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FINAL REPORT

CONSTRUCTION SITE ACTIVITY

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SUMMARY

This report presents results of the current project to characterize construction site activity. The purpose is to develop an updated data base for computing the health and welfare impacts of construction equipment noise on the total U.S. population. Key data elements compiled include: 1) construction equipment A-weighted noise levels at 50 feet and 2) typical construction site sizes according to site type, surrounding average population density and geographic location within the U.S. Other data compiled relate to: 1) construction equipment usage and noise emission characteristics, 2) construction site demographic data and boundary noise level measurements and 3) construction equipment operator populations and operator's daily noise exposure times.

For various generic types of construction equipment included in the EPA's Construction Site Noise Impact Model, revised values of the average A-weighted noise levels at 50 feet are presented in Section 2. These revisions were based on equipment noise data found in the open literature. A complete listing of this data, by equipment type, is presented in Tables A-1 through A-14 in Appendix A. Also presented in Appendix A is a discussion of the procedures used to develop analytical expressions relating equipment A-weighted noise level at 50 feet to engine horsepower rating. The results of a limited field testing and construction site survey program are also presented in Section 2. During this program, fourteen construction sites were visited to obtain data related to equipment and site boundary noise levels and site demographic and equipment usage characteristics. The construction equipment usage characteristics are presented in Tables B-1 through B-14 in Appendix B. Section 3 presents the results of an investigation to determine typical construction site size according to site type, population density and geographical location. Based on data obtained for 374 construction sites distributed throughout the U.S., the following conclusions were made:

- The national average construction site size can be represented by an equivalent circular area with a radius of approximately 200 feet.

- The national average construction site size, by site type can be represented by an equivalent circular area with the following approximate radii:

Site Type	Radius For Equivalent Circular Area (Feet)
Residential	200
Non-Residential	150
Industrial/Commercial	175
Public Works	125

- On a national basis, there is little variation in the average construction site size with respect to geographic location or average population density.

The data collection and analysis procedures used to obtain site data is discussed in Appendix C. Table C-4 presents a complete listing of these data.

Section 5 identifies nine scenarios developed to estimate the health/welfare impacts associated with variations in construction site sizes and construction equipment noise levels. Using the revised baseline data presented in Sections 2 and 3, the EPA's Construction Site Noise Impact Model was reprogrammed. Execution of the program showed that the revised data base resulted in an ENI decrease of approximately 3.39 million. In section 6, estimates of construction equipment operator populations and operator's daily noise exposure times are presented.

1.0 INTRODUCTION

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1.1 Background

The Noise Control Act of 1972 (Pub. L. 92-574, 86 Stat. 1234) established, by statutory mandate, a national policy "to promote an environment for all Americans free from noise that jeopardizes their health and welfare". As specified in the Noise Control Act of 1972, the first step towards promulgation of noise standards for new products is identification of those products that are major sources of noise.

Section 6(a)(1)(c) has identified construction equipment as one of four product categories to be considered for noise regulation. In determining whether a particular type of construction equipment is a major noise source and, therefore, subject to regulatory action, a health and welfare impact assessment is an essential and necessary consideration. To provide a quantitative assessment of the noise impact, a construction site model was developed to compute the number of people (on a national average) exposed to higher levels than the defined thresholds identified as requisite to protect the public health and welfare with an adequate margin of safety. The data base used in the development of this model was presented in a report prepared for the EPA in December, 1971.[46] However, this report was incomplete in that some of the basic data sources were not identified and some of the computation procedures were unclear. Subsequent studies[38,47,48,49] provided updates and revisions to some of the critical data elements but there is still a need to fill existing data gaps and to revise obsolete or poorly documented assumptions. The objectives of this study are to provide data which can be used for these purposes.

1.2 Study Objectives

The principal objectives of this study were to:

1) Review existing literature to obtain A-weighted noise level data at 50 feet for various generic types of construction equipment

2) Conduct a limited field survey to collect construction equipment and construction site data including:

- equipment noise level measurements to determine work cycle L_{eq}
- equipment usage characteristics
- site sizes
- surrounding population density and structure composition
- site boundary noise level measurements

3) Investigate typical construction site size and surrounding population density by site type and by geographic location within the United States

4) Reprogram the EPA's Construction Site Noise Impact Model based on the data developed under items 1), 2), and 3) above

5) Provide a summary of the relative changes in impact resulting from the revisions incorporated under item 4) above for various national construction site scenarios

6) Estimate the number of operators and average daily exposure times for various types of construction equipment.

This report presents the results of the efforts directed towards accomplishing these study objectives. It is intended to provide supporting documentation for the revision of various data base elements currently used in the EPA's construction site model and to present the relative changes in noise impact resulting from these revisions.

2.0 CONSTRUCTION EQUIPMENT NOISE LEVELS

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2.1 Noise Level Measurements Obtained From Literature Search

2.1.1 Equipment Types Selected

A literature search was conducted to obtain A-weighted noise level measurements at 50 feet for several generic types of construction equipment included in the EPA's health/welfare construction site model. The equipment types selected for this study were:

- Small cement/concrete mixers (non-truck type)
- Concrete mixers (truck type)
- Concrete pumps
- Concrete vibrators
- Cranes-derrick type
- Cranes - mobile type
- Generators
- Graders
- Pavers and mixers
- Pile drivers
- Pneumatic tools
- Pumps
- Rollers
- Saws - electric radial

2.1.2 Literature Review and Data Presentation

At the beginning of the literature search, over 50 references were collected concerning noise produced by construction equipment and construction site activities. However, the data found in many of these references were presented in such a way so as to preclude their use in this study. Nevertheless, over 400 equipment noise level measurements were obtained from:

1) private consultant reports, 2) government reports, 3) engineering and professional society publications and 4) trade association survey documents.[1-18] It should be noted that, in most cases, the measurement and data reduction procedures and instrumentation used to obtain the noise level data were not specified. Therefore, the degree of statistical uncertainty in the data obtained from the literature search could not be assessed.

In general, the measured noise data were presented in terms of average noise level for one of the following equipment operational modes:

- Low or idle
- Off-maximum or average
- High or maximum

In addition to the equipment noise level data, several of the references also presented operational data, usually in terms of engine horsepower. In some cases, operational parameters were determined from construction equipment specification tables.[22]

A complete listing of the noise level and operational data found in the literature survey is presented in Tables A-1 through A-14 in Appendix A. A summary discussion of this data is presented in the following sections.

2.1.3 Data Summary

Based on the data presented in Tables A-1 through A-14, the energy-average and arithmetic-average A-weighted noise levels, as a function of operational mode, have been determined for each of the generic types of construction equipment identified in Section 2.1.1. This data, along with the noise levels currently used in the EPA's construction site model and the revised levels for future noise impact evaluations, are presented in Table 2-1. The revised level for each construction equipment type was computed by averaging the combined off-maximum/average and high/minimum equipment noise level values. As seen from Table 2-1, the revised values and their relative difference as compared with the current baseline values are dependent upon the type of noise level averaging used. As expected, the energy-averaged levels are equal to or, in most cases, greater than the arithmetic-averaged levels. However, since the distribution of noise levels relative to the total population for each machine type is not known and since energy averaging tends to apply a greater relative weighting to the higher noise levels, the arithmetic-average level is believed to be more representative of each machine type.

Figure 2-1 presents the range of A-weighted noise levels at 50 feet as a function of operational mode and the range of the operational parameter selected for each equipment type.

2.2 Noise Level Measurements Obtained from Field Testing

2.2.1 Equipment Noise Measurements

Fourteen construction sites located throughout Fairfax County, Virginia, were visited during the field testing and site survey portion of this study. Table 2-2 presents a listing of the location, the construction company and the contact(s) for each site visited.

During the site visits, over 40 measurements of individual pieces of construction equipment were taken. Measurements were obtained for all but four of the equipment types identified for this study — 1) concrete pumps, 2) concrete vibrators, 3) pavers and mixers, and 4) pneumatic tools.

Table 2-3 presents a summary listing of the equipment types and their measured A-weighted noise levels at 50 feet. As in Section 2.1, the noise level measurements are presented with respect to equipment operational mode. Also shown on Table 2-3 is the estimated work cycle L_{eq} for each of the equipment types. The L_{eq} is based on the measured noise levels and information concerning the equipment's operational characteristics obtained

TABLE 2-1. CONSTRUCTION EQUIPMENT NOISE LEVELS

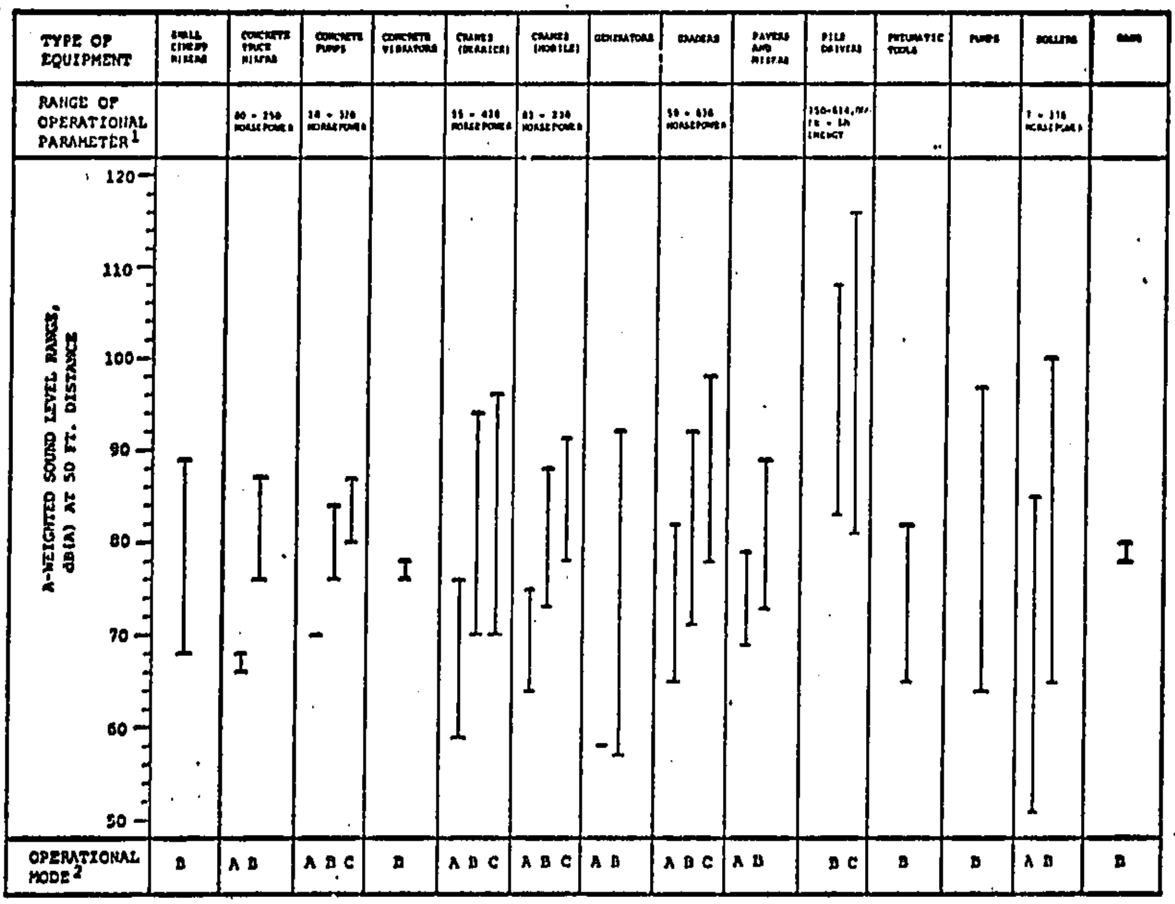
Equipment Type	AVERAGE A-WEIGHTED SOUND LEVELS AT 50 FEET, dBA								
	Energy Average			Arithmetic Average			Current Baseline Noise Levels	Revised Noise Levels	
	Low or Idle	Off Max. or Avg.	High or Max.	Low or Idle	Off Max. or Avg.	High or Max.		Energy Avg.(*)	Arithmetic Avg.(**)
Small Cement/ Concrete Mixers (non-truck type)	-	86(2)	-	-	79(2)	-	85	86(2)	79(2)
Concrete Mixers (truck type)	67(2)	84(10)	-	67(2)	83(10)	-	78	84(10)	83(10)
Concrete Pumps	70(1)	82(7)	85(2)	70(1)	81(7)	84(2)	82	83(9)	82(9)
Concrete Vibrators	-	77(3)	-	-	77(3)	-	76	77(3)	77(3)
Cranes-Derrick	70(23)	86(29)	88(21)	68(23)	81(29)	83(21)	88	87(50)	82(50)
Crane-Mobile	70(12)	83(18)	84(15)	69(12)	80(18)	83(15)	83	83(33)	81(33)
Generators	58(1)	82(14)	-	58(1)	75(14)	-	78	82(14)	75(14)
Graders	77(20)	85(72)	89(23)	74(20)	83(72)	86(23)	85	86(95)	84(95)
Pavers and Mixers	75(3)	87(16)	-	73(3)	85(16)	-	89	87(16)	85(16)
Pile Drivers	-	102(14)	109(11)	-	98(14)	99(11)	101	106(25)	99(25)
Pneumatic Tools	-	85(7)	-	-	82(7)	-	85	85(7)	82(7)
Pumps	-	76(17)	-	-	74(17)	-	76	76(17)	74(17)
Rollers	78(16)	88(43)	-	73(16)	81(43)	-	80	88(43)	81(43)
Saw-Electric Radial	-	79(9)	-	-	78(9)	-	78	79(9)	78(9)

NOTE: Numbers in parenthesis ( ) indicate number of measurements used to determine average level.

* Energy average of off-maximum/average and high/maximum noise levels.

** Arithmetic average of off-maximum/average and high/maximum noise levels.

FIGURE 2-1. SUMMARY OF CONSTRUCTION EQUIPMENT NOISE LEVELS FOUND IN THE LITERATURE SEARCH



1 Operational parameter range is representative of all equipment in each type

2 A: Low or idle
B: Off-maximum or average
C: High or maximum

TABLE 2-2. CONSTRUCTION SITE SURVEY INFORMATION

Site No.	Location	Construction Co.	Contact
1	Interstate I-66 at Rt. 495 Falls Church	James Julian, Inc.	Jim Million Roger Highlander
2	Gallows Rd. and Kidwell Dr. Tysons Corner	Briscoe, Inc. (Boing)	John Commack (Phil Korb)
3	Rt. 236 and Hummer Rd. Annandale	Delta Ratta, Inc.	Frank Papsidero
4	Rt. 236 and Burke Sta. Fairfax Square	Belleau-Wood, Inc.	Jerry Terry
5	Guinea Rd. and Burnetta Dr. Annandale	Foster Bros., Inc.	John Tue
6	University Dr. and Rt. 236 Fairfax City	William Hazel, Inc.	
7	Rt. 123 across from Masey Bldg. Fairfax City	L.F. Jennings, Inc.	Jim Newman
8	Braddock Rd. (9800 Block) Burke	Bo-Bud Const. Corp.	Russel Glorioso
9	Twinbrook Rd. and Guinea Rd. Burke	Richards Group of Wash.	Dan Graumann
10.	Greensboro Dr. and Westpark Dr. Tysons Corner	George Hyman Const. Corp.	Bob Christopher
11.	Idlewood Rd. and Rt. 7 Falls Church	Versant Corp.	Charles Ferst
12	Anderson Rd. and Rt. 123 McLean	Westgate Corp.	Walt Fred
13	Anderson Rd. and Rt. 123 McLean	Westgate Corp.	Walt Fred
14	Rt. 236 and Estel Rd. Fairfax	L.F. Jennings, Inc.	Jim Newman

TABLE 2-3. SITE MEASUREMENT DATA FOR INDIVIDUAL PIECES OF CONSTRUCTION EQUIPMENT

		Energy-Average Levels as a Function of Operational Mode, (dBA at 50')			
Site No.	Equipment Type	Low or Idle	Off-Max. or Ave.	High or Maximum	Work Cycle* L_{eq}
7	Small Cement/Concrete Mixers (non-truck type)	-	65(1)	70(1)	66
5,6,10	Concrete Mixers (truck type)	68(2)	77(3)	86(2)	82
2,4,12	Cranes-Derrick	75(2)	88(2)	96(3)	89
2,10	Cranes-Mobile	71(1)	78(2)	86(2)	79
1,2,6, 10	Generators	69(2)	78(4)	82(1)	80
1	Graders	70(1)	76(1)	79(1)	77
1,4	Pile Drivers	-	-	102(2)	102
4	Pumps	-	70(1)	-	70
1,6	Rollers	72(2)	84(2)	94(3)	88
	Saws	-	69(1)	82(1)	82

Note: Numbers in parentheses ( ) indicate number of measurements used to determine energy - average level.

* Based on percent usage shown in Table 2-4.

TABLE 2-4. EQUIPMENT USAGE AS A FUNCTION OF OPERATIONAL MODE - CONSTRUCTION SITE SURVEY

	Percent of Time Spent in Each Operational Mode		
Equipment Type	Low or Idle	Off-Max. or Ave.	High or Maximum
Small Cement/Concrete Mixers (non-truck type)	-	0.90	0.10
Concrete Mixers (truck-type)	0.20	0.50	0.30
Cranes - Derrick	0.40	0.50	0.10
Cranes - Mobile	0.40	0.50	0.10
Generators	0.10	0.45	0.45
Graders	0.10	0.70	0.20
Pile Drivers	-	-	1.00
Pumps	-	1.00	-
Rollers	0.10	0.70	0.20
Saws	-	0.10	0.90

from discussions with equipment operators and other construction site personnel and from observations made during the site visits. As shown in Table 2-4, this data is presented in terms of the percent of time spent in each operational mode.

