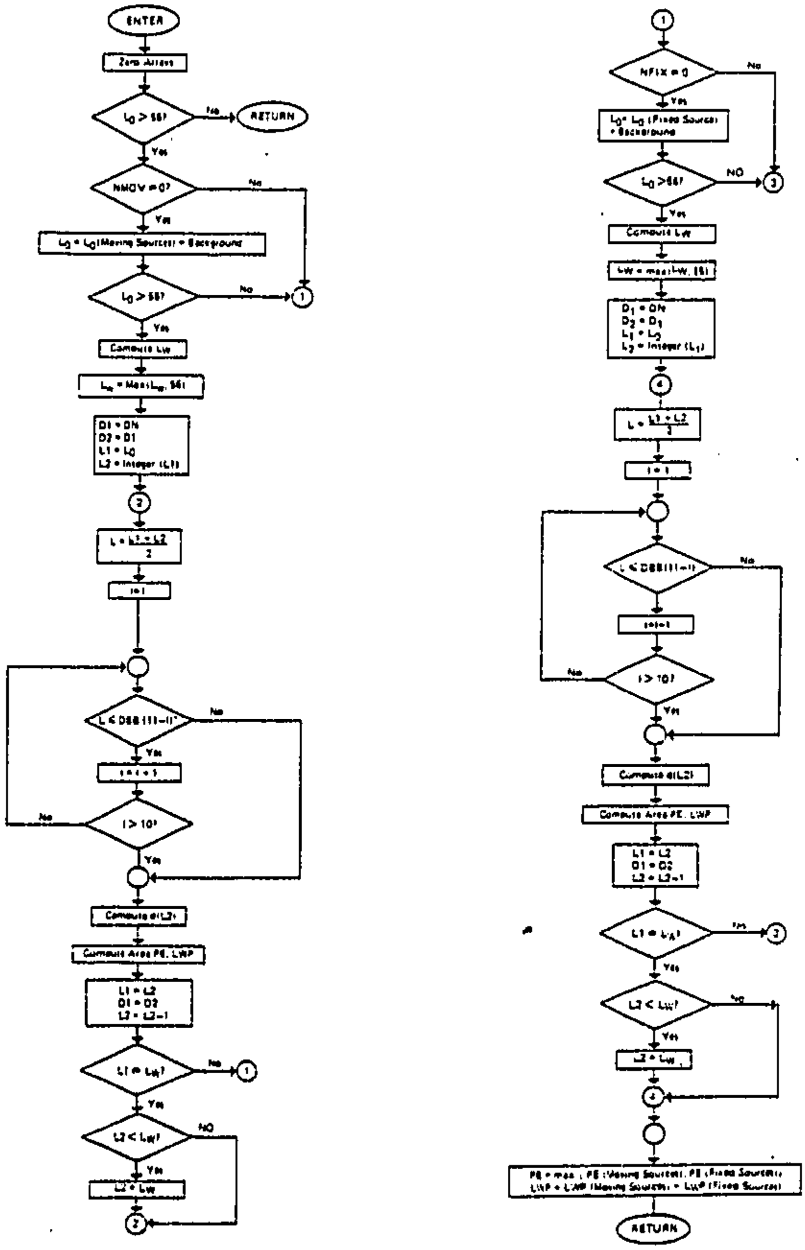


Figure 20. Subroutine IMPACT Flow Chart

```
C
C       COMPUTE H/W NOISE IMPACT
C
      SUBROUTINEIMPACT
      COMMON/B1/DR,DNMOV,DNFIX,ATTIND,ALENG,WIDTH,IWALL
      COMMON/B2/ATTM(10),ATTF(10),SMDN(7,10),SMEQ(7,10),SMMAX(7,10),
     2 SFDN(7,10),SFEQ(7,10),SFMAX(7,10),NMOV,NFIX
      COMMON/B4/PE,ENI,BLALL,ALMS,ALFS,ALBG,POPU
      COMMON/B6/DN,AF,ATT
      COMMON/B7/D1,D2
      COMMON/B8/PEDB(10),ENIDB(10),DBB(10)
      DIMENSIONPEDBM(10),PEDBF(10)
      DATAAGM,AGF/.002,.005/
      PE=0.
      ENI=0.
      PEM=0.
      ENIM=0.
      PEF=0.
      ENIF=0.
      DO1020I=1,10
      PEDBM(I)=0.
      PEDBF(I)=0.
      PEDB(I)=0.
      ENIDB(I)=0.
 1020 CONTINUE
      IF(BLALL.LE.55.)RETURN
      IF(NMOV.EQ.0)GOTO1001
C
C       COMPUTE IMPACT DUE TO MOVING SOURCES
C
      AF=AGM
      DN=DNMOV
      ALO=SUM(ALMS,ALBG)
      IF(ALO.LE.55.)GOTO1001
      ALE=ALMS-10.*ALOG10((DN+WIDTH)/DN)-AF*WIDTH
      ALL=SUM(ALE,ALBG)
      ALL=AMAX1(55.,ALL)
      D1=DN
      D2=D1
      AL1=ALO
      L1=AL1
      AL2=FLOAT(L1)
      IF(AL2.EQ.AL1)GOTO1002
 1003 CONTINUE
      AL=(AL1+AL2)/2.
      DO1021I=1,10
      J=11-I
      IF(AL.GT.DBB(J))GOTO1022
 1021 CONTINUE
 1022 CONTINUE
      ATT=ALMS-DIFF(AL2,ALBG)
      CALLNEWTON(D2,1)
      Z=AREA(1)*POPU/5280.**2
      PEDBM(J)=PEDBM(J)+Z
      PEM=PEM+Z
      Z=Z*(AL-55.)/20.
      ENIDB(J)=ENIDB(J)+Z
      ENIM=ENIM+Z
 1002 CONTINUE
      AL1=AL2
      IF(AL1.EQ.ALL)GOTO1001
      AL2=AL1-1.
      D1=D2
      IF(AL2.LT.ALL)AL2=ALL
      GOTO1003
```

