SOUTHERN CALIFORNIA TRANSIT DISTRICT
METRO RAIL PROJECT

TASK 18 BAF, BAH, BAJ, AND BAL OUTPUTS

NOISE AND VIBRATION

Prepared For:

Sedway/Cooke
304 S. Broadway
Los Angeles, California 90013

Prepared by:

WESTEC Services, Inc.
3211 Fifth Avenue
San Diego, California 92103

January 1983

23704930

TABLE OF CONTENTS

LIST OF FIGURES

TABLE OF CONTENTS (Continued)

LIST OF FIGURES (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

ATTACHMENTS

NOISE AND VIBRATION

INTRODUCTION

This report compiles information from various sources pertaining to noise and vibration impacts of the Metro Rail Project. The material contained herein includes a description of baseline noise and vibration conditions along alternative alignments, an assessment of noise and vibration impacts from various system components and configurations, a discussion of appropriate noise regulations, and a discussion of project noise and vibration design criteria.

The report is compiled into a basic text which includes a description of existing conditions, an assessment of noise and vibration impacts and a discussion of mitigation options. Two attachments are included dealing with design criteria and regulations and guidelines.

For the existing conditions section, noise and vibration measurements have been made outside representative buildings and in representative areas adjacent to all proposed Metro Rail system alignments, station yard, and facility locations. The purpose of these measurements is to provide a set of existing (ambient) baseline, benchmark community noise and vibration levels to which proposed Metro Rail systems generated levels may be compared. This data and community noise and vibrations design criteria (i.e., standards of acceptability) provide the basis for determining any areas in the community where system generated levels would potentially cause impacts and would therefore have to be mitigated using special design features. The existing conditions sections present both the data collected and a discussion of the basic units and descriptions used in noise and vibration studies.

To assess the noise and vibration impacts from the Metro Rail system, the expected levels of noise and vibrations generated by the operation of rolling stock, maintenance and yard operations, construction and feeder transit systems have been examined and compared to the existing ambient levels and the Metro Rail Noise and Vibration Criteria (Wilson, Ihrig, 1982a,b,e). Since the proposed transit system may consist of both above and below grade trackage, projections were made of the expected ground-borne noise levels from train operations in subway sections, and of the expected airborne noise levels produced by trains operating on the surface and aerial structure alternatives. The noise impact of fan and vent shafts, and ancillary facilities such as power substations and chiller plants have also been examined. Included in the assessment is an evaluation of the noise impact projections in terms of long-and short-term disturbance. A description is given of the recommended provisions to be included in the design of the Metro Rail system for minimizing harm to the environment from noise and vibration, and other mitigation measures are presented.

The source material for this report is a series of special studies conducted by Wilson Ihrig and Associates, Inc., who is the noise and vibration engineering design consultant to Southern California Rapid Transit District on the Metro Rail Project. Source material was compiled into this appendix by WESTEC Services, Inc. in association with Acoustical Impacts International. In most cases, the textual material which is included herein is taken verbatim from the various Wilson, Ihrig reports (Wilson, Ihrig, 1982a through f) called out in the reference section.

EXISTING CONDITIONS

Ambient Noise Environment

Establishing the existing noise level or noise environment in a community can be accomplished either by estimating the noise level from data on existing traffic volumes, traffic noise being the most prevalent noise in the communities, or by measuring the noise in a large number of locations at several different times of day and preferably on several different days and different times of the year. Community noise is a continually fluctuating entity dependent upon many factors but, generally, is primarily due to noise from street and highway traffic. Because the noise level does fluctuate over a relatively wide range, when established by on-site measurements it is necessary that the measurements be statistically significant and be amenable to analysis on a statistical basis.

The project alignments pass through several different types of community areas. In the downtown area and along Wilshire Boulevard, the area is primarily commercial with office buildings and retail stores. There are also a significant number of multi-family residences (apartments and condominiums) along some sections of Wilshire Boulevard. Along Fairfax Avenue there are sections of commercial buildings and some multi- and single-family residences. Between Fountain Avenue and Vineland Avenue the area is primarily residential with single- and multi-family residences. Between Vineland Avenue and Chandler the alignment the area has some commercial as well as residential areas. A more detailed description of the land usage along the alternative alignments is given in Table 1. Land use locations are referred to by engineering station number. A series of maps referencing engineering station numbers is given in Attachment 3.

For the commercial areas, with principally daytime occupancy, the possibility of intrusion from transit train operations is primarily a daytime consideration. In residential areas, the community ambient or background noise level is generally the lowest during the evening and nighttime hours and the possibility of intrusion from transit train operations is greatest during this time period. Thus, in the commercial areas, the environmental measurements are accomplished mainly in the daytime and the transit system design criteria are based primarily on daytime operations and noise levels. In the residential areas, the measurements are performed at several different characteristic times of the day and the transit system design criteria are based primarily on evening and nighttime operations and noise levels.

Although community noise data for the daytime in commercial areas and noise data for the evening and nighttime in residential areas are sufficient to establish the design criteria and evaluate the potential impact of the transit system, such measurements are not sufficient for a complete assessment of the community area environment. Therefore, measurements are generally made to provide data on the existing noise levels for several different times of day. Complete 24-hour surveys of the noise level can be performed in order to obtain a complete statistical representation of the daily noise exposure in a community area. It has been found, however, that the noise in communities can be characterized adequately by making spot-check measurements during at least four characteristic times of day. Because of the purpose of the noise measurements reported herein, the spot-check type of survey with a measurement duration of 10 minutes was performed at all of the measurement locations during appropriate characteristic times of day. These data are supplemented by complete 24-hour noise surveys at several selected measurement locations.

Table 1

LAND USAGE ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES

Station Number From Union Station			Description of Land Usage
CBD-WILSHIRE SEGMENT			
00+00	to	38+00	Low-rise commercial office buildings, Union Station (historical landmark), and El Pueblo de Los Angeles (historic district).
38+00	to	51+50	County Courthouse, State and City office buildings, and Law Library.
51+50	to	107+00	Mid-rise commercial office buildings, International Jewelry Center, theaters, hotels, apartments, Angeles Plaza Elderly Housing and Pershing Square.
107+00	to	111+00	Mid-rise office buildings, Hilton Hotel and Hyatt Regency Hotel.
111+00	to	165+50	Low-rise commercial office buildings, and Interstate Bank.
165+50	to	178+00	McArthur Park.
178+00	to	181+80	Art gallery, low-rise and mid-rise commercial office buildings.
181+80	to	191+50	Low-rise and mid-rise commercial buildings.
191+50	to	199+50	Lafayette Park and low-rise office buildings.
199+50	to	218+00	Sheraton West Hotel, bank buildings, department stores, low-rise and mid-rise commercial office buildings.
218+00	to	243+50	Mixed commercial, bank building offices and apartments, Ambassador Hotel, other hotels, South Western University. Immanuel Presbyterian Church at Station 226+50 and Wilshire Church at Station 243+50.
243+50	to	284+00	Wilshire-Hyatt Hotel commercial offices, Union Bank and other bank buildings and theaters. St. Basil Roman Catholic Church at Station 254+50, Wilshire Boulevard Temple at Station 259+50, and St. James Episcopal Church and St. James Episcopal School between Stations 280+00 and 282+50.

Table 1

LAND USAGE ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Station Number From Union Station			Description of Land Usage
284+00	to	330+00	Mixed commercial and office buildings, apartments, motels and bank buildings. Theater of Arts at Station 297+50. Scottish Rite and Wilshire Methodist Church between Stations 314+50 and 317+50. Wilshire Ebell Theater at Station 320+00.
330+00	to	350+00	Mixed commercial and office buildings and apartments. Farmers Insurance Home office at Station 340+00.
350+00	to	360+00	Residential and office buildings. Leona School and Burroughs Junior High School between Stations 353+00 and 357+50.
360+00	to	410+00	Commercial, office, bank and residential buildings.
410+00	to	435+00	Office buildings. Hancock Park. County Art Museum at Station 423+00. May Company department store.
435+00	to	460+00	Park La Brea Apartments and mixed commercial and office buildings. Hancock Park School at Station 452+00.
460+00	to	476+00	Mixed commercial, bank and residential buildings. Farmers Market between Stations 460+00 and 467+50. CBS Television City at Station 470+00.
476+00	to	530+00	Mixed commercial, bank and residential buildings and convalescent homes. Fairfax High School between Stations 491+00 and 503+50.

HOLLYWOOD SEGMENT
ALTERNATIVE A: CAHUENGA BEND

535+00	to	565+00	Mixed commercial, office, and residential buildings, and convalescent homes.
565+00	to	580+00	Apartments and single-family residences.

Table 1

LAND USAGE ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Station Number From Union Station			Description of Land Usage
580+00	to	660+00	Mixed commercial, office and residential buildings and motels. Hollywood High School between Stations 632+00 and 639+00. Blessed Sacrament School at Station 652+00.
660+00	to	692+00	Mixed commercial and office buildings.
692+00	to	710+00	Single-family residential dwellings (close to Hollywood Freeway).
710+00	to	730+00	Hollywood Bowl.
730+00	to	760+00	Open space.
760+00	to	820+00	Single-family residential and open space.
820+00	to	860+00	Mixed commercial and office buildings (close to Hollywood Freeway).
860+00	to	890+00	Apartments and Howard Johnson's Motel. Rio Vista School at Station 889+00 (all close to Hollywood Freeway).
890+00	to	910+00	Mixed commercial, apartment and single-family residential buildings (between Hollywood and Ventura Freeways).
910+00	to	950+00	Mixed single-family residential, commercial and apartment buildings.
950+00	to	987+00	Commercial and light industry buildings.
987+00	to	1005+00	Mixed commercial and residential buildings (close to Hollywood Freeway).
1005+00	to	1038+00	Apartment buildings and single-family residential.
1038+00	to	1042+00	Mixed commercial and apartment buildings.
1042+00	to	1057+00	Apartment buildings and some single-family residences.

Table 1

LAND USAGE ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Station Number From Union Station			Description of Land Usage
1057+00	to	1086+00	Single-family residences and some apartments.
ALTERNATIVE B: FAIRFAX EXTENDED			
530+00	to	580+00	Mixed commercial, office and apartment buildings. Isolated single-family residences. St. Ambrose School at Station 560+00.
580+00	to	594+00	Single-family residential and apartments and some commercial buildings.
594+00	to	735+00	Single-family residential and open space.
ALTERNATIVE C: LA BREA BEND			
535+00	to	550+00	Mixed commercial, office and residential buildings.
550+00	to	565+00	Apartments and single-family residences.
565+00	to	596+00	Apartments, isolated single-family residences and some commercial buildings.
596+00	to	613+00	Apartments and single-family residences.
613+00	to	640+00	Mixed commercial, bank and office buildings and some apartments. Playhouse theater at Station 622+30.
640+00	to	696+00	Mostly open space with a few isolated single-family residences, at both ends of this section.
696+00	to	760+00	Single-family residences and open space.
NORTH HOLLYWOOD SEGMENT LANKERSHIM ALTERNATIVE:			
760+00	to	780+00	Single-family residences with some apartments.
780+00	to	803+00	Hollywood Freeway, Universal City Studios and some single-family residences.

Table 1

LAND USAGE ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Station Number From Union Station			Description of Land Usage
803+00	to	864+50	Mixed commercial, office and bank buildings and some apartments.
VINELAND ALTERNATIVE:			
760+00	to	833+00	Single-family residential dwellings.
833+00	to	874+00	Commercial and some office buildings.
874+00	to	905+00	Residential and office buildings, and isolated houses.
905+00	to	1008+00	Mixture of apartments, houses, commercial and office buildings.
1008+00	to	1020+00	Residential and some commercial buildings.

LAND USAGE ALONG THE ALIGNMENT OF THE INTERMEDIATE CAPACITY TRANSIT SYSTEM ALTERNATIVE

Station Number From Fairfax Station			Description of Land Usage
0+00	to	130+00	Mixed commercial, office, and bank buildings and some apartments and motels. Samuel Goldwyn Studio between Stations 81+50 to 88+50. Hollywood West Hospital at Station 104+50.
130+00	to	150+00	Mixed office buildings and some apartments. Hollywood High School between Stations 139+00 and 144+00.
150+00	to	197+00	Mixed commercial, office and apartment buildings. Selma Avenue School between Stations 162+00 and 164+50.

A series of maps referencing engineering station numbers is given in Attachment 3.

Source: Wilson, Ihrig & Associates, Inc. (1982a,d,e).

A total of 78 measurement locations were chosen as representative of areas along the various proposed alingments. "Spot-check" or short-term noise and vibration measurements were made at all 45 locations. Twenty-four hour or long-term noise measurements were also performed at seventeen selected locations.

The first noise and vibration survey covered a total of 45 measurement locations along the SCRTD Board adopted Preferred Alternative II Route (U.S. DOT, 1980). That survey occurred during September and October 1981. Subsequent to that study, certain portions of the route have been revised, several alternative alignments in the Hollywood and North Hollywood areas have been considered. In order to characterize the existing noise and vibration environment along these new alignments, additional noise and vibration measurements were made at 33 new locations in September 1982.

The locations of the measurement sites are indicated in Figures 1 through 4, and a brief description of each measurement location and its relation to the alignment is given in Table 2. Table 3 gives a brief description of each of the 24-hour noise survey locations and their relation to the various proposed alignments.

The 1982 measurement locations are numbers 101 through 133 to differentiate them from the 1981 measurement locations which are numbered 1 through 45.

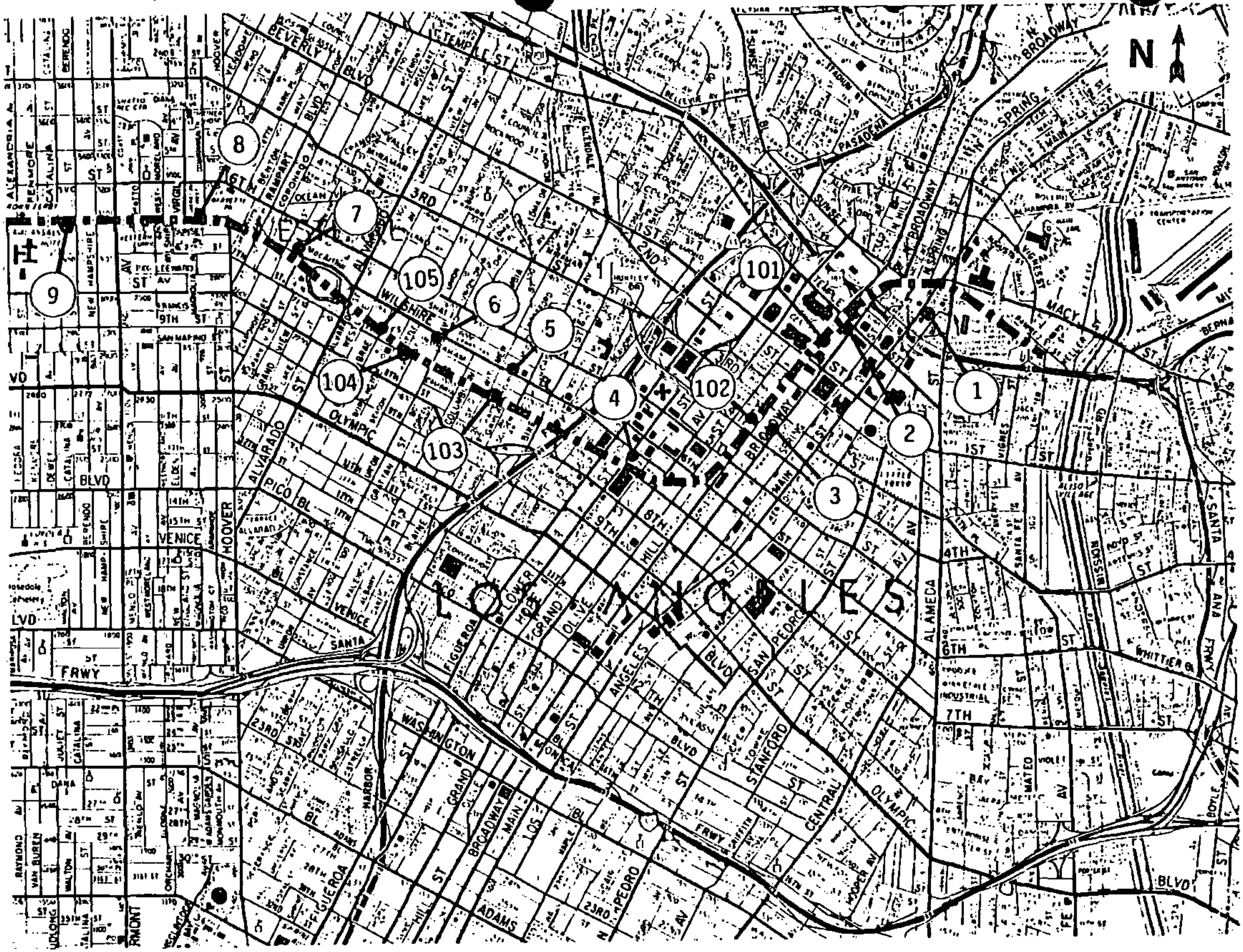
For the purpose of this study, the day was divided into four characteristic measurement periods representing:

Daytime:	10:00 a.m. to 2:00 p.m.
Rush Hour:	4:00 p.m. to 6:00 p.m.
Evening:	7:00 p.m. to 10:00 p.m.
Nighttime:	11:00 p.m. to 2:00 a.m.

No data were taken during the morning rush hour because it is generally found that the noise level results are essentially the same as for the evening rush hour.

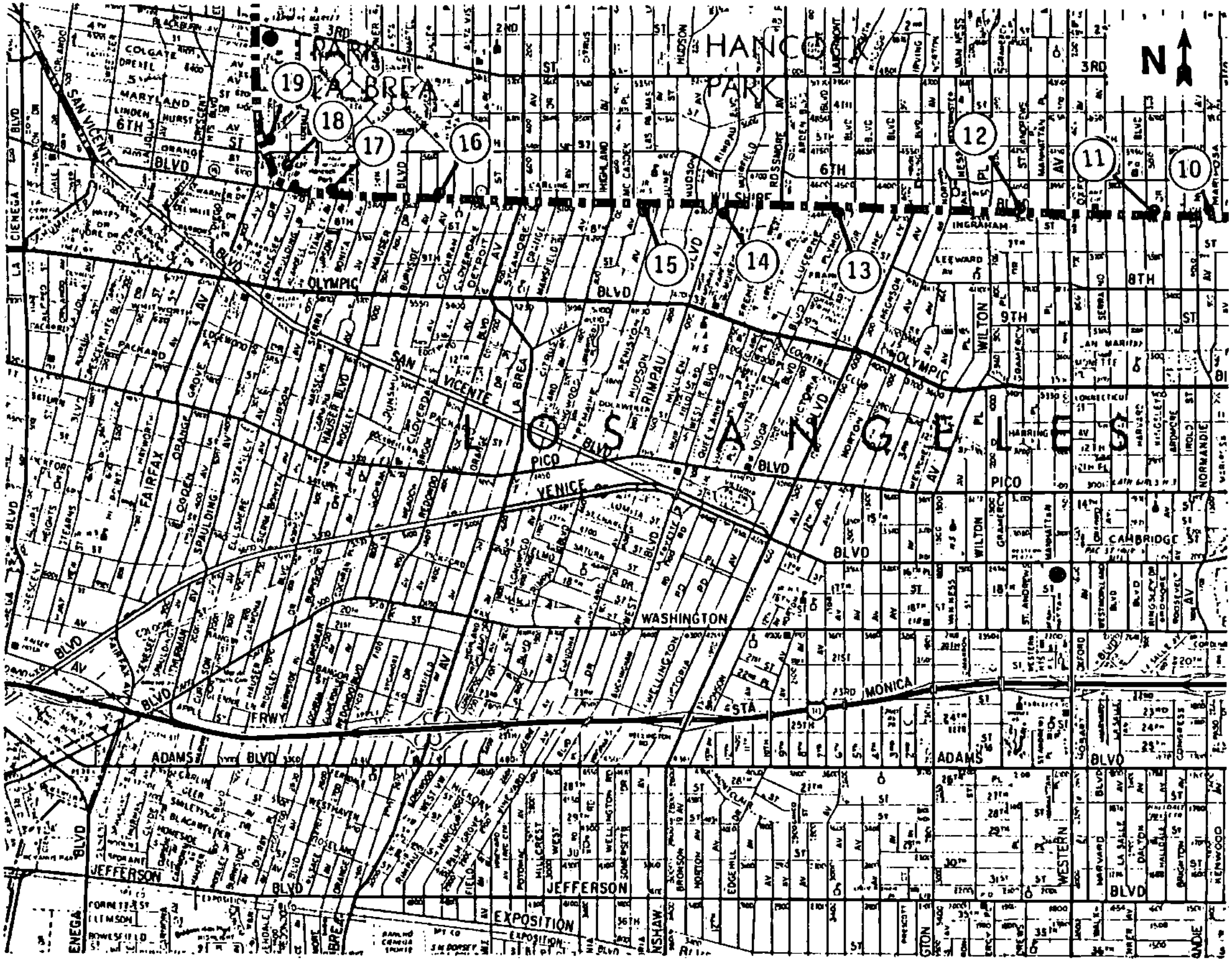
The results of the noise measurements and the description of the noise environments prevailing at each of the measurement locations in the community are based on a statistical analysis of the observed noise levels in decibels. The factors derived from the analysis are the levels exceeded 99 percent of the time, 90 percent of the time, 50 percent of the time, 10 percent of the time, and 1 percent of the time designated L_{99}, L_{90}, L_{50}, L_{10}, and L_1, respectively.

L_{99} and L_{90} are descriptors of the typical minimum or "residual" background noise level observed during a measurement period, normally made up of the summation of a large number of sound sources distant from the measurement position and not usually recognizable as individual sound sources. The most prevalent source of this residual noise is distant street and highway traffic, but L_{99} and L_{90} are not strongly influenced by occasional local motor vehicle passbys. However, they can be influenced by nearby stationary sources such as air conditioning equipment.



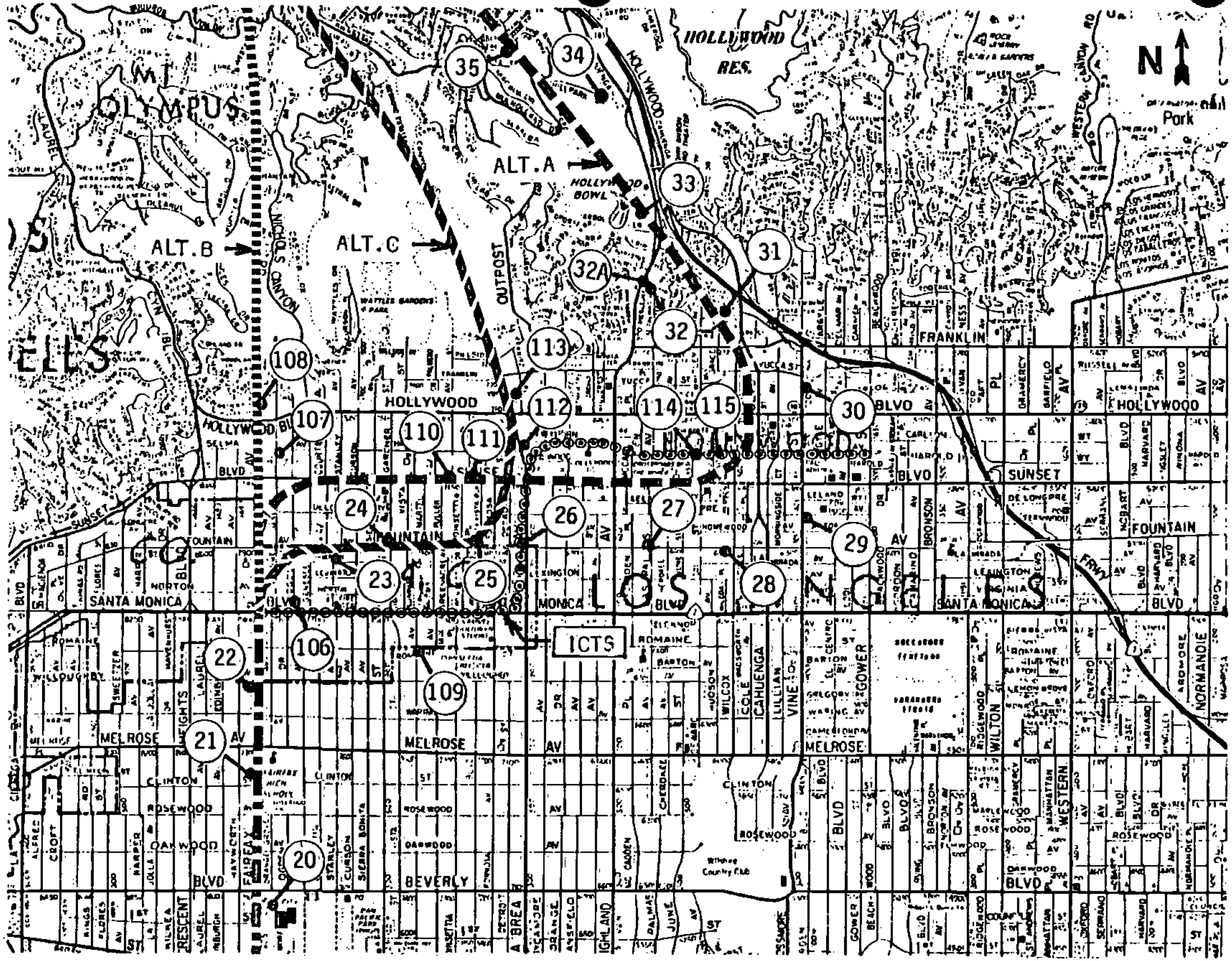
(SCALE: 1 INCH = 2800 FT)