2.2.2 Construction Site Boundary Noise Measurements

In addition to the equipment noise level measurements, construction site boundary noise levels were obtained for several of the sites visited. Table 2-5 presents a summary listing of the results of these measurements. It should be noted that, in general, measurements were taken for only a few minutes at each site location. Accordingly, the measurements are not necessarily representative of the actual construction site boundary L_{eq}* (8) noise levels or the boundary noise levels predicted from the EPA's construction site noise model.

2.3 Construction Site and Equipment Data Obtained From Field Survey

2.3.1 Site Data

For each of the fourteen construction sites visited during the field survey portion of this study, the following site data were obtained:

- Site type
- Approximate percent completed
- Estimated site size
- Surrounding land use
- Surrounding population density

A summary listing of this data is shown in Table 2-6. The site type, approximate percent completed and the estimated site size data were obtained from construction personnel while surrounding land use and population density were determined from area Census Tract and Land Use maps.

* Eight-hour energy equivalent noise level.

TABLE 2-5. SITE MEASUREMENT DATA FOR BOUNDARY NOISE LEVELS

Site No.	Location No.	Site Type	Noise Level Range at Boundary (dBA)	Dominant Noise Sources
1	1	Public Works	60-94	Scrapers, Dump Trucks, Watering Truck, Grader
2	1	Non-residential	62-92	Crawler Tractor, Arc Welders, Jack Hammer, Derrick Crane, Excavator, Saws, Back-up Alarm
2	2	Non-residential	69-82	Arc Welders, Derrick & Mobile Crane, Crawler Tractors, Back-up Alarm, Hammering, General Activity
4	1	Non-residential	64-94	Pile Driver, Derrick Crane, Saws
5	1	Residential	66-78	Crawler Tractor, Excavator, Saws, Carpentry Work
5	2	Residential	64-82	Concrete Truck
6	1	Industrial/commerical	64-84	Scraper, Arc Welders
6	2	Industrial/commercial	62-83	Wheeled Loader, Crawler Tractor, Scraper, Excavator
6	3	Industrial/commercial	62-92	Vibratory Roller,Grader, Concrete Truck
8	1	Residential	60-74	Concrete truck, Cement Mixers Small pump, Saws, Crawler Tractor, Carpentry Work, General Activity
8	2	Residential	74-78	Backhoe Loader, General Activity

TABLE 2-5.(Cont.)

Site No.	Location No.	Site Type	Noise Level Range at Boundary (dBA)	Dominant Noise Sources
10	1	Non-residential	70-82	Excavator, Roller, Concrete Truck, Mobile Crane
10	2	Non-residential	70-82	Excavator, Generator, Mobile Crane, Roller, Concrete Truck, General Activity
11	1	Residential	71-81	Crawler Tractor, Saws, Carpentry Work
14	1	Residential	67-82	Crawler Tractor,Roller, Dump Truck
14	2	Residential	72-86	Crawler Tractor, Dump Trucks, Roller

TABLE 2-6. CONSTRUCTION SITE SURVEY DATA

Site No.	Site Type	Approx. Percent Completed	Site Size (Sq.Ft.)	Land Use	Population Density (People/Sq.Mi.)
1	Public Works	10-15	1,900,000	Residential	5,654*
2	Non-Residential	50	522,720	Residential/ Commercial	1,304*
3	Non-Residential	10-15	108,900	Residential/ Commercial	5,284*
4	Non-Residential	5-10	120,000	Residential/ Commercial	3,662
5	Residential	10	871,200	Residential	3,073*
6	Industrial/ Commercial	25-30	1,393,920	Residential/ Commercial	3,662
7	Non-Residential	65	61,200	Residential/ Commercial	3,662
8	Residential	35-40	392,040	Residential	2,285
9	Residential	25	272,250	Residential	3,660
10	Non-Residential	10	435,600	Industrial/ Commercial	29
11	Residential	50	522,720	Residential	6,348
12	Non-Residential	10	87,120	Residential/ Commercial	10,327
13	Non-Residential	2	35,000	Residential/ Commercial	10,327
14	Residential	5	152,460	Residential/ Commercial	2,285

* Average population density for sites which are located on two or more adjacent density tracts.

2.3.2 Equipment Identification and Usage Characteristics

During the construction site visits, personnel were interviewed to obtain information concerning the types of equipment used over the course of the construction project. Using the list of construction equipment included in the EPA's construction site noise model, construction personnel were asked the following:

1) Was equipment used on construction project*
2) Number used
3) Time on site
4) Frequency of use
5) Duration per use

The complete listing of the results of this survey are presented in Tables B-1 through B-14 in Appendix B. In general, the number of pieces of equipment and their usage varied from site to site and appeared to be dependent on the duration of the project, type of construction and specific job requirements.

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* Personnel were asked whether a particular piece of equipment had been used, was currently being used or would be used on the construction project.

3.0 INVESTIGATION OF TYPICAL CONSTRUCTION SITE SIZE AND SURROUNDING POPULATION DENSITY

3.0 INVESTIGATION OF TYPICAL CONSTRUCTION SITE SIZE AND SURROUNDING POPULATION DENSITY

3.1 Areas Considered for the Investigation

For this investigation, the United States, excluding Alaska and Hawaii, was divided into five geographical regions. The states included in each region are identified in Figure 3-1. Within each region, several Standard Metropolitan Statistical Area (SMSA) Central Cities*, with populations of 100,000 or more, were randomly selected according to three population density categories**. These categories were:

- less than 3,000 people/sq. mile
- between 3,000 and 7,000 people/sq. mile
- greater than 7,000 people/sq. mile

The cities considered for this investigation are presented by region and population density category in Table 3-1.

3.2 Areas Selected for the Investigation

Fifteen cities, one for each region/population density category, were selected for this investigation. These cities are presented in Table 3-2 and are identified in Figure 3-2 according to geographic location within the U.S.

3.3 Construction Site Data Collection

For each city selected, aerial photographs of the central city and outside central city areas were obtained and evaluated by the Environmental Photographic Interpretation Center (EPIC). The EPIC was instructed to select 15 construction sites inside and 15 sites outside the corporate city limits. The EPIC was provided

* Definition of SMSA Central City is given on page 923 of Reference 55

** Based on data presented in Tables 20 and 28 of Reference 54.

Region 1

Maine
Vermont
New Hampshire
Massachusetts
Connecticut
Rhode Island
New York
New Jersey

Region 2

Pennsylvania
Delaware
Maryland
W. Virginia
Virginia
Kentucky
Tennessee
N. Carolina
S. Carolina
Mississippi
Alabama
Georgia
Florida

Region 3

Louisiana
Arkansas
Oklahoma
Texas
New Mexico
Arizona
California
Nevada

Region 4

Washington
Oregon
Idaho
Montana
North Dakota
South Dakota
Wyoming
Utah
Colorado
Nebraska
Kansas
Iowa
Missouri

Region 5

Minnesota
Wisconsin
Illinois
Michigan
Indiana
Ohio

FIGURE 3-1. STATES BY REGION

TABLE 3-1. CITIES CONSIDERED FOR THE CONSTRUCTION SITE STUDY; ARRANGED BY REGION AND POPULATION DENSITY CATEGORY

1970 Census - Cities with Populations of 100,000 or More

Category I <3000	Category II 3000-7000	Category III >7000
Region 1 -		
Stamford, Conn. (2,856)	Waterbury, Conn. (3,914)	Boston, Mass. (13,936)
	Worchester, Mass. (4,721)	Providence, R.I. (9,901)
	Springfield, Mass. (5,171)	Hartford, Conn. (9,081)
Region 2 -		
Newport News, Va. (2,000)	Allentown, Pa. (6,153)	Philadelphia, Pa. (15,164)
Huntsville, Ala. (1,263)	Ft. Lauderdale, Fla. (4,176)	Washington, D.C. (12,321)
Knoxville, Tenn. (2,267)	Richmond, Va. (4,140)	Baltimore, Md. (11,568)
Region 3 -		
Riverside, Cal. (1,959)	Los Angeles, Cal. (6,073)	San Francisco, Cal. (15,764)
San Bernadino, Cal. (2,348)	Oakland, Cal. (6,771)	Berkeley, Cal. (11,011)
San Diego, Cal. (2,199)	Dallas, Texas (3,179)	
Region 4 -		
Kansas City, Mo. (1,603)	Seattle, Wash. (6,350)	St. Louis, Mo. (10,167)
Salt Lake City, Utah (2,966)	Spokane, Wash. (3,357)	
Cedar Rapids, Iowa (2,182)	Omaha, Neb. (4,534)	
Region 5 -		
Indianapolis, In. (2,113)	Dayton, Oh. (6,360)	Chicago, Ill. (15,126)
	Grand Rapids, Mich. (4,402)	Detroit, Mich. (10,953)
	Akron, Ohio (5,082)	Cleveland, Oh. (9,893)

Note: Numbers in parentheses ( ) indicate average population density inside corporate city limits.

TABLE 3-2. CITIES SELECTED FOR THE CONSTRUCTION SITE STUDY

Region \ Population Density Category	I <3000 People/Sq.Mi.	II 3000-7000 People/Sq.Mi.	III >7000 People/Sq.Mi.
1	Stamford, Connecticut (2856)	Worcester, Massachusetts (4721)	Providence, Rhode Island (9901)
2	Huntsville, Alabama (1263)	Allentown, Pennsylvania (6153)	Baltimore, Maryland (11,568)
3	Riverside, California (1959)	Oakland, California (6771)	San Francisco, California (15,764)
4	Salt Lake City, Utah (2966)	Seattle, Washington (6350)	St. Louis, Missouri (10,167)
5	Indianapolis, Indiana (2113)	Akron, Ohio (5082)	Chicago, Illinois (15,126)

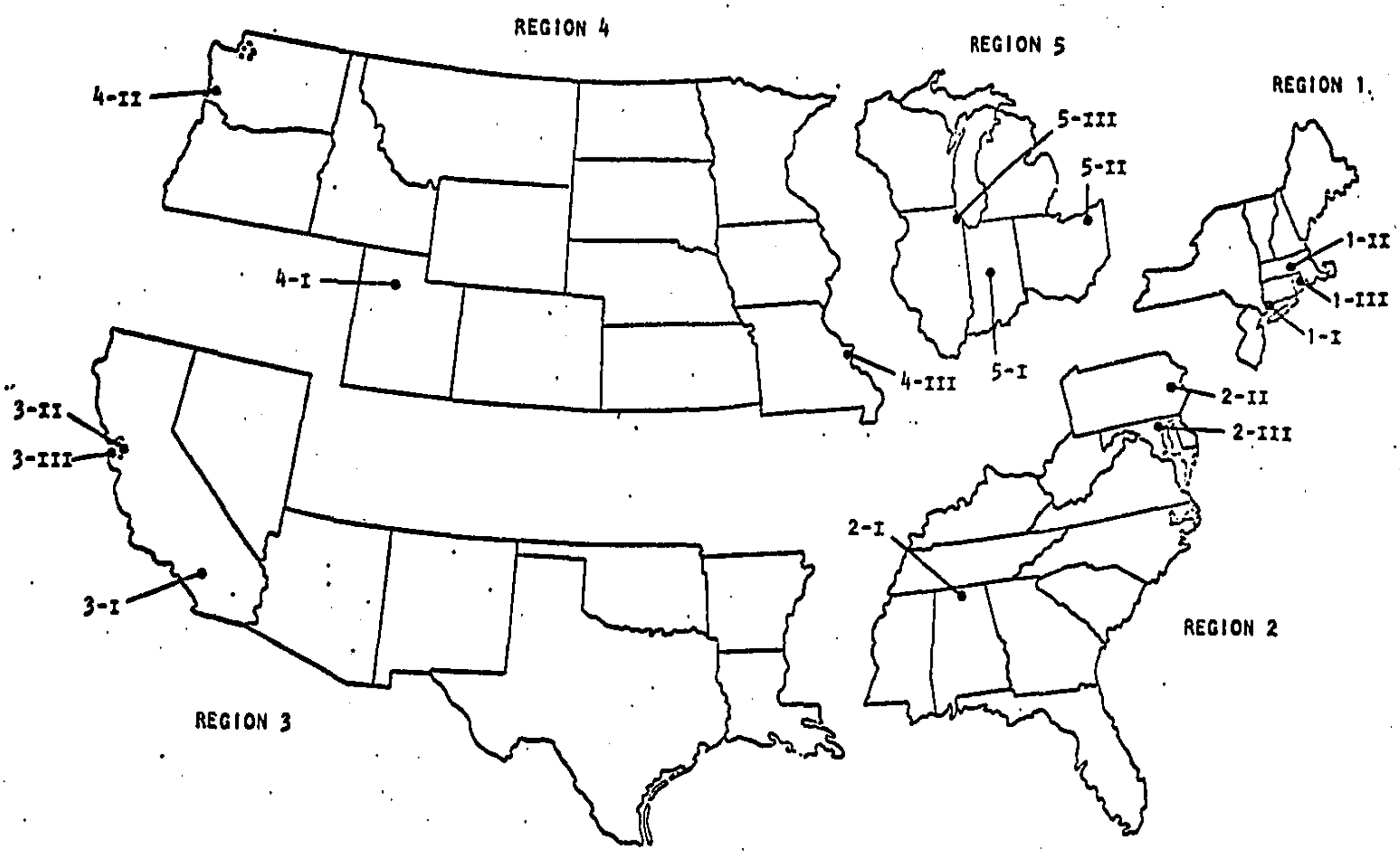

FIGURE 3-2. REGIONS AND CITIES IN THE U.S. USED IN THE CONSTRUCTION SITE AREA SURVEY

NOTE: Numbers identify cities by region and population density category, respectively.

with identification work sheets on which definitive data for each site could be listed. The site data recorded included:

- Region identification
- Population density category
- Site classification*
- Site type
- Predominant land use
- Site size
- Other relevant data including - USGS map identification, site number and date of photographs used to obtain data.

With the exception of Chicago, site data for all of the city areas selected for this study were obtained. However, in some cases, the required 30 sites for each city area could not be obtained. Nevertheless, 374 individual sites were identified. The distribution of the sites, by site type, is given below:

Site Type	Number of Sites
Residential	202
Non-Residential	58
Industrial/Commercial	90
Public Works	24

3.4 Site Data Evaluation

3.4.1 Population Density Identification and Site Type Distribution by Central City and Outside Central City Location

For each city selected for this investigation, Table 20 of reference 54 presents an average Central City (CC) and Outside Central City (OCC) population density. During the site data collection phase of this study, it was found that most of the sites were located in areas

* Sites inside corporate city limits were classified as "City" while those outside were classified as "Suburban/Rural".

which had population densities different from those listed for the CC or OCC areas. For these sites, a "local population density"* was determined. For those cases where the local population density could not be obtained, the appropriate CC or OCC density value was assigned.

Tables 3-3 through 3-5 present a summary listing, by region and population density category, of the estimated population densities of the areas in which the selected sites were located and the distribution of these sites by site type and by CC or OCC location. The data shown in these tables, along with site size and land use data, were arrayed and stored on a computer file. A complete listing of this file and a discussion of the procedures used in the statistical analyses of the site data is presented in Appendix C.

3.4.2 Site Size Evaluation

Tables 3-6 through 3-8 present listings of the average construction site sizes according to the following site classification groupings:

- City plus Suburban/Rural
- City only
- Suburban/Rural only

For each site classification grouping, the average site size and the radius for an equivalent circular area are determined for the following site type groupings, 1) all sites, 2) residential, 3) non-residential, 4) industrial/commercial and 5) public works. Along with the site area data, Tables 3-6 through 3-8 also show the range of radius variation for the 95 percent confidence interval assuming that construction site sizes are normally distributed.

Site size data for all sites by Region and by Population Density Category are presented in Table 3-9 and Table 3-10, respectively.

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* Table 31 in reference 54.