Table 19. Subroutine IMPACT Computer Code

```
      IF(NFIX.EQ.0)GOTO1010
C
C        COMPUTE IMPACT DUE TO FIXED SOURCES
C
      DN=DNFIX
      AF=AGF
      ALO=SUM(ALFS,ALBG)
      IF(ALO.LE.55.)GOTO1010
      ALE=ALFS-20.*ALOG10((DN+WIDTH)/DN)-AF*WIDTH
      ALL=SUM(ALE,ALBG)
      ALL=AMAX1(55.,ALL)
      D1=DN
      D2=D1
      AL1=ALO
      L1=AL1
      AL2=FLOAT(L1)
      IF(AL2.EQ.AL1)GOTO1004
 1005 CONTINUE
      AL=(AL1+AL2)/2.
      DO1023I=1,10
      J=11-I
      IF(AL.GT.DBR(J))GOTO1024
 1023 CONTINUE
 1024 CONTINUE
      ATT=ALFS-DIFF(AL2,ALBG)
      CALLNEWTON(D2,2)
      Z=AREA(2)*POPU/5280.**2
      PEDBF(J)=PEDBF(J)+Z
      PEF=PEF+Z
      Z=Z*(AL-55.)/20.
      ENIDB(J)=ENIDB(J)+Z
      ENIF=ENIF+Z
 1004 CONTINUE
      AL1=AL2
      IF(AL1.EQ.ALL)GOTO1010
      AL2=AL1-1.
      D1=D2
      IF(AL2.LT.ALL)AL2=ALL
      GOTO1005
 1010 CONTINUE
C
C        LWP IS SUM OF LWP OF FIXED AND MOVING SOURCES
C        PE IS MAXIMUM OF PE OF FIXED AND MOVING SOURCES
C
      PE=AMAX1(PEM,PEF)
      ENI=ENIM+ENIF
      DO1025I=1,10
      PEDB(I)=AMAX1(PEDBM(I),PEDBF(I))
 1025 CONTINUE
      RETURN
      END
```

4.13 Subroutine OUTPUT (LEV)

ARGUMENTS: LEV level
(i.e., 1 = baseline
2-6 = regulation levels 1-5 respectively
7 = maximum height wall level)

PURPOSE: To print out a table of noise levels (i.e., L_{dn}, L_{eq}, L_{max} of each noise source at the property line, and PE, LWP, ΔLWP, cost of wall, and wall height for level LEV

DATA: The input data required is listed in Table 20.

IS	ABBREVIATION	DESCRIPTION
1	HS	Hump switcher
2	MS	Makeup switcher
3	IS	Industrial switcher
4	CS	Classification switcher
5	IB	Inbound train
6	OB1	Outbound train (road haul)
7	OB2	Outbound train (local)
8	CI	Car impact
9	MR	Master retarder
10	IR	Inert retarder
11	CT	Crane truck
12	GT	Goat truck
13	IL	Idling locomotive
14	RC	Refrigerator car
15	LT	Load test

Table 20. Noise source code

The flow chart is shown in Figure 21, and the computer code is listed in Table 21.