FIGURE 1 LOCATION OF NOISE AND VIBRATION MEASUREMENT SITES ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES



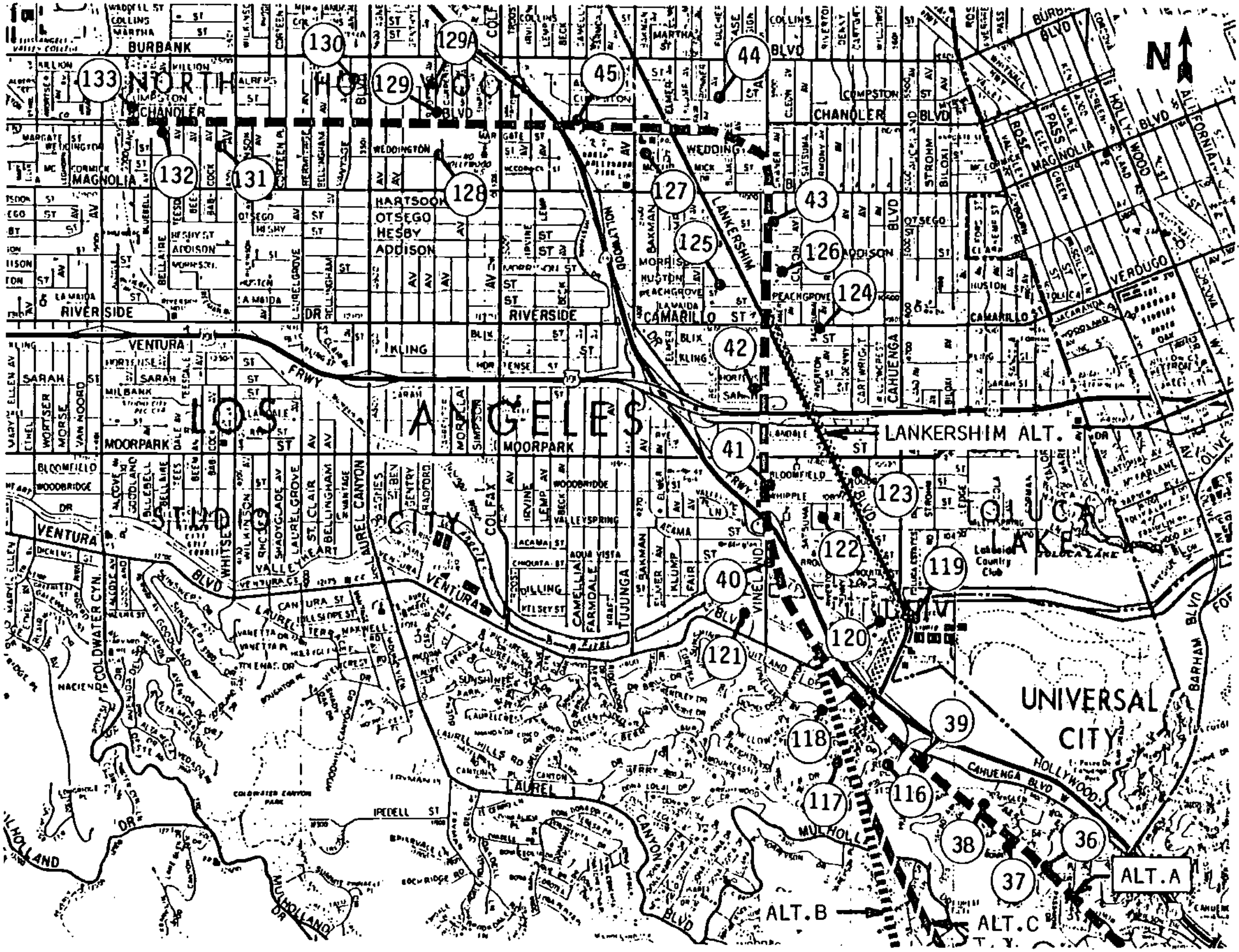
(SCALE: 1 INCH = 2800 FT)

FIGURE 2 LOCATION OF NOISE AND VIBRATION MEASUREMENT SITES ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES



(SCALE: 1 INCH = 2800 FT)

FIGURE 3 LOCATION OF NOISE AND VIBRATION MEASUREMENT SITES ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES



(SCALE: 1 INCH = 2800 FT)

FIGURE 4 LOCATION OF NOISE AND VIBRATION MEASUREMENT SITES ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
1	16+00	640	Near the band stage platform area located within the El Pueblo State Historical Park Plaza on Olivera Street.
2	34+00	30	On the west side of the intersection of North Broadway and Temple Street, near the Los Angeles County Hall of Records.
3	59+40	25	On the west side of Broadway between 3rd and 4th Streets
4	99+50	340	On the north side of the intersection of Wilshire Boulevard and Flower Street, near the corner of Wells Fargo Bank.
5	129+80	60	On the north side of Wilshire Boulevard and 165 feet southeast of the intersection of Wilshire Boulevard and Witmer, near the Hospital of the Good Samaritan.
6	143+20	25	On the south side of Wilshire Boulevard and 60 feet west of the intersection of Wilshire Boulevard and Union Avenue.
7	175+50	45	On the north side of the intersection of Wilshire Boulevard and Park View Street, near Otis/Parsons Art Gallery.
8	195+80	65	On the northwest of the intersection of Wilshire Boulevard and Commonwealth Avenue, near the corner of Sheraton Hotel.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
9	222+80	30	On the south side of the intersection of Wilshire Boulevard and Berendo Street, near the steps to Immanual Presbyterian Church.
10	240+20	35	On the north side of the intersection of Wilshire Boulevard and Normandie Avenue, near the Wilshire Christian Church.
11	250+20	25	On the north side of Wilshire Boulevard between Kingsley Drive and Harvard Boulevard, near the corner of St. Basil Roman Catholic Church.
12	276+60	45	On the north side of Wilshire Boulevard between St. Andrews and Gramercy Place, near the corner of St. James Episcopal School and an office building.
13	310+90	45	On the south side of Wilshire Boulevard between Lucerne Boulevard and Plymouth Boulevard, near the corner of Wilshire Methodist Church and the parking area.
14	337+30	20	On the north side of Wilshire Boulevard between Rimpau Boulevard and Hudson Avenue, near the Farmers' Insurance building and the parking area.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
15	352+50	65	On the east side of Longwood Avenue and 40 feet south of Wilshire Boulevard, near the Leona School.
16	389+10	35	On the northeast corner of the intersection of Wilshire Boulevard and Burnside Avenue, near the office building.
17	410+40	45	Near the La Brea Tar Pits located within Hancock Park, on the north side of the intersection of Wilshire Boulevard and Stanley Avenue.
18	418+30	620	Near the observation pit located within the grounds of the Art Museum, 140 feet south of the intersection of Ogden Drive and 6th Street.
19	425+30	850	Near the south end of Orange Grove Avenue.
20	510+25	240	In the parking area of CBS TV Studio on Fairfax Avenue and Beverly Boulevard.
21	534+40	25	On the west side of Fairfax Avenue and 100 feet north of the intersection of Fairfax Avenue and Clinton Street, near the Theater and King Solomon Home for the elderly.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
22	551+30	15	On the west side of Fairfax Avenue and 160 feet south of the intersection of Fairfax Avenue and Willoughby Avenue, near the driveway to the underground parking area of the County Villa Convalescent Home.
23	587+70	295	On the northeast corner of the intersection of Spaulding Avenue and Hampton Avenue.
24	598+80	25	On the northwest corner of the intersection of Fountain Avenue and Gardner Street.
25	616+00	20	On the northwest corner of the intersection of Fountain Avenue and Alta Vista Boulevard.
26	625+30	20	On the northwest corner of the intersection of Fountain Avenue and La Brea Avenue.
27	648+90	10	On the northwest corner of the intersection of Fountain Avenue and Las Palmas Avenue.
28	663+30	295	On the south side of Fountain Avenue and 50 feet west of the intersection of Fountain Avenue and Wilcox Avenue, near the Orchard Gables Convalescent Hospital.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
29	673+60	1060	On the southeast corner of the intersection of Vine Street and De Longpre Avenue.
30	695+00	890	On the west side of Vine Street and 330 feet north of the intersection of Vine Street and Hollywood Boulevard, near the Capitol Records Building.
31	714+90	45	On the south corner of Cerritos Place and Holly Hill Terrace.
32	724+80	755	On the west side of the intersection of Las Palmas Avenue and Milner Terrace.
33	740+60	20	Within the Hollywood Bowl parking area on Hollywood Bowl Drive.
34	760+80	750	Outside the apartments at 6720 Parkhill Drive off Cahuenga Boulevard.
35	779+80	185	Outside the house at 7010 Pacific View Drive.
36	812+70	335	Outside the house at 3149 Oakshire Drive near Adina Drive.
37	821+50	690	At the front of the garage of 3340 Bonnie Hill Drive.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
38	834+20	290	Outside the house at 3827 Broadlawn Drive off Cahuenga Boulevard.
39	847+20	190	Outside a commercial building at 3623 Cahuenga Boulevard, building located between Fredonia Drive and Regal Place.
40	896+90	95	In the parking area of Howard Johnson's Inn, 70 feet east side of the intersection of Vineland Avenue and Aqua Vista Street.
41	911+90	55	On the southeast corner of the intersection of Vineland Avenue and Bloomfield Street.
42	931+20	60	On the southwest corner of the intersection of Vineland Avenue and Hortense Street.
43	964+30	50	On the southeast corner of the intersection of Vineland Avenue and Hartsock Street.
44	987+70	565	On the northwest corner of the intersection of Cumpston Street and Fulcher Avenue.
45	1014+90	60	On the northeast corner of the intersection of Chandler Boulevard and Camellia Avenue.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
101	48+60	60	On the east side of Hill Street and approximately 350 feet south of First Street.
102	67+20	30	On the west side of Hill Street and approximately 250 feet north of Third Street.
103	131+60	30	On the west side of Seventh Street at the intersection of Hartford Avenue and Seventh Street.
104	150+70	20	In the parking lot of the Travelodge Motel near the intersection of Seventh Street and Little Street.
105	156+80	0	On the east side of Bonnie Brae Street between Wilshire Boulevard and Seventh Street and near the Mid-Wilshire Convalescent Hospital.
106	548+60 52+00 (ICTS)	700 75	On the east side of Ogden Drive and 75 feet north of Santa Monica Boulevard, adjacent to storage lot for Executive Car Leasing.
107	576+50 (A) 580+70 (B)	800 350	On the southeast corner of the intersection of Selma Avenue and Orange Grove Avenue.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
108	590+00 (B)	0	On the southeast corner of the intersection of Fairfax Avenue and Hillside Avenue.
109	74+60 (ICTS)	740	On the southeast corner of the intersection of Martel Avenue and Romaine Street.
110	609+00 (A)	30	On the northeast corner of the intersection of Sunset Boulevard and Fuller Avenue.
111	612+30 (A)	30	On the northeast corner of the intersection of Sunset Boulevard and Poinsetta Place.
112	621+30 (C) 129+30 (ICTS)	170 40	On the south side of Hawthorn Avenue and 30 feet east of La Brea Avenue, near the Bank of Hollywood.
113	630+40 (C)	200	On the northwest corner of the intersection of El Cerrito Place and Yucca Street.
114	655+40 (A) 163+50 (ICTS)	660 30	In the parking lot of the Selma Avenue School, near the intersection of Selma Avenue and Cassil Place.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
115	663+60 (A) 167+00 (ICTS)	600 20	On the northeast corner of the intersection of Selma Avenue and Hudson Avenue.
116	711+50 (B & C) 765+60 (L)	730 840	Outside the apartments at 362 Regal Place.
117	713+60 (B & C) 766+80 (L)	140 20	Outside the house at 7765 Skyhill Drive.
118	723+60 (B)	300 (AO) 390 (SO)	At the northeast corner of the intersection of Vineland Avenue and Willowcrest Avenue.
119	797+30 (L)	380	Within the parking lot of Universal City Studio at the intersection of Lankershim Boulevard and Valley Heart Drive, across from the Bank of America.
120	769+00 (L)	240	At the northeast corner of Valley Heart Drive and Willowcrest Avenue.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
121	873+00	510 (AO) 730 (SO)	Outside the apartments at 4185 Arch Drive.
122	821+20 (L)	560	Outside the house at 4261 Riverton Avenue.
123	825+10 (L)	330	Outside the house at 10705 Bloomfield Street.
124	854+90 (L)	850	Outside the apartments at 10830 Camarillo Street.
125	932+60	1000	Outside the house at 11137 Huston Street.
126	936+00	320	Outside the house at 10932 Morrison Street.
127	984+70	520	In the parking lot of the Community Health Center on Weddington Street.
128	1026+10	650	On the north side of Weddington Street and 60 feet west of the northern extension of Radford Avenue.
129	1026+70	80	Outside the house at 5400 Radford Avenue.
130	1044+70	880	Outside the house at 5524 Vantage Avenue.

Table 2

LOCATIONS USED FOR EVALUATION OF THE NOISE AND VIBRATION ENVIRONMENT ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
131	1069+90	450	Outside the house at 5310 Babcock Avenue.
132	1079+60	120	In the vacant lot at the intersection of Chandler Boulevard and Bellaire Avenue, and 75 feet south of Chandler Boulevard.
133	1086+00	250	On the southwest corner of the intersection of Goodland Avenue and Cumpston Street.

(A) = Alternative A
(B) = Alternative B
(C) = Alternative C
(L) = Lankershim Alternative
(AO) = Aerial Option
(SO) = Subway Option
(ICTS) = Intermediate capacity transit system

Sources: Wilson, Ihrig & Associates, Inc. (1982).

Table 3

24-HOUR NOISE SURVEY LOCATIONS ALONG THE RAIL ALIGNMENT ALTERNATIVES

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
5	129+80	60	On the north side of Wilshire Boulevard and 165 feet southeast of the intersection of Wilshire Boulevard and Witmer, near the Hospital of the Good Samaritan.
11	250+20	25	On the north side of Wilshire Boulevard between Kingsley Drive and Harvard Boulevard, near the corner of St. Basil Roman Catholic Church.
19	425+30	850	Near the south end of Orange Grove Avenue.
21	533+50	25	On the northwest corner of the intersection of Fairfax Avenue and Clinton Street.
23	587+70	295	On the northeast corner of the intersection of Spaulding Avenue and Hampton Avenue.
25	616+60	15	Outside the apartments at 7228 Fountain Avenue near Alta Vista Boulevard.
28	663+30	295	On the south side of Fountain Avenue and 50 feet west of the intersection of Fountain Avenue and Wilcox Avenue, near the Orchard Gables Convalescent Hospital.
32A	727+40	705	On the intersection of Highland Avenue and Rockledge Road near Las Palmas Avenue.
42	931+20	60	On the southwest corner of the intersection of Vineland Avenue and Hortense Street.

Table 3

24-HOUR NOISE SURVEY LOCATIONS ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
102	67+20	30	On the north side of Hill Street and approximately 250 feet west of 3rd Street.
107	576+50 (A) 580+70 (B)	800 350	On the southeast corner of the intersection of Selma Avenue and Orange Grove Avenue.
109	74+60 (ICTS)	710	On the northeast corner of the intersection of Martel Avenue and Romaine Street.
118	723+30 (B)	320 (AO) 390 (SO)	At the southwest corner of the intersection of Vineland Avenue and Willowcrest Avenue.
*42	912+80	90 (SO) 110 (AO)	On the southwest corner of the intersection of Vineland Avenue and Hortense Street.
125	932+40	1070	Outside the house at 11154 Huston Street.

Table 3

24-HOUR NOISE SURVEY LOCATIONS ALONG THE RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Station Number	Approximate Perpendicular Horizontal Distance From Near Track Centerline (ft)	Description of Site
129A	1026+90	730 (AO)	On the northwest corner of the intersection of Radford Avenue and Albers Street.
132	1079+80	50	On the south side of Chandler Boulevard and 40 feet west of Bellaire Avenue.

*This site was measured in 1981 and again in 1982

(A) Alternative A
(B) Alternative B
(ICTS) Intermediate capacity transit system
(AO) Aerial Option
(SO) Subway Option

Source: Wilson, Ihrig & Associates, Inc. (1982a,d).

L_{50} represents a long-term statistical average or median sound level over the measurement period and does reveal the long-term influence of local traffic. If the instantaneous sound level is sampled over a measurement period, the sound level is sampled over a measurement period, the sound level will be above L_{50} 50 percent of the time and below L_{50} 50 percent of the time.

L_{10} describes the average peak or maximum sound level occurring for example, during nearby passbys of trucks, buses, automobiles, trains, or airplanes. Thus, while L_{10} does not describe the long-term noise prevailing it does describe the typical maximum noise levels observed at a point and is strongly influenced by the momentary maximum sound level occurring during vehicle passbys.

L_1, the sound level exceeded 1 percent of the time, is representative of the occasional maximum or peak sound level which occurs in an area.

Because of some inherent deficiencies of the simple percentile measures described above in evaluating the noise exposure effects of short duration, high level sounds (such as truck or bus passbys), the Energy Equivalent level, Leq, has been developed and is widely used as a valid single-number descriptor of environmental noise. Because it is an energy integral over time, Leq represents the constant or steady sound level which would give the same energy level as the fluctuating value integrated over the total time period. Because sound energy is proportional to the square of the sound pressure, Leq places more emphasis on high noise level periods than does L_{50} or a straight arithmetic average of noise level over time. Some consider Leq a more useful measure than L_{50} for the average or typical noise exposure in an area and most recent evaluation systems such as CNEL (Community Noise Equivalent level) or Ldn (Day/Night Average Level) use the energy equivalent concept.

The Community Noise Equivalent Level (CNEL) is based on the Leq concept but provides an indication of the subjective response of people to the average community noise level over a 24-hour period. To accomplish this subjective sensitivity, acoustic psychologists and scientists have incorporated time weighted penalties into the CNEL measure to account for the increased annoyance people have to disturbing sounds during the evening, and late-night/early morning hours. In averaging evening noise levels into the 24 hour noise exposure to detemine the CNEL, a 5 dB burden is added to all noise exposures between the hours of 7 p.m. and 10 p.m. In averaging late night/early morning noise levels into the 24 hours noise exposure to determine the CNEL, a burden of 10 dB is added to all noise exposures between the hours of 10 p.m. and 7 a.m.

The Day-Night Sound Level (Ldn) is similar to the CNEL 24-hour noise descriptor, being based on the Leq concept with a penalty being added for the time of day that a noise occurs. The difference is that the Ldn is somewhat less sensitive and only weights the late-night/early morning hours noise exposures (with a 10 dB burden). As a rule, for most community noise environments, the difference between the CNEL and Ldn ratings for the same location is usually less than 1 dB and therefore not significant.

Existing Noise Levels

Table 4 presents a tabulation of the statistical analysis of the noise observed at each of the 78 noise measurement locations. All of the noise levels are presented in terms of A-weighted sound level in decibels, abbreviated dB(A). This measurement scale is used

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES

Location Number	Time of Day	Date	Noise Levels - dB(A) L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
1	Rush Hour	9/28/81	62	63	64	66	72	65
	Day	9/28/81	57	58	61	64	68	62
	Evening	9/28/81	53	54	56	60	66	58
	Night	9/28/81	52	53	54	57	60	55
2	Rush Hour	9/22/81	65	67	70	74	81	72
	Day	9/21/81	65	67	71	75	82	72
	Evening	9/22/81	63	64	67	71	76	68
3	Rush Hour	9/22/81	62	65	70	77	84	73
	Day	9/21/81	64	66	69	74	81	72
	Evening	9/22/81	54	57	63	71	79	68
4	Rush Hour	9/22/81	66	68	71	77	83	74
	Rush Hour*	9/28/81	68	69	72	78	85	75
	Day	9/21/81	66	68	72	77	83	74
	Day*	9/28/81	66	68	71	76	83	73
	Evening	9/22/81	59	61	64	71	79	68
	Evening*	9/22/81	58	60	64	70	79	68
5	Rush Hour	9/23/81	56	60	66	73	80	71
	Rush Hour*	9/28/81	57	60	68	74	81	71
	Day	9/21/81	56	60	64	69	77	67
	Day*	9/28/81	54	57	63	70	75	66
	Evening	9/21/81	51	53	58	65	76	63
	Evening*	9/28/81	52	55	63	70	79	68
	Night	9/22/81	50	51	55	64	70	60
6	Rush Hour	9/21/81	57	60	66	74	82	71
	Day	9/21/81	56	60	65	73	82	70
	Evening	9/21/81	54	57	63	71	80	68
7	Rush Hour	9/21/81	56	59	66	74	81	70
	Rush Hour*	10/1/81	58	60	66	73	79	69
	Day	9/21/81	56	59	66	73	80	70
	Day*	9/29/81	56	59	65	71	78	68
	Evening	9/21/81	51	53	59	69	77	66
	Night	9/21/81	49	50	53	62	66	57

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Noise Levels - dB(A)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_{1}	L_{eq}
8	Rush Hour	9/21/81	61	64	68	74	81	71
	Rush Hour*	10/1/81	61	63	67	72	78	69
	Day	9/21/81	60	63	67	72	78	69
	Day*	9/29/81	58	61	66	72	79	69
	Evening	9/21/81	55	57	64	70	79	67
	Night	9/21/81	50	51	57	65	72	61
9	Rush Hour	9/21/81	63	65	69	77	83	73
	Day	9/22/81	59	62	67	74	80	70
	Evening	9/21/81	56	57	69	69	77	66
	Night	9/21/81	54	55	61	68	75	66
10	Rush Hour	9/21/81	64	67	71	76	82	74
	Rush Hour*	10/1/81	63	66	71	82	84	76
	Day	9/22/81	62	65	70	75	82	72
	Day*	9/29/81	61	64	69	78	83	73
	Evening	9/21/81	57	60	65	71	78	68
	Night	9/21/81	55	58	64	70	76	67
11	Rush Hour	9/21/81	59	61	69	74	80	71
	Rush Hour*	10/1/81	61	64	69	74	82	72
	Day	9/22/81	62	64	70	76	79	72
	Day*	9/29/81	63	64	68	72	77	70
	Evening	9/21/81	56	59	65	71	74	67
	Night	9/22/81	49	51	58	68	75	64
12	Rush Hour	9/23/81	56	59	70	74	82	72
	Day	9/22/81	56	58	67	74	80	70
	Evening	9/23/81	51	55	65	71	75	67
13	Rush Hour	9/23/81	57	61	68	73	77	70
	Day	9/22/81	56	61	70	76	82	72
	Evening	9/22/81	52	56	66	71	76	68
	Night	9/23/81	44	47	57	68	74	63
14	Rush Hour	10/1/81	54	57	66	72	76	68
	Day	9/29/81	58	60	66	72	81	71
15	Rush Hour	9/23/81	57	60	65	69	76	67
	Day	9/23/81	50	53	63	69	78	67
	Day*	9/29/81	51	54	60	66	75	63
	Evening	9/23/81	47	50	59	67	71	63
	Night	9/25/81	40	42	47	63	69	58

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Noise Levels - dB(A)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
16	Rush Hour	9/24/81	59	62	68	74	83	72
	Day	9/23/81	56	59	68	75	84	72
	Evening	9/23/81	53	58	66	71	75	67
17	Rush Hour	9/24/81	54	58	63	68	73	65
	Day	9/23/81	54	58	63	67	73	64
	Evening	9/23/81	47	51	58	64	69	61
	Night	9/23/81	45	47	57	64	69	60
18	Rush Hour	9/23/81	50	52	56	59	63	56
	Day	9/23/81	49	51	54	58	63	55
	Day*	9/23/81	48	50	53	56	60	54
	Day*	9/30/81	52	53	55	57	63	55
19	Rush Hour	9/22/81	52	54	57	60	64	58
	Rush Hour*	9/30/81	51	54	57	61	65	58
	Day	9/22/81	50	53	57	60	63	57
	Day*	9/30/81	48	52	55	60	66	57
	Evening	9/22/81	48	51	55	59	64	56
	Night	9/23/81	39	41	45	52	60	49
20	Rush Hour	9/23/81	50	51	53	57	69	57
	Day	9/23/81	51	52	55	59	64	57
	Day*	9/29/81	48	50	52	55	60	53
	Day*	9/23/81	50	51	54	58	64	55
21	Rush Hour	9/22/81	57	62	68	72	76	69
	Day	9/22/81	54	59	66	71	76	67
	Day*	9/30/81	52	59	67	73	78	70
	Evening	9/22/81	50	58	65	71	77	68
	Night	9/25/81	44	50	60	71	78	67
22	Rush Hour	9/22/81	52	56	64	71	78	68
	Day	9/22/81	51	54	63	71	82	69
	Evening	9/22/81	48	51	59	69	74	64
	Night	9/24/81	44	46	53	64	70	59
23	Rush Hour	9/24/81	46	49	53	60	67	57
	Rush Hour*	9/30/81	46	47	58	60	67	56
	Day	9/23/81	42	44	48	57	65	54
	Day*	9/30/81	43	44	48	58	67	55
	Evening	9/23/81	39	41	47	54	63	51
	Night	9/24/81	34	35	38	49	60	47

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Noise Levels - dB(A)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
24	Rush Hour	9/24/81	56	62	68	72	79	70
	Day	9/24/81	59	62	68	72	78	70
	Evening	9/24/81	49	54	62	69	72	65
	Night	9/24/81	46	49	61	69	75	65
25	Rush Hour	9/24/81	49	57	66	72	74	68
	Rush Hour*	9/30/81	50	55	64	69	72	66
	Day	9/24/81	50	56	66	72	76	68
	Day*	9/30/81	46	49	63	69	73	66
	Evening	9/24/81	43	48	61	69	73	65
	Night	9/24/81	44	47	59	69	73	64
26	Rush Hour	9/24/81	66	68	72	75	82	73
	Day	9/24/81	63	68	72	76	81	73
	Evening	9/24/81	59	62	68	73	78	70
27	Rush Hour	9/24/81	59	62	66	70	75	67
	Day	9/24/81	55	61	66	71	78	68
	Evening	9/24/81	50	55	63	69	76	66
	Night	9/24/81	45	49	60	67	72	63
28	Rush Hour	9/28/81	57	60	65	70	76	67
	Day	9/28/81	54	57	64	69	74	66
	Evening	9/28/81	54	57	63	69	76	66
	Night	9/28/81	45	48	55	63	71	60
29	Rush Hour	9/24/81	62	65	70	75	80	72
	Day	9/24/81	58	62	66	72	77	68
	Day*	9/24/81	56	63	68	74	80	70
	Evening	9/24/81	57	60	66	73	79	69
30	Rush Hour	9/29/81	59	62	67	71	78	69
	Day	9/24/81	61	62	66	72	77	68
	Evening	9/24/81	56	58	62	68	72	64
	Evening*	9/24/81	55	57	62	67	75	65
31	Rush Hour	9/24/81	54	56	58	61	65	59
	Day	9/24/81	52	54	56	59	62	56
	Evening	9/24/81	50	53	56	58	62	56
	Night	9/24/81	44	47	52	58	62	54

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS
ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Noise Levels - dB(A)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_{1}	L_{eq}
32	Rush Hour	9/29/81	51	55	59	63	67	60
	Day	9/25/81	46	49	53	57	65	55
	Evening	9/29/81	49	53	58	63	68	61
	Night	9/29/81	46	48	54	58	63	55
33	Rush Hour	9/29/81	52	53	55	59	64	57
	Day	9/25/81	55	57	59	63	71	62
	Evening	9/29/81	49	50	52	58	73	59
34	Rush Hour	9/29/81	53	54	56	60	72	60
	Day	9/25/81	49	51	53	55	68	57
	Evening	9/29/81	51	52	54	57	66	57
	Night	9/30/81	49	50	52	56	67	56
35	Rush Hour	9/29/81	42	44	46	58	67	56
	Day	9/25/81	42	43	45	48	60	48
	Evening	9/29/81	41	42	44	58	68	55
	Night	9/29/81	39	44	45	47	53	46
36	Rush Hour	9/29/81	40	43	52	63	70	59
	Day	9/29/81	41	42	46	59	70	57
	Evening	9/29/81	41	42	43	53	69	55
	Night	9/29/81	42	43	44	52	62	52
37	Rush Hour	9/29/81	38	38	40	46	59	48
	Day	9/29/81	37	38	39	42	62	47
	Evening	9/29/81	44	44	45	46	62	49
	Night	9/29/81	42	42	43	46	52	46
38	Rush Hour	9/28/81	45	47	49	55	58	55
	Evening	9/28/81	45	46	48	50	54	48
	Night	9/29/81	43	44	46	48	55	48
39	Rush Hour	9/28/81	64	66	70	75	79	72
	Day	9/28/81	61	63	67	73	78	70
	Evening	9/28/81	59	61	65	71	79	69
40	Rush Hour	9/28/81	56	57	60	66	72	63
	Day	9/28/81	56	57	60	65	71	62
	Day*	9/30/81	55	57	60	64	72	62
	Evening	9/28/81	52	54	57	61	66	58
	Evening*	9/29/81	54	55	58	65	70	61
	Night	9/30/81	49	51	55	60	64	56