TABLE 3-3. SUMMARY OF CONSTRUCTION SITE SURVEY DATA; POPULATION DENSITY CATEGORY 1, REGIONS 1-5

Region	Pop.Den. Category	SMSA City	Pop.Density CC/OCC[1]	Other Localities	Local Pop.Density	No. of Sites[2] (CC/OCC) R	N/R	I/C	P/W	
1	1	Stamford, Connecticut	2856 2416	Norwalk South Pound Ridge, N.Y.	3596 2856	11 10 21	1 3 4	2 1 3	1 1 2	15 15 30
2	1	Huntsville, Alabama	1263 626	Meridianville Madison Jeff	1263;626 158 626	10 7 17	0 6 6	2 0 2	3 2 5	15 15 30
3	1	Riverside, California	1959 1751	San Bernardino, S. Redlands Fontana	1751 1668 1751	12 14 26	1 0 1	1 1 2	0 0 0	14 15 29
4	1	Salt Lake City, Utah	2966 2428	Fort Douglas Sugar House	2966 2428	10 11 21	4 1 5	1 3 4	0 0 0	15 15 30
5	1	Indianapolis, Indiana	2113 2614	Carmel Maywood Clermont Beech Grove Cumberland	2189 2113 2113;2614 3285 2614	3 6 9	5 0 5	4 9 13	1 0 1	13 15 28
						94	21	24	8	147

1 CC: Inside Corporate City Limits
OCC: Outside the Central City

2 R: Residential
N/R: Non-Residential
I/C: Industrial/Commercial
P/W: Public Works

TABLE 3-4. SUMMARY OF CONSTRUCTION SITE SURVEY DATA; POPULATION DENSITY CATEGORY 2, REGIONS 1-5.

ion	Pop.Den. Category	SMSA City	Pop.Density CC/OCC[1]	Other Localities	Local Pop.Density	No. of Sites[2] (CC/OCC) R	N/R	I/C	P/W	
[illegible]	2	Worcester, Massachusetts	4721 1507	Paxton	254	9 10 19	3 2 5	3 3 6	0 0 0	15 15 30
[illegible]	2	Allentown, Pennsylvania	6153 2664	Catasauqua Cementon	4386 2664	4 10 14	2 2 4	1 3 4	0 0 0	7 15 22
[illegible]	2	Oakland, California	6771 3252	San Leandro Richmond City Briones Valley Las Trampus Ridge	5409 2462 3252 3252	5 7 12	4 3 7	5 1 6	1 3 4	15 14 29
[illegible]	2	Seattle, Washington	6350 2177	Des Moines Renton Edmonds East Shilshole Bay	2978 1779 8275 6350	6 6 12	2 1 3	7 3 10	0 0 0	15 10 25
[illegible]	2	Akron, Ohio	5082 1791	Hudson Peninsula	1063 1791	4 9 13	1 0 1	3 4 7	0 2 2	8 15 23
						70	20	33	6	129

TABLE 3-5. SUMMARY OF CONSTRUCTION SITE SURVEY DATA; POPULATION DENSITY CATEGORY 3, REGIONS 1-5

egion	Pop.Den. Category	SMSA City	Pop.Density CC/OCC[1]	Other Localities	Local Pop.Density	No. of Sites[2] (CC/OCC) R	N/R	I/C	P/M	
1	3	Providence, Rhode Island	9901 2509	East Providence	3620	4 10 14	2 1 3	3 4 7	1 0 1	10 15 25
2	3	Baltimore, Maryland	11568 2914	Curtis Bay Relay Middle River Cockeysville Towson	11568;2914 2914 3692 2914 4229	2 8 10	6 1 7	5 3 8	0 2 2	13 14 27
3	3	San Francisco, California	15764 3252			4 0 4	3 0 3	3 2 5	3 2 5	13 4 17
4	3	St. Louis, Missouri	10167 3157	Clayton, Mo. Granite City, Ill. Webster Groves, Mo. Cahokia, Ill. Alton, Ill. Bethalto, Ill Florissant, Mo. Columbia Bottom, Ill.,Mo. Creve Coeür, Ill.,Mo. Kirkwood, Mo.	6489 5055 4654 1894 3609 2830 7323 1616 1422 3583	2 8 10	1 3 4	10 3 13	2 0 2	15 14 29
5	3	Chicago, Illinois	15126 3091	(Data not included)						
						38	17	33	12	98

TABLE 3-7. AVERAGE CONSTRUCTION SITE SIZES: CITY ONLY

Site Type	Number of Sites	Average Construction Site Area (sq.ft.)	Radius for Equivalent Circular Area (ft.)	Radius Variation for 95% Confidence Limits (ft.)
All	183	106,909	184	150 - 214
Residential	86	137,642	209	165 - 246
Non-Residential	35	68,058	147	92 - 187
Industrial/ Commercial	50	95,708	175	(*) - 248
Public Works	12	46,650	122	67 - 159

* Standard deviation is excessively large

TABLE 3-8. AVERAGE CONSTRUCTION SITE SIZES:
SUBURBAN/RURAL ONLY

Site Type	Number of Sites	Average Construction Site Area (sq.ft.)	Radius for Equivalent Circular Area (ft.)	Radius Variation for 95% Confidence Limits (ft.)
All	191	184,796	243	201 - 278
Residential	116	240,384	277	219 - 324
Non-Residential	23	101,018	179	54 - 248
Industrial/ Commercial	40	114,501	191	122 - 241
Public Works	12	42,333	116	70 - 148

TABLE 3-9. AVERAGE CONSTRUCTION SITE SIZES: ALL SITES BY REGION

All Sites	Number of Sites	Average Construction Site Area (sq.ft.)	Radius for Equivalent Circular Area (ft.)	Radius Variation for 95% Confidence Limits (ft.)
Region 1	85	30,883	99	62 - 126
Region 2	79	132,415	205	147 - 250
Region 3	75	227,132	269	204 - 321
Region 4	84	194,212	249	183 - 300
Region 5	51	165,212	229	131 - 297

TABLE 3-10. AVERAGE CONSTRUCTION SITE SIZES: ALL SITES BY POPULATION DENSITY CATEGORY

All Sites	Number of Sites	Average Construction Site Area (sq. ft.)	Radius for Equivalent Circular Area (ft.)	Radius Variation for 95% Confidence Limits (ft.)
Category 1	147	154,541	222	174 - 261
Category 2	129	148,395	217	178 - 250
Category 3	98	132,652	205	136 - 257

Based on the site size data presented in Tables 3-6 through 3-10, the following general conclusions can be made:

- The national average construction site size can be represented by an equivalent circular area with a radius of approximately 200 feet.
- The national average construction site size, by site type, can be represented by an equivalent circular area with the following approximate radii:

Site Type	Radius For Equivalent Circular Area (Feet)
Residential	200
Non-Residential	150
Industrial/Commercial	175
Public Works	125

- On a national basis, there is little variation in the average construction site size with respect to geographic location or average population density.

4.0 REVISIONS TO CONSTRUCTION SITE MODEL BASELINE DATA

4.0 REVISIONS TO CONSTRUCTION SITE MODEL BASELINE DATA

4.1 Equipment Noise Levels

Based on the data obtained from the literautre search portion of this study, the noise levels for some of the construction equipment types used in EPA's construction site model were revised. The following table presents a summary of these revisions and the relative change in baseline noise levels for each equipment type.

Equipment Type	A-Weighted Noise Levels at 50 Feet: Current Baseline	Revised* Baseline	Relative Change
Small Cement/Concrete Mixers (non-truck type)	85	79	-6
Concrete Mixers (truck type)	78	83	+5
Concrete Pumps	82	82	0
Concrete Vibrators	76	77	+1
Cranes - Derrick	88	82	-6
Cranes - Mobile	83	81	-2
Generators	78	75	-3
Graders	85	84	-1
Pavers and Mixers	89	85	-4
Pile Drivers	101	99	-2
Pneumatic Tools	85	82	-3
Pumps	76	74	-2
Rollers	80	81	+1
Saws	78	78	0

*Arithmetic-average of equipment noise level data

4.2 Average Construction Site Size

Based on the evaluation of construction site sizes presented in Section 3, the baseline distance (site radius) from the site center to the site boundary for each site type included in the EPA's construction site model was revised. The following table presents a summary of these revisions and the relative change in distance for each site type.

Site Type	Distance From Site Center to Site Boundary, Feet		
	Current	Revised	Relative Change
Residential	100	200	+100
Non-Residential	100	150	+ 50
Industrial/Commerical	100	175	+ 75
Public Works	50	125	+ 75

5.0 NATIONAL CONSTRUCTION SITE SCENARIOS MODELED

5.0 NATIONAL CONSTRUCTION SITE SCENARIOS MODELED

5.1 Scenarios Modeled

Nine scenarios were developed to estimate the health/welfare impacts associated with variations in construction site sizes and construction equipment noise levels. These scenarios were:

A. Current Baseline Case - no change in site sizes or equipment noise levels currently used in construction site model

B. Change in equipment noise levels in accordance with the revised baseline values presented in Section 4.1 and no change in site sizes

C. Change in site sizes in accordance with the revised site size data presented in Section 4.2 and no change in equipment noise levels

D. Revised Baseline Case - change in site sizes and in equipment noise levels in accordance with the values presented in Sections 4.1 and 4.2, respectively.

E. Same as D with portable air compressors regulated

F. Same as E with trucks regulated*

G. Same as F with tractors (wheel and crawler) regulated

H. Same as G with all other construction site equipment noise levels reduced by 5 dBA

I. Same as G with all other construction site equipment noise levels reduced by 10 dBA

A listing of the equipment noise levels used for each of the above construction site scenarios is presented in Table 5-1.

5.2 Noise Impact Analyses

By exercising the EPA's construction site model, the noise impacts for scenarios A through I were determined and are presented in Table 5-2. The results of the impact analyses for scenarios B, C, and D are relative to the current baseline case only. However, the results of the

* Including concrete transit mixers - truck type

TABLE 5-1. CONSTRUCTION EQUIPMENT NOISE LEVELS FOR VARIOUS NATIONAL CONSTRUCTION SITE SCENARIOS

EQUIPMENT TYPE	Equipment Noise Levels at 50 Ft. for Various National Construction Site Scenarios, dBA								
	A.	B.	C.	D.	E.	F.	G.	H.	I.
Air Compressors	81.0	81.0	81.0	81.0	67.0	67.0	67.0	67.0	67.0
Concrete Mxrs, Truck Mtd.	78.0	83.0	78.0	83.0	83.0	78.0	78.0	78.0	78.0
Small Cement/Concrete Mixers	85.0	79.0	85.0	79.0	79.0	79.0	79.0	74.0	69.0
Concrete Pumps	82.0	82.0	82.0	82.0	82.0	82.0	82.0	77.0	72.0
Concrete Vibrators	76.0	77.0	76.0	77.0	77.0	77.0	77.0	72.0	67.0
Cranes, Derrick	88.0	82.0	88.0	82.0	82.0	82.0	82.0	77.0	72.0
Cranes, Mobile	83.0	81.0	83.0	81.0	81.0	81.0	81.0	76.0	71.0
W & C Tractors, 20-89 HP	79.5	79.5	79.5	79.5	79.5	79.5	72.0	72.0	72.0
W & C Tractors, 90-199 HP	81.0	81.0	81.0	81.0	81.0	81.0	74.0	74.0	74.0
W & C Tractors, 200-350 HP	83.3	83.3	83.3	83.3	83.3	83.3	78.0	78.0	78.0
W & C Tractors, 351-500 HP	85.9	85.9	85.9	85.9	85.9	85.9	85.9	80.9	75.9
Excavators, <375 HP	84.2	84.2	84.2	84.2	84.2	84.2	84.2	79.2	74.2
Excavators, 376-500 HP	86.7	86.7	86.7	86.7	86.7	86.7	86.7	81.7	76.7
Excavators, Cable	85.0	85.0	85.0	85.0	85.0	85.0	85.0	80.0	75.0
Generators	78.0	75.0	78.0	75.0	75.0	75.0	75.0	70.0	65.0
Graders	85.0	84.0	85.0	84.0	84.0	84.0	84.0	79.0	74.0
Integral Backhoe/Loaders	81.3	81.3	81.3	81.3	81.3	81.3	81.3	76.3	71.3
Pavers and Mixers	89.0	85.0	89.0	85.0	85.0	85.0	85.0	80.0	75.0
Paving Breakers, Portable	84.6	84.6	84.6	84.6	84.6	84.6	84.6	79.6	74.6
Paving Breakers, Mounted	89.1	89.1	89.1	89.1	89.1	89.1	89.1	84.1	79.1
Pile Drivers	101.0	99.0	101.0	99.0	99.0	99.0	99.0	94.0	89.0
Pneumatic Tools	85.0	82.0	85.0	82.0	82.0	82.0	82.0	77.0	72.0
Pumps	76.0	74.0	76.0	74.0	74.0	74.0	74.0	69.0	64.0
Rock Drills, Portable	87.8	87.8	87.8	87.8	87.8	87.8	87.8	82.8	77.8
Rock Drills, Mounted	95.8	95.8	95.8	95.8	95.8	95.8	95.8	90.8	85.8
Rollers	80.0	81.0	80.0	81.0	81.0	81.0	81.0	76.0	71.0
Saws	78.0	78.0	78.0	78.0	78.0	78.0	78.0	73.0	68.0
Scrapers, <375 HP	83.5	83.5	83.5	83.5	83.5	83.5	83.5	78.5	73.5
Scrapers, 376-650 HP	85.6	85.6	85.6	85.6	85.6	85.6	85.6	80.6	75.6
Skid Steer Loaders	73.5	73.5	73.5	73.5	73.5	73.5	73.5	68.5	63.5
Trenchers, Ladder <20 HP	71.7	71.7	71.7	71.7	71.7	71.7	71.7	66.7	61.7
Trenchers, Ladder >20 HP	76.2	76.2	76.2	76.2	76.2	76.2	76.2	71.2	66.2
Trenchers, Wheel	76.2	76.2	76.2	76.2	76.2	76.2	76.2	71.2	66.2
Trucks, Off Highway	88.0	88.0	88.0	88.0	88.0	78.0	78.0	78.0	78.0
Trucks, Rear Dump	88.0	88.0	88.0	88.0	88.0	78.0	78.0	78.0	78.0

TABLE 5-2. ESTIMATED NOISE IMPACT FOR VARIOUS NATIONAL CONSTRUCTION SITE SCENARIOS

NATIONAL CONSTRUCTION SITE SCENARIO	POPULATION EXPOSED MILLIONS	POPULATION IMPACTED MILLIONS	ENI MILLIONS	ΔENI MILLIONS	RCI PERCENT*
A Current Baseline	40.91	40.91	12.56	0	0
B	38.05	38.05	11.07	-1.49	+11.86
C	40.36	40.36	10.94	-1.62	+12.90
D Revised Baseline	35.90	35.90	9.17	-3.39	+26.99
E	35.50	35.50	9.02	-3.54 (-0.15)	+28.18 (+1.64)
F	32.42	32.42	8.01	-4.55 (-1.16)	+36.23 (+12.65)
G	26.33	26.33	6.45	-6.11 (-2.72)	+48.65 (+29.66)
H	12.70	12.70	2.36	-10.20 (-6.81)	+81.21 (+74.26)
I	4.64	4.64	0.88	-11.68 (-8.29)	+92.99 (+90.40)

Note: Numbers in parentheses ( ) are relative to revised baseline case (scenario D).

* Relative Change in Impact (RCI) is defined such that positive values indicate a decrease in ENI compared with baseline case.

impact analyses for scenarios E through I are presented relative to both the current and the revised baseline cases.

Scenarios B and C provide a sensitivity check on the relative effects of changing equipment noise levels compared with changes in site sizes. It can be seen from Table 5-2 that, for the revisions in baseline data as specified in Section 4, changes in equipment noise levels and changes in site size have a comparable influence on the total number of people exposed and the total ENI.

Based on the results of the impact analyses, the following conclusions can be made:

- Compared with the current baseline case (scenario A), the revised baseline case (scenario D) results an ENI decrease of approximately 3.39 million
- The relative decrease in ENI for the revised baseline case is due to comparable ENI reductions resulting from the changes in equipment noise levels and the changes in construction site sizes
- Compared with the revised baseline case, the regulation scenarios, E, F, and G, result in ENI reductions of 0.15, 1.16, and 2.72 million, respectively.

6.0 NUMBER OF CONSTRUCTION EQUIPMENT OPERATORS AND AVERAGE DAILY EXPOSURE TIME

6.0 NUMBER OF CONSTRUCTION EQUIPMENT OPERATORS AND AVERAGE DAILY EXPOSURE TIME

This section presents an estimate of the number of operators and of the operator exposure time for various types of construction equipment. The following is a discussion of the procedures and assumptions used to obtain these estimates. A summary listing of the results is presented in Table 6-1.

6.1 Number of Operators

6.1.1 Data Requirements

In order to obtain an estimate of the number of operators of a given machine type, the following information is required: 1) number of machines in use, 2) number of hours of machine operation for a specified time interval and 3) number of operators that work on each machine type over the same specified time interval.

6.1.2 Data Sources

For the equipment types included in the EPA's construction site noise model, estimates of the number of machines used in construction and of the number of annual hours of use were obtained from: 1) Table 3-4 in reference 50 or, 2) computations based on machine usage and duration of construction activity by phase.

The average annual hours worked by various equipment operators is estimated to be 1331 hours. This estimate was obtained by averaging the number of hours worked in 1976 by 35 member unions of the International Union of Operating Engineers (IUOE).[61] The 35 member unions were located in various cities distributed within 23 different states and thus, provided data from which a representative national average could be obtained.

6.1.3 Estimation Procedure

Based on the three information requirements stated in Section 6.1.1, the number of operators was estimated for some of the machine

TABLE 6-1. ESTIMATED NUMBER OF CONSTRUCTION EQUIPMENT OPERATORS AND TYPICAL OPERATOR EXPOSURE TIME TO SPECIFIC MACHINE NOISE EMISSIONS

MACHINE TYPE	NUMBER USED IN CONSTRUCTION	NO. OF ANNUAL HOURS OF USE	NO. OF OPERATORS PER MACHINE	NO. OF OPERATORS FOR ALL MACHINES	INDIVIDUAL DAILY EXPOSURE TO MACHINE NOISE IN HOURS	
					FIRST OPERATOR	SECOND OPERATOR
Air Compressors	35490	1300	0.98*	34780	5.42	-
Concrete Mxrs, Truck Mtd.	16137	1800	1.35	21785	5.55	1.95
Small Cement/Concrete Mixers	13464	1500	1.13	15174	5.55	0.70
Concrete Pumps	28085	1600	1.20	33702	5.55	1.12
Concrete Vibrators	26485	1600	1.20	31782	5.55	1.12
Cranes, Derrick	5607	2000	1.50	8411	5.55	2.79
Cranes, Mobile	27405	1600	1.20	32886	5.55	1.12
W&C Tractors, 20-89 HP	156408	1259	0.95*	148588	5.25	-
W&C Tractors, 90-199 HP	88484	1259	0.95*	84060	5.25	-
W&C Tractors, 200-350 HP	16886	1259	0.95*	16042	5.25	-
W&C Tractors, 351-500 HP	7494	1259	0.95*	7119	5.25	-
Excavators, <375 HP	17477	1448	1.09	19050	5.55	0.48
Excavators, 376-500 HP	1015	1433	1.08	1096	5.55	0.42
Excavators, Cable	1015	1433	1.08	1096	5.55	0.42
Generators	96757	1300	0.98*	94822	5.42	-
Graders	15795	1400	1.05	16585	5.55	0.29
Integral Backhoe/Loaders	104897	1519	1.14	119583	5.55	0.78
Pavers and Mixers	14345	1200	0.90*	12911	5.00	-
Paving Breakers, Portable	67932	550	0.41*	27852	2.29	-
Paving Breakers, Mounted	5712	500	0.38*	2171	2.08	-
Pile Drivers	5802	1000	0.75*	4352	4.17	-
Pneumatic Tools	53770	1200	0.90*	48393	5.00	-
Pumps	328722	1200	0.90*	295850	5.00	-
Rock Drills, Portable	2454	700	0.53	1301	2.92	-
Rock Drills, Mounted	1548	900	0.68	1053	3.75	-
Rollers	27450	1200	0.90*	24705	5.00	-
Saws	125078	1400	1.05	131332	5.55	0.29
Scrapers, <375 HP	27155	1811	1.36	36931	5.55	2.00
Scrapers, 376-650 HP	6738	1869	1.40	9433	5.55	2.24
Skid Steer Loaders	41292	600	0.45*	18581	2.50	-
Trenchers, Ladder <20 HP	214612	153	0.11*	23607	0.64	-
Trenchers, Ladder >20 HP	62071	529	0.40*	24828	2.20	-
Trenchers, Wheel	1015	1300	0.98*	995	5.42	-
Trucks, Off Highway	11466	1400	1.05	12039	5.55	0.28
Trucks, Rear Dump	5265	1400	1.05	5528	5.55	0.28

* Implies that Machine's Operating Time is less than the Operator's Average Working Time

types identified in this study. The number of operators was computed in the following manner:

1. Divide the number of annual hours of machine use by the average annual hours worked by equipment operators to determine the number of operators per machine
2. Multiply the number of operators per machine by the number of machines used in construction to determine the total number of operators per machine type

Referring to Table 6-1, it should be noted that less than one operator per machine implies that the machine's average operating time is less than the operator's average working time.