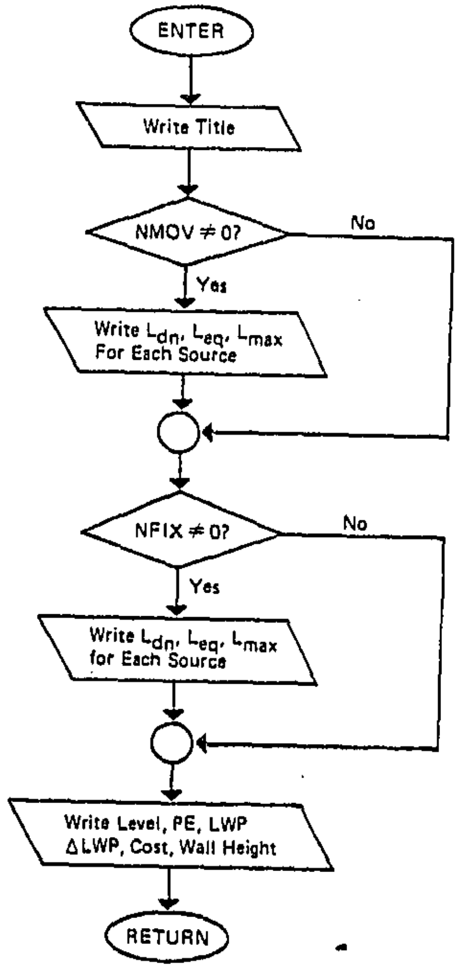


Figure 21. Subroutine OUTPUT Flow Chart

```
C         OUTPUT SUBROUTINE FOR EACH NOISE LEVEL
      SUBROUTINEOUTPUT(LEV)
      COMMON/B2/ATTM(10),ATTF(10),SMDN(7,10),SMEQ(7,10),SMMAX(7,10),
     2 SFDN(7,10),SFEQ(7,10),SFMAX(7,10),NMOV,NFIX
      COMMON/B5/LREG(7),ISM(10),ISF(10),ALEV(7),PEA(7),ENIA(7),
     2 DENIA(7),COSTA(7),IW(7)
      DIMENSIONSOURCE(15)
      DATASOURCE/'HS','MS','IS','CS','IB','OB1','OB2','CI','MR','IR',
     2 'CT','GT','IL','RC','LT'/
      IF(LEV.EQ.1.OR.LEV.EQ.7)WRITE(6,5)LREG(LEV)
5     FORMAT('0',A4)
      IF(LEV.GT.1.AND.LEV.LT.7)WRITE(6,6)LREG(LEV)
      FORMAT('0',I4)
      WRITE(6,1)
      FORMAT('0',T8,'SOURCE',2X,'LDN',3X,'LEQ',3X,'LMAX'/)
      IF(NMOV.EQ.0)GOTO1001
      DO1002IMOV=1,NMOV
      WRITE(6,2)SOURCE(ISM(IMOV)),SMDN(LEV,IMOV),SMEQ(LEV,IMOV),
     2 SMMAX(LEV,IMOV)
      FORMAT(T10,A4,3F6.1)
1002  CONTINUE
 001  CONTINUE
      IF(NFIX.EQ.0)GOTO1003
      DO1004IFIX=1,NFIX
      WRITE(6,2)SOURCE(ISF(IFIX)),SFDN(LEV,IFIX),SFEQ(LEV,IFIX),
     2 SFMAX(LEV,IFIX)
1004  CONTINUE
1003  CONTINUE
      WRITE(6,3)
      FORMAT('0',T8,'LEVEL',4X,'PE',8X,'ENI',6X,'DENI',6X,'COST',
     2 6X,'WALL'/)
      WRITE(6,4)ALEV(LEV),PEA(LEV),ENIA(LEV),DENIA(LEV),COSTA(LEV),
     2 IW(LEV)
4     FORMAT(T8,F5.1,4(1PE10.2),I6)
      RETURN
      END
```

Table 21. Subroutine OUTPUT Computer Code

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5.0 INTERPRETATION OF SAMPLE OUTPUT

The control terms and constants which direct the calculation procedures for the sample railyards are listed in Table 22. The variable input data for an example railyard is shown in Table 23. The resulting data output for the example yard is listed in Table 24. The grand totals of the output data for all the sample railyards and the projected totals for all the active (estimated) railyards in the United States are listed in Table 25. For more explanation on what is contained in the input and the interpretation of the output, see "RYNEM User Manual."

For Airline, Milwaukee, Wisconsin, a type 1 yard (low volume hump), the population density is 10,152 with a usage of 0.43. So the effective population density is 10,152/0.43 = 23,609. The background noise level is, according to the 100 sites equation,

$$10 \log_{10}(10{,}152) + 22 = 62.1 \text{ dB}$$

Notice that 62.1 > 54, so L_{BG} is set to 54. The yard has five areas: R1, C1/R, C2/R, R2, R3. For R1, we have:

length of track = 1,500 ft

width of area = 8,000 ft

DB = 100 ft

excess industrial attenuation = 0

excess residential attenuation = 8 dB

DNM = 250 ft

NMS = 3

NMF = 0

```
 1.     LOW VOL HUMP
 2.     MEDIUM VOL HUMP
 3.     HIGH VOL HUMP
 4.     LOW VOL FLAT
 5.     MEDIUM VOL FLAT
 6.     HIGH VOL FLAT
 7.     INDUSTRIAL
 8.     SMALL INDUSTRIAL
 9.     55.58.61.64.67.70.73.76.79.82.
10.     55-58
11.     58-61
12.     61-64
13.     64-67
14.     67-70
15.     70-73
16.     73-76
17.     76-79
18.     79-82
19.     >82
20.       BL   MW
21.      75 70 65 60 55
22.       3
```

Table 22. Control Terms and Constants

23.	AIRLINE, MILWAUKEE, WI						110152.	.43	5
24.	R1	1500.	8000.	100.	0.	8.	250.	0.	3
25.		119.	7.						
6.		55.2	2.4						
7.		65.2	2.4						
28.	C1/R	1000.	8000.	0.	0.	8.	100.	250.	2
29.		55.2	2.4						
30.		65.2	2.4						
31.		9666.	267.						
32.	C2/R	1000.	8000.	0.	0.	8.	100.	250.	2
33.		55.2	2.4						
34.		65.2	2.4						
35.		8666.	267.						
36.	R2	1000.	8000.	0.	0.	8.	100.	250.	2
37.		55.2	2.4						
38.		65.2	2.4						
39.		8666.	267.						
40.		10170.	70.						
41.	R3	2000.	8000.	0.	0.	8.	100.	0.	4
42.		28.	3.						
43.		311.	4.						
44.		55.2	2.4						
45.		71.3	.6						

Table 23. Impact Data for Sample Railyard

Table 24. Output Data for Sample Railyard

```
REGULATED LEVELS ARE   75   70   65   60   55


AIRLINE, MILWAUKEE, WI                    LOW VOL HUMP

    POP DEN  USAGE       EFF POP  DKGD     # AREAS

    10152.0   0.43       23609.3  62.1          5

   AREA  LENGTH  WIDTH   DB    DI  DR  DNM   DMF     NMS  NFB

   R1     1500.  8000.   100.  0.  8.  250.    0.     3    0

   DB BANDS FOR BASELINE

         55-58     58-61     61-64     64-67     67-70     70-73     73-76     76-79     79-82     >82

PE     1.44E+03  2.60E+02  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
ENI    7.88E+01  5.30E+01  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  BL

     SOURCE  LDN   LEQ   LMAX

       HS    64.0  59.4  85.9
       ID    60.7  55.4  93.5
       OD1   60.7  55.4  93.5

     LEVEL    PE         ENI       DENI       COST       WALL

      67.1  1.71E+03  1.32E+02  0.0        0.0           0

  65

     SOURCE  LDN   LEQ   LMAX

       HS    59.0  54.4  80.9
       ID    55.7  50.4  88.5
       OD1   55.7  50.4  88.5

     LEVEL    PE         ENI       DENI       COST       WALL

      62.5  1.45E+03  9.95E+01  3.23E+01  5.55E+04      7

  60

     SOURCE  LDN   LEQ   LMAX

       HS    55.7  51.1  77.6
       ID    52.5  47.1  85.2
       OD1   52.5  47.1  85.2

     LEVEL    PE         ENI       DENI       COST       WALL

      59.9  7.60E+02  3.33E+01  9.85E+01  1.40E+05     16

  NW
```