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Noise Levels - dB(A)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
41	Rush Hour	9/28/81	55	58	63	68	79	68
	Day	9/28/81	55	57	63	69	75	66
	Evening	9/28/81	52	54	58	65	73	62
	Night	9/29/81	41	43	48	56	66	56
42	Rush Hour	9/28/81	56	58	63	69	75	66
	Day	9/28/81	59	61	64	68	75	65
	Evening	9/28/81	55	57	60	65	70	62
	Night	9/29/81	43	46	50	58	62	54
43	Rush Hour	9/28/81	52	56	65	71	76	67
	Day	9/28/81	50	54	64	72	79	68
	Evening	9/28/81	49	52	61	69	77	66
	Night	9/29/81	42	44	50	63	70	59
44	Rush Hour	9/28/81	48	49	54	64	69	59
	Day	9/28/81	44	45	53	64	72	61
	Evening	9/28/81	44	45	48	54	63	52
	Night	9/29/81	42	42	45	46	51	45
45	Rush Hour	9/28/81	56	58	62	70	80	68
	Day	9/28/81	53	55	59	68	77	66
	Evening	9/28/81	53	54	57	68	76	64
	Night	9/28/81	48	49	52	56	68	57
September 1982								
101	Rush Hour	9/20-21/82	60	62	68	74	81	71
	Day	9/20-21/82	58	60	64	70	77	67
	Evening	9/20-21/82	52	54	59	68	77	65
	Night	9/20,22/82	50	51	54	63	72	60
102	Rush Hour	9/20-21/82	60	63	67	73	79	70
	Day	9/20-21/82	59	60	64	70	76	67
	Evening	9/20-21/82	53	55	60	66	75	64
	Night	9/21-22/82	50	52	57	66	76	63
103	Rush Hour	9/20-21/82	55	61	67	73	77	69
	Day	9/20-21/82	59	62	66	71	77	68
	Evening	9/20-21/82	52	54	59	67	71	64
	Night	9/21-22/82	50	51	54	62	68	58

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Noise Levels - dB(A)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
104	Rush Hour	9/20-21/82	55	58	63	70	75	66
	Day	9/20-21/82	56	58	63	69	78	67
	Evening	9/20-21/82	49	52	58	67	74	64
	Night	9/20,22/82	47	48	52	63	72	60
105	Rush Hour	9/20-21/82	54	56	59	66	74	63
	Day	9/20-21/82	54	55	58	65	77	66
	Evening	9/20-21/82	48	50	54	60	68	58
	Night	9/20-21/82	45	46	49	57	66	54
106	Rush Hour	9/20,23/82	50	54	59	65	72	62
	Day	9/21/82	50	54	59	65	72	62
	Evening	9/21,23/82	47	51	57	62	66	59
	Night	9/21,24/82	44	48	56	61	68	58
107	Rush Hour	9/20-21/82	47	49	54	65	72	61
	Day	9/21-22/82	47	48	52	62	74	60
	Evening	9/20,22/82	44	46	49	57	67	57
	Night	9/21/82	41	43	46	55	66	53
108	Rush Hour	9/20,22/82	48	50	54	61	72	60
	Day	9/21-22/82	46	48	52	57	63	54
	Evening	9/20,22/82	45	48	52	57	64	55
	Night	9/20/82	44	46	50	54	64	53
109	Rush Hour	9/20-21/82	46	48	52	63	72	60
	Day	9/21-22/82	43	45	49	59	68	57
	Evening	9/20-21/82	44	46	49	58	68	56
	Night	9/21-22/82	42	43	44	51	59	49
110	Rush Hour	9/22/82	60	62	68	72	78	69
	Day	9/22/82	57	60	66	72	79	69
	Evening	9/22-23/82	59	62	66	71	78	68
	Night	9/23/82	56	59	65	70	75	67
111	Rush Hour	9/21/82	59	62	70	76	83	74
	Day	9/21/82	56	59	68	74	78	70
112	Rush Hour	9/21-22/82	57	62	66	71	75	68
	Day	9/21-22/82	57	61	65	70	75	67
	Evening	9/21-22/82	52	56	61	67	73	64
	Night	9/21/82	48	52	58	65	71	62

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Noise Levels - dB(A)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
113	Rush Hour	9/21-22/82	49	51	55	61	71	59
	Day	9/20-21/82	48	51	54	61	69	58
	Evening	9/20,23/82	47	49	53	60	68	58
	Night	9/20-21/82	44	46	50	57	67	56
114	Rush Hour	9/23/82	50	53	58	64	72	62
	Day	9/23-24/82	47	49	53	58	66	57
	Evening	9/23/82	45	47	52	60	64	56
	Night	9/23/82	43	45	50	60	66	56
115	Rush Hour	9/22/82	54	57	62	67	76	65
	Day	9/22-23/82	54	56	62	69	76	67
	Evening	9/23/82	48	52	59	66	72	63
	Night	9/21/82	45	48	54	62	68	58
116	Rush Hour	9/21-22/82	43	44	46	50	62	50
	Day	9/21,23/82	43	44	46	53	60	51
	Evening	9/21-22/82	48	49	51	54	58	52
	Night	9/20,22/82	43	46	47	49	54	48
117	Rush Hour	9/22-23/82	41	42	44	50	58	48
	Day	9/21-22/82	41	42	44	49	56	47
	Evening	9/21-22/82	47	48	49	51	56	50
	Night	9/21-22/82	44	45	47	48	52	47
118	Rush Hour	9/21-22/82	47	49	53	64	73	62
	Day	9/21-22/82	44	45	49	59	68	56
	Evening	9/21-22/82	49	50	51	56	69	56
	Night	9/20,22/82	46	47	48	51	58	50
119	Rush Hour	9/21-22/82	55	56	59	63	70	61
	Day	9/21/82	54	57	61	66	70	63
	Evening	9/21-22/82	54	55	57	60	66	58
	Night	9/21-23/82	52	53	55	59	64	57
120	Rush Hour	9/23/82	52	52	54	60	70	60
	Day	9/23/82	49	50	54	58	66	56
	Evening	9/23/82	46	47	50	53	55	51
	Night	9/23/82	47	48	50	52	56	50
121	Rush Hour	9/22-23/82	44	45	47	58	66	54
	Day	9/21-22/82	43	44	46	59	69	57
	Evening	9/20,22/82	49	50	52	55	66	55
	Night	9/20-22/82	44	45	47	51	61	51

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Noise Levels - dB(A)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_{1}	L_{eq}
122	Rush Hour	9/21,23/82	46	47	50	59	67	56
	Day	9/21,23/82	43	44	47	54	61	51
	Evening	9/20-21/82	47	48	49	51	67	55
	Night	9/20-21/82	42	44	45	49	53	47
123	Rush Hour	9/21,23/82	45	46	48	58	71	60
	Day	9/21-22/82	43	44	46	52	64	53
	Evening	9/20,23/82	46	47	48	51	60	51
	Night	9/21-22/82	44	45	47	50	61	50
124	Rush Hour	9/21,23/82	48	51	61	68	74	64
	Day	9/21-22/82	44	48	59	69	79	66
	Evening	9/20,23/82	46	47	53	65	73	61
	Night	9/21,23/82	41	42	45	58	71	58
125	Rush Hour	9/21,23/82	48	49	51	61	71	59
	Day	9/21,23/82	46	48	50	57	74	60
	Evening	9/20,22/82	47	48	50	53	64	53
	Night	9/21,23/82	45	47	49	51	54	49
126	Rush Hour	9/22-23/82	48	49	51	60	76	62
	Day	9/21,23/82	44	45	48	53	61	51
	Evening	9/20,22/82	48	49	52	55	62	54
	Night	9/21,23/82	44	45	48	51	54	49
127	Rush Hour	9/20,23/82	47	52	56	63	77	63
	Day	9/21,23/82	50	52	54	61	66	58
	Evening	9/20,22/82	48	49	51	56	64	55
	Night	9/21,23/82	47	49	51	53	57	51
128	Rush Hour	9/20,23/82	46	47	50	56	70	57
	Day	9/21-22/82	43	44	47	58	65	54
	Evening	9/21-22/82	49	50	53	59	66	56
	Night	9/20,22/82	43	44	45	48	52	46
129	Rush Hour	9/20,23/82	48	51	59	65	69	61
	Day	9/21-22/82	44	47	55	64	71	60
	Evening	9/20,22/82	48	49	51	58	66	54
	Night	9/20,22/82	45	46	47	51	63	52
130	Rush Hour	9/20,22/82	43	45	49	56	64	54
	Day	9/21-22/82	42	43	46	56	66	54
	Evening	9/21,23/82	47	49	52	58	67	56
	Night	9/20,22/82	42	44	47	49	52	47

Table 4

ENVIRONMENTAL NOISE LEVELS MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Noise Levels - dB(A)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_{1}	L_{eq}
131	Rush Hour	9/21-22/82	42	43	45	55	72	57
	Day	9/22-23/82	38	40	42	51	66	54
	Evening	9/21,23/82	45	46	49	51	54	49
	Night	9/21-22/82	43	44	46	49	59	50
132	Rush Hour	9/21-22/82	46	48	56	63	69	59
	Day	9/22-23/82	41	44	51	61	68	57
	Evening	9/21,23/82	44	45	49	58	65	54
	Night	9/21-22/82	44	45	47	54	60	51
133	Rush Hour	9/21-22/82	45	46	50	57	66	55
	Day	9/22-23/82	41	42	45	50	58	48
	Evening	9/21,23/82	45	46	48	50	56	48
	Night	9/21-22/82	46	47	48	51	55	49

Source: Wilson, Ihrig & Associates, Inc. (1982d).

because it has become accepted as the best compromise scale, using frequency weighting which approximates the hearing characteristics of the average human ear. The A-weighted sound level shows good correlation of the subjective response of people and communities with measured noise levels. Also, most noise ordinances, standards and specifications are written in terms of A-weighted sound level.

Each measurement to determine the noise data in Table 4 consisted of a 10 minute long continuous sample of noise at the site, recorded by means of a calibrated multi-channel precision magnetic tape recorder equipped with a sound level meter microphone. The recordings obtained were later analyzed to noise levels. The tape recordings can be used in the future to obtain spectral analysis of the noise at the sites (such as octave band or 1/3 octave band analyses) and are permanently retained as a record of the noise environment existing at the time of the measurements. Most measurement sites were visited on several occasions, and the data obtained on each day was averaged to obtain the data shown on Table 4.

Each measurement location was chosen to obtain the noise levels characteristic of an area or near a potentially noise sensitive building. Wherever possible the measuring microphone was located at the setback line of the nearby buildings.

Review of the sound level data obtained during the spot-check or 10-minute measurements indicates that the residual background noise levels, L_{99} and L_{90} range from 37 to 69 dB(A) during the rush hours and day, and 34 to 64 dB(A) during the evening and nighttime hours. At most locations the noise levels do show a significant decrease during the evening and nighttime hours when compared with the rush hour and daytime noise levels. At some locations, a temperature inversion was evident during the evening and nighttime measurements periods and resulted in a somewhat higher residual background noise level during the evening and nighttime than during the daytime and rush hour.

The median or L_{50} noise level for the different sites ranges from 40 to 72 dB(A) during the rush hour, 39 to 72 dB(A) during the day, 43 to 69 dB(A) during the evening and 38 to 64 dB(A) during the night.

At many measurement locations, the data for L_{10} and L_{1} show typical levels for a high volume of vehicular traffic on city streets. This results in L_{10} and L_{1} noise levels greater than 70 dB(A), and at some locations, greater than 80 dB(A). An L_{1} noise level of 80 dB(A) or greater is generally considered a high noise level for commercial and residential developed areas. At several of the measurement locations there was only a slight decrease in the L_{1} and L_{10} noise levels during the evening and nighttime hours which indicates that there is a significant volume of nearby vehiclular traffic at night.

The Energy Equivalent Level, Leq, ranges from 48 to 76 dB(A) during the rush hour, 47 to 74 dB(A) during the daytime, 48 to 70 dB(A) during the evening and 45 to 67 dB(A) during the nighttime. As with the noise levels characterized by the other statistical descriptors, the noise levels represented by the upper bound of the range for each time period are quite high are are due primarily to vehicular traffic on the nearby streets.

Since most of the noise impact is from local activities and local traffic, different areas along the proposed alignment have different noise environments as is shown by the wide range of noise levels represented by each statistical descriptor when examining all of the measurement locations over the entire length of the route. The range of noise levels encountered during a particular time period over the entire length of the alignment is 20 to 30 dB which indicates that very different noise environments were observed. Despite this wide range of observed noise levels, the noise data indicate a high level of ambient noise along most of the alignment which is primarily due to vehicular traffic.

During the noise and vibration survey, traffic counts were taken during the measurement periods. At those measurement locations where possible, these traffic counts made during the rush hour were compared with those provided by the City of Los Angeles as being characteristic for the year 1980 (LADOT, 1982). This comparison indicates that the traffic counts observed during the noise and vibration measurements varied from the 1980 established counts by 1 percent to 29 percent with an average value about 14 percent less than that indicated by the City. With respect to the noise produced by this local traffic, the correlation is excellent since it takes a 30 percent change in the local traffic to change the noise exposure level by 1 dB, a change which would not be noticeable. A 100 percent change in the traffic volume would change the resulting noise by about 3 dB(A) which would be noticeable since it usually takes at least a 2 to 3 dB change in the noise level to be noticeable. In addition, at most locations, visits during the same time period were made on different days. The average variation in Leq on different days for the same location and time period was less than 2 dB. Thus the measured environmental noise levels represent a reasonable evaluation of the community environment for the purposes of this environmental study since the results are based on data and characteristics related to the principal noise source in the area and since the results are characteristic of particular measurement locations.

As stated previously, 24-hour or long-term noise measurements were made at 17 measurement locations. Sixteen separate sites were measured with one long-term measurement at Location 42 being repeated since the original measurement made in 1981 was not over a full 24-hour period. These long-term measurements were made in order to obtain a complete statistical representation of the daily noise expsoure in a community area and to show that the short-term or spot-check sample data correlate well with the variation of noise levels characteristic of the four time periods used. As with the spot-check measurements, the 24-hour or long-term noise measurements are reported in terms of A-weighted sound level in decibels, abbreviated dB(A).

The equipment used for the long-term noise evaluation consisted of calibrated, precision, digital acoustical data acquisition systems with a sampling rate of 60 measurements per minute. These digital data acquisition systems digitize the A-weighted noise level each second, and then store these digitized data on tape cassettes for subsequent laboratory statistical analysis of the noise levels observed. Although the digital data acquisition systems can provide information on the noise levels over a long period of time, since these units digitize the A-weighted noise level, they cannot provide information on the spectrum of noise, i.e., octave band or 1/3 octave band analyses are not possible.

Since these digital data acquisition systems operate unattended, they were generally secured to a telephone or street light-pole which usually located the measuring microphone closer to nearby vehicular traffic but higher above the ground than the microphone of the spot-check measuring system. Thus the peak noise levels measured by the digital data acquisition system are often greater than that observed by the spot-check measurement system. However, these data do show good correlation with that obtained with the spot-check measuring system.

With the long-term measurement system, single number descriptors of the noise environment over a 24-hour time period can be obtained. The descriptors, CNEL and Ldn are by definition, based on a 24-hour time period and are minor variations of Leq. As described earlier these descriptors take into consideration the fact that people are generally more annoyed by a given sound level at night than during the day.

CNEL is the noise descriptor specified in the California State Aeronautic Code for evaluation of noise impact of aircraft operations. CNEL is also specified in the California State Noise Insulation Standards for new multi-family residential dwellings. Hence, local compliance with these standards often necessitates that community noise be specified in terms of CNEL. Although no long term noise descriptor levels are specified by any legislative body for operation or construction of the Metro Rail System, CNEL, Ldn and Leq (24) are reported for each long-term measurement location. The CNEL ranges from a low of 58 dB(A) at Location 109 to a high of 78 dB(A) at Location 32A, while the Leq (24) ranges from a low of 55 dB(A) at Location 109 to a high of 73 dB(A) at Location 32A.

Figures 5 through 21 are plots of the time history of the noise levels at the long-term measurement locations. These figures also show the date and time each survey began, as well as the values for CNEL, Ldn and Leq (24). These surveys are representative of weekday activities and generally show the decrease in noise levels during the nighttime and early morning hours which is characteristic of urban noise dominated by transportation activities. The data obtained at Location 125 shows the effect of a temperature inversion. A temperature inversion can have the effect of raising the residual background noise by focusing some distant noise to a receiver, in this case either the Hollywood or Ventura Freeways. Some uncharacteristically high noise levels were observed for short periods at Locations 107 and 109. These high noise levels have not been included in the determination of the values for CNEL, Ldn and Leq (24) at these locations, since these high noise levels are not considered characteristic of these noise measurements.

Based on the ambient noise measurements made during the four characteristic times of day, the day-night equivalent level, Ldn has been estimated. Except at those locations where complete 24-hour surveys were performed and Ldn was determined directly, the estimates are based on the characteristic fluctuations of noise levels over a 24-hour period as observed via the sixteen 24-hour surveys performed as part of the measurement program and which have also been observed in many other urban areas of the United States. Table 5 presents in tabular form the data shown on Figures 1 through 4.

As previously stated, at each of the long-term measurement locations, the time history of the noise levels show the characteristic pattern of urban noise dominated by transportation activities. Thus the noise levels are the greatest during the rush hour period, the same or somewhat lower during the daytime, still somewhat lower during the evening and considerably lower during the nighttime. This characteristic pattern of the variation of noise level over a full day was shown at each of the locations where a long-term measurement was made, thus the correlation between the short- and long-term measurements can be drawn at those locations where both types of measurements were made. This noise level variation over a full day has been shown to be characteristic of noise environments in a large number of urban areas in the USA and Canada. This correlation of noise measurements during different times of the day can be logically extended to the short-term noise measurements, thus validating them as characteristic for the appropriate time of day and accurately characterizing the noise environment at a particular location without the need for a complete 24-hour survey.

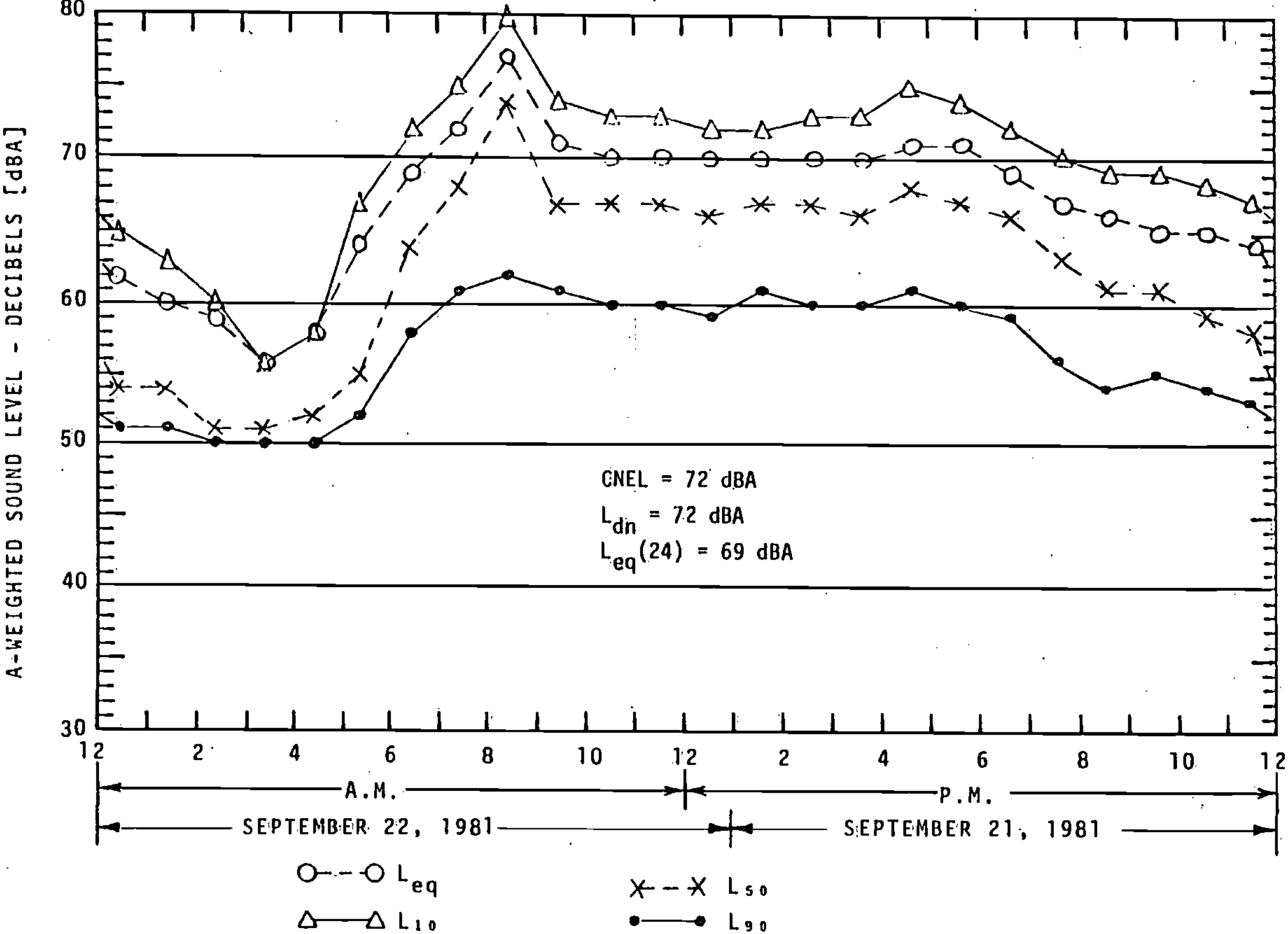


FIGURE 5 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 5, OVER THE 24-HOUR PERIOD BEGINNING 1PM, MONDAY SEPTEMBER 21, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

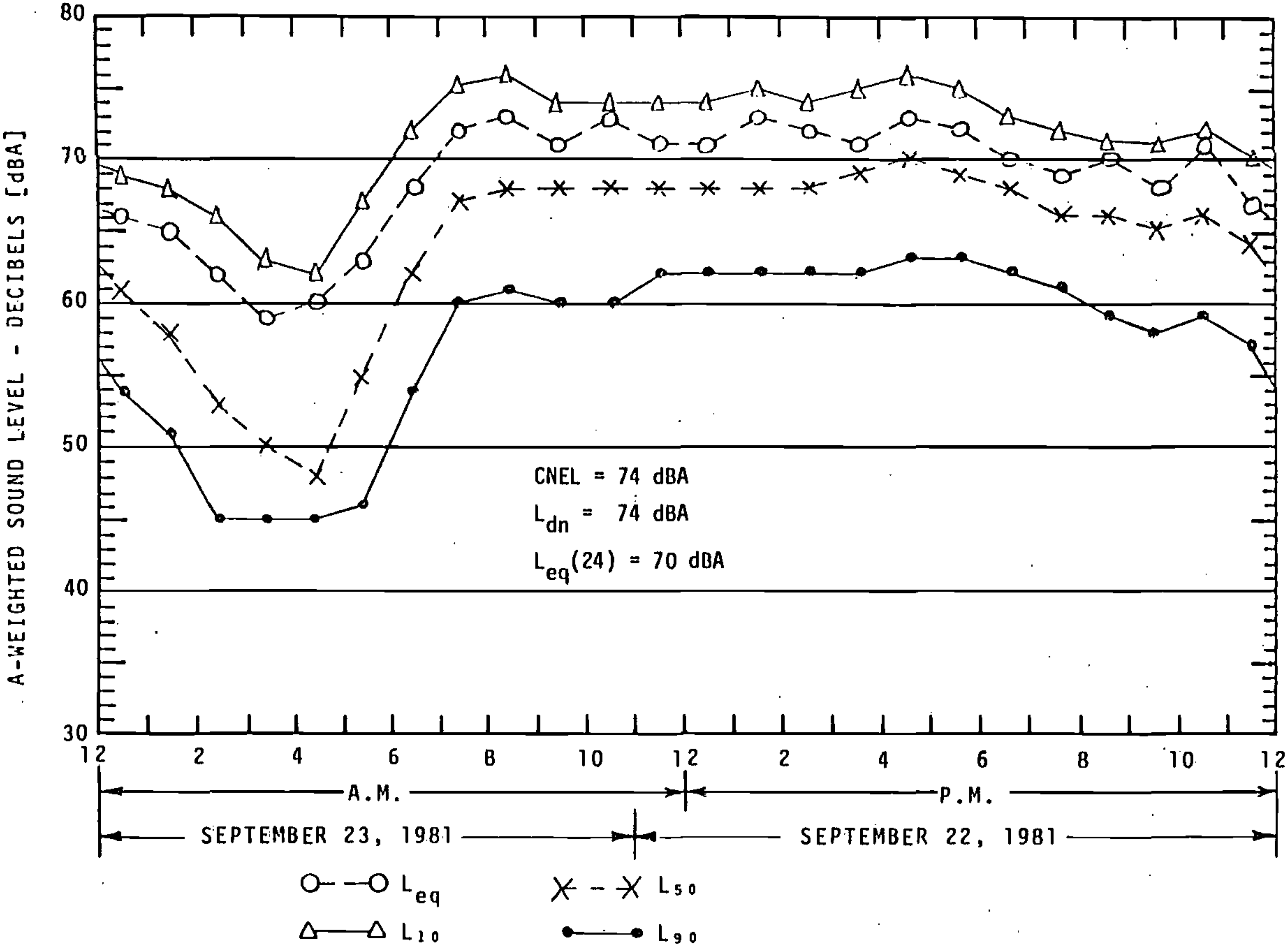


FIGURE 6 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 11, OVER THE 24-HOUR PERIOD BEGINNING 11AM, TUESDAY, SEPTEMBER 22, 1981