6.2 Operator's Average Daily Noise Exposure Time

The average daily noise exposure time for operators of various types of construction equipment is a function of two variables: 1) the average number of operators per machine and 2) the average daily operating time of each machine. The first variable was estimated from data developed under Section 6.1. The second variable can be obtained by dividing the number of annual hours of machine use by an assumed number of days per year that each machine operates. Using 240 as the assumed number of days of machine operation per year, the operator's average daily exposure time to machine noise was computed in the following manner:

1. Determine the average daily operating time for each machine type by dividing the number of annual hours of machine use by 240
2. Determine the average daily working time for machine operators by dividing the average annual hours worked by machine operators by 240

3. In cases where there is more than one operator per machine, the average daily exposure time for the first operator is equal to the average daily working time for machine operators (step 2). The difference between the machine's average daily operating time and the average daily exposure time for the first operator is assigned to subsequent operators.
4. In cases where there is less than one operator per machine, the average daily exposure time is assumed to be the same as the machine's average daily operating time (step 1).

The results obtained using the above computational procedures are presented in Table 6-1.

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APPENDIX A

APPENDIX A

EQUIPMENT NOISE LEVELS AND NOISE LEVEL VERSUS ENGINE HORSEPOWER RELATIONSHIPS

This appendix presents a detailed listing of noise levels and operational parameters obtained from the literature search portion of this study. In addition, based on the literature search data, analytical expressions relating equipment A-weighted noise level at 50 feet to engine horsepower rating are presented.

A.1 Equipment Noise Levels

Through an extensive literature search,[1-18] noise level data were obtained for the fourteen pieces of construction equipment included in this study. These data represent the A-weighted equipment noise levels measured at a distance of 50 feet from the machine.

The levels are presented in terms of one or more of the following three machine operational modes:

(1) low or idle

(2) off-maximum or average, and

(3) high or maximum

Tables A-1 through A-14 present these data. Where it was identifiable from the literature search, an operational parameter value associated with a particular machine type, is also shown.

A.2 Noise Level As a Function of Engine Horsepower

Using the data obtained in the literature search, a least squares linear regression analysis was used to develop relationships between the A-weighted noise level at 50 feet and the $\log_{10}$ of machine horsepower. In relating the off-maximum/average noise levels with $\log_{10}$ (horsepower), 98 data points were used, giving a correlation coefficient of 0.50 and a standard error of 5.36. The equation for the regression line was determined to be:

$$L = 66.05 + 6.769 \log_{10} (hp) \qquad \text{Equation (1)}$$

where L = estimated noise level at 50 feet, dBA

hp = machine horsepower

An analysis was also performed using the combined data for both the off-maximum/average and the high/maximum noise levels. Here, 151 data points were used in the regression analysis, yielding a correlation coefficient of 0.54 and a standard error of 5.37. The resulting regression equation was of the form:

$$L = 63.13 + 8.566 \log_{10}(hp) \qquad \text{Equation (2)}$$

It is interesting to note that equation (2) is in reasonably good agreement with a similar function relating machine noise level versus horsepower presented in reference 16. This function is given by:

$$L = 60 + 10 \log_{10}(hp) \qquad \text{Equation (3)}$$

It should be noted that the regression constants for equations (1) and (2) were determined using an arithmetic average of the noise levels in terms of dB.

However, unlike energy averaging, arithmetic averaging of noise data expressed in dB does not reflect the influence of the higher range of levels on the overall average. Thus, in order to use the above equations to predict average A-weighted noise levels at 50 feet on an energy basis, it is recommended that the regression constants 66.05, 63.13 and 60 for equations (1), (2), and (3), respectively, be increased by 2 dB. This 2 dB adjustment is based on the average difference between the arithmetic-and energy-averaged noise levels computed for each of the machine types considered in the regression analyses.

Figures A-1 through A-6 present the following:

Figure Number	Description
A-1	A-weighted off-maximum/average noise level as a function of engine horsepower as compared with prediction equations.
A-2	A-weighted off-maximum plus high/maximum noise level as a function of engine horsepower as compared with prediction equations.
A-3	Arithmetic-averaged A-weighted off-maximum/average noise level as a function of average engine horsepower as compared with prediction equations.

A-4 Arithmetic- averaged A-weighted off-maximum/average plus high/maximum noise level as a function of average engine horsepower as compared with prediction equations.

A-5 Energy- averaged A-weighted off-maximum/average noise level as a function of average engine horsepower as compared with prediction equations.

A-6 Energy- averaged A-weighted off-maximum/average plus high/maximum noise level as a function of average engine horsepower as compared with prediction equations.

TABLE A-1. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Small Cement/Concrete Mixers (Non-Truck Type)

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER:
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
13		89		
13		68		

TABLE A-2. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Concrete Mixers (Truck Type Only)

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
10		85		
11		83		
11		85		
13		83		
14		85		225
15		87		
16	66	76		250
16	68	83		250
16		80		250
18		83		

TABLE A-3. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Concrete Pumps

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
8		76		
10		82		
11		82		
13		82		
14		82		35
16	70			105
16			80	125
16			87	139
16		84		130
16		81		125

TABLE A-4. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Concrete Vibrators

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
13		76		
14		76		3
16		78		

TABLE A-5. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Cranes (Derrick)

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
10		88		
11		88		
12			77	192
12			82	170
12			70	116
12			82	93
12			76	110
12			94	287
12			84	100
13		88		
15	70	77		110
15	74	76		110
15		71		89
15		94		287
15		75		100
15		72 (2)		100
15	71	84		100
15		85		190
15		82		93
15		94		
15	70	86		
15	62	70		116
15	73	76		116
15	72	76		170
15	76	82		170
15	74	77		192
15		91		
16	64			105
16	66			130
16	67			140
16	67			170
16	68			145
16	59			220
16	60			270
16	63			285
16	64			275
16	64			310
16	65			325

Note: Numbers in parentheses ( ) indicate number of measurements

TABLE A-5. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Cranes (Derrick)

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER : HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
16	69			300
16	70			350
16	72			310
16			75	120
16			78	115
16			79	140
16			85	160
16			87	200.
16			75	280
16			78	330
16			86	320
16			88	330
16			86	370
16			92	400
16			93	390
16			96	360
16			86	700
16		75		115
16		83		200
16		74		235
16		74		280
16		82		310
16		83		300
16		84		320
18		88		

TABLE A-6. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Cranes (Mobile)

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
10		85		
12			79	143
13		83		
13		77		
13			78	
13		88		
13		83		
15		82		142
15		88		123
15	68	73		
15	69	74		
16	70			105
16	70			120
16	70			130
16	70			140
16	68			118
15	69			130
16	68			135
16	64			110
16	66			180
16	75			165
16		79		105
16		74		125
16		73		140
16		75		150
16		79		155
16		80		155
16		86		190
16		86		250
16			81	109
16			83	130
16			79	130
16			83	145
16			83	155
16			83	160
16			80	165
16			84	165

TABLE A-6. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Cranes (Mobile)

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
16			84	160
16			84	150
16			85	170
16			88	199
16			91	270
18		83		

TABLE A-7. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Generators

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER : HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
8		73		
10		78		
11		78		
13		78		
13		76		7
14		78		7
15	58	79		
15		62		
15		92		
16		83		
16		73		
17		57		1
17		65		3
17		72		

TABLE A-8. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Graders

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
8		84		
8		92		
8		91		
10		90		
11		85		
12			91	225
12			86	225
12			83	150
12			84	150
12			85	150
12			85 (2)	
12			84	
12			82	125
12			92	125
12			81	
12			83	
12			88	
12			84	160
12			87	
13	72	83		
13		85		125
13		73		150
13	65	78		150
13		82		135
13		73		59
13		81 (2)		125
13		82 (3)		
13		81 (3)		
13	78	80 (2)		150
13		87		150
14		85		100
15	82			134
15	77 (3)	87		
15	68	78		
15	65	74		
15		85 (2)		
15		83 (3)		

Note: Numbers in parentheses ( ) indicate number of measurements.

TABLE A-8. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Graders

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
15		77 (2)		
15		84		156
15		85		145
15		88		
15		82 (4)		
15		84 (2)		
15		80 (2)		
15		81		
15	80	86		125
15	77 (2)	82 (3)		125
15	72 (2)	88		125
15	74	80 (4)		125
15		89		125
15		81		125
15		83 (2)		125
15		92		125
15		84 (2)		150
15		85		150
15		83		150
15		92		225
15	82	86		225
15		91		225
16	69			165
16	71			180
16	76			180
16	75			450
16			78	180
16			79	200
16			78	210
16			88	200
16			85	300
16			98	420
16			91	560
16			95	600
16		71		170
16		81		190
16		83		210
16		82		185
16		84		500
16		85		500

Note: Numbers in parentheses ( ) indicate number of measurements

TABLE A-9 CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Pavers and Mixers

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER:
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
8		89		
8		87		
10		87		
11		89		
13		89		
14		88		
15	79	78 (2)		
15	69	88		
15	70	84 (2)		
15		85		
15		82		
15		73		
16		89		
18		89		

Note: Numbers in parentheses ( ) indicate number of measurements.

TABLE A-10. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Pile Drivers

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: Ft-Lb/BLOW
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
2		107		700
2		104		
2		98		25,200
2		99		18,800
3			81	
3			90	
3			92	
3			104	
3			109	
3			114	
3			116	
4		98		
6		108		
7			92	26,200
8		90		
8			91	
8			102	
9		97		
10		92		
14		101		
15		83		
15		94		
16		93		12,000-18,000
16		104		20,000-32,000
18			103	

TABLE A-11. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Pneumatic Tools

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER:
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
1		76		
1		88		
10		87		
13		86		
13		65		
14		86		
16		85		

TABLE A-12. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Pumps

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER:
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
1		68		25
1		71		50
1		74		100
1		77		250
8		79		
8		78		
8		70		
10		70		
13		78		
13		76		
14		74		
15		78		
15		68		
15		75		
15		82		
16		77		
17		64		

TABLE A-13. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Rollers

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER: HORSEPOWER
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
8		78		
8		85		
8		73		
14		80		
15	85	84		
15	73 (2)	85 (2)		
15	76	82 (5)		
15	68	100		
15	51	78 (3)		
15	75	80		
15	65	83 (2)		
15	74	66		
15		79		
15		86 (2)		
15		89		
15		65		
15	72			105
15		65		60
15		73		38
15	85			88
15	83			62
15	72	78		87
15		88		
15	74			80
15		98		
15		74		
15		84		75
15	65			96
15		72		
15		76		38
15		86		100
15		92		
15		79		95
16		74		
16		78		
16		82		
16	71			
16		82		195
16		81		145
16		78		185

Note: Numbers in parentheses ( ) indicate number of measurements.

TABLE A-14. CONSTRUCTION EQUIPMENT SOUND LEVEL DATA FOUND IN LITERATURE SEARCH

Equipment Type - Saws (Electric Radial)

REFERENCE	A-WEIGHTED SOUND LEVEL AT 50 FEET AS A FUNCTION OF OPERATIONAL MODE, dBA			OPERATIONAL PARAMETER:
	LOW OR IDLE	OFF-MAXIMUM OR AVERAGE	HIGH OR MAXIMUM	
8		79		
10		79		
13		78 (2)		
13		80 (3)		
14		79		
16		70		

Note: Numbers in parentheses ( ) indicate number of measurements

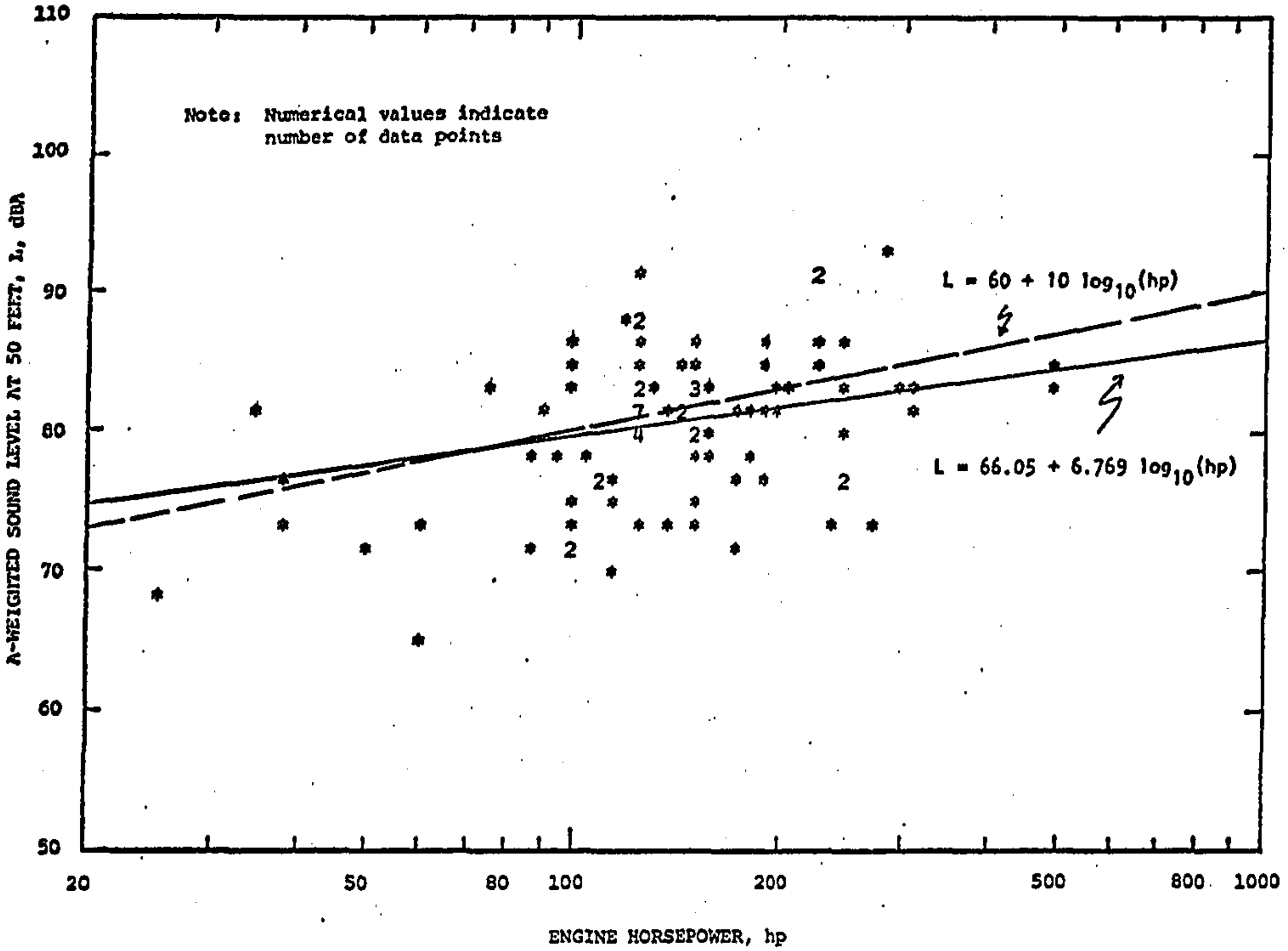

FIGURE A-1. A-WEIGHTED OFF-MAXIMUM/AVERAGE NOISE LEVEL AS A FUNCTION OF ENGINE HORSEPOWER AS COMPARED WITH PREDICTION EQUATIONS.