SOURCE	LDN	LEQ	LMAX
HS	51.0	47.2	73.7
IB	40.6	43.2	81.3
OB1	40.6	43.2	81.3

LEVEL	PE	ENI	DENI	COST	WALL
57.4	2.16E+02	3.64E+00	1.20E+02	2.66E+05	30

AREA	LENGTH	WIDTH	DD	DI	DR	DNH	DNF	NHS	NFS
C1/R	3000.	8000.	0.	0.	8.	100.	250.	2	1

DB BANDS FOR BASELINE

	55-58	58-61	61-64	64-67	67-70	70-73	73-76	76-79	79-82	>82
PE	6.51E+02	1.25E+02	3.47E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	4.52E+01	2.07E+01	1.04E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0

BL

SOURCE	LDN	LEQ	LMAX
IB	65.0	59.6	97.8
OB1	65.0	59.6	97.8
HR	65.8	60.9	83.0

LEVEL	PE	ENI	DENI	COST	WALL
70.2	7.76E+02	7.39E+01	0.0	0.0	0

70

SOURCE	LDN	LEQ	LMAX
IB	65.0	59.6	97.8
OB1	65.0	59.6	97.8
HR	60.6	55.7	77.8

LEVEL	PE	ENI	DENI	COST	WALL
60.9	7.76E+02	6.92E+01	4.76E+00	2.70E+04	5

65

SOURCE	LDN	LEQ	LMAX
IB	60.0	54.6	92.8
OB1	60.0	54.6	92.8
HR	58.5	53.6	75.7

LEVEL	PE	ENI	DENI	COST	WALL

44.7	6.46E+02	4.94E+01	2.45E+01	3.70E+04	7

60

SOURCE	LDN	LEQ	LMAX
ID	54.7	49.3	87.4
DB1	54.7	49.3	87.4
MR	51.9	47.0	69.0

LEVEL	PE	ENI	DENI	COST	WALL
60.0	1.09E+02	6.80E+00	6.70E+01	1.05E+05	18

MW

SOURCE	LDN	LEQ	LMAX
ID	51.6	46.2	84.4
DB1	51.6	46.2	84.4
MR	49.2	44.3	66.4

LEVEL	PE	ENI	DENI	COST	WALL
58.0	6.06E+01	9.69E-01	7.29E+01	1.77E+05	30

AREA	LENGTH	WIDTH	DB	DI	DR	DNM	DNF	NMB	NFS
C2/R	1000.	8000.	0.	0.	8.	100.	250.	2	1

DD BANDS FOR BASELINE

	55-58	58-61	61-64	64-67	67-70	70-73	73-76	76-79	79-82	>82
PE	6.51E+02	1.25E+02	3.47E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	4.33E+01	2.76E+01	1.04E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0

BL

SOURCE	LDN	LEQ	LMAX
ID	65.0	59.6	97.8
DB1	65.0	59.6	97.0
CI	65.1	60.2	90.3

LEVEL	PE	ENI	DENI	COST	WALL
69.9	7.76E+02	7.09E+01	0.0	0.0	0

65

SOURCE	LDN	LEQ	LMAX
ID	60.0	54.6	92.0

```
     OB1    60.0  54.6  92.8
     CI     59.0  54.1  84.2

    LEVEL     PE         ENI        DENI       COST       WALL

     64.8  6.46E102  5.02E101  2.06E101  3.70E104      7

 60

    SOURCE  LDN   LEQ   LMAX

     ID     54.3  48.9  87.1
     OB1    54.3  48.9  87.1
     CI     52.4  47.5  77.6

    LEVEL     PE         ENI        DENI       COST       WALL

     59.8  1.70E102  5.79E100  6.51E101  1.10E105     19

 NW

    SOURCE  LDN   LEQ   LMAX

     ID     51.6  46.2  84.4
     OB1    51.6  46.2  84.4
     C1     50.0  45.1  75.2

    LEVEL     PE         ENI        DENI       COST       WALL

     58.1  6.06E101  9.69E-01  6.99E101  1.77E105     30

  AREA  LENGTH  WIDTH   ND     DI  DR  DNM   DNF    NMS  NFS

  R2      1000.  8000.     0.  0.  8.  100.  250.    2    2

  NB BANDS FOR BASELINE

        55-58      58-61      61-64      64-67      67-70      70-73      73-76      76-79      79-82      >82

PE     6.51E102  1.25E102  3.47E-02  0.0        0.0        0.0        0.0        0.0        0.0        0.0
ENI    4.64E101  2.95E101  1.04E-02  0.0        0.0        0.0        0.0        0.0        0.0        0.0

 BL

    SOURCE  LDN   LEQ   LMAX

     ID     65.0  59.6  97.0
     OB1    65.0  59.6  97.0
     CI     65.1  60.2  90.3
     IR     59.0  54.8  83.5

    LEVEL     PE         ENI        DENI       COST       WALL

     70.3  7.76E102  7.59E101  0.0        0.0          0
```