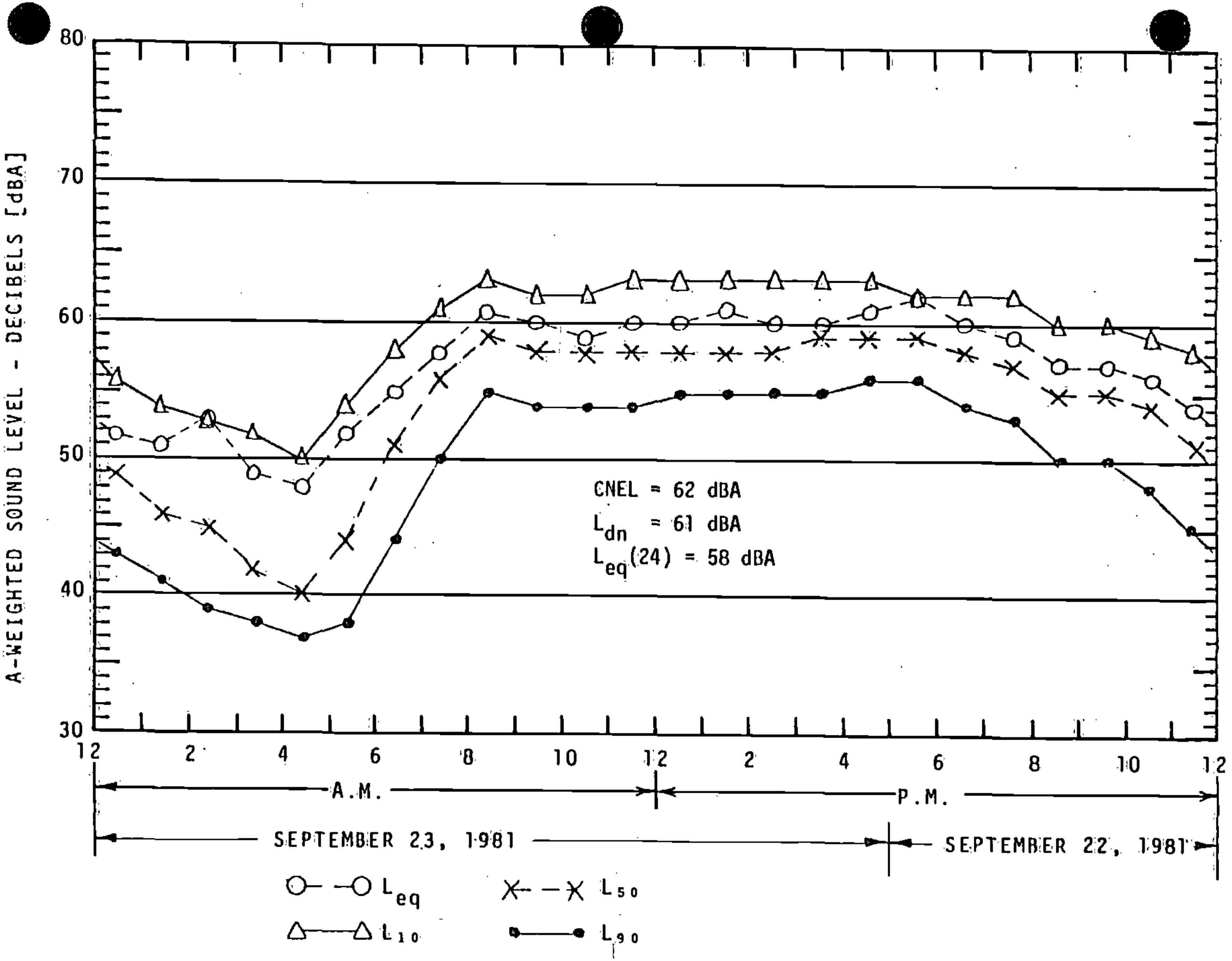


FIGURE 7 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 19, OVER THE 24-HOUR PERIOD BEGINNING 5PM, TUESDAY, SEPTEMBER 22, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

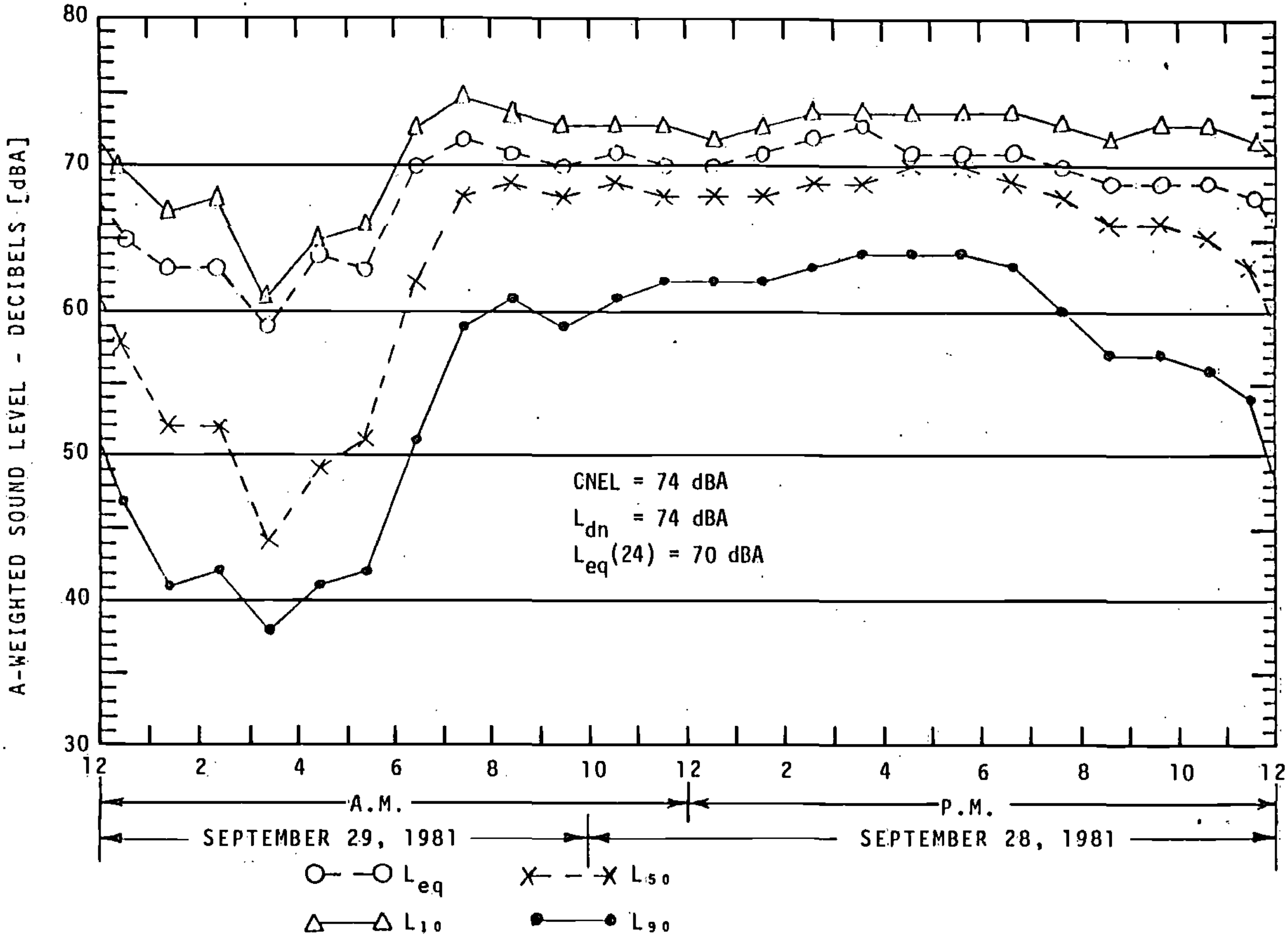


FIGURE 8 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 21, OVER THE 24-HOUR PERIOD BEGINNING 10AM, MONDAY, SEPTEMBER 28, 1981

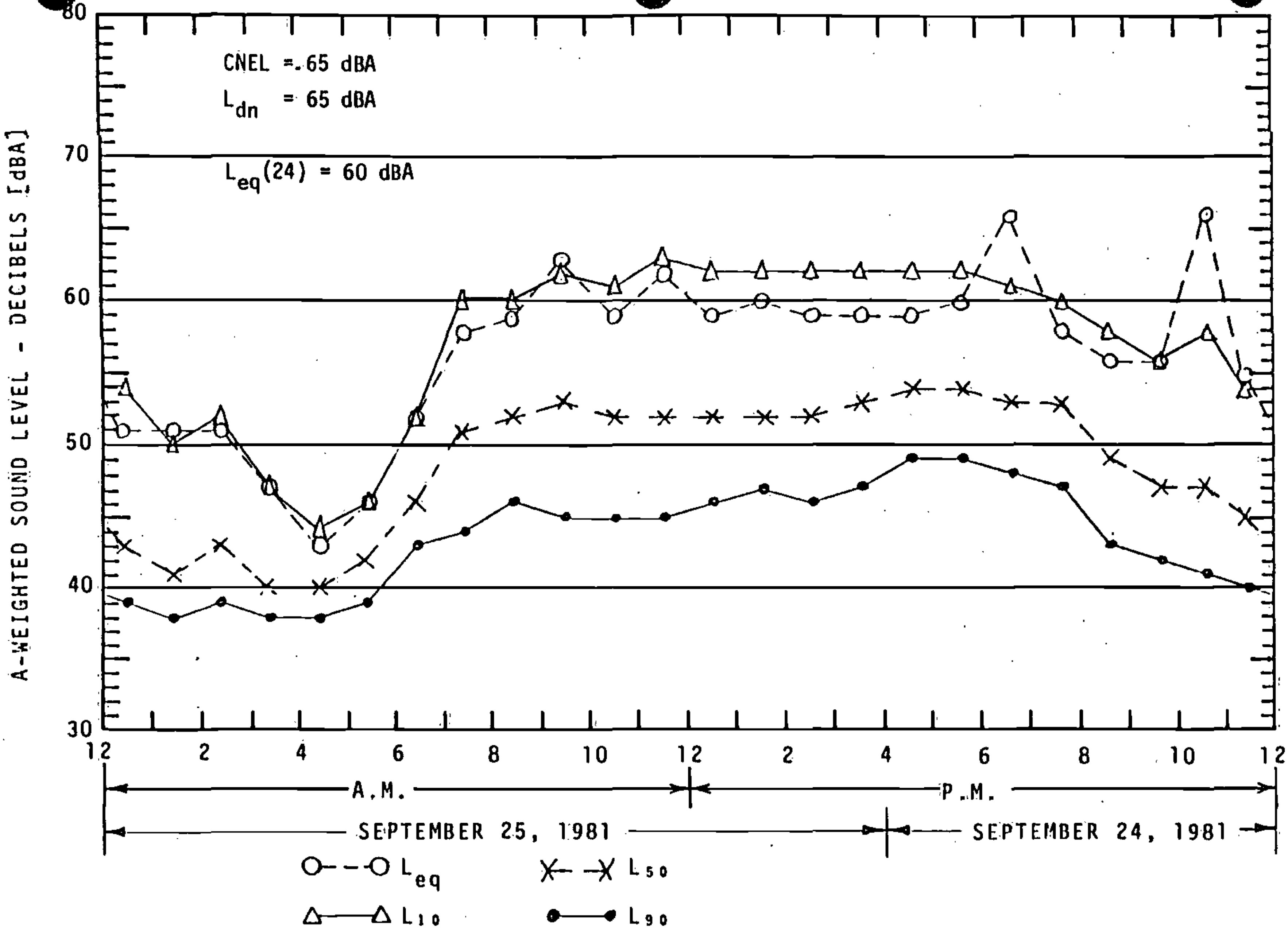


FIGURE 9 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 23, OVER THE 24-HOUR PERIOD BEGINNING 4PM, THURSDAY, SEPTEMBER 24, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

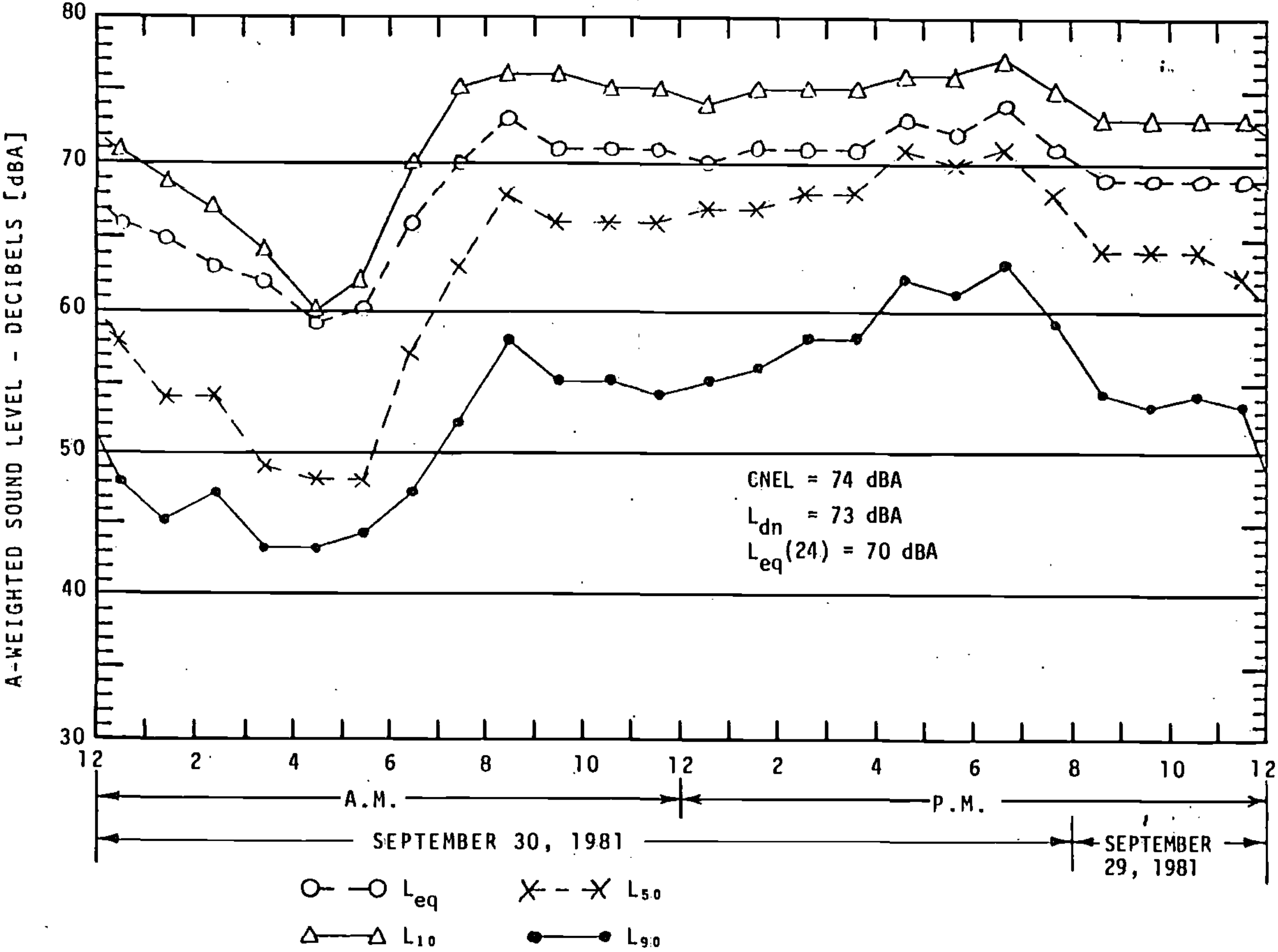


FIGURE 10 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 25, OVER THE 24-HOUR PERIOD BEGINNING 8PM, TUESDAY, SEPTEMBER 29, 1981

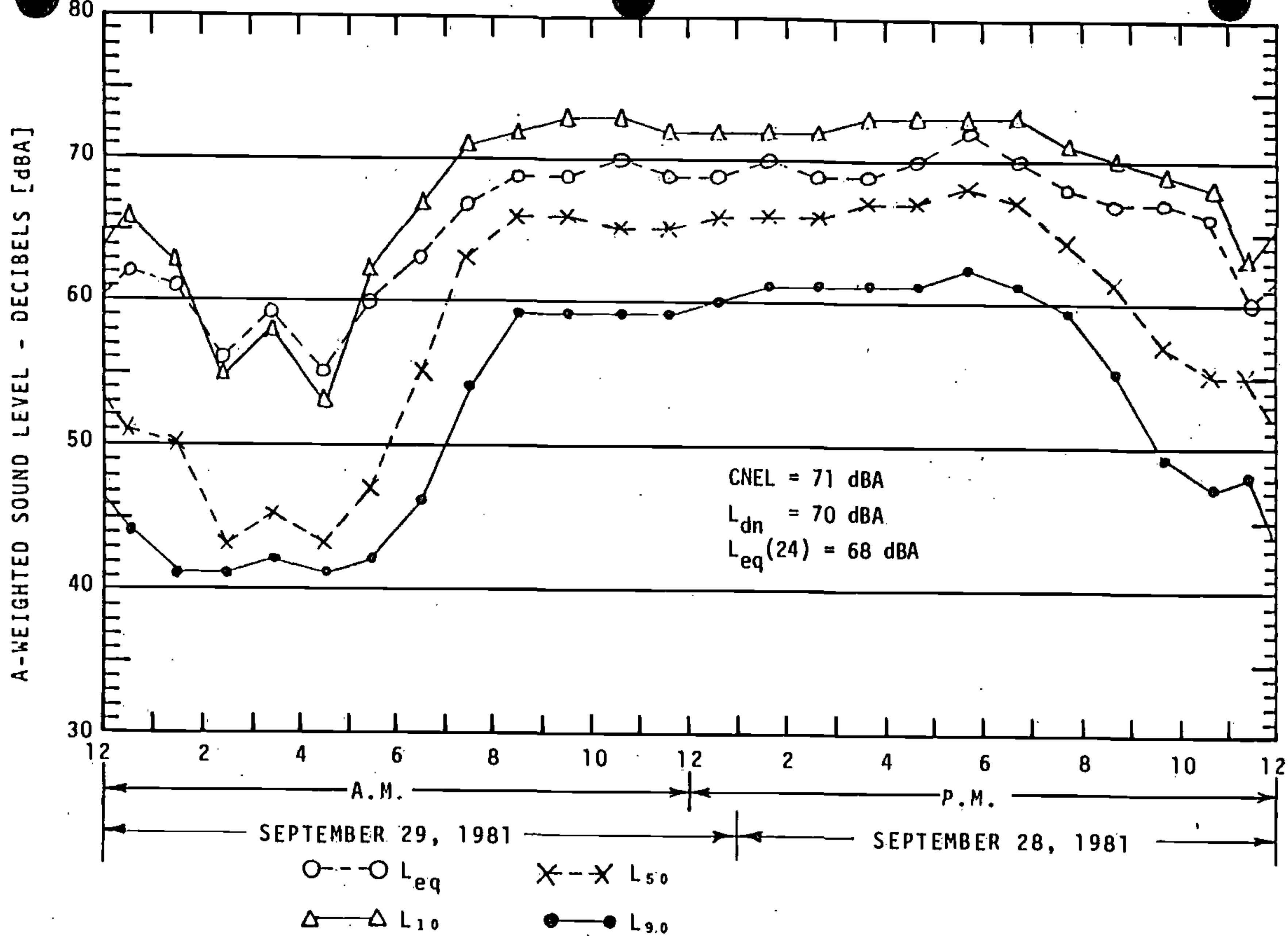


FIGURE 11 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 28, OVER THE 24-HOUR PERIOD BEGINNING 1PM, MONDAY, SEPTEMBER 28, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

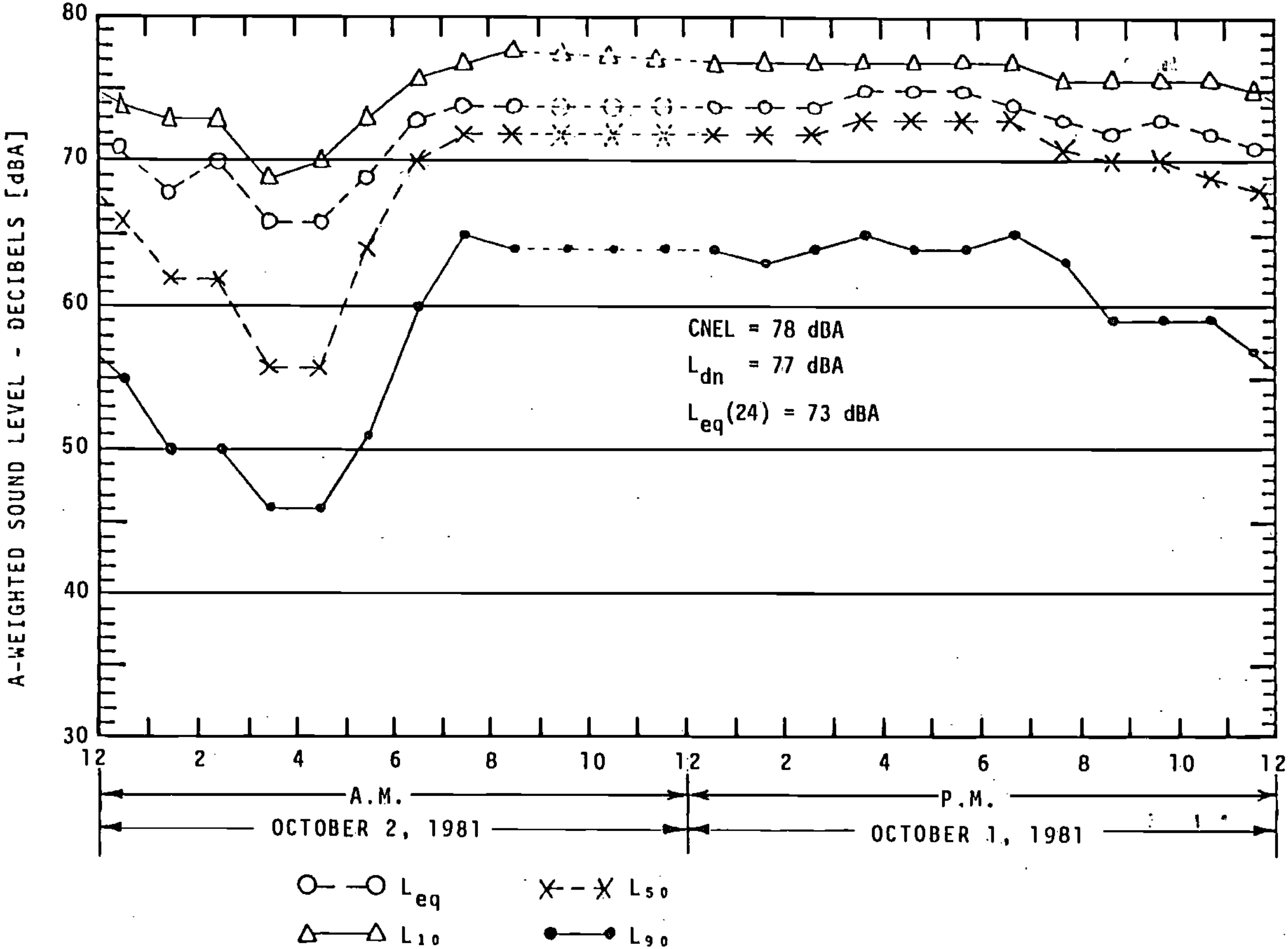


FIGURE 12 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 32a, OVER THE 21-HOUR PERIOD BEGINNING 12NOON, THURSDAY, OCTOBER 1, 1981

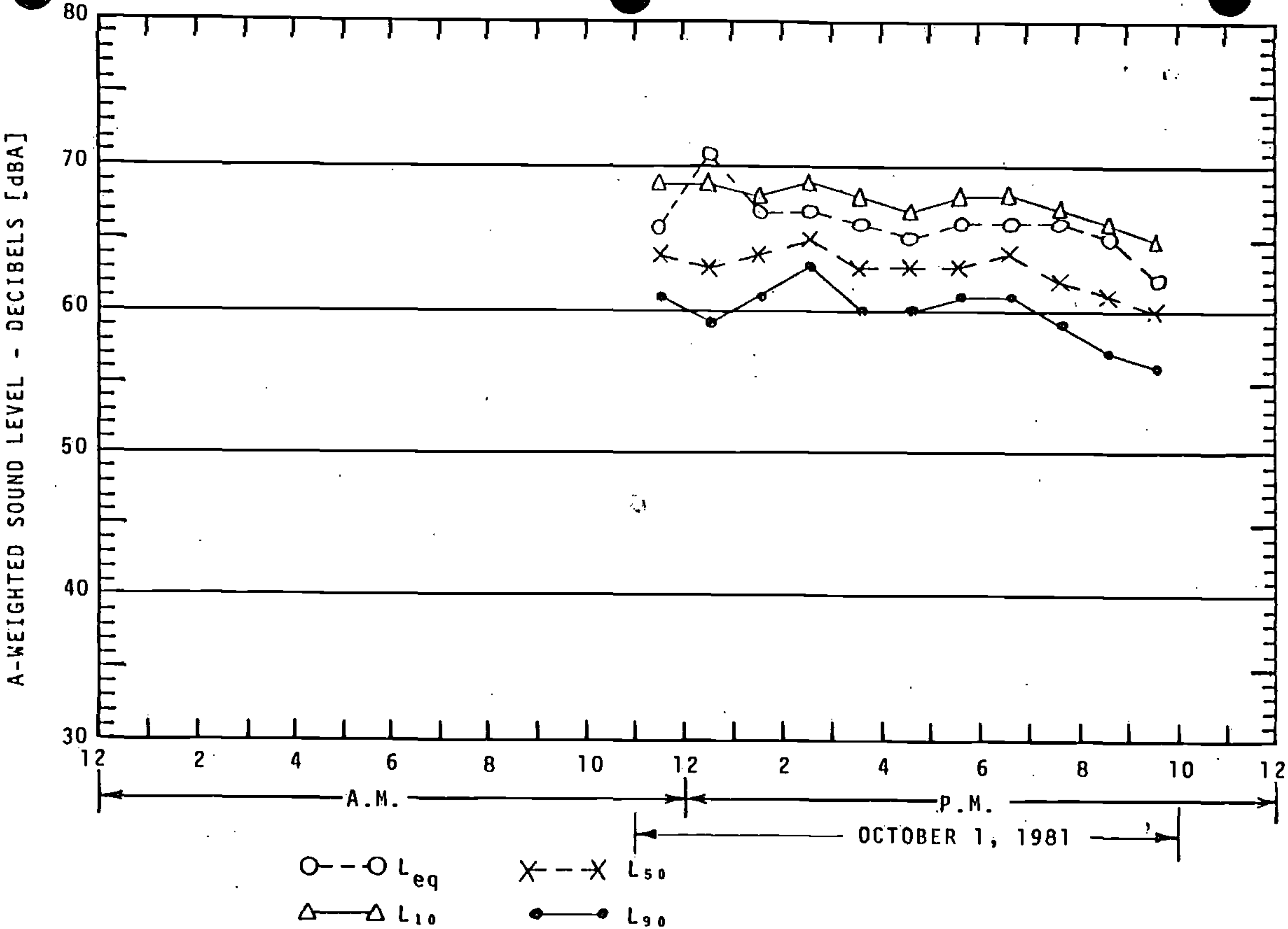


FIGURE 13 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 42, OVER THE 11-HOUR PERIOD BEGINNING 11AM, THURSDAY, OCTOBER 1, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