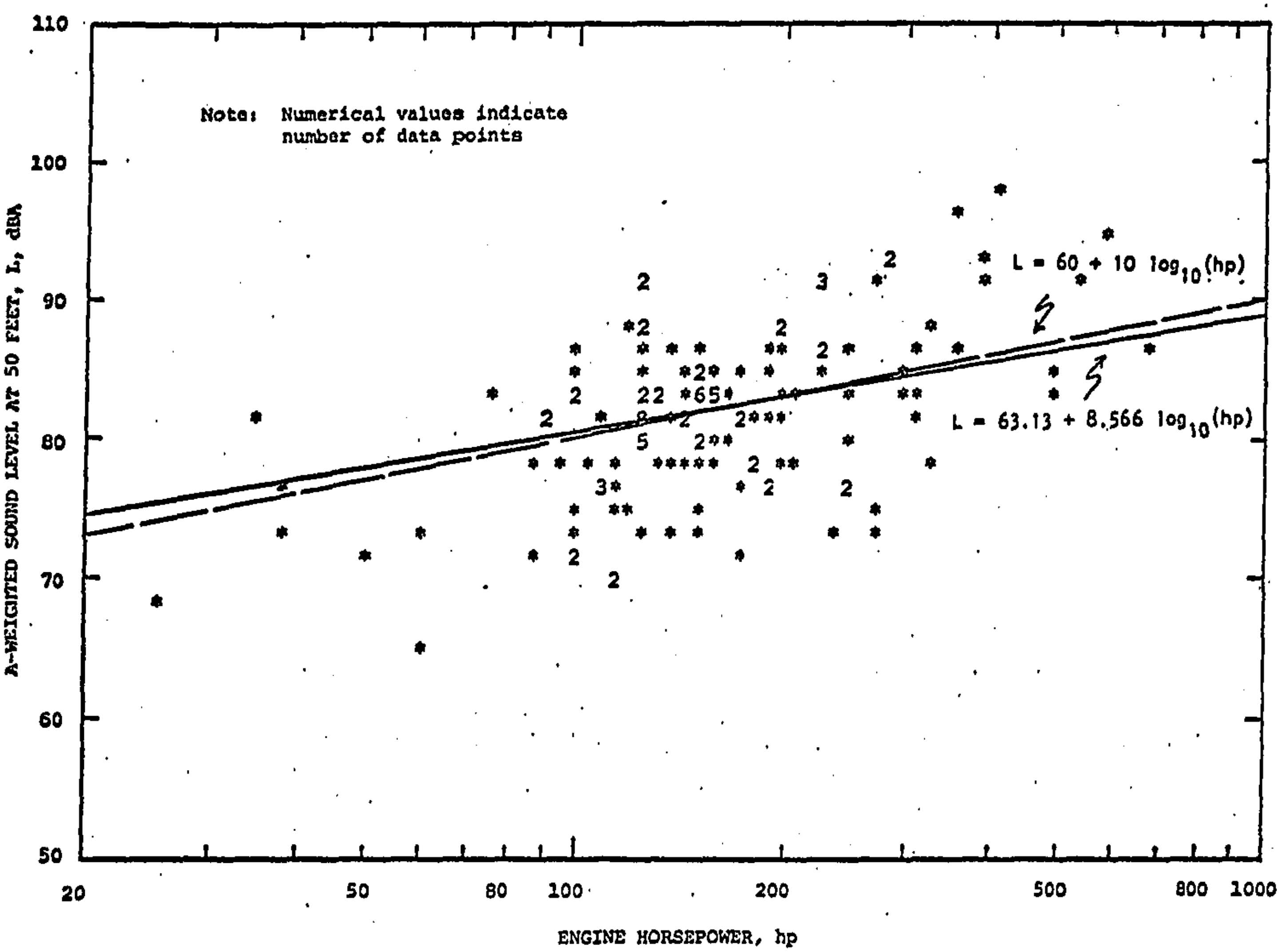

FIGURE A-2. A-WEIGHTED OFF-MAXIMUM/AVERAGE PLUS HIGH/MAXIMUM NOISE LEVEL AS A FUNCTION OF ENGINE HORSEPOWER AS COMPARED WITH PREDICTION EQUATIONS.

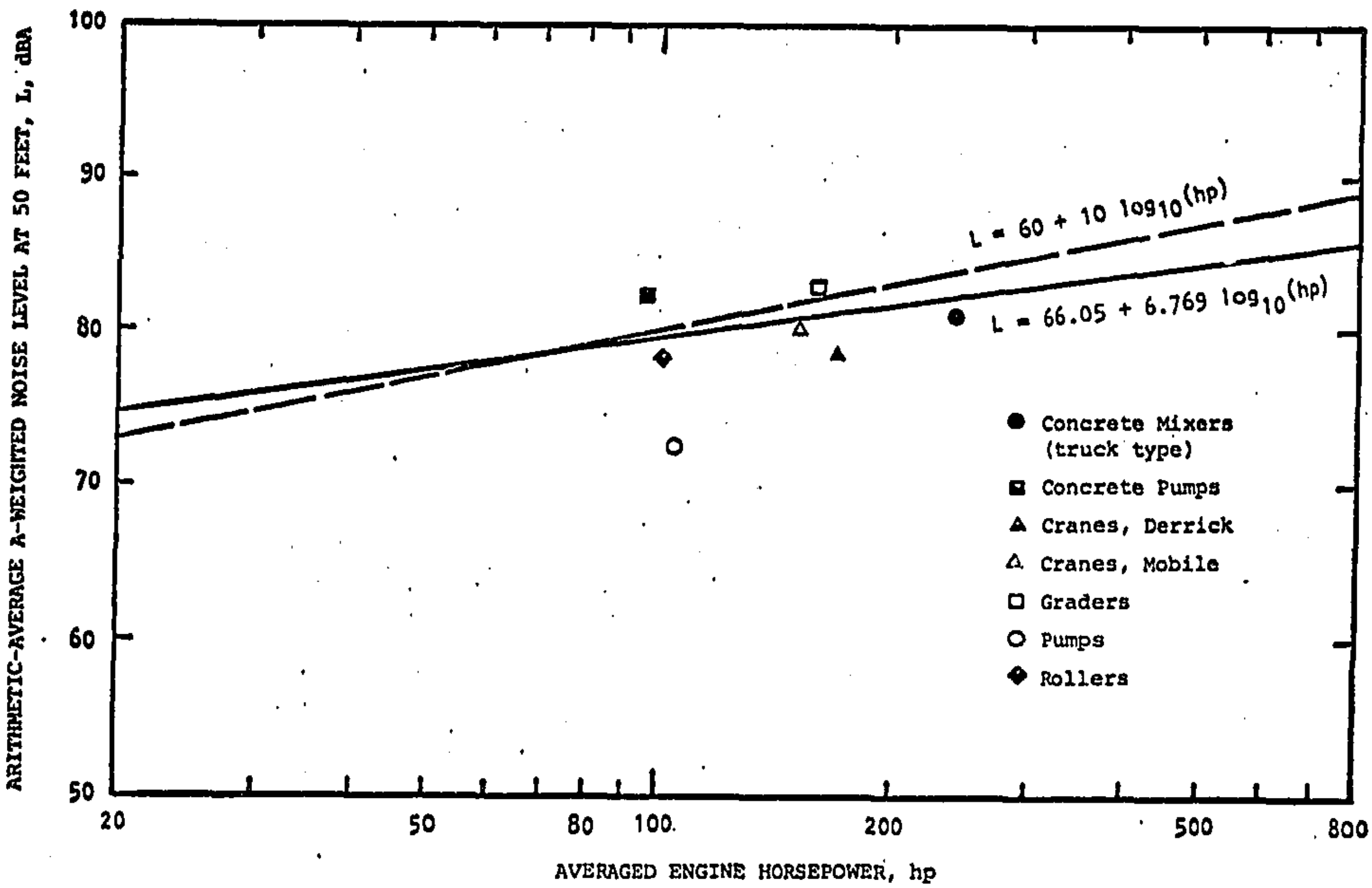

FIGURE A-3. ARITHMETIC-AVERAGED A-WEIGHTED OFF-MAXIMUM/AVERAGE NOISE LEVEL AS A FUNCTION OF AVERAGE ENGINE HORSEPOWER AS COMPARED WITH PREDICTION EQUATIONS.

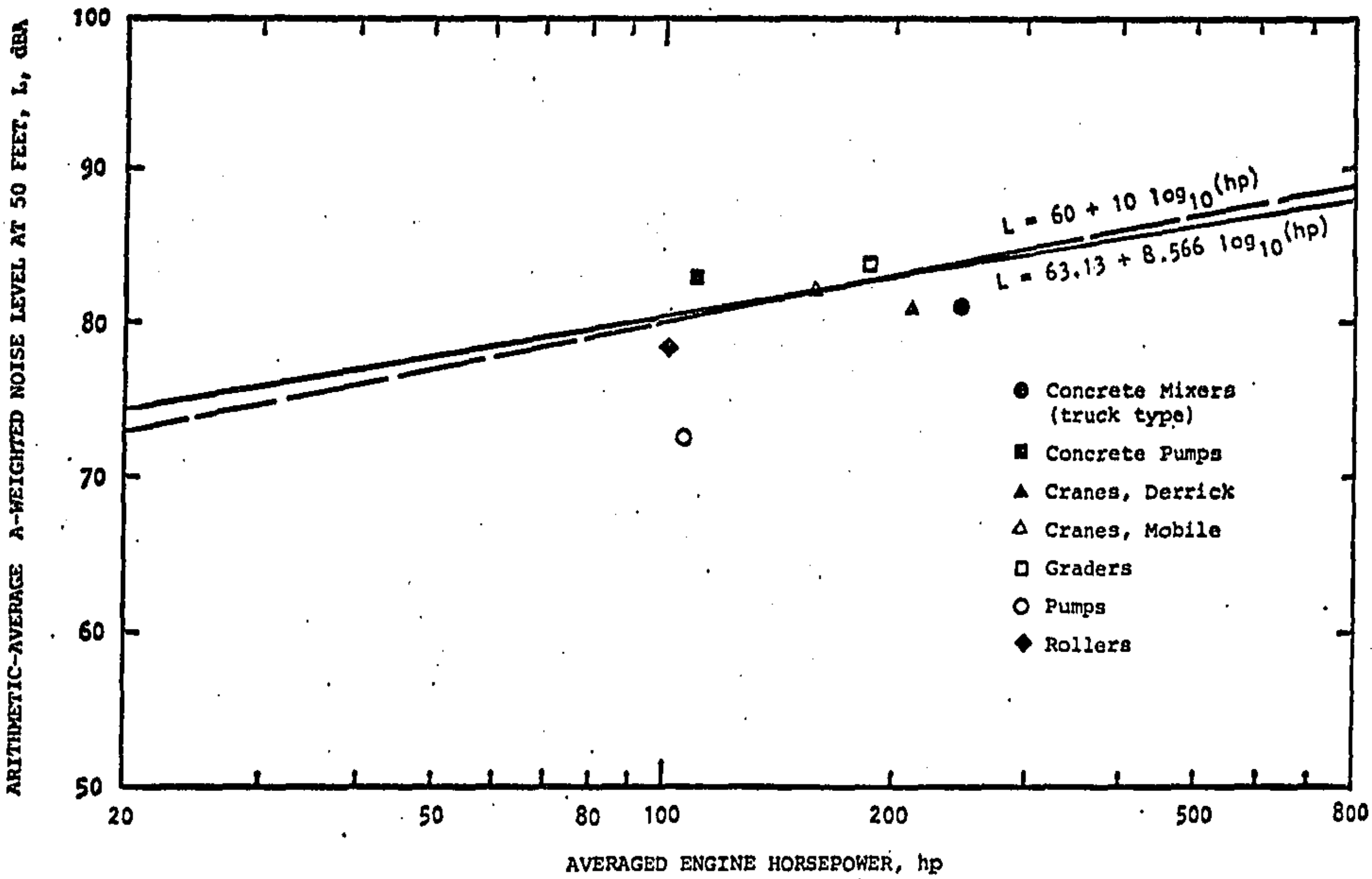

FIGURE A-4. ARITHMETIC-AVERAGED A-WEIGHTED OFF-MAXIMUM/AVERAGE PLUS HIGH/MAXIMUM NOISE LEVEL AS A FUNCTION OF AVERAGE ENGINE HORSEPOWER AS COMPARED WITH PREDICTION EQUATIONS.

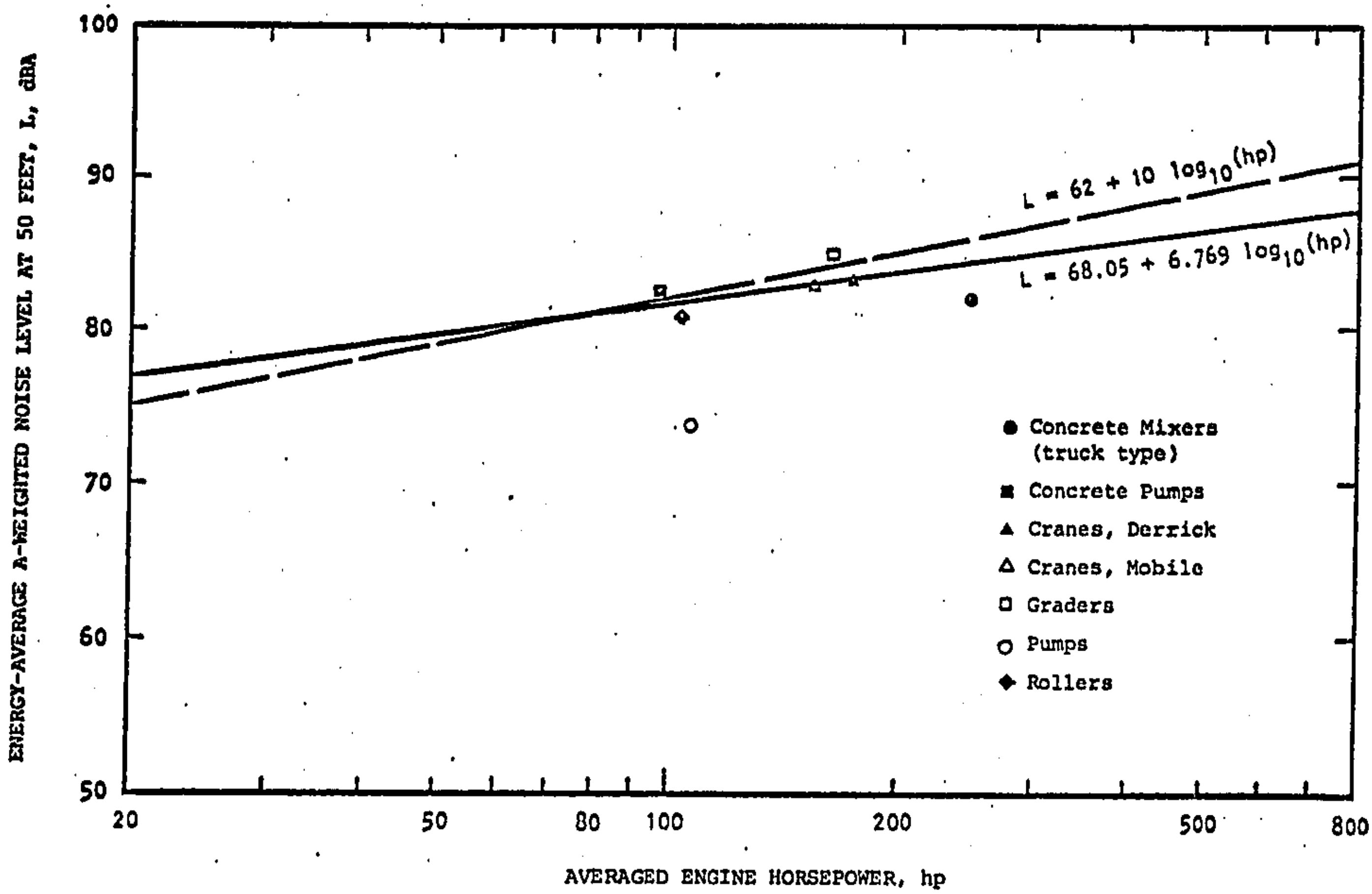

FIGURE A-5. ENERGY-AVERAGED A-WEIGHTED OFF-MAXIMUM/AVERAGE NOISE LEVEL AS A FUNCTION OF AVERAGE ENGINE HORSEPOWER AS COMPARED WITH PREDICTION EQUATIONS.