70

SOURCE	LDN	LEQ	LMAX
ID	65.0	59.6	97.8
OD1	65.0	59.6	97.8
CI	60.1	55.2	85.3
IR	54.6	49.6	78.3

LEVEL	PE	ENI	DENI	COST	WALL
69.0	7.76E+02	7.11E+01	4.79E+00	2.70E+04	5

65

SOURCE	LDN	LEQ	LMAX
ID	59.8	54.4	92.5
OD1	59.8	54.4	92.5
CI	58.2	53.3	83.4
IR	51.4	46.4	75.1

LEVEL	PE	ENI	DENI	COST	WALL
64.7	6.21E+02	4.75E+01	2.04E+01	4.20E+04	8

60

SOURCE	LDN	LEQ	LMAX
ID	54.0	48.6	86.7
OD1	54.0	48.6	86.7
CI	52.1	47.3	77.3
IR	45.3	40.3	69.0

LEVEL	PE	ENI	DENI	COST	WALL
59.8	1.54E+02	4.93E+00	7.09E+01	1.16E+05	20

NW

SOURCE	LDN	LEQ	LMAX
ID	51.6	46.2	84.4
OD1	51.6	46.2	84.4
CI	50.0	45.1	75.2
IR	43.2	38.2	66.9

LEVEL	PE	ENI	DENI	COST	WALL
58.2	6.06E+01	9.69E-01	7.49E+01	1.77E+05	30

AREA LENGTH WIDTH DD DT DR DNH DNF NHB NFS

R3 2000. 0000. 0. 0. 8. 100. 0. 4 0

DB BANDS FOR BASELINE

	55-58	58-61	61-64	64-67	67-70	70-73	73-76	76-79	79-82	>82
PE	1.55E+04	3.22E+02	5.57E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	8.24E+01	6.06E+01	1.82E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0

BL

SOURCE	LDN	LEQ	LMAX
HS	63.4	58.7	90.0
IS	64.7	60.1	90.0
IB	65.0	59.6	97.8
DB2	54.2	48.8	90.0

LEVEL	PE	ENI	DENI	COST	WALL
69.5	1.93E+03	1.69E+02	0.0	0.0	0

65

SOURCE	LDN	LEQ	LMAX
HS	58.4	53.7	85.0
IS	59.7	55.1	85.0
IB	60.0	54.6	92.8
DB2	49.2	43.8	85.0

LEVEL	PE	ENI	DENI	COST	WALL
64.7	1.63E+03	1.31E+02	3.85E+01	7.40E+04	7

60

SOURCE	LDN	LEQ	LMAX
HS	52.7	48.0	79.3
IS	54.0	49.4	79.3
IB	54.3	48.9	87.1
DB2	43.5	38.1	79.3

LEVEL	PE	ENI	DENI	COST	WALL
59.9	4.90E+02	2.07E+01	1.49E+02	2.21E+05	19

HW

SOURCE LDN LEQ LMAX

HS	50.0	45.3	76.6
IS	51.3	46.7	76.6
IR	51.6	46.2	84.4
RR2	40.0	35.4	76.6

LEVEL	PE	ENI	HENI	COST	WALL
58.1	2.13E102	5.50E100	1.64E102	3.54E105	30

TOTALS FOR YARD

DB BANDS FOR BASELINE

	55-58	58-61	61-64	64-67	67-70	70-73	73-76	76-79	79-82	>82
PE	4.94E103	9.66E102	5.50E101	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	2.96E102	2.07E102	1.82E101	0.0	0.0	0.0	0.0	0.0	0.0	0.0

LEVEL	PE	ENI	HENI	COST	NA	IC
BL	5.97E103	5.22E102	0.0	0.0	5	
75	5.97E103	5.22E102	0.0	0.0	5	1
70	5.97E103	5.12E102	9.55E100	5.40E104	5	0
65	5.00E103	3.77E102	1.44E102	2.46E105	5	0
60	1.76E103	7.15E101	4.50E102	6.92E105	5	0
55	0.0	0.0	5.22E102	1.15E106	0	0
NW	6.10E102	1.21E101	5.10E102	1.15E106	5	

HIGH VOL HUMP

ROANOKE, ROANOKE, VA

POP DEN	USAGE	EFF POP	BKGD	# AREAS
4520.0	0.61	7409.0	58.6	11

AREA	LENGTH	WIDTH	RB	DI	DR	DNR	DNF	NNB	NFB
C1	1000.	5000.	300.	0.	4.	1000.	700.	1	2

DB BANDS FOR BASELINE

	55-58	58-61	61-64	64-67	67-70	70-73	73-76	76-79	79-82	>82
PE	6.72E102	2.23E102	4.00E101	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	7.10E101	8.07E101	1.74E101	0.0	0.0	0.0	0.0	0.0	0.0	0.0