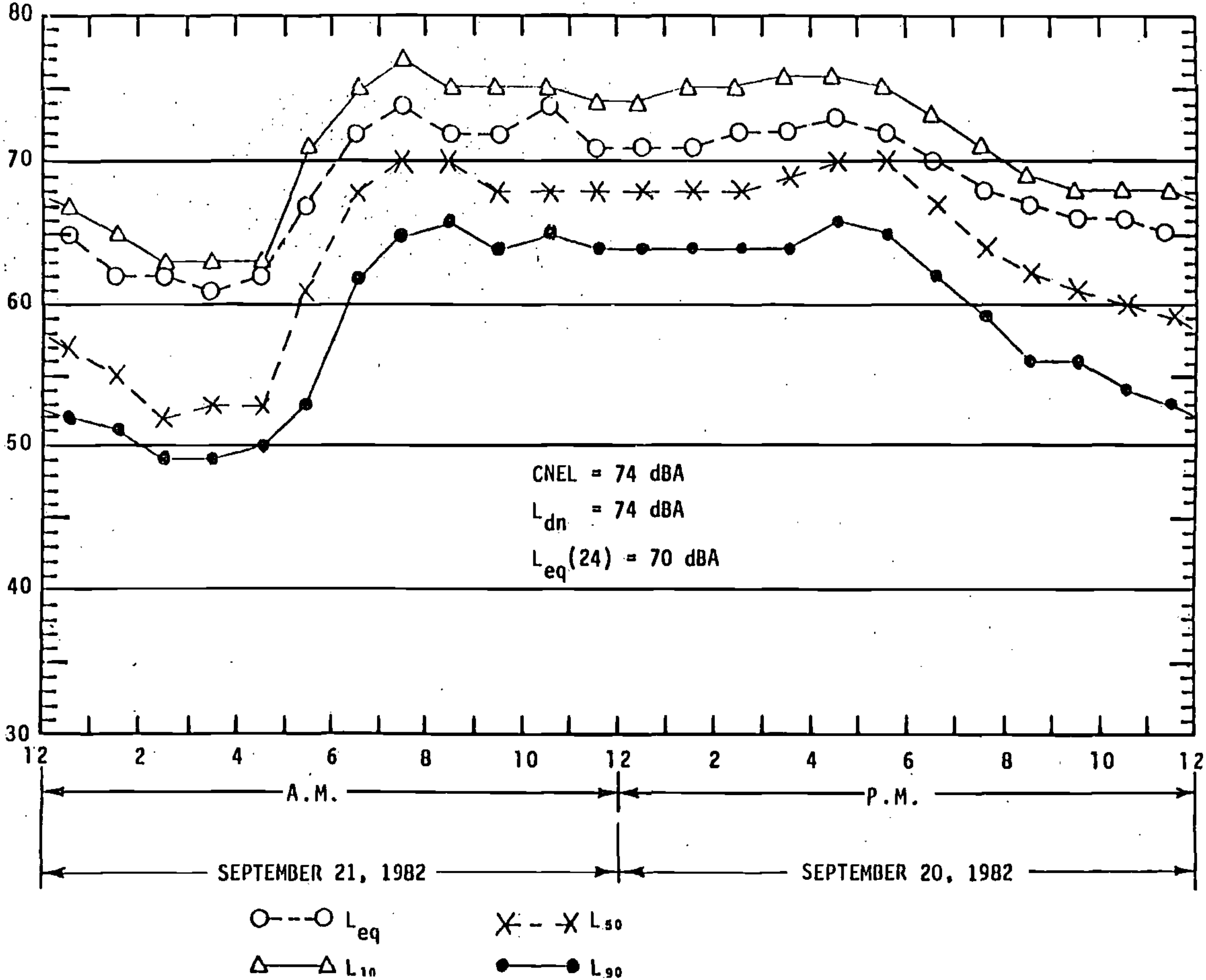


FIGURE 14 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 102, OVER THE 24-HOUR PERIOD BEGINNING 12 NOON, MONDAY, SEPTEMBER 20, 1982

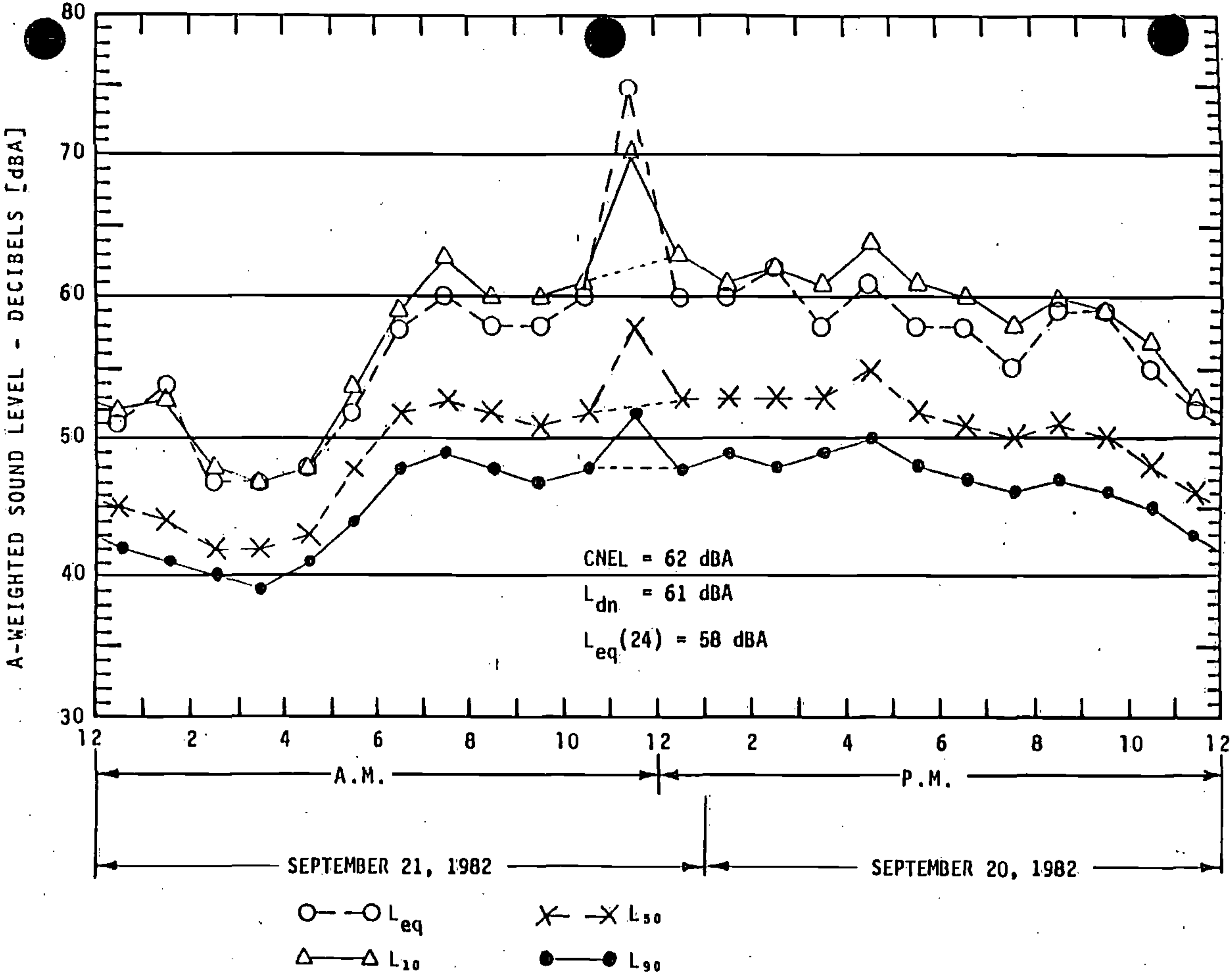


FIGURE 15 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 107, OVER THE 24-HOUR PERIOD BEGINNING 1PM, MONDAY, SEPTEMBER 20, 1982

WILSON, IHRIG & ASSOCIATES, INC. 1982d

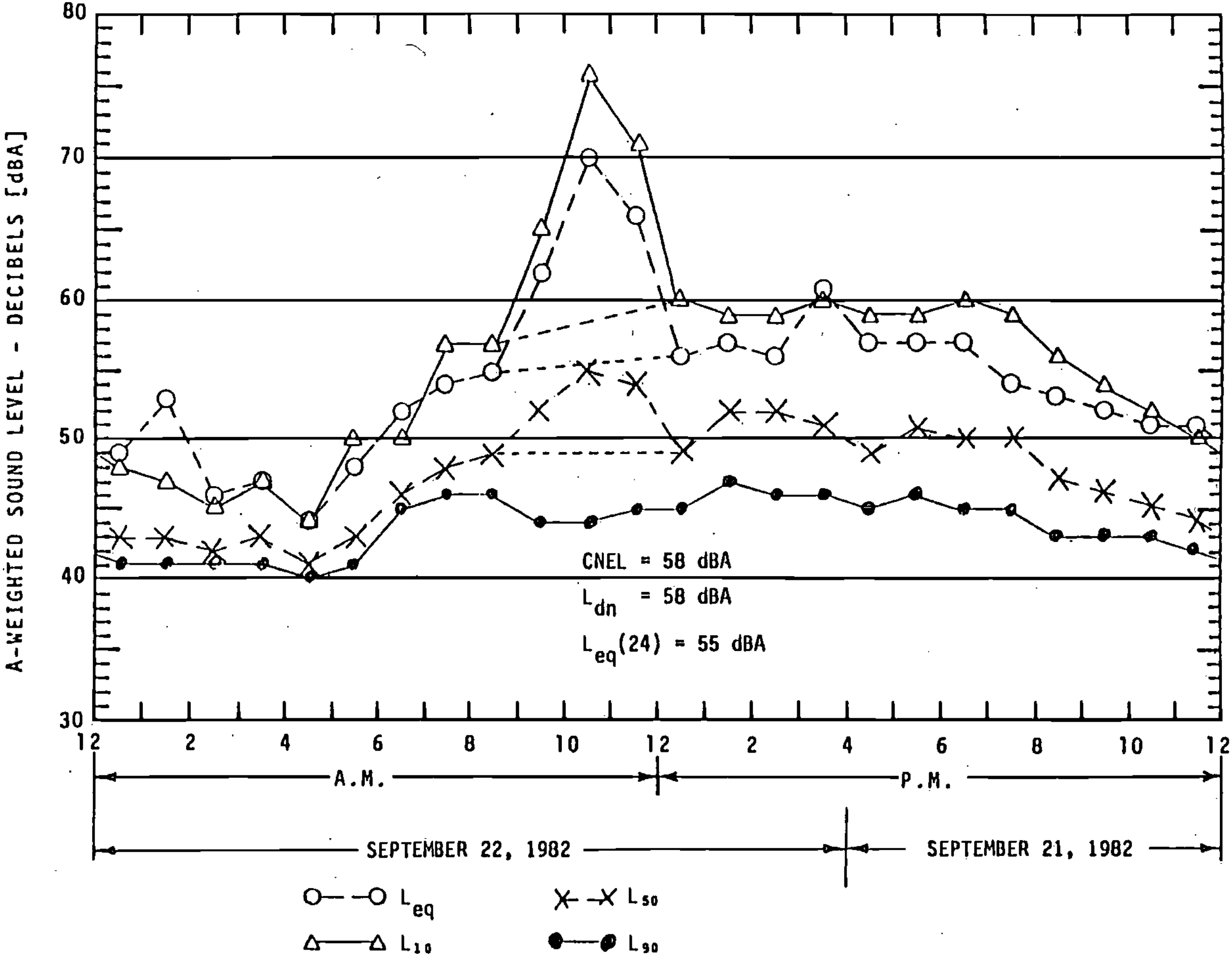


FIGURE 16 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 109, OVER THE 24-HOUR PERIOD BEGINNING 4PM, TUESDAY, SEPTEMBER 21, 1982

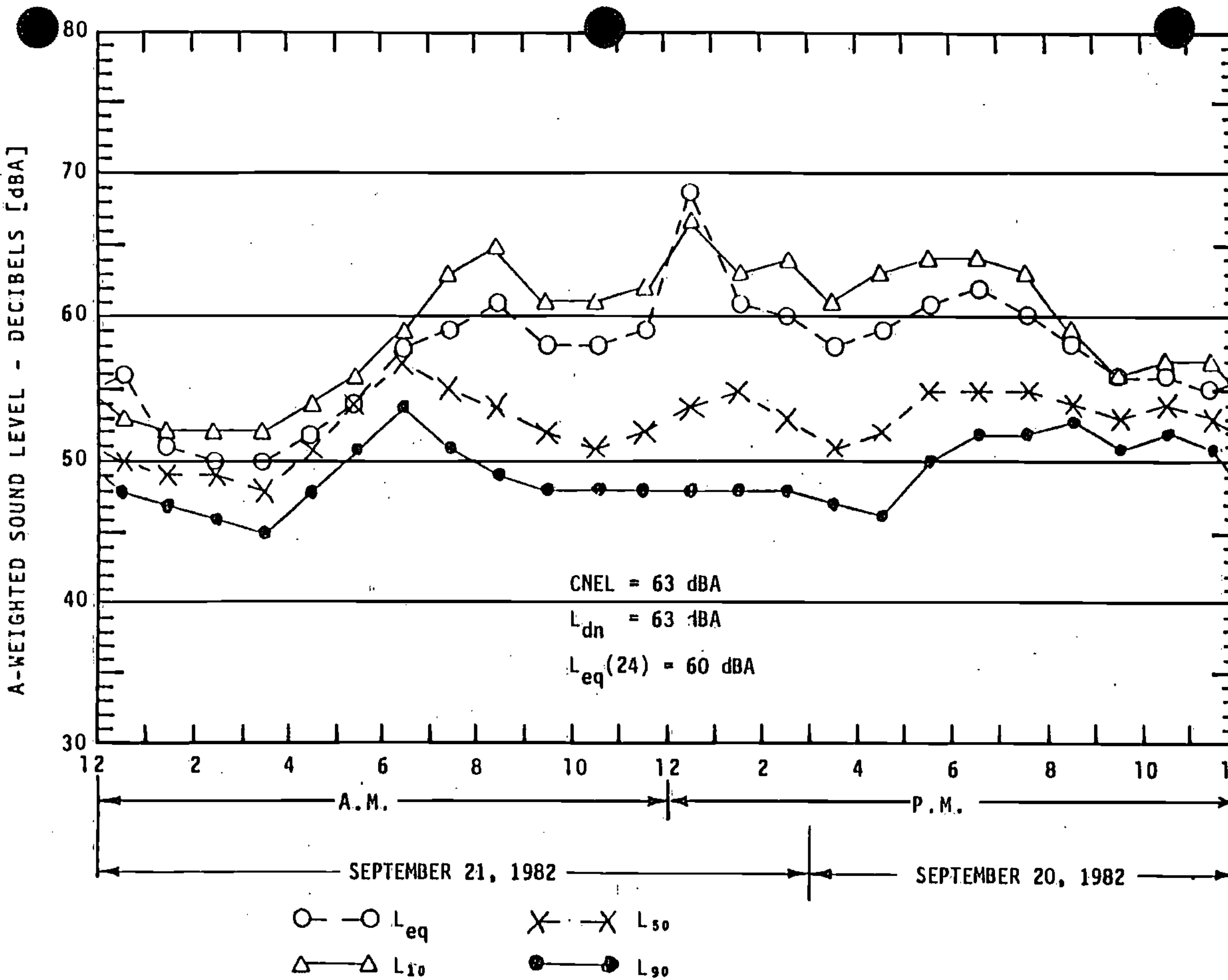


FIGURE 17 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 118, OVER THE 24-HOUR PERIOD BEGINNING 3PM, MONDAY, SEPTEMBER 20, 1982

WILSON, IHRIG & ASSOCIATES, INC. 1982d

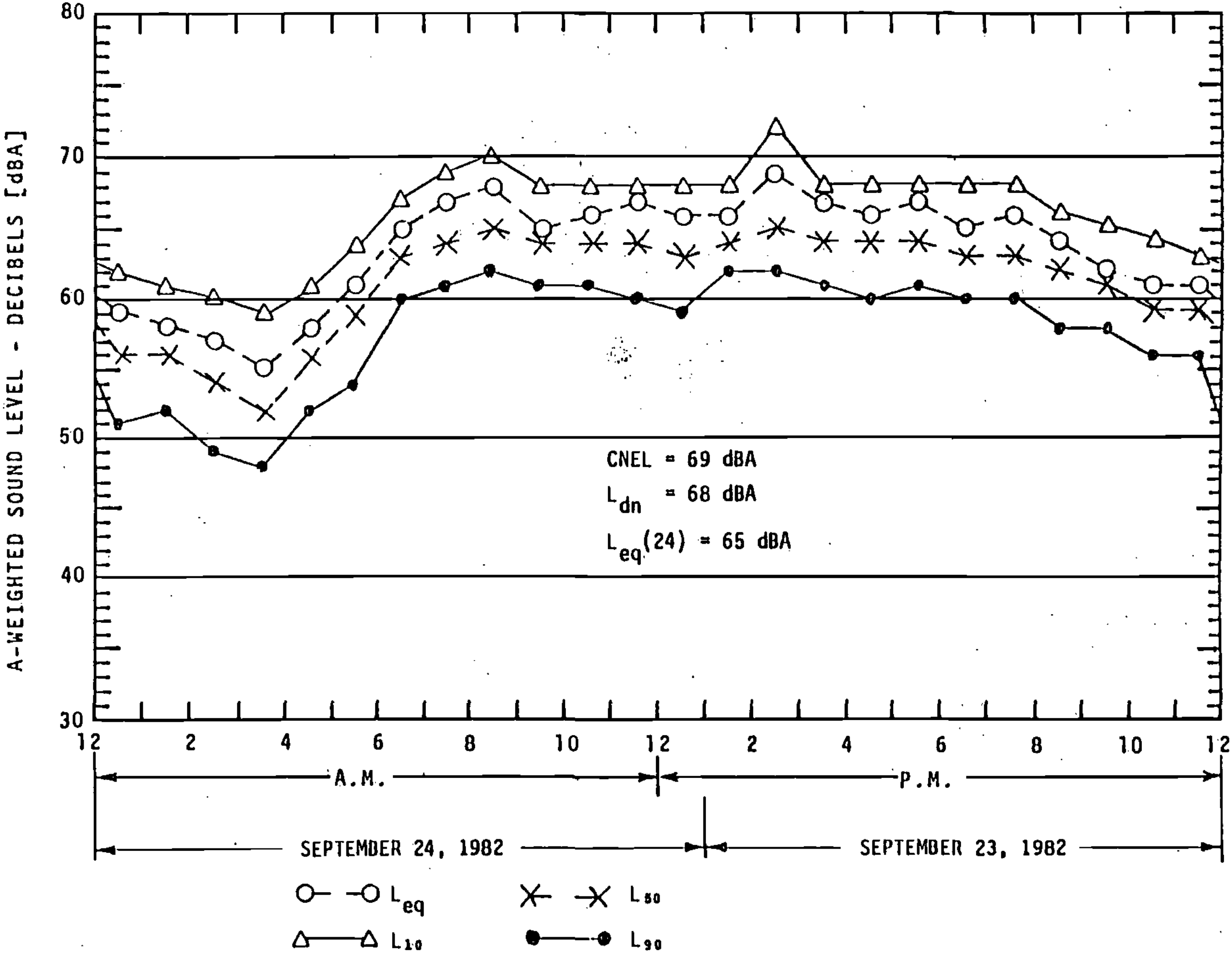


FIGURE 18 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 42, OVER THE 24-HOUR PERIOD BEGINNING 1PM, THURSDAY, SEPTEMBER 23, 1982

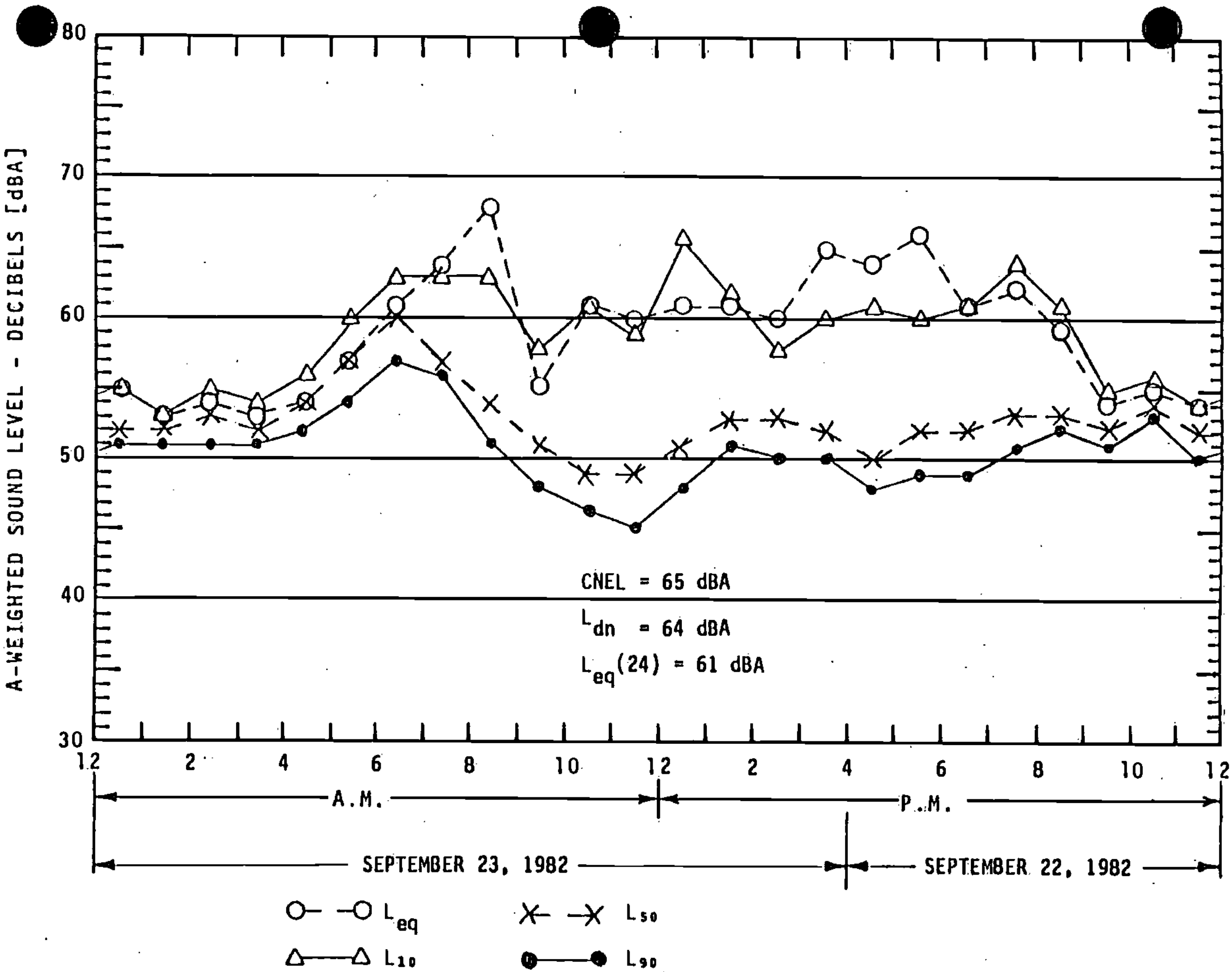


FIGURE 19 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 125, OVER THE 24-HOUR PERIOD BEGINNING 4PM, WEDNESDAY, SEPTEMBER 22, 1982

WILSON, IHRIG & ASSOCIATES, INC. 1982d

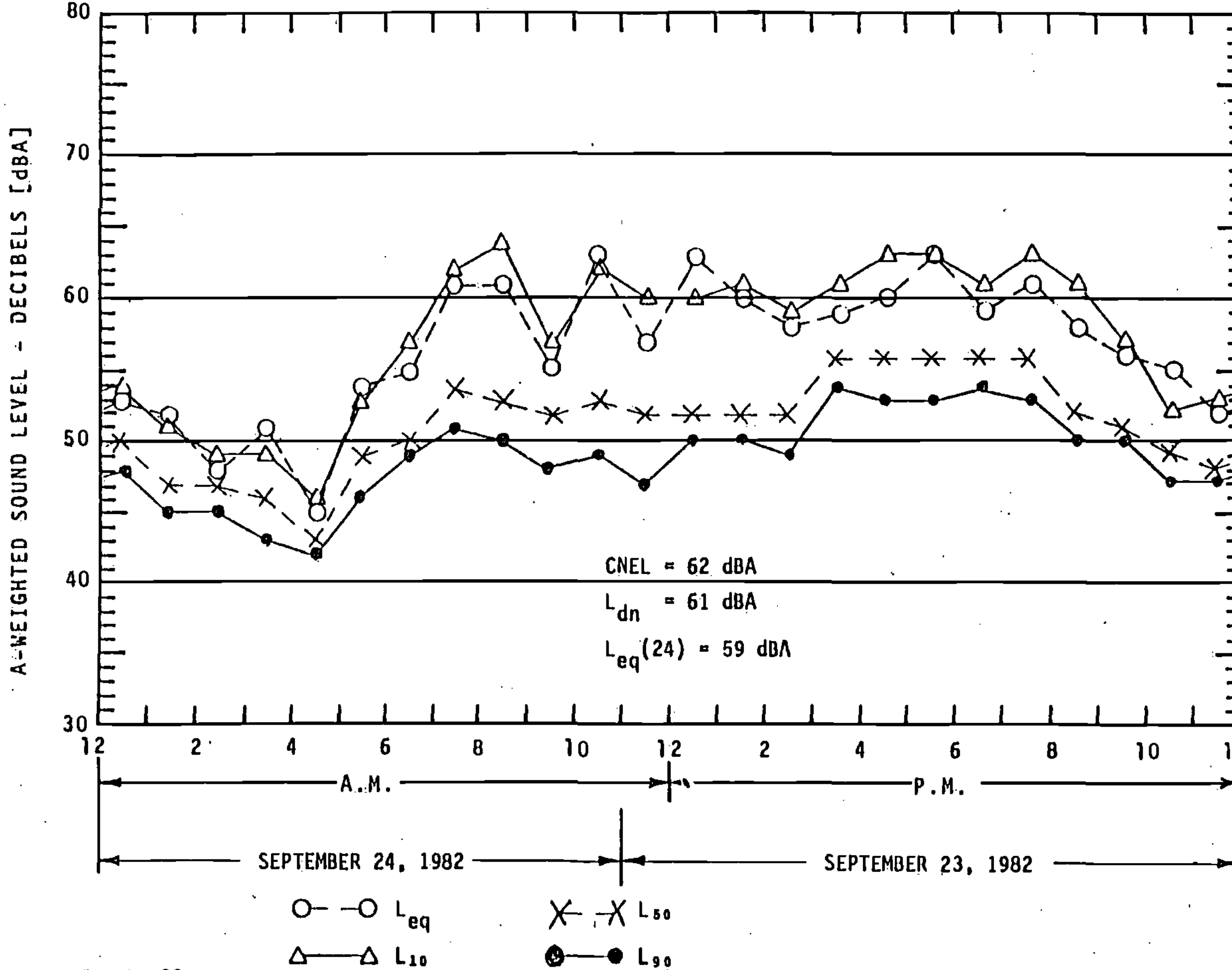


FIGURE 20 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 129A, OVER THE 24-HOUR PERIOD BEGINNING 11AM, THURSDAY, SEPTEMBER 23, 1982