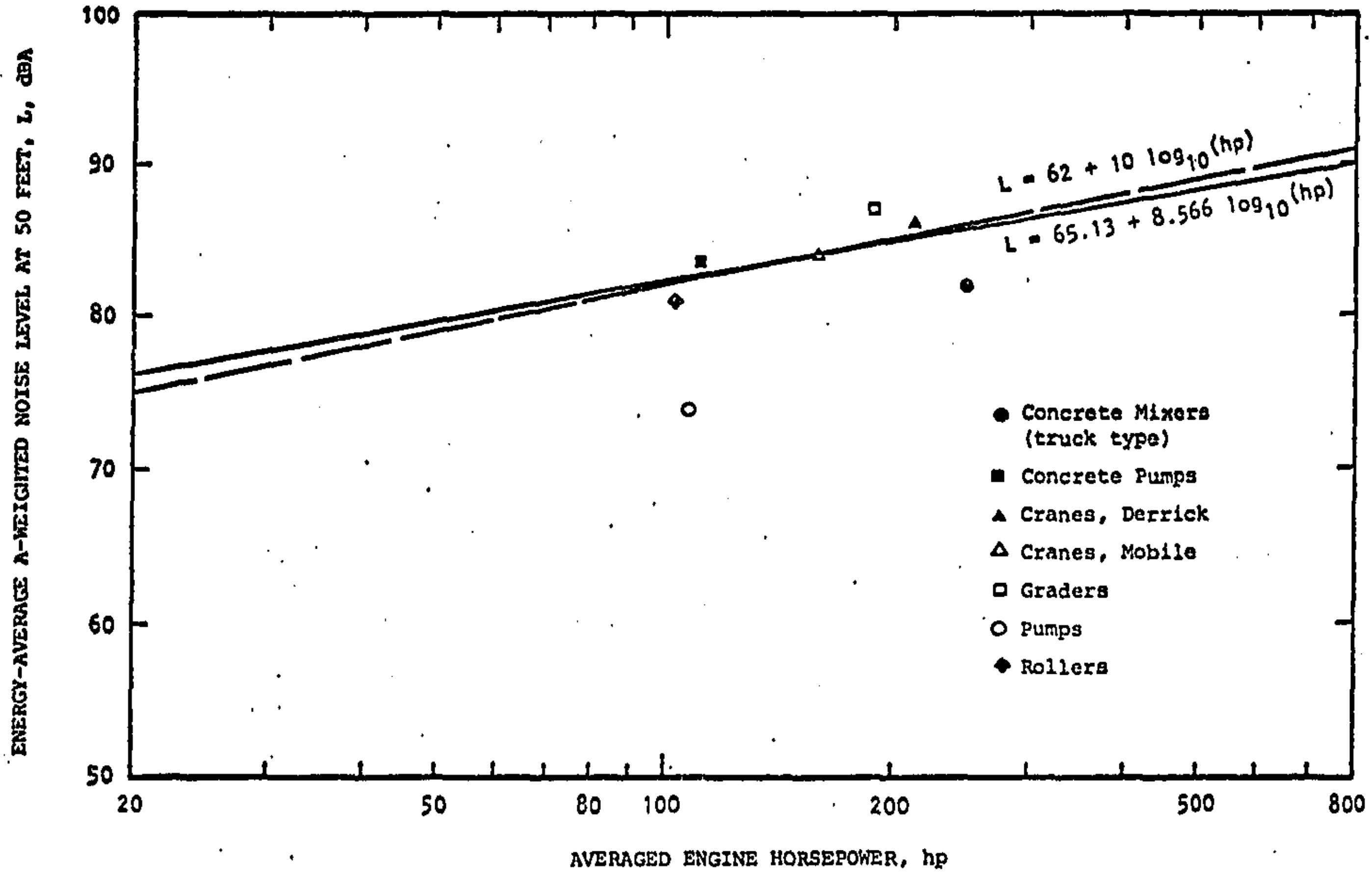

FIGURE A-6. ENERGY-AVERAGED A-WEIGHTED OFF-MAXIMUM/AVERAGE PLUS HIGH/MAXIMUM NOISE LEVEL AS A FUNCTION OF AVERAGE ENGINE HORSEPOWER AS COMPARED WITH PREDICTION EQUATIONS.

APPENDIX B

APPENDIX B

EQUIPMENT IDENTIFICATION AND USAGE CHARACTERISTICS DATA OBTAINED FROM CONSTRUCTION SITE SURVEY

This appendix contains the tabulated results of the construction site survey portion of this study. A separate table is provided for each of the fourteen sites visited. Except for sites 2, 6, and 14, the data shown on these tables were obtained from construction site personnel during the site visits. For sites 2, 6 and 14, the equipment types identified were observed as being present at the time of the site visit.

TABLE B-1. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 1
Site Type - Public Works
Approximate Construction Duration - 2 Years

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	2-3 (†)	D	V (**)	V (*)
Concrete Mx. Truck Mtd.	Yes	V D	D	C (**)	20-30 minutes
Sm. Cement/ Concrete Mx.	Yes	1	D	V (**)	4-5 minutes
Concrete Pumps	No				
Concrete Vibrators	Yes	2-3 (†)	D	Continuous During pour	V
Cranes, Derrick	Yes	2-3 (†)	2-3 Weeks	C	AD
Cranes Mobile	Yes	1-2 (†)	1-2 Days	C	AD
Wheel&Crawl. Tractors	Yes	4-5 (†)	D	V (**)	V (*)
Excavators	Yes	1	2-3 Months	C	AD
Generators	Yes	4-5 (†)	D	V (**)	V (*)
Graders	Yes	3-4 (†)	D	V (**)	V (*)
Integral Backhoe/Load.	Yes	2-3 (†)	D	V (**)	V (*)
Pavers and Mixers	Yes	1-2 (†)	2-3 Months	C	AD
Paving Breakers	Yes	1	D	V (**)	2-3 Weeks
Pile Drivers	Yes	1	1 Year	V (*)	V (*)
Pneumatic Tools	No				
Pumps	Yes	3-4 (†)	1 Year	V (*)	V (*)
Rock Drills	No				
Rollers	Yes	3-4 (†)	1½ Years	V (*)	V (*)
Saws	Yes	V (†)	D	V (*)	10-30 seconds (*)
Scrapers	Yes	2-5 (†)	1½ Years	V (*)	V(*)
Skid Steer Loaders	No				
Trenchers	Possible	1	1 Month	C	AD
Trucks, Off Hwy., Rear Dump	Yes	V D	D	C (**)	V (*)

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-2. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 2

Site Type - Non-Residential

Approximate Construction Duration - 18 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1			
Concrete Mx. Truck Mtd.	Yes				
Sm. Cement/ Concrete Mx.	None Observed				
Concrete Pumps	None Observed				
Concrete Vibrators	None Observed				
Cranes, Derrick	Yes	1			
Cranes Mobile	Yes	1			
Wheel&Crawl. Tractors	Yes	3			
Excavators	Yes	1			
Generators	Yes	1			
Graders	None Observed				
Integral Backhoe/Load.	Yes	1			
Pavers and Mixers	None Observed				
Paving Breakers	Yes	1			
Pile Drivers	None Observed				
Pneumatic Tools	None Observed				
Pumps	None Observed				
Rock Drills	None Observed				
Rollers	Yes	2			
Saws	Yes	several			
Scrapers	None Observed				
Skid Steer Loaders	None Observed				
Trenchers	None Observed				
Trucks, Off Hwy., Rear Dump	Yes	3-4			

D - Duration of the Construction Project

V - Varies Over the Time Period that Equipment is on Site

VD - Varies Daily

C - Continuous Use While Equipment is on Site

AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)

* - Depends on Specific Job Requirements

** - Used Over the Duration of the Construction Project

† - Number Operating at the Same Time Will Depend on Specific Job Requirements

Note: Equipment identified above was observed during site visit.

TABLE B-3. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 1
Site Type - Non-Residential
Approximate Construction Duration - 10 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	No				
Concrete Mx. Truck Mtd.	Yes	2-3 Per Day	3-4 Days	2-3 Pours Per Day	10-20 Minutes
Sm.Cement/ Concrete Mx.	Yes	1	D	V (**)	V (*)
Concrete Pumps	No				
Concrete Vibrators	Yes	2-3 (†)	During Concrete Pouring	Continuous dur. Pour	3-4 Minutes
Cranes, Derrick	Yes	1	2-3 Days	C	AD
Cranes Mobile	Yes	1	2-3 Days	C	AD
Wheel&Crawl. Tractors	Yes	1	1 Week	V (*)	V (*)
Excavators	Yes	1	1 Week	V (*)	V (*)
Generators	No				
Graders	No				
Integral Backhoe/Load.	Yes	1	2 Days	V (*)	V (*)
Pavers and Mixers	No				
Paving Breakers	No				
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	No				
Rock Drills	No				
Rollers	No				
Saws	Yes	V D (†)	2-3 Months	V (*)	10-30 Seconds (*)
Scrapers	No				
Skid Steer Loaders	No				
Trenchers	No				
Trucks, Off Hwy., Rear Dump	Yes	V D	D	V (**)	V (*)

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-4. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 4
Site Type - Non-Residential
Approximate Construction Duration - 12 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1	D	V (**)	2 Hours Per Month
Concrete Mx. Truck Mtd.	Yes	VD	3-4 Months	C	20-30 Minutes
Sm.Cement/ Concrete Mx.	Possible	1	1-2 Months	V (*)	5 - 10 Minutes
Concrete Pumps	Possible	1	1-2 Weeks	V (*)	2-3 Hours
Concrete Vibrators	Yes	1	D	Continuous during Pour	2-3 Minutes
Cranes, Derrick	Yes	1	3-4 Weeks	C	AD
Cranes Mobile	Yes	1	1-2 Weeks	C	AD
Wheel&Crawl. Tractors	Yes	1-3 (†)	D	V (**)	2-3 Weeks
Excavators	Yes	1	3-4 Weeks	C	AD
Generators	Yes	1	D	V (**)	V (*)
Graders	Yes	1	2 Weeks	C	AD
Integral Backhoe/Load.	Yes	1-2 (†)	D	V (**)	V (*)
Pavers and Mixers	Yes	1	2 Weeks	C	AD
Paving Breakers	Yes	1	D	V (*)	2 Hours Per Month
Pile Drivers	Yes	1	3-4 Weeks	10 Minutes Per Pile	½ Day
Pneumatic Tools	No				
Pumps	Yes	1	D	V (**)	V (*)
Rock Drills	Yes	1	2-3 Months	V (*)	V (*)
Rollers	Yes	1	2 Weeks	C	AD
Saws	Yes	VD (†)	D	V (*)	10 - 30 Seconds (*)
Scrapers	Yes	1	3-4 Weeks	C	AD
Skid Steer Loaders	No				
Trenchers	No				
Trucks, Off Hwy., Rear Dump	Yes	V D	D	V (**)	V (*)

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-5 CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 5
Site Type - Residential
Approximate Construction Duration - 7 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1	D	V (**)	V (*)
Concrete Mx. Truck Mtd.	Yes	V D	1 Month	C	20-30 Minutes
Sm.Cement/ Concrete Mx.	Yes	2-4 (†)	4-5 Months	V (*)	5-10 Minutes
Concrete Pumps	No				
Concrete Vibrators	No				
Cranes, Derrick	No				
Cranes Mobile	No				
Wheel&Crawl. Tractors	Yes	1-3 (†)	D	C	AD
Excavators	Yes	1	5 Weeks	C	AD
Generators	Yes	1	D	V (*)	1 Hour Per Day
Graders	Yes	1	2-3 Weeks	C	AD
Integral Backhoe/Load.	Yes	1	3-4 Months	V (*)	V (*)
Pavers and Mixers	Yes	1	2-3 Days	C	AD
Paving Breakers	Yes	1	D	V (**)	V (*)
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	Yes	2	D	V (**)	V (*)
Rock Drills	Yes				
Rollers	Yes	1	D	V (**)	V (*)
Saws	Yes	V (†)	D	V (*)	10-30 (*) Seconds
Scrapers	Yes	1-2 (†)	1-2 Months	V (*)	V (*)
Skid Steer Loaders	No				
Trenchers	Yes	1	1-2 Weeks	C	AD
Trucks, Off Hwy., Rear Dump	Yes	V D	D	V (**)	V (*)

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-6. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 6

Site Type - Commercial

Approximate Construction Duration - Unknown

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1			
Concrete Mx. Truck Mtd.	Yes	2			
Sm. Cement/ Concrete Mx.	Yes	3			
Concrete Pumps	No				
Concrete Vibrators	No				
Cranes, Derrick	No				
Cranes Mobile	Yes	1			
Wheel&Crawl. Tractors	Yes	3			
Excavators	Yes	1			
Generators	Yes	2			
Graders	Yes	1			
Integral Backhoe/Load.	Yes	2			
Pavers and Mixers	No				
Paving Breakers	No				
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	No				
Rock Drills	No				
Rollers	Yes	2			
Saws	No				
Scrapers	Yes	2			
Skid Steer Loaders	No				
Trenchers	Yes				
Trucks, Off Hwy., Rear Dump	Yes	4-5			

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

Note: Equipment identified above was observed during site visit.

TABLE B-7. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 7
Site Type - Non-Residential
Approximate Construction Duration - 7 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1	D	V (**)	V (*)
Concrete Mx. Truck Mtd.	Yes	VD	2-3 Weeks	C (*)	20-30 Minutes
Sm. Cement/ Concrete Mx.	Yes	1-2	2-3 Months	V (*)	5-10 Minutes
Concrete Pumps	Yes	1	2-3 Weeks	V (*)	3-4 Hours
Concrete Vibrators	Yes	1-2	2-3 Weeks	Continuous During Pour	5-10 Minutes
Cranes, Derrick	Yes	1	2 Months	C	AD
Cranes Mobile	Yes	1	1 Month	C	Ad
Wheel&Crawl. Tractors	Yes	1	D	V (**)	V (*)
Excavators	Yes	3	2-3 Weeks	C	AD
Generators	No				
Graders	No				
Integral Backhoe/Load.	Yes	1	2-3 Months	V(*)	V (*)
Pavers and Mixers	Yes	1	2-3 Days	C	AD
Paving Breakers	Yes	1	D	V (**)	3-4 Days
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	Yes	1	D	V (**)	V (*)
Rock Drills	No				
Rollers	Yes	1	2-3 Weeks	V (*)	V (*)
Saws	Yes	2-4 (†)	D	V (*)	10 - 30 Seconds (*)
Scrapers	No				
Skid Steer Loaders	No				
Trenchers	No				
Trucks, Off Hwy., Rear Dump	Yes	VD	D	C (**)	V (*)

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-8. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 8
Site Type - Residential
Approximate Construction Duration - 12 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1	10 Months	V (*)	V (*)
Concrete Mx. Truck Mtd.	Yes	VD	6 Months	C	30-40 Minutes
Sm.Cement/ Concrete Mx.	Yes	3	8 Months	V (*)	5-10 Minutes
Concrete Pumps	No				
Concrete Vibrators	No				
Cranes, Derrick	No				
Cranes Mobile	Yes	1	1 Month	V (*)	2-3 Hours
Wheel&Crawl. Tractors	Yes	2-3 (†)	D	V (**)	V (*)
Excavators	Yes	1	2-3 Weeks	C	AD
Generators	No				
Graders	Yes	1-2	2-3 Weeks	C	AD
Integral Backhoe/Load.	Yes	1	6-8 Months	V (*)	V (*)
Pavers and Mixers	Yes	1	2-3 Weeks	C	AD
Paving Breakers	Yes	1	10 Months	V (*)	V (*)
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	Yes	2-3 (†)	10 Months	V (*)	V (*)
Rock Drills	No				
Rollers	Yes	1	2-3 Weeks	C	AD
Saws	Yes	VD (†)	8-10 Months	V (*)	10-20 Seconds (*)
Scrapers	No				
Skid Steer Loaders	No				
Trenchers	No				
Trucks, Off Hwy., Rear Dump	Yes	VD	D		V (*)

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-9. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 9

Site Type - Residential

Approximate Construction Duration - 14 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	No				
Concrete Mx. Truck. Mtd.	Yes	VD	8-9 Months	VD	20-30 Minutes
Sm. Cement/ Concrete Mx.	Yes	1	1 Month	V (*)	V (*)
Concrete Pumps	No				
Concrete Vibrators	No				
Cranes, Derrick	No				
Cranes Mobile	No				
Wheel&Crawl. Tractors	Yes	2-3 (†)	D	V (**)	V (*)
Excavators	Yes	1	2-3 Weeks	C	AD
Generators	Yes	2	1 Month	C	AD
Graders	Yes	2	5-6 Weeks	C	AD
Integral Backhoe/Load.	Yes	1	3-4 Weeks	C	AD
Pavers and Mixors	Yes	1	1 Week	C	AD
Paving Breakers	No				
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	No				
Rock Drills	No				
Rollers	Yes	1	2-3 Days	C	AD
Saws	Yes	VD (†)	10-12 Months	V (*)	5-10 Seconds (*)
Scrapers	No				
Skid Steer Loaders	No				
Trenchers	Yes	1	3 Months	V (*)	V (*)
Trucks, Off Hwy., Rear Dump	Yes	VD	D	V (**)	V (*)

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-10. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 10
Site Type - Non- Residential
Approximate Construction Duration - 15 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1	D	V (**)	V (*)
Concrete Mx. Truck Mtd.	Yes	VD	3-4 Months	VD	15-20 Minutes
Sm.Cement/ Concrete Mx.	No				
Concrete Pumps	Possible	1	1-2 Months	V	4-5 Hours
Concrete Vibrators	Yes	1-2 (†)	3-4 Months	Continuous During Pour	5-10 Minutes
Cranes, Derrick	No				
Cranes Mobile	Yes	1	1-2 Weeks	C	AD
Wheel&Crawl. Tractors	Yes	2-4 (†)	D	V (**)	V (*)
Excavators	No				
Generators	Yes	2	3 Months	C	AD
Graders	Yes	1-2 (†)	2 Months	C	AD
Integral Backhoe/Load.	Yes	1-2 (†)	2 Months	C	AD
Pavers and Mixers	Yes	1	1 Month	C	AD
Paving Breakers	Yes	1	D	V (**)	V (*)
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	Yes	2	D	V (**)	V (*)
Rock Drills	Yes	1	D	V (**)	V (*)
Rollers	Yes	2-3 (†)	10 - 12 Months	V (**)	V (*)
Saws	Yes	6-8 (†)	12 - 15 Months	V (*)	(*) 5-10 Seconds
Scrapers	Yes	1-4 (†)	3-4 Months	V (*)	V (*)
Skid Steer Loaders	No				
Trenchers	Yes	1	1-2 Weeks	C	AD
Trucks, Off Hwy., Rear Dump	Yes	10 - 15 Per Day	D	VD	15-20 Minutes

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-11. CONSTRUCTION EQUIPMENT USAGE DATA
OBTAINED FROM FIELD SURVEY

Site Number 11
Site Type - Residential
Approximate Construction Duration - 16 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1	2 Months	V (*)	V (*)
Concrete Mx. Truck Mtd.	Yes	VD	8-9 Months	V (*)	15 - 20 Minutes
Sm.Cement/ Concrete Mx.	Yes	3-4 (†)	4-5 Months	V (*)	5 - 10 Minutes
Concrete Pumps	No				
Concrete Vibrators	No				
Cranes, Derrick	No				
Cranes Mobile	Yes	1	1 Month	C	AD
Wheel&Crawl. Tractors	Yes	2-4 (†)	D	V (**)	V (*)
Excavators	Yes	1	5 Months	V (*)	V (*)
Generators	No				
Graders	Yes	2	2-3 Months	V (*)	V (*)
Integral Backhoe/Load.	Yes	2-4 (†)	D	V (**)	V (*)
Pavers and Mixers	Yes	1	1 Month	C	AD
Paving Breakers	Yes	1	2 Months	V (*)	V (*)
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	Yes	2	2 Months	V (*)	V (*)
Rock Drills	No				
Rollers	Yes	1	1 Year	V (*)	V (*)
Saws	Yes	10-12 (†)	12 -14 Months	V (*)	10 - 15 Seconds (*)
Scrapers	No				
Skid Steer Loaders	No				
Trenchers	No				
Trucks, Off Hwy., Rear Dump	Yes	VD	D	V (*) (**)	V (*)