BL

SOURCE	LDN	LEQ	LMAX
HR	64.3	59.6	79.1
IL	64.4	58.4	58.4
LT	63.9	62.9	65.9

LEVEL	PE	ENI	HENI	COST	WALL

Table 25. Total Data for Sample Yards and Projected Totals for All Yards

GRAND TOTAL FOR ALL YARDS

	SAMPLE					PROJECTED					
	# YD	PE	ENT	DENT	COST	# YD	PE	ENT	DENT	COST	# IC
LOW VOL. HUMP											
BL	1	5.97E+03	5.22E+02	0.0	0.0	44	2.63E+05	2.30E+04	0.0	0.0	
75	1	5.97E+03	5.22E+02	0.0	0.0	44	2.63E+05	2.30E+04	0.0	0.0	1
70	1	5.97E+03	5.12E+02	9.55E+00	5.40E+04	44	2.63E+05	2.25E+04	4.20E+02	2.30E+06	0
65	1	5.00E+03	3.77E+02	1.44E+02	2.46E+05	44	2.20E+05	1.66E+04	6.35E+03	1.08E+07	0
60	1	1.76E+03	7.15E+01	4.50E+02	6.92E+05	44	7.76E+04	3.15E+03	1.98E+04	3.05E+07	0
55	1	0.0	0.0	5.22E+02	1.15E+06	44	0.0	0.0	2.30E+04	5.06E+07	0
HW	1	6.10E+02	1.21E+01	5.10E+02	1.15E+06	44	2.69E+04	5.33E+02	2.24E+04	5.06E+07	
MEDIUM VOL. HUMP											
BL	3	1.46E+04	2.26E+03	0.0	0.0	51	2.49E+05	3.85E+04	0.0	0.0	
75	3	1.45E+04	2.19E+03	7.03E+01	9.60E+04	51	2.46E+05	3.73E+04	1.20E+03	1.63E+06	2
70	3	1.26E+04	1.66E+03	6.02E+02	5.14E+05	51	2.15E+05	2.82E+04	1.02E+04	8.73E+06	0
65	3	1.02E+04	1.04E+03	1.22E+03	1.40E+06	51	1.73E+05	1.77E+04	2.08E+04	2.38E+07	0
60	3	4.52E+03	2.32E+02	2.03E+03	3.76E+06	51	7.69E+04	3.94E+03	3.45E+04	6.39E+07	0
55	3	0.0	0.0	2.26E+03	5.09E+06	51	0.0	0.0	3.85E+04	1.00E+08	0
HW	3	3.41E+03	2.26E+02	2.04E+03	5.09E+06	51	5.81E+04	3.85E+03	3.46E+04	1.00E+08	
HIGH VOL. HUMP											
BL	1	1.30E+04	2.16E+03	0.0	0.0	29	3.99E+05	6.25E+04	0.0	0.0	
75	1	1.30E+04	2.16E+03	0.0	0.0	29	3.99E+05	6.25E+04	0.0	0.0	1
70	1	9.87E+03	1.33E+03	8.29E+02	4.59E+05	29	2.86E+05	3.85E+04	2.40E+04	1.33E+07	0
65	1	7.74E+03	8.37E+02	1.32E+03	8.30E+05	29	2.24E+05	2.43E+04	3.82E+04	2.41E+07	0
60	1	3.21E+03	1.81E+02	1.97E+03	2.13E+06	29	9.30E+04	5.25E+03	5.73E+04	6.18E+07	0
55	1	0.0	0.0	2.16E+03	2.83E+06	29	0.0	0.0	6.25E+04	8.21E+07	0
HW	1	2.40E+03	1.22E+02	2.03E+03	2.83E+06	29	6.96E+04	3.54E+03	5.90E+04	8.21E+07	
LOW VOL. FLAT											
BL	0	0.0	0.0	0.0	0.0	476	0.0	0.0	0.0	0.0	
75	0	0.0	0.0	0.0	0.0	476	0.0	0.0	0.0	0.0	0
70	0	0.0	0.0	0.0	0.0	476	0.0	0.0	0.0	0.0	0
65	0	0.0	0.0	0.0	0.0	476	0.0	0.0	0.0	0.0	0
60	0	0.0	0.0	0.0	0.0	476	0.0	0.0	0.0	0.0	0
55	0	0.0	0.0	0.0	0.0	476	0.0	0.0	0.0	0.0	0
HW	0	0.0	0.0	0.0	0.0	476	0.0	0.0	0.0	0.0	
MEDIUM VOL. FLAT											
BL	0	0.0	0.0	0.0	0.0	346	0.0	0.0	0.0	0.0	
75	0	0.0	0.0	0.0	0.0	346	0.0	0.0	0.0	0.0	0
70	0	0.0	0.0	0.0	0.0	346	0.0	0.0	0.0	0.0	0
65	0	0.0	0.0	0.0	0.0	346	0.0	0.0	0.0	0.0	0
60	0	0.0	0.0	0.0	0.0	346	0.0	0.0	0.0	0.0	0
55	0	0.0	0.0	0.0	0.0	346	0.0	0.0	0.0	0.0	0
HW	0	0.0	0.0	0.0	0.0	346	0.0	0.0	0.0	0.0	

HIGH VOL FLAT

BL	0	0.0	0.0	0.0	0.0	130	0.0	0.0	0.0	0.0	
75	0	0.0	0.0	0.0	0.0	130	0.0	0.0	0.0	0.0	0
70	0	0.0	0.0	0.0	0.0	130	0.0	0.0	0.0	0.0	0
65	0	0.0	0.0	0.0	0.0	130	0.0	0.0	0.0	0.0	0
60	0	0.0	0.0	0.0	0.0	130	0.0	0.0	0.0	0.0	0
55	0	0.0	0.0	0.0	0.0	130	0.0	0.0	0.0	0.0	0
HW	0	0.0	0.0	0.0	0.0	130	0.0	0.0	0.0	0.0	

INDUSTRIAL

BL	0	0.0	0.0	0.0	0.0	830	0.0	0.0	0.0	0.0	
75	0	0.0	0.0	0.0	0.0	830	0.0	0.0	0.0	0.0	0
70	0	0.0	0.0	0.0	0.0	830	0.0	0.0	0.0	0.0	0
65	0	0.0	0.0	0.0	0.0	830	0.0	0.0	0.0	0.0	0
60	0	0.0	0.0	0.0	0.0	830	0.0	0.0	0.0	0.0	0
55	0	0.0	0.0	0.0	0.0	830	0.0	0.0	0.0	0.0	0
HW	0	0.0	0.0	0.0	0.0	830	0.0	0.0	0.0	0.0	

SMALL INDUSTRIAL

BL	0	0.0	0.0	0.0	0.0	1779	0.0	0.0	0.0	0.0	
75	0	0.0	0.0	0.0	0.0	1779	0.0	0.0	0.0	0.0	0
70	0	0.0	0.0	0.0	0.0	1779	0.0	0.0	0.0	0.0	0
65	0	0.0	0.0	0.0	0.0	1779	0.0	0.0	0.0	0.0	0
60	0	0.0	0.0	0.0	0.0	1779	0.0	0.0	0.0	0.0	0
55	0	0.0	0.0	0.0	0.0	1779	0.0	0.0	0.0	0.0	0
HW	0	0.0	0.0	0.0	0.0	1779	0.0	0.0	0.0	0.0	