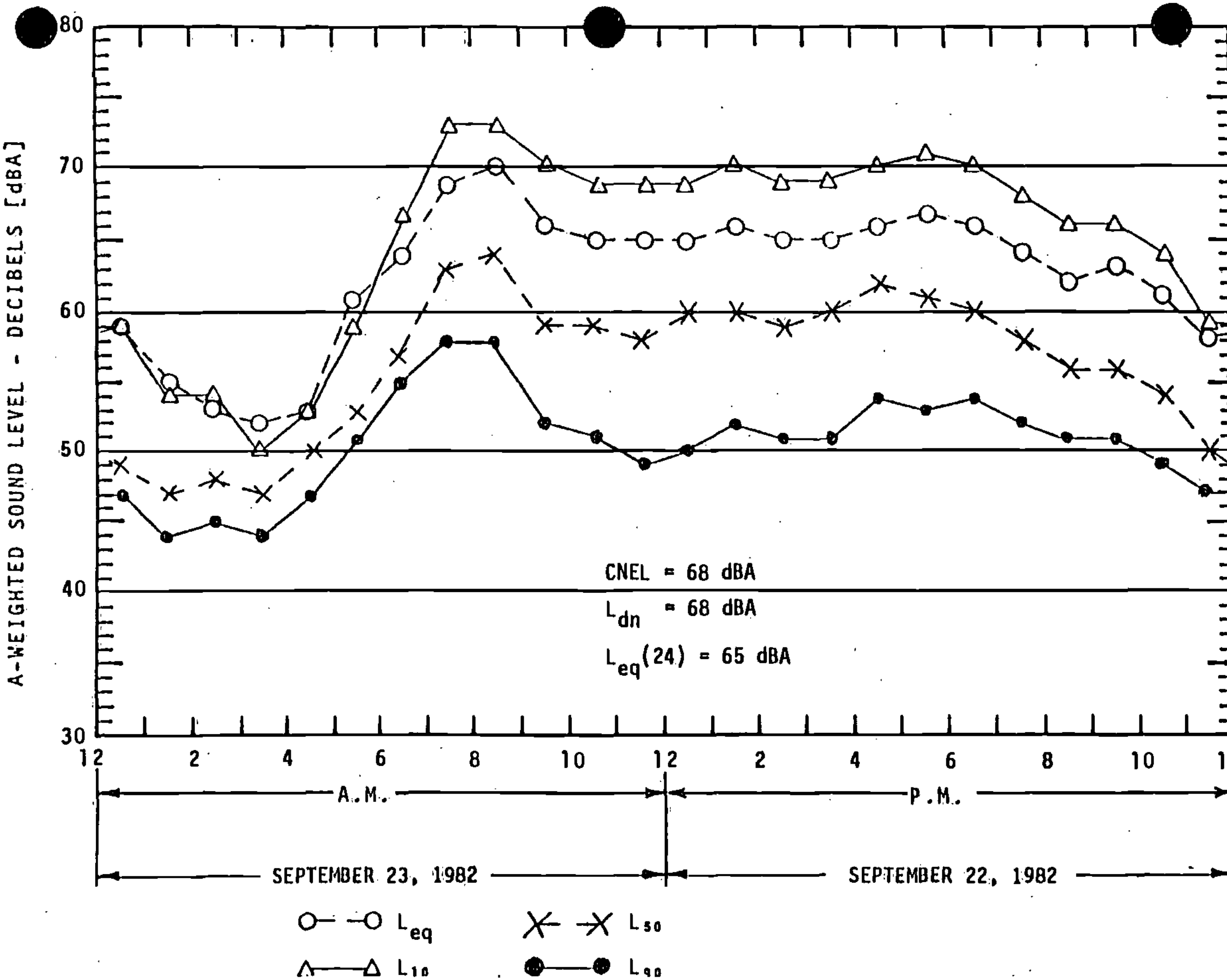


FIGURE 21 TIME HISTORY OF THE NOISE LEVEL MEASURED AT LOCATION 132, OVER THE 24-HOUR PERIOD BEGINNING 12 NOON, WEDNESDAY, SEPTEMBER 22, 1982

WILSON, IHRIG & ASSOCIATES, INC. 1982d

Table 5

ESTIMATED DAY-NIGHT EQUIVALENT LEVELS AT NOISE MONITORING SITES

Location Number	Estimated L_{dn} - dB(A)	Location Number	Estimated L_{dn} - dB(A)
1	62-64	29	69-71
2	70-72	30	71-73
3	70-72	31	60-62
4	72-74	32A	77*
5	72*	33	60-62
6	69-71	34	62-64
7	68-70	35	53-55
8	69-71	36	58-60
9	72-74	37	52-54
10	73-75	38	52-54
11	74*	39	70-72
12	69-71	40	64-66
13	71-73	41	66-68
14	69-71	42	68*
15	65-67	43	68-70
16	70-72	44	57-59
17	66-68	45	66-68
18	56-58	101	65-67
19	61*	102	74*
20	56-58	103	67-69
21	74*	104	67-69
22	68-70	105	64-66
23	65*	106	64-66
24	71-73	107	61*
25	73*	108	59-61
26	71-73	109	58*
27	69-71	110	72-74
28	70*	111	71-73

Table 5

ESTIMATED DAY-NIGHT EQUIVALENT LEVELS AT NOISE MONITORING SITES (Continued)

Location Number	Estimated L_{dn} - dB(A)	Location Number	Estimated L_{dn} - dB(A)
112	68-70	123	56-58
113	62-64	124	66-68
114	62-64	125	64*
115	66-68	126	56-58
116	54-56	127	59-61
117	53-55	128	55-57
118	63*	129A	61*
119	64-66	130	55-57
120	58-60	131	56-58
121	58-60	132	68*
122	54-56	133	55-57

*Measured during 24-hour survey

Source: Wilson, Ihrig & Associates, Inc. (1982e).

Ambient Vibration Environment

The perception of vibration by people has been discussed extensively in the literature, however, most of the criteria are based on the results obtained from steady-state sinusoidal vibration excitation in laboratory environments. Relatively little information is available on the response of humans to low level random vibration or to transient vibration levels. Recently more information on this type of vibration has been obtained from the results of measurements and subjective evaluations of transit train vibration in Toronto, Washington, DC, San Francisco and Atlanta.

A number of scales for evaluating the effect of vibration on man have been devised. Units such as Pal and Trem have been presented for establishing scales of response to vibration similar to the A-weighted sound level or the various loudness scales which have been used for the determination of subjective response to noise levels. None of the scales have been widely accepted in evaluating human response to vibration levels and, in general, the criteria for response are presented as charts with ranges of response as a function of vibration frequency. As for the subjective response to noise, the human sensitivity to vibration varies with frequency. Therefore, the frequency must be taken into consideration in assessing annoyance due to vibration. A number of studies have indicated that at frequencies above approximately 12 to 16 Hz, sensitivity to vibration is primarily determined by the velocity amplitude and is relatively independent of frequency. Since the frequency range over which human sensitivity is approximately proportional to velocity amplitude covers the range of principal vibration components from transit trains, and since the noise level generated by the vibration of buildings' surfaces is approximately proportional to vibration velocity level, it is appropriate to present vibration criteria and data in terms of velocity level.

A curve of human response to vibration has evolved from the studies which have been done and has been documented in the International Standards Organization document 2631 and Draft ANSI Standard S3.29-198X. Additional information on human sensitivity to vibration is contained in the CHABA Publication, "Guidelines for Preparing Environmental Impact Statements on Noise" which has utilized much of the information contained in the ISO Standard. These standards and publications do indicate that below about 12 to 16 Hz the sensitivity to vibration velocity is somewhat lower. This is characterized in Figure 22 which indicates human response to building vibration. The curve shape is based on information in the CHABA publication and in this report will be known as CHABA weighting. These curves show the vibration perception level ranges in decibels, dB, re 1.0 micro in/sec, as a function of frequency in Hertz, Hz.

The existing exterior vibration sources include automobiles, trucks, buses, underground mechanical equipment, and on a local scale, pedestrians. Most of the vibration sources, except stationary mechanical equipment operating continuously, create transient vibration levels. The observed level of vibration at a particular location is the summation of the vibrations created by all the various sources, near and far. This is analogous to ambient community noise which represents the summation of many noise soruces.

For this survey, the vibration level data were taken simultaneously with, and at the same locations as, the sound level data. Vibration acceleration was measured using a piezoelectric accelerometer, with a signal recorded on one channel of the data tape recorder.

The data were analyzed to obtain a single-number velocity level weighted in such a way to approximate the CHABA weighting shown in Figure 22. To obtain the weighted

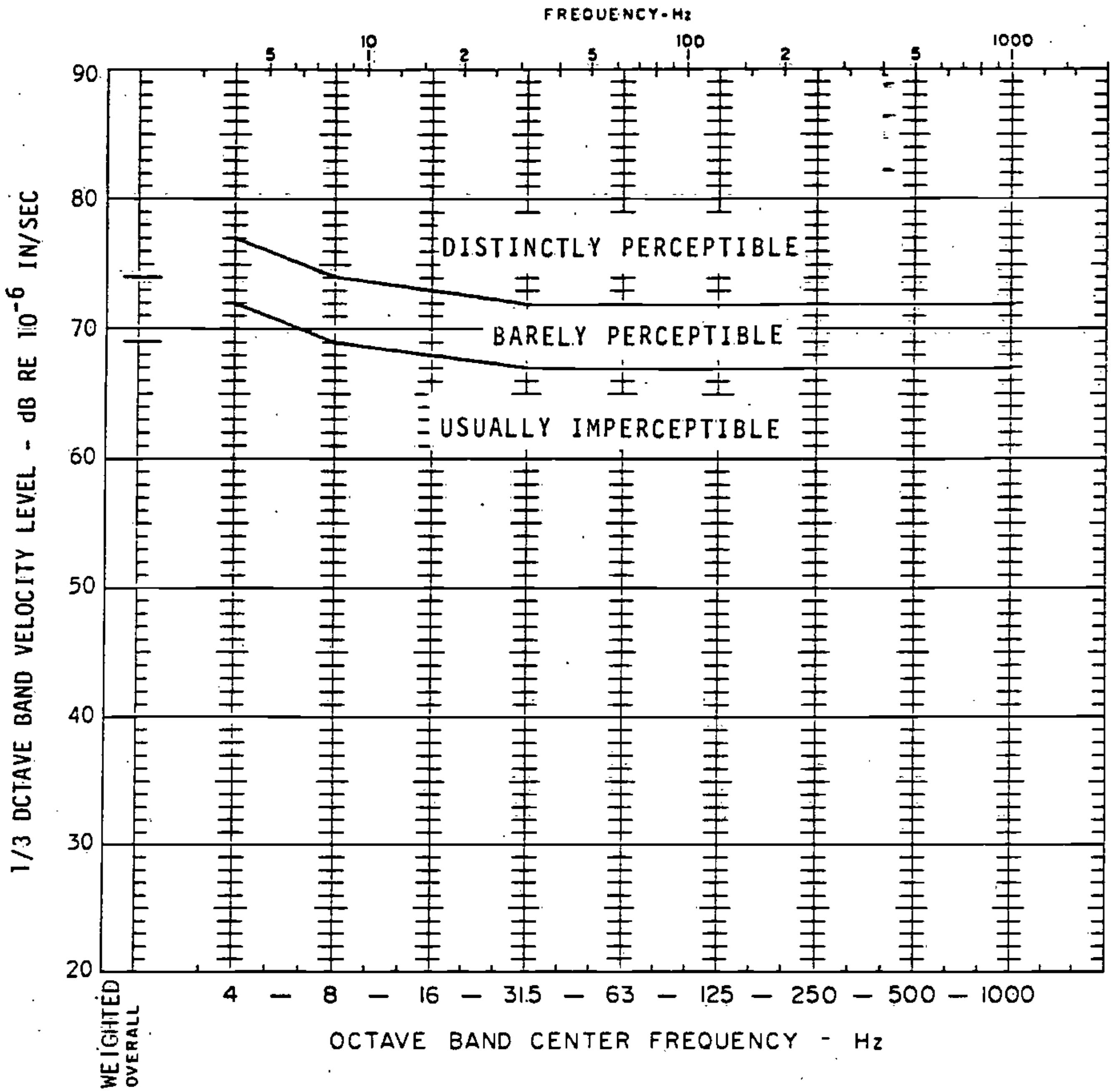


FIGURE 22 RESPONSE OF PERSONS SEATED OR STANDING TO BUILDING VIBRATION

WILSON, IHRIG & ASSOCIATES, INC. 1982b

velocity level from the acceleration data, an electronic integrator and filter with approximately the inverse of the CHABA weighting were used.

Although the CHABA weighting is not a standardized measurement, the resultant weighted velocity level is a good single-number indication of the human response to vibration. Figure 22 indicates that weighted vibration velocity levels below about 69 dB overall level are generally imperceptible or just perceptible as vibration to the average person under normal conditions.

The weighted vibration velocity levels obtained in this manner were statistically analyzed to obtain the same statistical parameters used to describe the existing noise levels; L_{99}, L_{90}, L_{50}, L_{10}, L_1, and Leq.

Table 6 presents a complete tabulation of the statistical analysis of the weighted vibration velocity levels observed at each measurement site. In general those locations with the highest noise levels also have the highest vibration levels and vice versa, since in most cases, trucks and buses which produce high noise levels also produce high vibration levels. However, this correlation is not always true since airplanes, motorcycles, and some cars can produce high noise levels but not necessarily high vibration levels.

Review of the vibration data indicates that as for the noise data there is a considerable range of levels at different locations over the length of the alignment. The lowest vibration levels were observed at Locations 32, 33, 34, 35, and 37, 116, 117, and 118, which are located away from nearby vibration producing activities, especially during the evening and nighttime measurement periods. These locations are on or near the Hollywood Hills/Santa Monica Mountains which in addition to having few nearby vibration producing activities may also be on or near rock. Although rock transmits vibration more efficiently than soil, it takes a greater vibration energy level at the source to produce the same vibration amplitude at the receiver.

There are a number of locations where the L_1 vibration velocity level exceeds 69 dB. This means that for approximately 6 seconds in 10 minutes the vibration from passing vehicles was at least barely perceptible at the measurement location. Vibration at other locations with the L_1 vibration velocity level less than 69 dB should not be perceptible as mechanical motion. Excluding Locations 32, 33, 34, 35, 37, 116, 117 and 118, the weighted vibration velocity Leq ranges from 34 to 64 dB which is typical of commercial and residential areas near heavily traveled streets and boulevards. Comparing these data with that obtained during previous environmental vibration studies performed by WIA indicates that the vibration levels are typical of other large cities (such as Baltimore and Chicago).

To provide some indication of the frequency content of the measured ground-borne vibration, five representative examples of the vibration levels are statistically analyzed by 1/3 octave bands. For the statistical analysis the unweighted vibration velocity level as a function of time was analyzed in each of the 1/3 octave bands from 3.15 Hz through 1000 Hz. The results of these are shown on Figures 23 through 27. Although several analyses indicate somewhat similar overall vibration velocity levels, each of the charts show a somewhat different shape for the frequency spectrum.

It should be noted that establishing the existing vibration environment requires the same measurement and analysis procedures as establishing the existing noise environment. The vibration environment has the same general statistical variation as the

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1]
MEASURED AT LOCATIONS ALONG THE METRO RAIL
ALIGNMENT ALTERNATIVES

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec) L_{99}	L_{90}	L_{50}	L_{10}	L_{1}	L_{eq}
1	Rush Hour	9/28/81	41	44	48	52	57	49
	Day	9/28/81	45	48	51	54	58	52
	Evening	9/28/81	37	39	42	48	52	44
	Night	9/28/81	34	37	40	46	52	43
2	Rush Hour	9/22/81	46	49	54	60	66	56
	Day	9/21/81	48	51	54	60	67	57
	Evening	9/22/81	47	48	52	58	66	55
3	Rush Hour	9/22/81	44	47	52	59	68	57
	Day	9/21/81	44	48	52	61	69	57
	Evening	9/22/81	38	41	46	55	68	54
4	Rush Hour	9/22/81	40	42	46	51	57	48
	Rush Hour*	9/28/81	40	42	46	51	56	48
	Day	9/21/81	42	44	48	52	58	51
	Day*	9/28/81	41	43	46	50	56	47
	Evening	9/22/81	34	36	39	44	54	43
	Evening*	9/28/81	33	36	39	45	52	42
5	Rush Hour	9/23/81	42	44	49	57	64	54
	Rush Hour*	9/28/81	41	43	49	56	60	52
	Day	9/21/81	43	45	49	53	58	50
	Evening	9/21/81	34	36	38	43	52	41
	Evening*	9/28/81	38	40	44	50	57	47
	Night	9/22/81	39	41	44	47	52	45
6	Rush Hours	9/21/81	49	52	58	64	70	61
	Day	9/21/81	49	53	56	62	69	59
	Evening	9/21/81	44	48	53	58	68	58
7	Rush Hour	9/21/81	44	46	54	62	71	59
	Rush Hour*	10/01/81	44	47	54	60	69	58
	Day	9/21/81	46	49	54	60	66	57
	Day*	9/29/81	44	47	53	60	68	57
	Evening	9/21/81	40	42	46	56	66	53
	Night	9/21/81	38	39	42	49	58	48

[1] Corrected for Human Perception Curve (see text)

* Repeat Measurements

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1] MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec) L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
8	Rush Hour	9/21/81	51	53	57	62	73	61
	Rush Hour*	10/1/81	52	54	58	64	70	60
	Day	9/21/81	49	50	54	60	65	56
	Day*	9/29/81	50	53	56	62	70	59
	Evening	9/21/81	44	46	50	54	64	53
	Night	9/21/81	46	48	50	56	67	55
9	Rush Hour	9/21/81	44	46	49	55	60	52
	Day	9/22/81	40	41	45	51	58	48
	Evening	9/21/81	40	41	45	51	55	47
	Night	9/21/81	39	42	46	51	61	50
10	Rush Hour	9/21/81	50	52	56	62	67	58
	Rush Hour*	10/1/81	44	48	54	61	67	57
	Day	9/22/81	44	46	50	56	61	53
	Day*	9/29/81	43	46	50	57	61	53
	Evening	9/21/81	42	45	50	56	59	52
	Night	9/21/81	42	44	48	54	61	51
11	Rush Hour	9/21/81	41	43	47	51	59	49
	Rush Hour*	10/1/81	38	40	45	56	67	54
	Day	9/22/81	37	39	42	46	52	44
	Day*	9/29/81	40	43	47	51	56	48
	Evening	9/21/81	40	41	45	52	60	50
	Night	9/22/81	37	39	42	46	51	44
12	Rush Hour	9/23/81	42	44	49	54	62	52
	Day	9/22/81	40	44	47	51	56	48
	Evening	9/23/81	42	46	50	56	62	52
13	Rush Hour	9/23/81	40	43	47	54	59	50
	Day	9/22/81	33	36	42	50	56	46
	Evening	9/23/81	31	33	40	46	56	44
	Night	9/23/81	37	40	43	48	58	47
14	Rush Hour	10/1/81	35	38	43	51	60	49
	Day	9/29/81	36	39	44	51	59	49

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1]
MEASURED AT LOCATIONS ALONG THE METRO RAIL
ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
15	Rush Hour	9/23/81	38	42	46	52	61	50
	Day	9/23/81	38	42	46	52	62	50
	Day*	9/29/81	31	34	42	50	61	48
	Evening	9/23/81	26	30	37	45	54	44
	Night	9/25/81	22	24	28	39	50	38
16	Rush Hour	9/24/81	43	45	49	56	64	53
	Day	9/23/81	43	46	50	56	62	53
	Evening	9/23/81	35	39	45	52	62	50
17	Rush Hour	9/24/81	39	43	49	58	68	55
	Day	9/23/81	38	42	47	54	68	55
	Evening	9/23/81	38	41	46	52	59	49
	Night	9/23/81	32	35	44	55	67	53
18	Rush Hour	9/23/81	38	40	44	49	55	46
	Day	9/23/81	35	40	44	50	55	47
	Day*	9/30/81	28	33	38	43	46	39
19	Rush Hour	9/22/81	38	41	44	49	54	46
	Rush Hour*	9/30/81	36	40	44	50	58	48
	Day	9/22/81	39	42	46	52	59	49
	Day*	9/30/81	32	37	41	45	53	44
	Evening	9/22/81	37	39	43	47	54	45
	Night	9/23/81	36	39	42	46	54	44
20	Rush Hour	9/23/81	40	42	46	49	54	47
	Day	9/23/81	42	45	50	54	57	51
	Day*	9/29/81	38	40	44	48	53	45
	Evening	9/23/81	39	42	44	50	54	49
21	Rush Hour	9/22/81	42	46	52	57	62	54
	Day	9/30/81	34	40	52	59	65	55
	Evening	9/22/81	39	42	49	57	65	54
	Night	9/25/81	30	32	39	57	68	55
22	Rush Hour	9/22/81	44	46	48	51	55	49
	Day	9/22/81	41	43	45	49	54	47
	Evening	9/22/81	42	44	46	50	56	48
	Night	9/24/81	40	42	44	48	53	46

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1]
MEASURED AT LOCATIONS ALONG THE METRO RAIL
ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec) L_{99}	L_{90}	L_{50}	L_{10}	L_{1}	L_{eq}
23	Rush Hour	9/24/81	36	41	46	50	54	48
	Rush Hour*	9/30/81	31	34	37	43	53	42
	Day	9/23/81	39	42	45	48	54	46
	Day*	9/30/81	32	36	40	44	49	41
	Evening	9/23/81	35	37	40	44	54	43
	Night	9/24/81	35	38	41	45	51	43
24	Rush Hour	9/24/81	44	47	53	59	64	56
	Day	9/24/81	39	43	50	58	68	55
	Evening	9/24/81	38	41	49	58	64	54
	Night	9/24/81	31	34	43	54	60	50
25	Rush Hour	9/24/81	38	42	47	52	56	49
	Rush Hour*	9/30/81	32	37	44	50	54	46
	Day	9/24/81	39	42	47	52	58	49
	Day*	9/30/81	34	38	44	50	55	47
	Evening	9/24/81	30	34	41	49	54	45
	Night	9/24/81	36	39	44	51	55	47
26	Rush Hour	9/24/81	42	45	49	53	56	50
	Day	9/24/81	42	45	50	54	59	51
	Evening	9/24/81	35	39	45	52	57	48
27	Rush Hour	9/24/81	41	44	49	55	62	52
	Day	9/24/81	42	45	50	56	62	53
	Evening	9/24/81	35	40	46	53	57	49
	Night	9/24/81	29	33	42	52	59	48
28	Rush Hour	9/28/81	38	43	49	54	58	50
	Day	9/28/81	38	42	49	54	58	51
	Evening	9/28/81	32	38	46	54	61	50
	Night	9/28/81	26	29	36	49	55	44
29	Rush Hour	9/24/81	42	47	55	64	70	60
	Day	9/24/81	44	47	53	59	64	56
	Day*	9/24/81	41	46	53	61	67	57
	Evening	9/24/81	40	43	50	61	67	57
30	Rush Hour	9/29/81	42	45	50	56	62	53
	Day	9/24/81	46	48	53	58	67	59
	Evening	9/24/81	41	43	47	56	63	52
	Evening*	9/24/81	38	40	45	53	61	51

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1] MEASURED AT LOCATIONS ALONG THE METRO RAIL ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_{1}	L_{eq}
31	Rush Hour	9/24/81	36	38	41	44	48	42
	Day	9/24/81	36	39	42	47	53	44
	Evening	9/24/81	35	37	41	46	53	43
	Night	9/24/81	34	37	41	46	53	44
32	Rush Hour	9/29/81	36	38	41	44	48	41
	Day	9/25/81	32	34	37	41	45	38
	Evening	9/29/81	25	27	32	38	45	35
	Night	9/29/81	22	24	29	34	46	34
33	Rush Hour	9/29/81	36	37	40	43	46	41
	Day	9/25/81	32	35	38	45	56	44
	Evening	9/29/81	27	29	32	35	38	33
34	Rush Hour	9/29/81	34	37	40	44	47	41
	Day	9/25/81	25	28	32	38	45	35
	Evening	9/29/81	20	22	26	32	39	29
	Night	9/30/81	18	20	24	29	35	26
35	Rush Hour	9/29/81	22	24	29	36	49	36
	Day	9/25/81	24	26	32	42	44	39
	Evening	9/29/81	21	24	28	34	44	33
	Night	9/29/81	18	20	24	28	31	25
36	Rush Hour	9/29/81	30	32	35	47	55	43
	Day	9/29/81	36	38	41	46	54	44
	Evening	9/29/81	32	33	35	40	55	42
	Night	9/29/81	32	33	35	40	55	43
37	Rush Hour	9/29/81	22	25	29	34	41	32
	Day	9/29/81	22	24	27	30	43	31
	Evening	9/29/81	20	21	23	26	45	35
	Night	9/29/81	20	22	24	27	32	27
38	Rush Hour	9/28/81	37	39	42	46	50	43
	Evening	9/28/81	33	36	39	44	52	42
	Night	9/29/81	30	32	35	40	54	41
39	Rush Hour	9/28/81	39	42	48	53	60	50
	Day	9/28/81	36	41	47	54	63	52
	Evening	9/28/81	29	32	40	48	61	48

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1]
MEASURED AT LOCATIONS ALONG THE METRO RAIL
ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec) L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
40	Rush Hour	9/28/81	42	44	46	50	56	48
	Day	9/28/81	44	46	50	57	67	55
	Day*	9/30/81	42	44	48	53	58	50
	Evening	9/28/81	39	41	44	48	56	46
	Evening*	9/29/81	39	41	44	50	58	49
	Night	9/30/81	36	37	41	46	51	43
41	Rush Hour	9/28/81	48	52	57	64	72	61
	Day	9/28/81	47	51	56	64	74	62
	Evening	9/28/81	40	44	51	59	67	56
	Night	9/29/81	38	40	46	58	71	56
42	Rush Hour	9/28/81	44	46	51	58	67	55
	Day	9/28/81	46	48	51	57	64	55
	Evening	9/28/81	42	46	50	57	64	54
	Night	9/29/81	39	41	46	52	58	49
43	Rush Hour	9/28/81	47	50	54	60	66	57
	Day	9/28/81	43	46	53	60	67	57
	Evening	9/28/81	45	48	54	63	69	59
	Night	9/29/81	41	43	48	58	66	55
44	Rush Hour	9/28/81	45	47	49	56	63	53
	Day	9/28/81	43	45	49	56	62	52
	Evening	9/28/81	50	51	52	56	64	54
	Night	9/29/81	46	48	50	53	55	51
45	Rush Hour	9/28/81	46	48	52	56	61	54
	Day	9/28/81	48	49	50	54	58	52
	Evening	9/28/81	36	39	43	49	57	47
	Night	9/28/81	35	38	42	48	56	45
101	Rush Hour	9/20-21/82	42	46	51	57	66	55
	Day	9/20-21/82	43	46	51	57	64	54
	Evening	9/20-21/82	36	39	44	54	65	53
	Night	9/20,22/82	35	37	41	49	58	47
102	Rush Hour	9/20-21/82	44	49	55	63	70	59
	Day	9/21/82	41	46	52	59	67	56
	Evening	9/20-21/82	37	41	47	56	67	55
	Night	9/21-22/82	34	37	43	51	63	51