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-12. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 12

Site Type - Non Residential

Approximate Construction Duration - 12 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1	1 Month	V (*)	V (*)
Concrete Mx. Truck Mtd.	Yes	VD	2-3 Months	VD (*)	15 - 30 Minutes
Sm.Cement/ Concrete Mx.	No				
Concrete Pumps	Possible	1	5-6 Weeks	V	3-4 Hours
Concrete Vibrators	Possible	1-2	5-6 Weeks	C	2 - 3 Minutes
Cranes, Derrick	Yes	1	7 Months	V	V
Cranes Mobile	Yes	1	3 Months	V (*)	V (*)
Wheel&Crawl. Tractors	Yes	1	2 Months	V (*)	V (*)
Excavators	Yes	1	1-2 Weeks	C	AD
Generators	Yes	1	3-4 Months	C	AD
Graders	Yes	1	1-2 Weeks	C	AD
Integral Backhoe/Load.	No				
Pavers and Mixers	Yes	1	1-2 Weeks	C	AD
Paving Breakers	No				
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	Yes	1	1-2 Weeks	V	V (*)
Rock Drills	No				
Rollers	Yes	1	1-2 Days	C	AD
Saws	Yes	V (†)	4 - 5 Months	V (*)	5 - 10 Seconds (*)
Scrapers	No				
Skid Steer Loaders	No				
Trenchers	No				
Trucks, Off Hwy., Rear Dump	Yes	VD	D	V (**)	V (*)

D - Duration of the Construction Project

V - Varies Over the Time Period that Equipment is on Site

VD - Varies Daily

C - Continuous Use While Equipment is on Site

AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)

* - Depends on Specific Job Requirements

** - Used Over the Duration of the Construction Project

† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-13. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 13
Site Type - Non- Residential
Approximate Construction Duration - 6 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	Yes	1	10 Days	V (*)	V (*)
Concrete Mx. Truck Mtd.	Yes	VD	1 Month	VD (*)	15 - 30 Minutes
Sm.Cement/ Concrete Mx.	Yes	1	5 Months	V (*)	5 -10 Minutes
Concrete Pumps	Yes	1	2 Weeks	V	3-4 Hours
Concrete Vibrators	Yes	1- 2	2 Weeks	C	2-3 Minutes
Cranes, Derrick	No				
Cranes Mobile	Yes	1	2 Weeks	C	AD
Wheel&Crawl. Tractors	Yes	1	2 Weeks	C	AD
Excavators	No				
Generators	Yes	1	3-4 Months	C	AD
Graders	Yes	1	1-2 Weeks	C	AD
Integral Backhoe/Load.	Yes	1	1-2 Weeks	C	AD
Pavers and Mixers	Yes	1	1-2 Weeks	C	AD
Paving Breakers	No				
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	Yes	1	1-2 Weeks	V (*)	V (*)
Rock Drills	No				
Rollers	Yes	1	2-3 Days	C	AD
Saws	Yes	V (†)	2-3 Months	V (*)	5 - 10 Seconds (*)
Scrapers	No				
Skid Steer Loaders	No				
Trenchers	Yes	1	2-3 Days	C	AD
Trucks, Off Hwy., Rear Dump	Yes	VD	D	C	AD

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

TABLE B-14. CONSTRUCTION EQUIPMENT USAGE DATA OBTAINED FROM FIELD SURVEY

Site Number 14
Site Type - Residential
Approximate Construction Duration - 9 Months

Equipment Type	Used On Project	Number Used	Time On Site	Frequency Of Use	Duration Per Use
Air Compressor	No				
Concrete Mx. Truck Mtd.	No				
Sm. Cement/ Concrete Mx.	No				
Concrete Pumps	No				
Concrete Vibrators	No				
Cranes, Derrick	No				
Cranes Mobile	No				
Wheel&Crawl. Tractors	Yes	1			
Excavators	No				
Generators	No				
Graders	No				
Integral Backhoe/Load.	No				
Pavers and Mixers	No				
Paving Breakers	No				
Pile Drivers	No				
Pneumatic Tools	No				
Pumps	No				
Rock Drills	No				
Rollers	Yes	1			
Saws	No				
Scrapers	No				
Skid Steer Loaders	No				
Trenchers	No				
Trucks, Off Hwy., Rear Dump	Yes	2			

D - Duration of the Construction Project
V - Varies Over the Time Period that Equipment is on Site
VD - Varies Daily
C - Continuous Use While Equipment is on Site
AD - Equipment Operates Over the Entire Working Day (Assumes 6-8 hrs. of actual equipment operation per day)
* - Depends on Specific Job Requirements
** - Used Over the Duration of the Construction Project
† - Number Operating at the Same Time Will Depend on Specific Job Requirements

Note: Equipment identified above was observed at the construction site.

APPENDIX C

APPENDIX C

INVESTIGATION OF TYPICAL CONSTRUCTION SITE SIZE

This appendix presents a discussion of the data collection and analysis procedures used in the investigation of typical construction site sizes. In addition, a tabulated listing of the site data obtained during this investigation is presented.

C.1 Data Collection Procedure

Aerial photographs of construction sites throughout the U.S. were reviewed by the EPA's Environmental Photographic Interpretation Center (EPIC) and each site was located on a United States Geological Survey (USGS) map. Information obtained from the photographs and maps, such as site size, site type, site classification, etc., was recorded on a construction site identification work sheet. A sample work sheet is presented as Figure C-1. The construction sites included in this survey were chosen randomly from the areas inside and outside the corporate limits of the cities selected for the construction site study. For each population density category and each geographical region, approximately 15 sites were reviewed for the two site classifications shown on the work sheet. To facilitate site identification, descriptions of each construction site type and of typical land uses were provided to the EPIC personnel. These descriptions are presented in Figures C-2 and C-3.

C.2 Construction Site Data

The data presented on the work sheets, along with population density and computed site size data, were arrayed and stored on a computer file. Table C-4 presents a listing of these data. The columns in Table C-4 are identified as follows:

Column No.	Description of Information
1	Geographic Region
2	Population Density Category
3	Site Classification
4	Site Type
5	Land Use
6	Site Area (Sq.Ft.)
7	Population Density-Local (people/sq.mi.)
8	Population Density-Central City (people/sq.mi.)
9	Population Density-Outside Central City (people/sq.mi.)

C.3 Computation of Average Site Size and Variation in Equivalent Site Radius

Using the data in Table C-4 and a computer program from the Statistical Package for the Social Sciences (SPSS), the average site size, in sq.ft., and the standard deviation were computed for various site type combinations. Assuming a normal distribution of site sizes, a "Student's t" approximation was used in calculating the upper and lower bounds for the 95% confidence interval. The equation used to calculate these values was:

$$\bar{A} \pm t_{(\alpha,N-1)} \, [S/\sqrt{N-1}]$$

where $\bar{A}$ = mean site size

S = standard deviation

N = number of sites

$t_{(\alpha,N-1)}$ = tabulated value for a given confidence interval and number of sites

From the mean site size and confidence intervals, the radii for equivalent circular areas and radius variations were determined using the equation:

$$R = \sqrt{A/\Pi}\ .$$

where

R = radius for equivalent site area

Π = 3.142

FIGURE C-1. SAMPLE

CONSTRUCTION SITE IDENTIFICATION WORK SHEET

REGION IDENTIFICATION (1-5)	POPULATION DENSITY CATEGORY (1-3)	SITE CLASSIFICATION	CONSTRUCTION SITE IDENTIFICATION						DATE OF PHOTO-GRAPH
			TYPE	LAND USE	SIZE	LOCATION			
						USGS MAP	SITE NO.	REMARKS	
I Stamford, Connecticut	I	Suburban/Rural	1	1	80' x 60'	Stamford	1		1977
			2	1	120' x 120' x 60'	Norwalk South	1	L-Shaped addition to existing building	1977
			1	1	48' x 28'	Stamford	7		1977
			1	1	60' x 60' x 30'	Norwalk South	2	L-Shaped house	1977

POPULATION DENSITY CATEGORY

1. <3000 People/Sq. Mi.
2. 3000-7000 " " "
3. >7000 " " "

SITE CLASSIFICATION

1. City-Inside Corporate Limits
2. Suburban/Rural - Outside Corporate Limits

CONSTRUCTION SITE IDENTIFICATION

TYPE

1. Residential
2. Non-Residential
3. Industrial/Commercial
4. Public Works (Excluding Highways)

LAND USE

1. Residential
2. Residential/Commercial
3. Industrial/Commercial
4. Other (Agriculture, Forest, Wet Lands, etc.)

Residential - Single family, buildings with 2-4 units, buildings with 5 or more units.

Non-Residential - Education, hospitals, religions, other buildings.

Industrial/Commercial - Industry, stores and other mercantile buildings, service stations and repair garages, amusement, other non-residential.

Public Works - Road and street sites, road maintenance sites, water, sewer, gas, electric.

FIGURE C-2. SITE TYPE DEFINITIONS.

Residential - Residential areas with single family units only.

Residential/Commercial - Residential areas with single family units, apartments and hotels, open space recreational.

Industrial/Commercial - Industry, office buildings, retail stores, etc., with primarily daytime occupancy. Open space parks and suburban areas near highways or high speed boulevards with distant residential buildings.

Other - Agricultural, Forest, Wet Lands.

FIGURE C-3. LAND USE DEFINITIONS.

TABLE C-4. CONSTRUCTION SITE DATA USED TO DETERMINE AVERAGE CONSTRUCTION SITE SIZE

1	2	3	4	5	6	7	8	9
1	1	1	3	2	10000	2856	2856	2416
1	1	1	1	1	1900	2956	2956	2416
1	1	1	1	1	1800	2856	2856	2416
1	1	1	1	1	2700	2956	2856	2416
1	1	1	1	1	90000	2956	2856	2416
1	1	1	3	2	25000	2856	2856	2416
1	1	1	1	1	2400	2856	2856	2416
1	1	1	1	1	2400	2856	2856	2416
1	1	1	1	1	3200	2956	2856	2416
1	1	1	2	1	54000	2956	2856	2416
1	1	1	1	1	1456	2956	2856	2416
1	1	1	1	1	1248	2956	2856	2416
1	1	1	1	1	1248	2956	2856	2416
1	1	1	4	1	24000	2956	2956	2416
1	1	1	1	1	1248	2856	2856	2416
1	1	2	1	1	4800	2416	2856	2416
1	1	2	2	1	10800	3596	2856	2416
1	1	2	1	1	1344	2416	2856	2416
1	1	2	1	1	2700	3596	2856	2416
1	1	2	1	1	2160	3596	2856	2416
1	1	2	3	2	3500	3596	2856	2416
1	1	2	1	2	4800	2416	2856	2416
1	1	2	1	1	2744	2416	2856	2416
1	1	2	2	1	3000	2416	2856	2416
1	1	2	1	1	1260	2416	2856	2416
1	1	2	1	1	1092	2416	2856	2416
1	1	2	4	1	32000	2416	2856	2416
1	1	2	2	1	7500	2416	2856	2416
1	1	2	1	1	1248	2416	2856	2416
1	1	2	1	1	1800	2416	2856	2416
1	2	1	1	2	80000	4721	4721	1507
1	2	1	1	1	120000	4721	4721	1507
1	2	1	3	3	2240	4721	4721	1507
1	2	1	1	1	660000	4721	4721	1507
1	2	1	1	1	1512	4721	4721	1507
1	2	1	1	1	1344	4721	4721	1507
1	2	1	2	2	24700	4721	4721	1507
1	2	1	2	2	8800	4721	4721	1507
1	2	1	2	1	140000	4721	4721	1507
1	2	1	3	2	23100	4721	4721	1507
1	2	1	3	3	19000	4721	4721	1507
1	2	1	1	1	2400	4721	4721	1507

TABLE C-4. Cont.

1	2	3	4	5	6	7	8	9
1	2	1	1	1	210000	4721	4721	1507
1	2	1	1	1	2160	4721	4721	1507
1	2	1	1	1	18000	4721	4721	1507
1	2	2	2	1	4800	254	4721	1507
1	2	2	1	1	330000	254	4721	1507
1	2	2	2	4	12000	254	4721	1507
1	2	2	3	2	1800	254	4721	1507
1	2	2	1	1	1680	1507	4721	1507
1	2	2	1	1	1456	1507	4721	1507
1	2	2	3	3	35000	1507	4721	1507
1	2	2	1	3	1248	1507	4721	1507
1	2	2	1	1	1800	1507	4721	1507
1	2	2	1	1	1344	1507	4721	1507
1	2	2	1	1	1344	1507	4721	1507
1	2	2	3	3	16000	1507	4721	1507
1	2	2	1	4	2400	254	4721	1507
1	2	2	1	1	3600	254	4721	1507
1	2	2	1	1	1296	254	4721	1507
1	3	1	3	3	4000	9901	9901	2509
1	3	1	2	2	14000	9901	9901	2509
1	3	1	2	3	18000	9901	9901	2509
1	3	1	3	2	2800	9901	9901	2509
1	3	1	1	2	30000	9901	9901	2509
1	3	1	1	1	1560	9901	9901	2509
1	3	1	1	1	40000	9901	9901	2509
1	3	1	1	1	11100	9901	9901	2509
1	3	1	4	2	23400	9901	9901	2509
1	3	1	2	2	18000	9901	9901	2509
1	3	2	1	1	936	3620	9901	2509
1	3	2	3	2	6000	3620	9901	2509
1	3	2	1	1	1680	3620	9901	2509
1	3	2	1	1	1568	3620	9901	2509
1	3	2	1	1	1456	3620	9901	2509
1	3	2	2	1	156000	3620	9901	2509
1	3	2	1	1	2304	3620	9901	2509
1	3	2	1	1	200000	3620	9901	2509
1	3	2	3	3	12600	3620	9901	2509
1	3	2	1	1	832	3620	9901	2509
1	3	2	3	3	2800	2509	9901	2509
1	3	2	3	3	800	2509	9901	2509
1	3	2	1	1	832	2509	9901	2509
1	3	2	1	1	1120	2509	9901	2509
1	3	2	1	1	41000	2509	9901	2509
2	1	1	3	2	21000	1263	1263	626
2	1	1	4	3	38000	1263	1263	626
2	1	1	3	3	18000	1263	1263	626
2	1	1	4	3	6250	1263	1263	626
2	1	1	1	2	5000	1263	1263	626
2	1	1	1	1	2400	1263	1263	626

TABLE C-4. Cont.

1	2	3	4	5	6	7	8	9
2	1	1	1	1	1200	1263	1263	626
2	1	1	1	1	1800	1263	1263	626
2	1	1	4	1	60000	1263	1263	626
2	1	1	1	1	1872	1263	1263	626
2	1	1	1	1	2160	1263	1263	626
2	1	1	1	1	2160	1263	1263	626
2	1	1	1	4	1344	1263	1263	626
2	1	1	1	1	1344	1263	1263	626
2	1	1	1	4	1920	1263	1263	626
2	1	2	1	1	1344	626	1263	626
2	1	2	1	1	864	626	1263	626
2	1	2	1	1	864	626	1263	626
2	1	2	2	4	24053	626	1263	626
2	1	2	2	3	90000	158	1263	626
2	1	2	1	1	1248	158	1263	626
2	1	2	1	1	1352	158	1263	626
2	1	2	1	1	1288	158	1263	626
2	1	2	4	3	2827	159	1263	626
2	1	2	4	4	28800	159	1263	626
2	1	2	2	2	6300	158	1263	626
2	1	2	2	2	25000	158	1263	626
2	1	2	1	1	1248	158	1263	626
2	1	2	2	1	6400	158	1263	626
2	1	2	2	1	576	158	1263	626
2	2	1	2	2	87120	6153	6153	2664
2	2	1	2	1	27225	6153	6153	2664
2	2	1	1	2	87120	6153	6153	2664
2	2	1	3	3	163350	6153	6153	2664
2	2	1	1	2	500940	6153	6153	2664
2	2	1	1	2	391150	6153	6153	2664
2	2	1	1	2	653400	6153	6153	2664
2	2	2	1	2	43560	2664	6153	2664
2	2	2	1	1	136124	4386	6153	2664
2	2	2	3	2	348480	4386	6153	2664
2	2	2	3	3	653400	4386	6153	2664
2	2	2	3	3	163350	4386	6153	2664
2	2	2	2	1	408375	2664	6153	2664
2	2	2	1	4	2003760	2664	6153	2664
2	2	2	1	2	10890	4386	6153	2664
2	2	2	1	4	952875	2664	6153	2664
2	2	2	1	4	54450	4386	6153	2664
2	2	2	1	1	272250	4386	6153	2664
2	2	2	1	2	190575	4386	6153	2664
2	2	2	1	1	10090	2664	6153	2664
2	2	2	1	2	517275	4386	6153	2664
2	2	2	2	3	462825	2664	6153	2664
2	3	1	2	2	240000	11568	11569	2914
2	3	1	2	2	255000	11568	11568	2914
2	3	1	2	2	19500	11569	11568	2914

TABLE C-4. Cont.