HUMP YARDS--ALL VOLUMES

BL	5	3.44E+04	4.94E+03	0.0	0.0	124	8.52E+05	1.23E+05	0.0	0.0	
75	5	3.42E+04	4.07E+03	7.03E+01	9.60E+04	124	8.40E+05	1.21E+05	1.74E+03	2.38E+06	4
70	5	2.85E+04	3.50E+03	1.44E+03	1.03E+06	124	7.06E+05	8.68E+04	3.57E+04	2.55E+07	0
65	5	2.29E+04	2.26E+03	2.67E+03	2.40E+06	124	5.68E+05	5.59E+04	6.66E+04	6.14E+07	0
60	5	9.49E+03	4.85E+02	4.46E+03	6.50E+06	124	2.35E+05	1.20E+04	1.11E+05	1.63E+08	0
55	5	0.0	0.0	4.94E+03	9.07E+06	124	0.0	0.0	1.23E+05	2.45E+08	0
HW	5	6.43E+03	3.60E+02	4.58E+03	9.07E+06	124	1.59E+05	8.94E+03	1.14E+05	2.45E+08	

FLAT YARDS--ALL VOLUMES

BL	0	0.0	0.0	0.0	0.0	952	0.0	0.0	0.0	0.0	
75	0	0.0	0.0	0.0	0.0	952	0.0	0.0	0.0	0.0	0
70	0	0.0	0.0	0.0	0.0	952	0.0	0.0	0.0	0.0	0
65	0	0.0	0.0	0.0	0.0	952	0.0	0.0	0.0	0.0	0
60	0	0.0	0.0	0.0	0.0	952	0.0	0.0	0.0	0.0	0
55	0	0.0	0.0	0.0	0.0	952	0.0	0.0	0.0	0.0	0
HW	0	0.0	0.0	0.0	0.0	952	0.0	0.0	0.0	0.0	

DB BANDS FOR BASELINE

	55-58	58-61	61-64	64-67	67-70	70-73	73-76	76-79	79-82	>82
LOW VOL HUMP										
SAMPLE										
PE	4.94E+03	9.66E+02	5.50E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	2.96E+02	2.07E+02	1.02E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PROJECTED										
PE	2.10E+05	4.25E+04	2.46E+03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	1.30E+04	9.12E+03	8.02E+02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEDIUM VOL HUMP										
SAMPLE										
PE	9.51E+03	2.99E+03	1.41E+03	5.59E+02	2.02E+02	2.46E+01	9.00E+00	0.0	0.0	0.0
ENI	6.16E+02	6.67E+02	5.29E+02	2.09E+02	1.33E+02	2.01E+01	9.34E+00	0.0	0.0	0.0
PROJECTED										
PE	1.62E+05	5.08E+04	2.39E+04	9.50E+03	3.44E+03	4.10E+02	1.67E+02	0.0	0.0	0.0
ENI	1.05E+04	1.13E+04	9.00E+03	4.92E+03	2.26E+03	3.41E+02	1.59E+02	0.0	0.0	0.0
HIGH VOL HUMP										
SAMPLE										
PE	8.91E+03	2.97E+03	1.39E+03	5.36E+02	4.26E+01	0.0	0.0	0.0	0.0	0.0
ENI	6.15E+02	7.25E+02	5.10E+02	2.71E+02	2.75E+01	0.0	0.0	0.0	0.0	0.0
PROJECTED										
PE	2.50E+05	8.60E+04	4.02E+04	1.55E+04	1.24E+03	0.0	0.0	0.0	0.0	0.0
ENI	1.70E+04	2.10E+04	1.50E+04	7.85E+03	7.90E+02	0.0	0.0	0.0	0.0	0.0
LOW VOL FLAT										
SAMPLE										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PROJECTED										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEDIUM VOL FLAT										
SAMPLE										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PROJECTED										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HIGH VOL FLAT										
SAMPLE										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PROJECTED										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INDUSTRIAL

SAMPLE										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PROJECTED										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SMALL INDUSTRIAL

SAMPLE										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PROJECTED										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

HUMP YARDS--ALL VOLUMES

SAMPLE										
PE	2.34E+04	6.92E+03	2.05E+03	1.09E+03	2.45E+02	2.46E+01	9.80E+00	0.0	0.0	0.0
ENI	1.53E+03	1.60E+03	1.06E+03	5.60E+02	1.60E+02	2.01E+01	9.34E+00	0.0	0.0	0.0
PROJECTED										
PE	5.79E+05	1.72E+05	7.07E+04	2.72E+04	6.00E+03	6.10E+02	2.43E+02	0.0	0.0	0.0
ENI	3.79E+04	3.97E+04	2.64E+04	1.39E+04	3.97E+03	4.98E+02	2.32E+02	0.0	0.0	0.0

FLAT YARDS--ALL VOLUMES

SAMPLE										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PROJECTED										
PE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

These numbers agree with the output within roundoff. The composite L_{dn} of all moving sources at property line is 66.9. The composite L_{dn} with background at property line is 67.1.

Subtracting the excess residential attenuation of 8 dB, one obtains the starting level at property line as 58.9 (without BG), and 60.1 (with BG). So it should start off in the 58-61 dB band. At the far end of the 58-61 dB band, the level is, naturally enough, 58 dB. So we have a noise source (without BG) attenuating from 58.9 to 55.8, i.e., $\Delta = 3.1$. So the distance is roughly doubled, i.e., $R(58) \approx 500$ ft. So

$$PE = [(250)(1,500)/(5280)^2](23,609) \approx 300$$

This agrees with the more exact calculation in the output. Using the number generated by the computer (268), we will now compute LWP in the band. The average level in the band is $(60.1 + 58)/2 \approx 59$. So

$$LWP = (268)[(59-55)/20] = 53.6$$

Again, this agrees with the more precise 1-dB band calculation in the program.