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1]
MEASURED AT LOCATIONS ALONG THE METRO RAIL
ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
103	Rush Hour	9/20-21/82	43	48	55	65	76	64
	Day	9/20-21/82	43	48	56	64	74	63
	Evening	9/20-21/82	37	41	45	58	70	56
	Night	9/21-22/82	34	38	42	50	62	50
104	Rush Hour	9/20-21/82	37	43	51	58	66	55
	Day	9/20-21/82	39	45	52	60	67	56
	Evening	9/20-21/82	31	37	44	52	62	50
	Night	9/20,22/82	27	32	39	49	62	49
105	Rush Hour	9/20-21/82	39	44	50	57	66	54
	Day	9/20-21/82	37	41	47	53	62	51
	Evening	9/20-21/82	34	38	43	49	59	48
	Night	9/20-21/82	32	35	40	47	58	46
106	Rush Hour	9/20,23/82	36	40	46	52	58	49
	Day	9/21/82	37	42	48	55	60	52
	Evening	9/21,23/82	34	39	45	50	57	48
	Night	9/21,24/82	31	36	42	49	57	45
107	Rush Hour	9/20-21/82	33	37	42	48	54	45
	Day	9/21-22/82	33	36	41	47	54	45
	Evening	9/20,22/82	31	34	39	45	55	45
	Night	9/21/82	30	33	39	46	58	45
108	Rush Hour	9/20,22/82	31	36	41	48	53	45
	Day	9/21-22/82	29	34	40	47	54	44
	Evening	9/20,22/82	29	33	38	44	50	41
	Night	9/20/82	28	31	36	42	49	43
109	Rush Hour	9/21/82	27	31	38	44	53	49
	Day	9/21-22/82	27	31	37	45	51	42
	Evening	9/20-21/82	25	29	34	41	55	44
	Night	9/21-22/82	23	27	32	38	47	36
110	Rush Hour	9/22/82	34	38	44	52	62	51
	Day	9/22/82	34	38	44	51	58	48
	Evening	9/22-23/82	34	38	43	49	56	47
	Night	9/23/82	31	35	41	48	56	46
111	Rush Hour	9/21/82	42	47	53	60	67	57
	Day	9/21/82	47	50	55	61	68	58

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1]
MEASURED AT LOCATIONS ALONG THE METRO RAIL
ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec) L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
112	Rush Hour	9/21-22/82	44	48	54	61	68	58
	Day	9/21-22/82	42	47	54	61	68	58
	Evening	9/21-22/82	39	44	51	58	65	55
	Night	9/21/82	35	40	48	56	64	53
113	Rush Hour	9/21-22/82	36	40	46	53	61	51
	Day	9/20-21/82	35	40	47	54	61	51
	Evening	9/20,23/82	31	35	40	47	56	45
	Night	9/20-21/82	31	35	40	47	56	45
114	Rush Hour	9/23/82	36	40	44	50	56	49
	Day	9/23-24/82	35	38	43	48	54	47
	Evening	9/23/82	30	35	41	47	52	44
	Night	9/23/82	28	33	39	47	53	43
115	Rush Hour	9/22/82	43	45	49	53	60	51
	Day	9/22-23/82	43	46	49	54	62	52
	Evening	9/23/82	33	38	43	50	56	47
	Night	9/21/82	32	36	42	49	58	47
116	Rush Hour	9/21-22/82	20	23	28	35	46	35
	Day	9/21,23/82	22	24	28	35	44	33
	Evening	9/21-22/82	17	21	24	29	35	27
	Night	9/20,22/82	14	17	22	26	33	27
117	Rush Hour	9/22-23/82	21	24	27	31	37	29
	Day	9/21-22/82	19	22	26	31	36	30
	Evening	9/21-22/82	18	21	24	27	31	25
	Night	9/21-22/82	14	17	22	26	30	23
118	Rush Hour	9/21-22/82	15	21	27	38	52	36
	Day	9/21-22/82	19	23	29	36	47	36
	Evening	9/21-22/82	13	16	22	30	45	33
	Night	9/20,22/82	14	18	22	28	37	29
119	Rush Hour	9/21-22/82	36	41	49	56	63	53
	Day	9/21/82	38	43	50	58	65	55
	Evening	9/21-22/82	31	36	44	54	61	50
	Night	9/21,23/82	28	33	40	50	58	47

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1]
MEASURED AT LOCATIONS ALONG THE METRO RAIL
ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec)					
			L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
120	Rush Hour	9/23/82	33	36	40	47	57	45
	Day	9/23/82	32	34	39	46	55	43
	Evening	9/23/82	28	30	34	38	43	36
	Night	9/23/82	24	27	32	37	44	34
121	Rush Hour	9/22-23/82	30	34	38	44	52	42
	Day	9/21-22/82	35	38	42	47	54	44
	Evening	9/20,22/82	33	35	38	43	51	41
	Night	9/20-22/82	28	32	35	39	46	37
122	Rush Hour	9/21,23/82	29	33	38	42	47	39
	Day	9/21,23/82	30	34	39	44	50	40
	Evening	9/20-21/82	27	31	35	40	45	37
	Night	9/20-21/82	26	30	34	40	46	37
123	Rush Hour	9/21,23/82	34	38	44	49	55	46
	Day	9/21-22/82	35	39	44	48	53	46
	Evening	9/20,23/82	32	36	41	45	52	46
	Night	9/21-22/82	30	33	38	43	49	40
124	Rush Hour	9/21,23/82	39	43	48	56	62	52
	Day	9/21-22/82	35	39	45	53	62	51
	Evening	9/20,23/82	32	37	42	52	60	48
	Night	9/21,23/82	27	30	36	46	56	44
125	Rush Hour	9/21,23/82	33	37	41	47	55	45
	Day	9/21,23/82	34	38	42	47	53	45
	Evening	9/20,22/82	30	33	37	43	53	42
	Night	9/21,23/82	27	29	33	38	43	35
126	Rush Hour	9/22-23/82	43	45	48	52	59	50
	Day	9/21,23/82	43	46	48	52	58	50
	Evening	9/20,22/82	35	38	42	47	57	46
	Night	9/21,23/82	27	30	36	42	49	39
127	Rush Hour	9/20,23/82	39	43	49	54	61	52
	Day	9/21,23/82	40	44	49	55	60	52
	Evening	9/20,22/82	34	38	43	50	56	47
	Night	9/21,23/82	30	34	39	46	56	45

Table 6

WEIGHTED OVERALL VIBRATION VELOCITY LEVELS[1]
MEASURED AT LOCATIONS ALONG THE METRO RAIL
ALIGNMENT ALTERNATIVES (Continued)

Location Number	Time of Day	Date	Weighted Vibration Velocity Levels (dB re 1 micro in/sec) L_{99}	L_{90}	L_{50}	L_{10}	L_1	L_{eq}
128	Rush Hour	9/20,23/82	38	41	46	52	58	49
	Day	9/21-22/82	36	38	43	48	54	46
	Evening	9/21-22/82	34	37	42	48	55	45
	Night	9/20,22/82	28	30	34	39	47	37
129	Rush Hour	9/20,23/82	36	40	47	55	63	52
	Day	9/21-22/82	34	39	45	53	61	50
	Evening	9/20,22/82	28	32	38	47	54	44
	Night	9/20,22/82	23	27	33	41	43	41
130	Rush Hour	9/20,22/82	40	45	50	54	59	52
	Day	9/21-22/82	39	43	49	54	59	51
	Evening	9/21,23/82	37	41	45	50	55	47
	Night	9/20,22/82	30	34	39	46	52	43
131	Rush Hour	9/21-22/82	40	44	49	54	58	51
	Day	9/22-23/82	39	42	47	52	57	49
	Evening	9/21/82	34	37	42	47	52	44
	Night	9/21-22/82	33	37	41	47	52	43
132	Rush Hour	9/21-22/82	36	42	50	60	66	56
	Day	9/22-23/82	36	41	47	56	63	53
	Evening	9/21,23/82	29	33	41	54	62	50
	Night	9/21-22/82	25	29	35	49	59	47
133	Rush Hour	9/21-22/82	36	40	45	51	57	48
	Day	9/22-23/82	33	36	41	48	57	46
	Evening	9/21,23/82	29	32	38	44	53	42
	Night	9/21-22/82	26	32	38	45	60	47

Source: Wilson, Ihrig & Associates, Inc. (1982e).

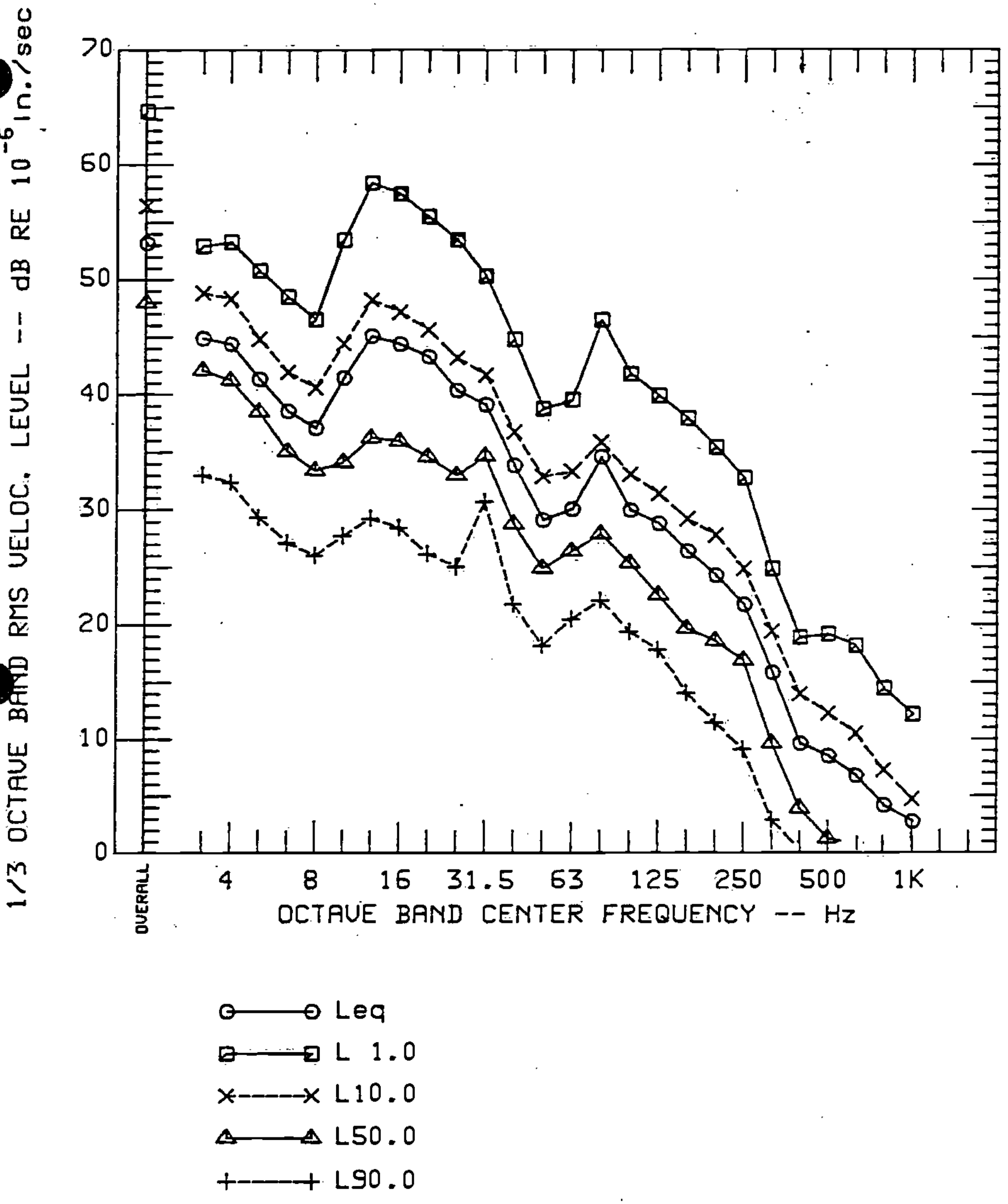


FIGURE 23 ONE-THIRD OCTAVE BAND VIBRATION VELOCITY LEVEL STATISTICS DURING RUSH HOUR AT LOCATION 5 ON SEPTEMBER 23, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

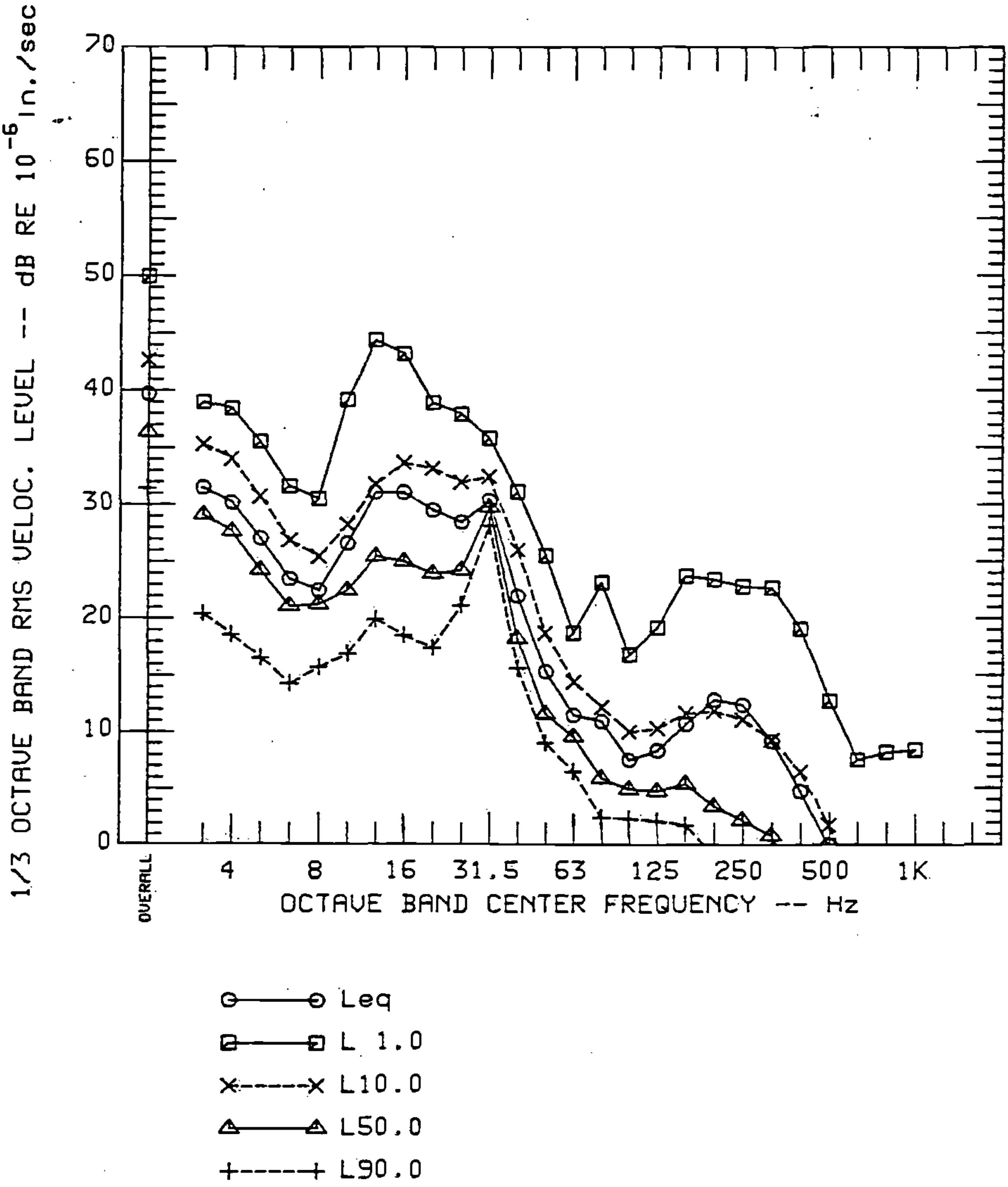


FIGURE 24 ONE-THIRD OCTAVE BAND VIBRATION VELOCITY LEVEL STATISTICS DURING THE EVENING AT LOCATION 5 ON SEPTEMBER 21, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

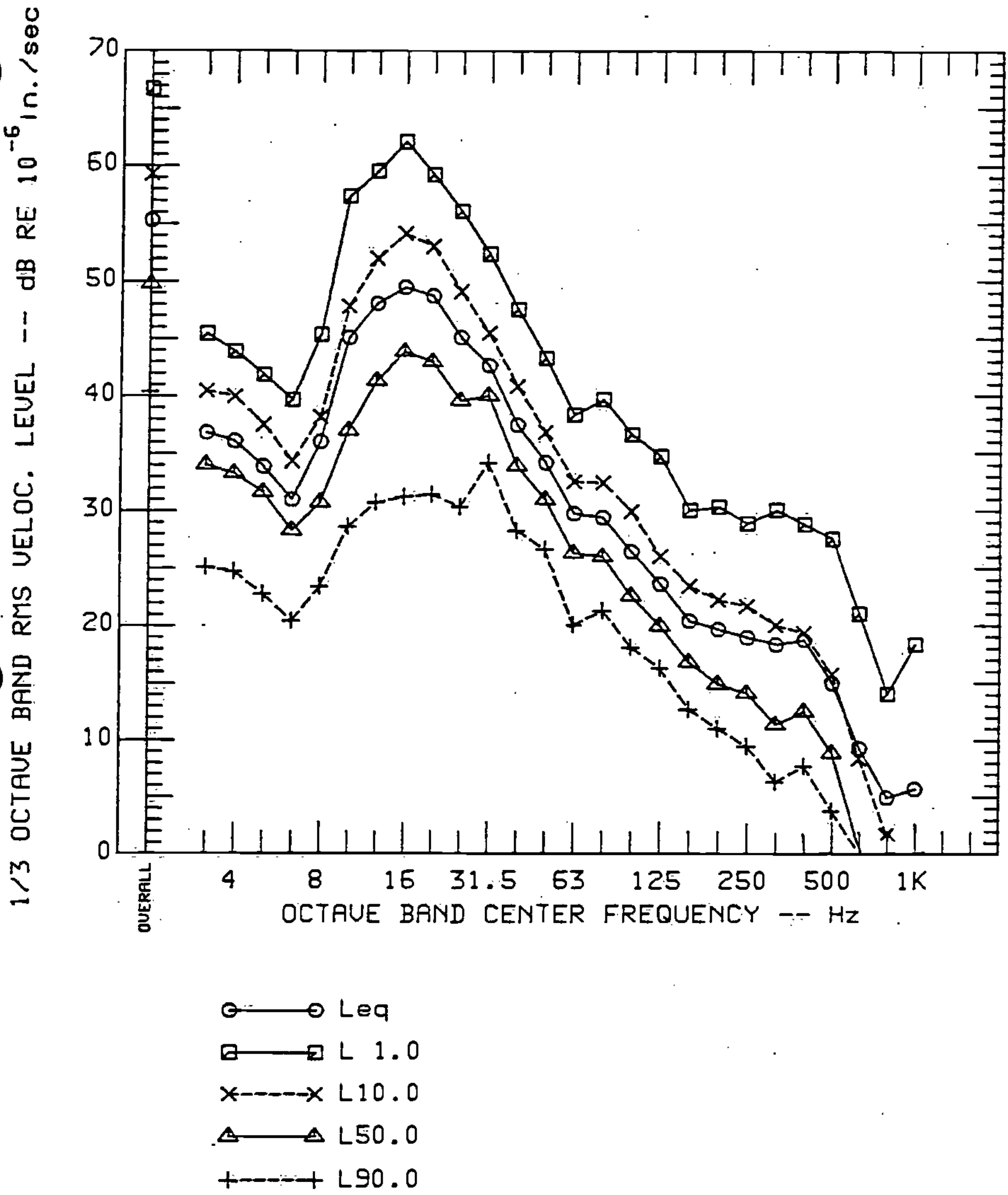


FIGURE 25 ONE-THIRD OCTAVE BAND VIBRATION VELOCITY LEVEL STATISTICS DURING RUSH HOUR AT LOCATION 7 ON SEPTEMBER 21, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

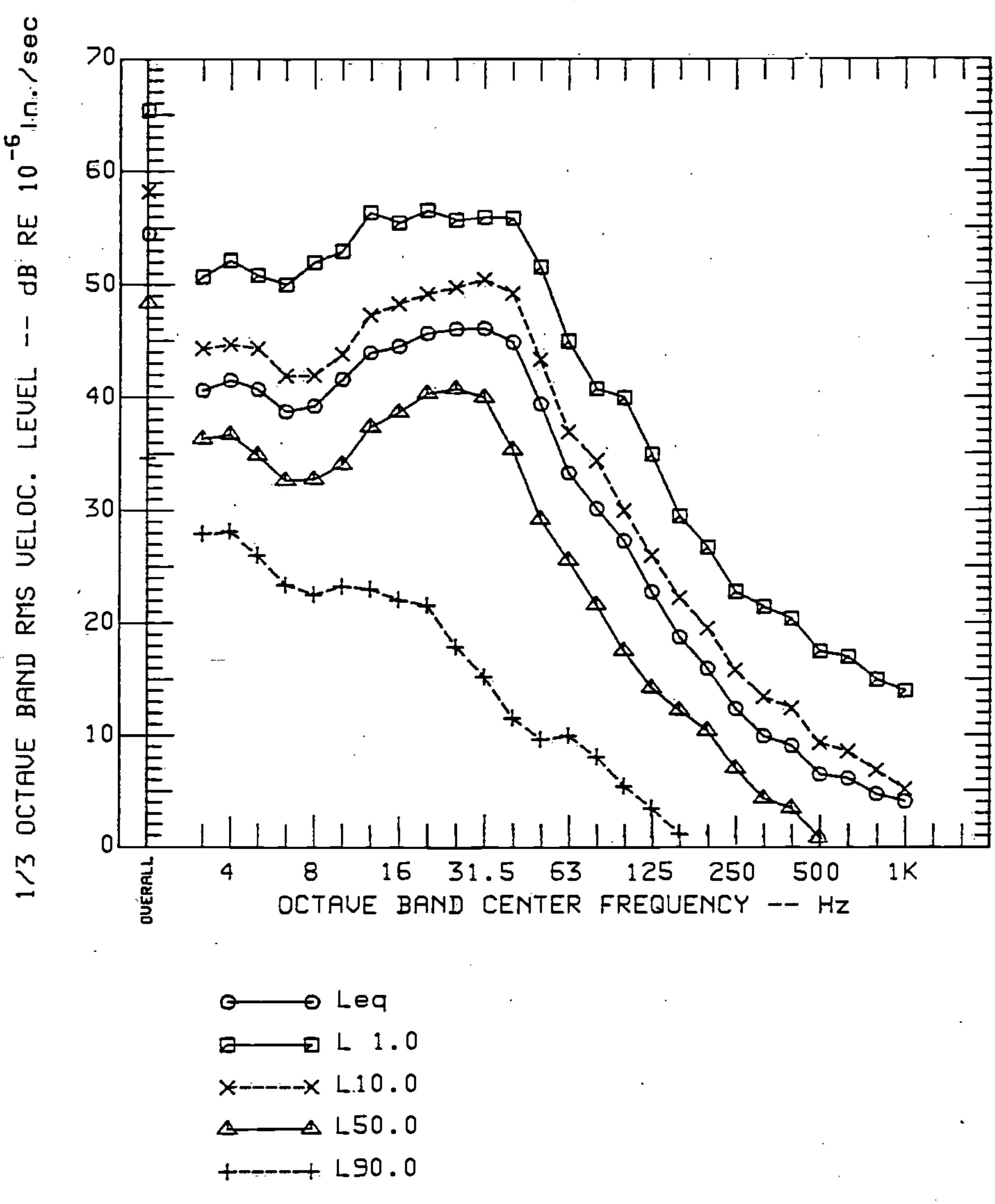


FIGURE 26 ONE-THIRD OCTAVE BAND VIBRATION VELOCITY LEVEL STATISTICS DURING THE DAY AT LOCATION 21 ON SEPTEMBER 30, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

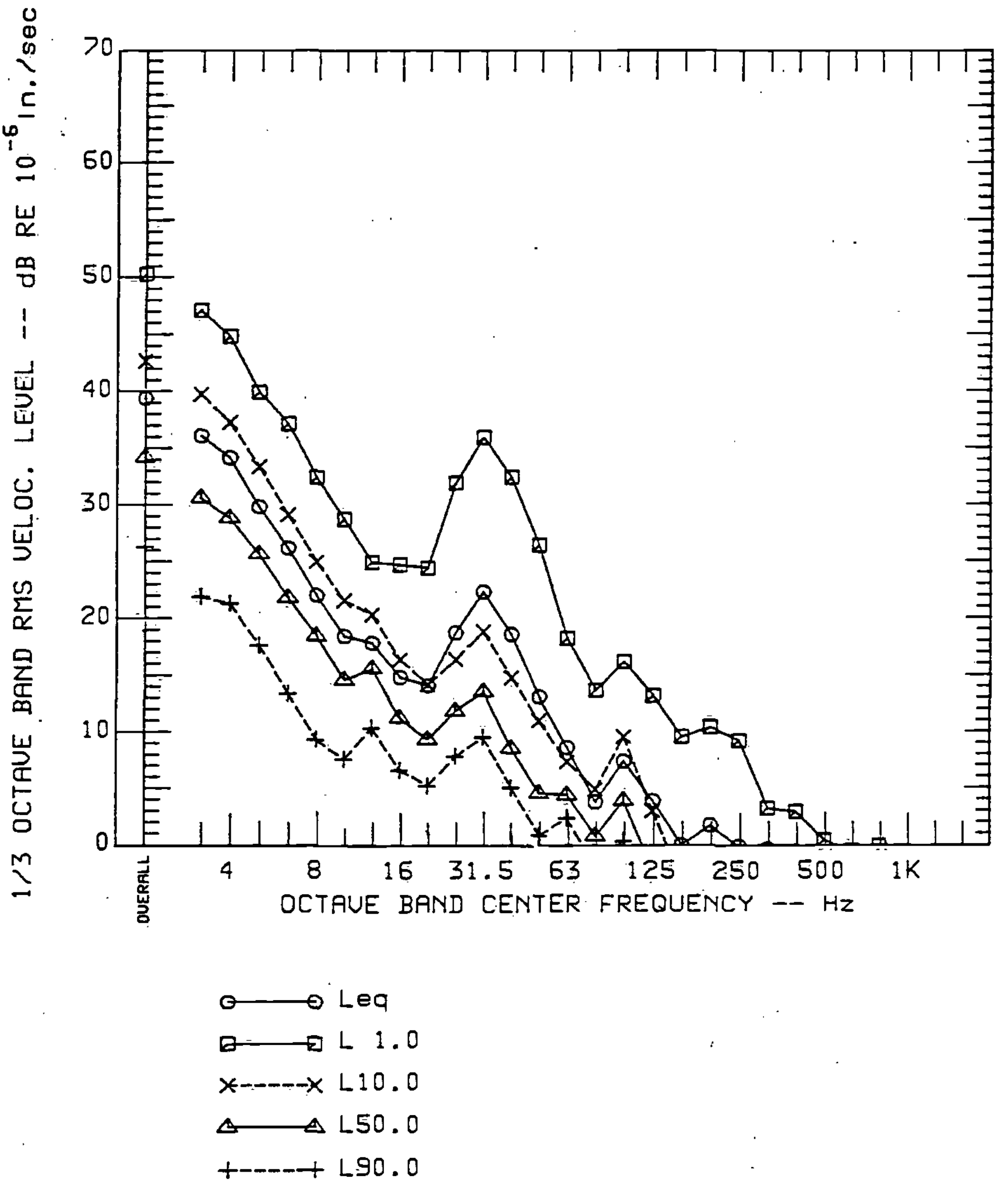


FIGURE 27 ONE-THIRD OCTAVE BAND VIBRATION VELOCITY LEVEL STATISTICS DURING THE DAY AT LOCATION 34 ON SEPTEMBER 29, 1981

WILSON, IHRIG & ASSOCIATES, INC. 1982b

existing noise environment. Therefore the remarks about the variance and analysis of noise for the most part are applicable to vibration.