1	2	3	4	5	6	7	8	9
2	3	1	1	2	120000	11568	11568	2914
2	3	1	3	2	44100	11568	11568	2914
2	3	1	2	3	27000	11568	11568	2914
2	3	1	1	2	52000	11568	11568	2914
2	3	1	2	2	80000	11568	11568	2914
2	3	1	3	2	20800	11568	11568	2914
2	3	1	3	2	36100	11568	11568	2914
2	3	1	3	2	15000	11568	11568	2914
2	3	1	2	2	33000	11568	11568	2914
2	3	1	3	2	160000	11568	11568	2914
2	3	2	3	3	12000	2914	11568	2914
2	3	2	4	4	240	2914	11568	2914
2	3	2	4	1	21600	2914	11568	2914
2	3	2	1	1	1440	2914	11568	2914
2	3	2	3	4	33000	2914	11568	2914
2	3	2	1	3	5980	2914	11568	2914
2	3	2	3	1	15500	3692	11568	2914
2	3	2	1	4	18000	3692	11568	2914
2	3	2	1	4	10000	3692	11568	2914
2	3	2	1	4	8000	2914	11568	2914
2	3	2	1	4	1344	2914	11568	2914
2	3	2	1	1	630000	4229	11568	2914
2	3	2	1	1	55200	4229	11568	2914
2	3	2	2	1	60000	2914	11568	2914
3	1	1	1	1	57750	1959	1959	1751
3	1	1	2	1	660000	1959	1959	1751
3	1	1	1	1	150000	1959	1959	1751
3	1	1	1	1	2400	1959	1959	1751
3	1	1	1	1	100000	1959	1959	1751
3	1	1	3	1	9000	1959	1959	1751
3	1	1	1	1	420000	1959	1959	1751
3	1	1	1	1	1210000	1959	1959	1751
3	1	1	1	1	237500	1959	1959	1751
3	1	1	1	1	175000	1959	1959	1751
3	1	1	1	1	202500	1959	1959	1751
3	1	1	1	1	280000	1959	1959	1751
3	1	1	1	1	450000	1959	1959	1751
3	1	1	1	1	845000	1959	1959	1751
3	1	2	1	1	968750	1751	1959	1751
3	1	2	3	2	10000	1668	1959	1751
3	1	2	1	1	1260000	1751	1959	1751
3	1	2	1	1	2304	1751	1959	1751
3	1	2	1	1	2560000	1668	1959	1751
3	1	2	1	1	540000	1668	1959	1751
3	1	2	1	1	450000	1751	1959	1751
3	1	2	1	3	12600	1751	1959	1751
3	1	2	1	1	300000	1751	1959	1751
3	1	2	1	1	300000	1751	1959	1751
3	1	2	1	1	810000	1751	1959	1751

TABLE C-4. Cont.

1	2	3	4	5	6	7	8	9
3	1	2	1	2	10000	1751	1959	1751
3	1	2	1	1	337500	1751	1959	1751
3	1	2	1	1	218750	1751	1959	1751
3	1	2	1	1	753750	1751	1959	1751
3	2	1	2	1	13500	6771	6771	3252
3	2	1	1	2	120000	6771	6771	3252
3	2	1	2	2	18000	6771	6771	3252
3	2	1	1	1	1800	6771	6771	3252
3	2	1	1	2	480000	6771	6771	3252
3	2	1	2	2	16000	6771	6771	3252
3	2	1	3	3	7200	6771	6771	3252
3	2	1	3	2	49087	6771	6771	3252
3	2	1	1	1	2600	6771	6771	3252
3	2	1	1	1	480	6771	6771	3252
3	2	1	3	3	14000	6771	6771	3252
3	2	1	4	3	16500	6771	6771	3252
3	2	1	3	3	17671	6771	6771	3252
3	2	1	3	3	15000	6771	6771	3252
3	2	1	2	1	12000	5409	6771	3252
3	2	2	1	4	1344	2462	6771	3252
3	2	2	1	3	125000	2462	6771	3252
3	2	2	4	3	50000	2462	6771	3252
3	2	2	4	3	25000	2462	6771	3252
3	2	2	1	4	200000	3252	6771	3252
3	2	2	1	1	2520	3252	6771	3252
3	2	2	1	1	3000	3252	6771	3252
3	2	2	2	2	6300	3252	6771	3252
3	2	2	3	2	52900	3252	6771	3252
3	2	2	2	4	30000	3252	6771	3252
3	2	2	1	1	1300000	3252	6771	3252
3	2	2	1	1	2250	3252	6771	3252
3	2	2	4	4	158125	3252	6771	3252
3	2	2	2	2	81250	3252	6771	3252
3	3	1	1	2	250000	15764	15764	3252
3	3	1	2	2	42000	15764	15764	3252
3	3	1	3	2	7500	15764	15764	3252
3	3	1	3	3	12100	15764	15764	3252
3	3	1	2	2	7500	15764	15764	3252
3	3	1	1	3	210000	15764	15764	3252
3	3	1	4	2	2400	15764	15764	3252
3	3	1	3	3	25000	15764	15764	3252
3	3	1	2	2	24750	15764	15764	3252
3	3	1	4	2	11250	15764	15764	3252
3	3	1	1	2	5760	15764	15764	3252
3	3	1	1	2	4900	15764	15764	3252
3	3	1	4	3	100000	15764	15764	3252
3	3	2	3	2	7500	3252	15764	3252
3	3	2	4	2	55000	3252	15764	3252
3	3	2	3	3	70000	3252	15764	3252

TABLE C-4. Cont.

1	2	3	4	5	6	7	8	9
3	2	2	4	2	45000	2252	15764	2252
4	1	1	1	1	1920	2966	2966	2428
4	1	1	1	1	1872	2966	2966	2428
4	1	1	1	1	375	2966	2966	2428
4	1	1	1	1	1536	2966	2966	2428
4	1	1	2	1	39900	2966	2966	2429
4	1	1	1	1	90000	2966	2966	2428
4	1	1	1	1	1456	2966	2966	2429
4	1	1	1	1	2920	2966	2966	2428
4	1	1	1	2	90000	2966	2966	2428
4	1	1	3	2	12500	2966	2966	2429
4	1	1	1	1	420000	2966	2966	2428
4	1	1	2	1	37500	2966	2966	2429
4	1	1	1	1	550000	2966	2966	2429
4	1	1	2	2	120000	2966	2966	2429
4	1	1	2	2	25447	2966	2966	2429
4	1	2	1	1	54000	2429	2966	2429
4	1	2	1	1	1249	2428	2966	2429
4	1	2	1	1	1920	2428	2966	2428
4	1	2	1	1	1568	2428	2966	2428
4	1	2	3	3	30000	2429	2966	2428
4	1	2	3	3	20000	2428	2966	2428
4	1	2	2	1	18000	2428	2966	2429
4	1	2	1	1	120000	2429	2966	2428
4	1	2	3	2	30000	2428	2966	2428
4	1	2	1	3	360000	2428	2966	2428
4	1	2	1	1	6240	2428	2966	2429
4	1	2	1	1	302500	2429	2966	2428
4	1	2	1	1	200000	2428	2966	2428
4	1	2	1	1	180000	2428	2966	2428
4	1	2	1	2	1800	2429	2966	2428
4	2	1	1	2	10000	6350	6350	2177
4	2	1	3	3	363000	6350	6350	2177
4	2	1	1	1	36300	6350	6350	2177
4	2	1	3	3	163350	6350	6350	2177
4	2	1	3	3	76230	6350	6350	2177
4	2	1	1	1	10000	6350	6350	2177
4	2	1	3	3	43560	6350	6350	2177
4	2	1	2	1	65340	6350	6350	2177
4	2	1	3	3	108900	6350	6350	2177
4	2	1	3	3	98010	6350	6350	2177
4	2	1	1	3	10000	6350	6350	2177
4	2	1	1	3	65340	6350	6350	2177
4	2	1	2	2	21780	6350	6350	2177
4	2	1	1	2	10000	6350	6350	2177
4	2	1	3	3	21780	6350	6350	2177
4	2	2	3	3	566280	2978	6350	2177
4	2	2	3	3	108900	2978	6350	2177
4	2	2	1	1	43560	1779	6350	2177

TABLE C-4. Cont.

1	2	3	4	5	6	7	8	9
4	2	2	1	1	43560	1779	6350	2177
4	2	2	1	3	27225	1779	6350	2177
4	2	2	3	3	947430	2978	6350	2177
4	2	2	1	2	326700	2177	6350	2177
4	2	2	2	3	27225	2978	6350	2177
4	2	2	1	1	471900	8275	6350	2177
4	2	2	1	1	363000	1779	6350	2177
4	3	1	3	2	22500	6489	10167	3157
4	3	1	4	4	40000	6489	10167	3157
4	3	1	3	3	57600	6489	10167	3157
4	3	1	3	2	87000	5055	10167	3157
4	3	1	1	3	22500	5055	10167	3157
4	3	1	3	3	87000	5055	10167	3157
4	3	1	4	2	174000	5055	10167	3157
4	3	1	3	3	4800	5055	10167	3157
4	3	1	3	3	25600	5055	10167	3157
4	3	1	3	3	19200	4654	10167	3157
4	3	1	3	2	80000	4654	10167	3157
4	3	1	1	1	10400	1994	10167	3157
4	3	1	2	2	22500	1894	10167	3157
4	3	1	3	2	38400	1394	10167	3157
4	3	1	1	1	435000	1994	10167	3157
4	3	2	1	1	3045000	3609	10167	3157
4	3	2	1	1	208000	2930	10167	3157
4	3	2	1	2	451200	7323	10167	3157
4	3	2	1	2	1128906	7323	10167	3157
4	3	2	1	2	1305000	1616	10167	3157
4	3	2	1	2	435000	1616	10167	3157
4	3	2	1	1	391500	1616	10167	3157
4	3	2	2	2	870000	1616	10167	3157
4	3	2	3	3	7800	1422	10167	3157
4	3	2	2	1	9000	1422	10167	3157
4	3	2	2	2	4000	1422	10167	3157
4	3	2	3	2	62500	6489	10167	3157
4	3	2	3	3	28800	3583	10167	3157
4	3	2	1	2	478500	4654	10167	3157
5	1	1	2	2	10800	2189	2113	2614
5	1	1	3	2	11400	2113	2113	2614
5	1	1	1	1	942500	2113	2113	2614
5	1	1	2	1	16200	2113	2113	2614
5	1	1	1	1	1176	2113	2113	2614
5	1	1	1	2	16000	2113	2113	2614
5	1	1	2	2	10000	2113	2113	2614
5	1	1	3	2	12000	2113	2113	2614
5	1	1	2	2	34000	2113	2113	2614
5	1	1	4	2	64000	2113	2113	2614
5	1	1	3	3	2400000	2113	2113	2614
5	1	1	3	3	2880	2113	2113	2614
5	1	1	2	2	4000	2113	2113	2614

TABLE C-4. Cont.

1	2	3	4	5	6	7	8	9
5	1	2	3	3	18750	2614	2113	2614
5	1	2	3	3	36100	2614	2113	2614
5	1	2	3	3	60000	2614	2113	2614
5	1	2	1	1	936	2614	2113	2614
5	1	2	3	3	31500	2614	2113	2614
5	1	2	1	1	768	2614	2113	2614
5	1	2	1	1	2880	2614	2113	2614
5	1	2	3	3	10500	2614	2113	2614
5	1	2	3	3	425000	2614	2113	2614
5	1	2	3	3	450000	3285	2113	2614
5	1	2	1	1	7840	2614	2113	2614
5	1	2	1	1	810000	2614	2113	2614
5	1	2	1	1	490000	2614	2113	2614
5	1	2	3	2	18000	2614	2113	2614
5	1	2	3	3	105000	2614	2113	2614
5	2	1	1	3	762300	5082	5082	1791
5	2	1	3	3	145200	5082	5082	1791
5	2	1	2	3	152460	5082	5092	1791
5	2	1	3	3	12250	5082	5082	1791
5	2	1	1	2	1024	5082	5082	1791
5	2	1	3	3	130680	5082	5082	1791
5	2	1	1	2	43560	5082	5082	1791
5	2	1	1	2	14520	5082	5082	1791
5	2	2	3	3	15000	1063	5082	1791
5	2	2	1	1	1568	1063	5082	1791
5	2	2	1	1	1920	1791	5082	1791
5	2	2	1	1	1568	1791	5082	1791
5	2	2	3	3	125235	1791	5082	1791
5	2	2	1	1	405000	1063	5082	1791
5	2	2	4	1	38400	1063	5082	1791
5	2	2	3	4	7600	1063	5082	1791
5	2	2	3	3	21000	1063	5082	1791
5	2	2	1	1	495000	1063	5092	1791
5	2	2	4	1	51000	1063	5082	1791
5	2	2	1	1	1600	1063	5082	1791
5	2	2	1	1	3150	1063	5082	1791
5	2	2	1	1	1792	1791	5082	1791
5	2	2	1	1	1680	1063	5082	1791

APPENDIX D

APPENDIX D

INSTRUMENTATION AND PROCEDURES USED IN CONSTRUCTION SITE NOISE SURVEY

At the beginning of each test day, the data acquisition and analysis systems (Figure D-1) were calibrated using a General Radio sound level calibrator which produced a tone of known frequency and amplitude. As noted in Figure D-1, the sound measured by the microphone was transmitted to a sound level meter through a pre-amplifier. The sound was recorded on a magnetic tape recorder with the sound level meter setting on the linear scale at fast response.

For analysis, the tape was played back through an oscilloscope (to obtain a visual representation of the data) and the sound level meter (A-weighted, fast response). The signal was transmitted to a graphic level recorder, where strip charts were produced for further analysis. Table D-1 presents these components.

TABLE D-1. INSTRUMENTATION COMPONENTS

Equipment/Instrumentation	Manufacturer	Model	Serial#
Sound Level Calibrator	General Radio	1562-A	12075
Microphone	General Radio	1961-9601	1285
Sound Level Meter	General Radio	1933	2019
Milti Channel Tape Recorder	Nagra	IV-SJ	10005
Dual Trace Oscilloscope	Bruel & Kjaer	1470	11125
Graphic Level Recorder	Bruel & Kjaer	2305	152074
Windscreen	General Radio		
Extension Cable	General Radio		
Tripod	General Radio		

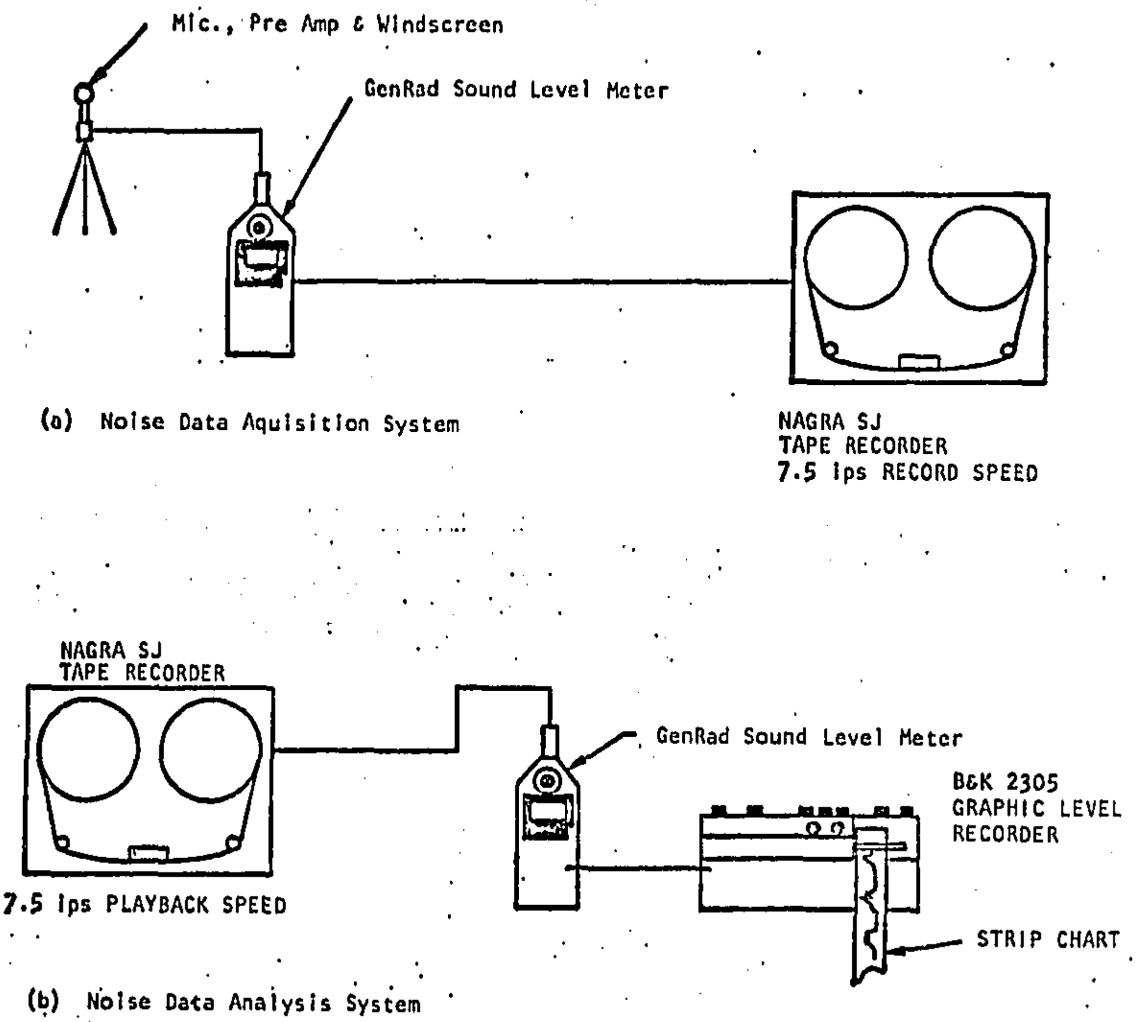

FIGURE D-1. DATA AQUISITION AND ANALYSIS SYSTEMS.