Next, we proceed to the 55-58 dB band. 55 with BG is equivalent to 51.1 without, so

$$\Delta = 58.9 - 51.1 = 7.8$$

Therefore $R(55) \approx (250)\ 10^{7.8/10} \approx 1,500$ ft

$$PE \approx [(1,000)(1,500)/(5,280)^2](23,609) \approx 1,200$$

$$LWP = [(56.5-55)/20](1,440) = 10.8$$

Again our rough PE calculation agrees with the more exact computer solution. We overestimated LWP because most of the area covered is closer to 55 than to 58 (remember the final level is 51.1). When we use the mean 56.5 instead of the 1-dB bands in the program we should expect the result to be somewhat larger.

We conclude that the L_{dn} and baseline computation procedures are doing the right thing.

Proceeding to barrier calculations, notice that the source height is 10 ft in each case, so the minimum height wall to block line of sight, h, is

$$h = [(10-5)/(250)](100) + 5$$

or $h = 7$

With a 7-ft wall in place, the attenuation due to the wall is 5 dB. So the L_{dn} of each source is reduced by 5 dB, and the composite level is (66.9-5) + BG, which gives us 62.5 dB, as presented in the output. The cost of the wall is (1,500)ICOST(7) = (1,500)(37) = 5.55×10^4. For a wall of 16 ft, the attenuation is 8.2 dB for each case, so that

$$L_{dn}(1) = 55.8$$
$$L_{dn}(5) = 52.5$$
$$L_{dn}(6) = 52.5$$

The sources are IS = 1 HS with parameters 19,7

5 IB 5.2, 2.4

6 OB1 5.2, 2.4

Thus, at 100 ft, from the noise source equation given in LEV100, the noise levels are as shown in Table 26.

IS	L_{dn}	L_{eq}	L_{max}
1	68.1	63.5	90.0
5	65.0	59.6	97.8
6	65.0	59.6	97.8

Table 26. Source Noise Levels at 100 Feet

At property line, from the equation given in LEVBD, attentuation for IS = 1 is 4.1

5 4.3

6 4.3

At property line, the noise levels are as listed in Table 27.

IS	L_{dn}	L_{eq}	L_{max}
1	64.0	59.4	85.9
5	60.7	55.3	93.5
6	60.7	55.3	93.5

Table 27. Source Noise Levels at Receiving Property

The cost of the wall in this case is (1,500)(93.6) = 1.404×10^5. All the results agree with those of the output. So we conclude that the barrier attenuation computations are also correct.

Skipping to the final tables of grand totals, we see that the righthand side results are indeed scaled up by the factor of yard ratios of the lefthand side.

6.0 DICTIONARY OF PERTINENT VARIABLES

In the following tables, a list of variables and their meanings have been gathered in alphabetical order.

As a preliminary, a list of indices is provided in Table 28.

INDEX	RANGE	DESCRIPTION
IAREA	1-NAREAS	area number
IFIX	1-NFIX	fixed source number (area specific)
IL, LEV	1-7	regulation level number
IMOV	1-NMOV	moving source number (area specific)
IS	1-15	source number (constant)
IT	1-8	yard type number
IWALL	5-30	wall height

Table 28. List of Indices

In general, I and J are dummy indices and have no fixed meaning.

In general the suffix

YT	indicates	yard type
YD		yard total
A		area total
M		moving source
F		fixed source
DB		dB band

and the prefix

PE	indicates	population exposed
ENI		LWP
DENI		ΔLWP
COST		cost of wall
I	is usually	an index
N	is usually	the upper limit of a range of indices

In Table 29, we present only the F version (fixed source) of the variables pertaining to noise sources

NAME	DESCRIPTION
ALALL	composite noise level of all fixed and moving sources
ALBG	background L_{dn}
ALENG	length of area
ALEV(LEV)	BLALL at level LEV
ALFS	composite noise level of fixed sources
ATTF(IFIX)	barrier attenuation of source IFIX
ATTIND	excess industrial attenuation
ATTRES	excess residential attenuation
BLALL	composite level of all sources and background
DB	distance from property line to barrier
DBB(I)	lower limit of the 3-dB bands
DNFIX	distance from fixed source to property lines
ED	number of daytime events
EN	number of nighttime events
IC(LEV)	number of areas that meet level LEV <u>without</u> barrier

Table 29. Definiton of Terms

NAME	DESCRIPTION
IHFMIN(IFIX)	height of minimum wall to block line of sight
IP	output switch
ISF(IFIX)	source number of source IFIX
IW(LEV)	smallest IWALL which meets level LEV
IWSF	switch that wall height is higher than the minimum wall height of at least one source
LREG(LEV)	regulation level
NA(LEV)	number of areas that meet level LEV with barrier
NAMEYD(I)	name of yard
NAREAS	number of areas in yard
NFIX	number of fixed sources
NYD(IT)	number of yards of type IT in dataset
NYDC(LEV,IT)	number of yards of type IT in compliance with level LEV without barrier
POP	population density of yard vicinity
POPU	effective population density
PU	residential usage of yard vicinity
RDBB(J,I)	description of the 3-dB bands
SEQ	L_{eq} of source at property line
SFDN(LEV,IFIX)	L_{dn} of source IFIX at level LEV
SFEQ(LEV,IFIX)	L_{eq} of source IFIX at level LEV
SFMAX(LEV,IFIX)	L_{max} of source IFIX at level LEV
SLDN	L_{dn} of source at property line
SM(IS)	maximum passby level of source IS at 100 ft
SMAX	L_{max} of source at property line
WCOST(IWALL)	cost of wall per linear foot at height IWALL
WIDTH	width of area
YDTYPE(I,IT)	yard type description