ENVIRONMENTAL IMPACT ASSESSMENT

Overview

The impact assessment for the system has been performed on a progressive basis, starting at one end of the proposed system (i.e., the Union Station terminal) and incrementally stepping along the proposed alignment alternatives, projecting (i.e., modeling) the system generated noise and vibration levels and determining the impacts by the surrounding land uses and noise and vibration environments. Since the noise and vibration migitating features, which may be incorporated into the system design and construction, all raise system costs, the impact projections have been made using "standard" Metro Rail system facilities except where reductions would be necessary to comply with the Metro Rail design criteria.

A number of the Metro Rail system design features and exact locations of facilities have not yet been determined, i.e., round or horseshoe tunnels, all concrete or steel and concrete aerial structures, location of fan and vent shafts, etc. However, to determine noise and vibration impacts, certain general assumptions have been made as to the type of structures and facilities that will be used in the design of the Metro Rail system. The proposed system will be a "heavy rail" system and it has been assumed that the characteristics of the system will be similar to the recent vintage rapid transit systems which have been built or are being built in San Francisco, Washington, DC, Atlanta, and Baltimore. Thus, the data used for projecting the expected noise and vibration from the Metro Rail system are based to a large degree on operating transit systems which utilize the latest technology, and have similar vehicles and facilities to those expected for the Metro Rail system.

The standard design features used on a modern rail transit system include many provisions which result in much lower noise and vibration levels than traditionally expected for a rail system. These features include such items as continuous welded rail, resilient (rubber) rail fasteners, concrete aerial structures rather than steel structures, use of wheel and rail grinding or truing machines to maintain the smoothness of the wheels and rail, use of vehicles with lightweight trucks which provide minimum unsprung weight, and the use of noise and vibration limits in the specifications and contract documents. All of these result in baseline noise and vibration levels for the system that are considerably reduced compared to older transit systems.

A direct comparison of the potential noise and vibration impact of an aerial structure to a subway alignment has not been made for the following reasons. The character of noise from transit trains traveling on aerial structures is different from the character of noise which arises from transit trains operating in a subway. The noise from trains traveling on aerial structures is airborne and can be perceived by individuals outside of a building or inside of a building at an attenuated level after the noise has passed through the windows, door or walls of the building. The noise from trains traveling in a subway is ground-borne and can be perceived only when an individual is inside a building near the subway; outdoors the ground-borne noise is not audible. A train operating in a subway creates vibration at the wheel/rail interface which is transmitted to the subway structure to the ground and then through the ground to a building structure where it is then radiated in the form of a low-frequency noise which can be heard and sometimes felt as mechanical vibration only inside buildings near the subway. Trains operating on aerial structures will produce vibration levels in the ground which are low enough in level that they will not be felt by occupants of nearby buildings, while the vibration levels produced by trains operating in subways can in some situations be high enough in level that they can be felt by occupants of nearby buildings. As for ground-borne noise, vibration from train operations in subways is only perceived by people inside buildings.

Table 7 summarizes the preceding discussion for convenience. Examination of Table 7 indicates that in order to undertake a meaningful direct comparison of the potential noise and vibration impact from subway and aerial structure train operations, the comparison must be done for occupants inside buildings adjacent to the alignment. Some of the necessary information includes size of the building structure, building construction materials and assemblies, number of doors, operable and inoperable windows facing the alignment, etc. Thus, in order to undertake a general review of the potential community noise and vibration impact from transit train operations either in subway or on aerial structures, we have compared the expected noise levels from train operations with appropriate acceptability criteria for the community.

Table 7

POSSIBILITY FOR NOISE AND VIBRATION
IMPACTS DUE TO TRANSIT TRAIN OPERATIONS

Type of Structure	Outside	Inside
Subway	None	Possible - due to ground-borne noise and/or ground-borne vibration
Aerial	Possible - due to airborne noise	Possible - due to airborne noise transmitted through building walls

Source: Wilson, Ihrig & Associates, Inc. (1982e).

Since acoustical impact is a very important factor influencing community and patron acceptance of any new transportation system and, particularly, the acceptance of a new rail transit system, the Metro Rail system has established an elaborate criteria for maximum noise and vibration levels. These noise level criteria are more restrictive than those applied to any other transportation system and, while they will not insure zero impact on the community, are, in fact, more restrictive than those applied by many community noise standards and ordinances. Therefore, when reviewing the following sections on the various impact categories, the quality level of standards and criteria being used for assessment should be kept in mind. Noise and vibration design criteria are detailed in Attachment 1.

Ground-borne Noise and Vibration From Subway Operations

Underground operations of rail rapid transit systems do result in ground-borne vibration and noise which is transmitted from the subway structure to adjacent buildings via the intervening geologic strata. The ground-borne vibration originates at the wheel/rail interface and is due to vibration and noise generated by the wheels rolling on the rails. The level of this vibration at the source is influenced by the degree of roughness or smoothness of the wheels and rails, the speed of the train, and by the type of subway structure and geologic strata in which the structure is founded.

The vibration which can be perceived from the operation of transit trains in subways is generally perceived as a low-pitched rumbling noise radiated inside nearby buildings due to the vibration of the building structure induced by the ground-borne vibration and noise. The vibration may also be perceptible as mechanical motion, although the usual sensation, if perceived, is that of a low-frequency rumbling noise.

It should be noted that the vibration is of such a low level that there is no possibility or potential for structural damage due to the ground-borne vibration transmitted to buildings near the subways. It should also be noted that trains operating on aerial structures will produce vibration levels which will be low enough in level that they will not be felt by nearby occupants of buildings. This is due primarily to the fact that the airborne noise from trains traveling on aerial structures generally overpowers the perception of ground-borne noise and vibration if there is a perception of the train passby.

The transmission of the ground-borne vibration and noise to buildings near the subway structure is affected by a number of factors, primarily the type of intervening strata between the subway and buildings, i.e., rock or soil, and by the type of building and building foundations. In general it has been found that the various factors can be generalized to reduce the number of variables sufficiently to define classes of situations where the noise can be predicted with a reasonable degree of confidence.

For the distances over which ground-borne vibration from transit trains is of concern, the small variations in soil or rock strata (which can have an influence in vibration transmitted over long distances) are insignificant. Therefore, the only significant factor with regard to the strata, as far as transit system ground-borne vibration is concerned, is whether the founding and intervening media are rock or earth. Buildings near a subway structure can be classified either as small, lightweight buildings -- such as one- or two-story brick or frame single-family dwellings -- or small commercial buildings and large, masonry buildings -- such as multi-story office, commercial, hotel or apartment buildings. There is a gray area between the two categories; however, most buildings can be assumed to be within one of the two categories. Using these simplifications and the considerable amount of data from the Toronto Transit Commission (TTC) facilities and some data from the Bay Area Rapid Transit District (BART), Washington Metropolitan Area Transit Authority (WMATA Metro) and Metropolitan Atlanta Rapid Transit Authority (MARTA) facilities, it is possible to derive expected ground-borne vibration levels in the occupied spaces of buildings near the subway structures.

There is a considerable amount of background information available which permits prediction of the noise levels to be expected from ground-borne vibration due to transit trains. The measurements which have been accomplished at TTC, BART, WMATA Metro and MARTA facilities provide a well-founded empirical basis for determining the expected noise levels. The measurements have included evaluations with different types of subway structures and with different types of founding and intervening geologic strata, including rock and soil. Data for both types of configurations have been obtained at the TTC and WMATA Metro facilities. The data provide a basis for evaluation and verification of theoretical estimates of the difference between ground-borne vibration from earth-founded and rock-founded subways.

The evaluations of subway operations have also included the determination of the effects of resilient rail fasteners, resiliently supported ties and floating slab trackbeds for reduction of ground-borne vibration. These evaluations have shown that resiliently supported ties reduce the ground-borne noise and vibration by 6 to 10 dB, while floating slab trackbeds reduce the ground-borne noise and vibration by 15 to 20 dB. These reductions are relative to the ground-borne noise and vibration that transit trains produce when operating on direct fixation resilient rail fasteners which already reduce the ground-borne noise and vibration a significant amount over the direct fasteners which have been used on older systems. The reduction of ground-borne noise and vibration attributable to these special design features occurs in the frequency range where rumbling noise is most predominant and audible in the buildings near the subway structure.

Figures 28 through 30 show cross-sectional drawings of these three methods of track fixation in subways as used at particular transit systems. These are the three methods of track fixation which have been used in the projection of ground-borne noise from transit train operations in buildings adjacent to the proposed subway alignments of the Metro Rail system.

As previously indicated, the Metro Rail system has adopted strict design criteria for ground-borne noise and vibration (Wilson, Ihrig & Associates, Inc., 1982b, Sections 7.4.2 and 7.4.3). Tables 8 through 12 indicate a comparison of the expected performance with the criterion. These comparisons provide a means for determining those areas where special design features (i.e., resiliently supported ties and floating slab trackbeds) are needed to reduce the noise and vibration to levels below those for the standard design facilities. Engineering station locations are referenced on the series of maps included in Attachment 3.

Although the exact type of subway structure has not been determined at this time, for the purposes of this analysis, it has been assumed that the subway structure will be a round tunnel with concrete tunnel lining. The subway structure will be located entirely in earth (as opposed to rock). Calculations of the expected ground-borne noise have been completed for a number of buildings or groups of buildings along the alternative alignments using procedures which have been developed based on data obtained from other modern systems as previously discussed.

Tables 8 through 12 present the results of calculations of the expected noise levels from ground-borne vibration due to transit train operations in the subway structures along the locally preferred alternative route as well as the different alternatives under consideration. The data include the location along the alignment by civil station number, the type of structure, the depth of the top-of-rail below grade, the distance from the centerline of the near track subway to the buildings under consideration, and the maximum train speed for the area. Using these data in conjunction with the data and techniques which have been developed for computing expected noise levels from ground-borne vibration, the noise levels shown were calculated for the three different types of track fixation considered. If the expected level for ground-borne noise is significantly below the criterion for acceptable levels with the use of the resilient

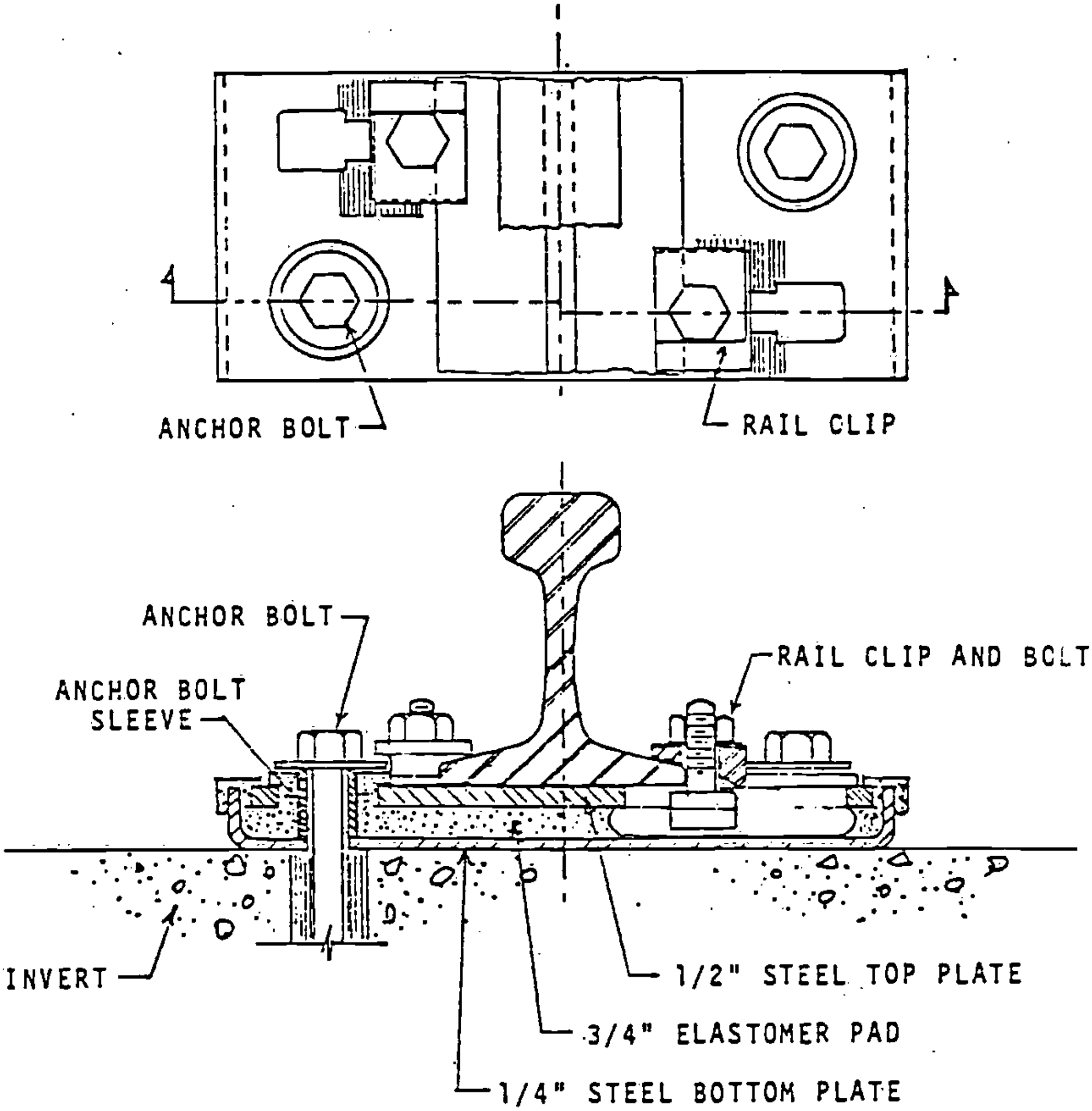


FIGURE 28 BART DIRECT FIXATION RESILIENT RAIL FASTENER WITH BONDED ELASTOMER PAD

WILSON, IHRIG & ASSOCIATES, INC. 1982e

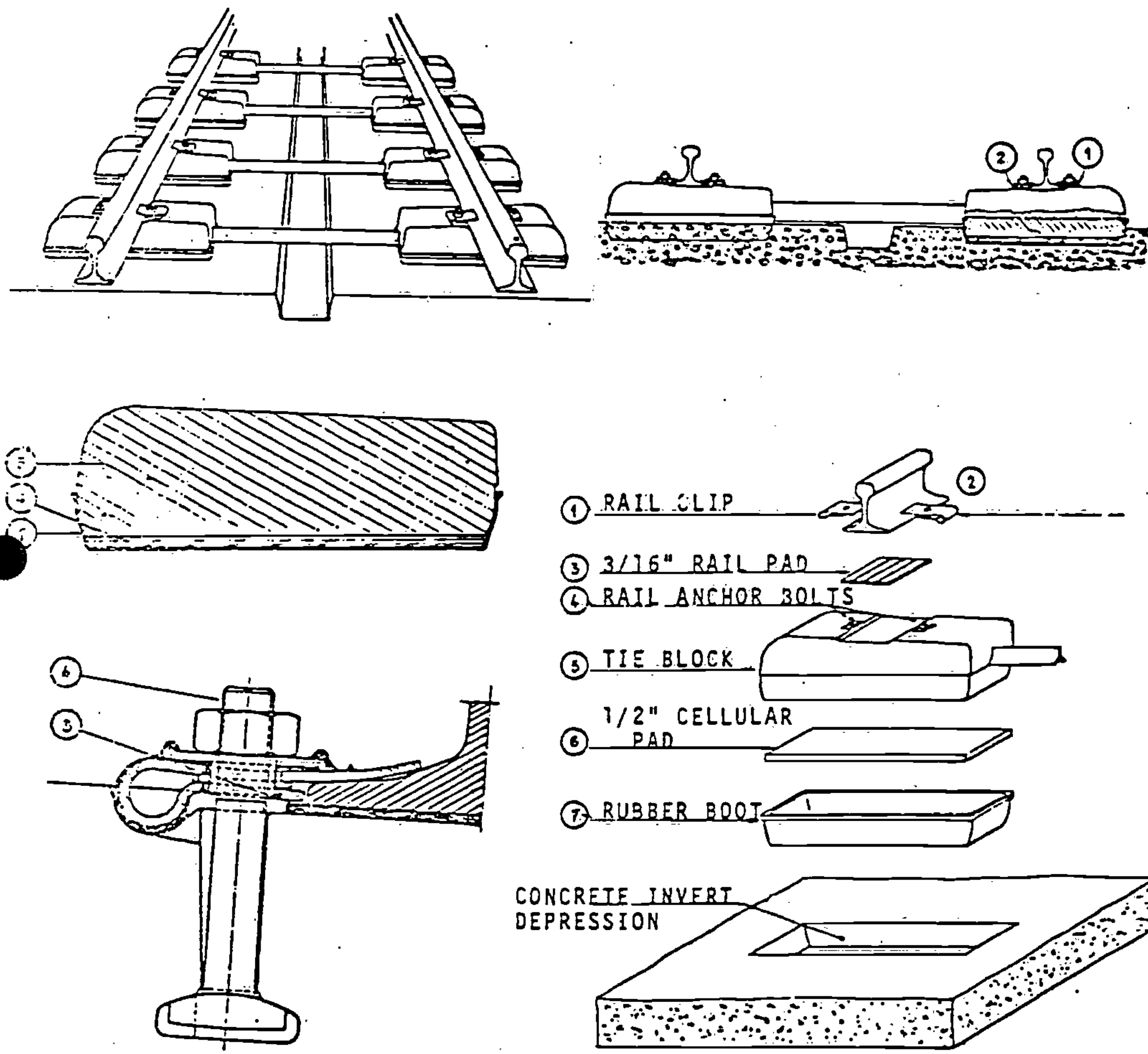


FIGURE 29 RS-STEDEF RESILIENTLY SUPPORTED RAIL TIE SYSTEM COMPONENTS

WILSON, IHRIG & ASSOCIATES, INC. 1982e

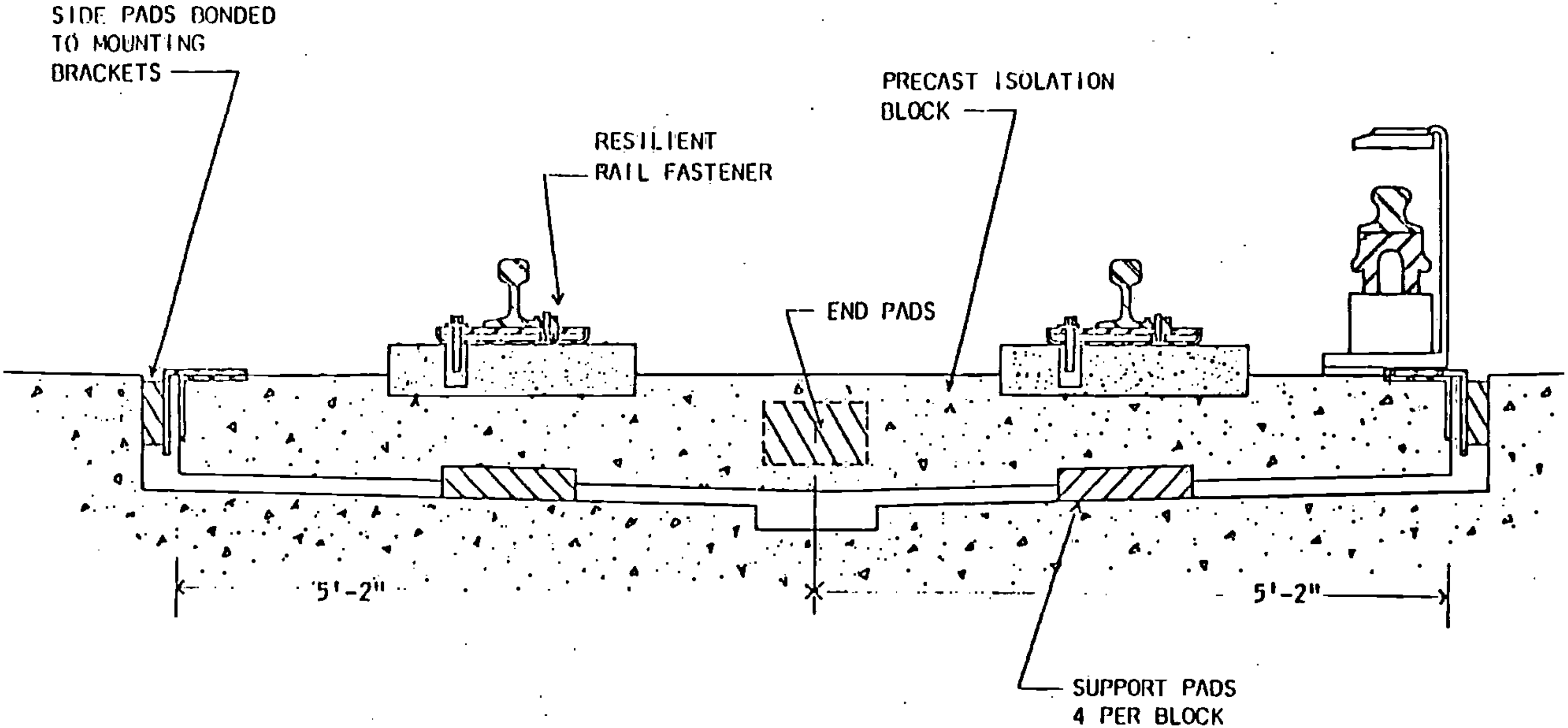


FIGURE 30 CROSS-SECTION OF THE DISCONTINUOUS FLOATING SLAB TRACK SUPPORT SYSTEM USED AT THE MARTA SYSTEM

direct fixation fastener, then the predicted noise levels with the other two types of track fixation are not shown, since these track fixation methods will reduce the ground-borne noise even further below the criterion. The "distance required for criterion compliance" is indicated at those locations where the resilient direct fixation fasteners are not sufficient to reduce the ground-borne noise to the level required by the criterion. This distance is the separation distance necessary with the resilient D.F. fasteners for the ground-borne noise to be at or below the criterion level.

Since the calculations are done for each frequency range, on an octave band basis, the expected ground-borne noise level is first determined in terms of octave band levels. The octave band analyses of the expected noise levels have been converted to an equivalent A-weighted noise level. Tables 8 through 12 show the expected A-weighted noise level at each location for the different types of track fixation.

Review of the expected levels indicated on Tables 8 through 12 shows that resiliently supported ties or floating slab trackbeds should be used to reduce the levels of ground-borne noise in buildings adjacent to the subway alignment along significant portions of the locally preferred alternative and each of the other alternatives.

Table 8 indicates the expected levels along the CBD-Wilshire Segment. Based on the alignment plan and profile currently under study, there are a number of sections that will require the use of resiliently supported ties or floating slab trackbeds to reduce the levels of ground-borne noise in buildings adjacent to the subway alignment. In addition, with the current alignment configuration, there are several locations where the use of resiliently supported ties or floating slab trackbeds will not reduce the ground-borne noise from transit train operations to acceptable levels. These locations include the following: the theater located at station 75+50, Theater of Arts located between stations 296+90 and 298+20, King Solomon Home for the Elderly located at station 497+00, Country Villa Wilshire Convalescent Hospital located at station 515+70, Garden of Palms Rest Home located between stations 520+60 and 522+10 and the apartments located between stations 524+50 and 526+00. The somewhat higher noise levels expected in these buildings is due primarily to a very shallow tunnel (depth to top-of-rail of 30 to 40 ft) and/or to the presence of a crossover in the tunnel which raises the expected noise level on the order of 10 decibels. These specific locations will be reanalyzed during final design to determine specific measures which will further reduce the ground-borne noise. These include such measures as minor alignment relocation, crossover relocation, subway structure modification, train speed modification and non-standard (heavier weight) floating slab.

Tables 9 through 11 indicate expected ground-borne noise levels for Alternatives A, B, and C in the Hollywood Segment. As with other sections of the proposed Metro Rail alignment, there are sections along each of these alternatives where the use of resiliently supported ties or floating slab trackbeds will be needed to reduce the ground-borne noise levels from transit train operations. For all three alternatives, even with the use of floating slab trackbeds in the area of the crossover between station 537+50 and approximately 544+00, the levels of ground-borne noise in some buildings adjacent to the alignment due to transit trains traversing the crossover in the tunnel will be greater than the appropriate criterion. This is due to the shallow depth of the tunnel at this crossover location (depth to top-of-rail of approximately 35 feet). This location will be reanalyzed during final design to determine the specific measures which should be used to further reduce the noise. These measures include those previously discussed for such areas along the adopted alignment.

TABLE 8 GROUND-BORNE NOISE PROJECTIONS FOR THE METRO RAIL SYSTEM SUBWAY (LOCALLY PREFERRED ALIGNMENT)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
11+00 to 16+00	(OB)	Post Office Terminal Annex	60	90	50	45	27-33	--	--	
18+00 to 21+00	(IB)	El Pueblo de Los Angeles (3)	65	25	50	45-50	35-41	--	--	--
19+00 to 27+80	(OB)	Commercial (3)	55	0	50	55	44-50	--	--	--
22+80 to 24+70	(OB)	Commercial (2)	50	20	50	55	44-50	--	--	--
33+50 to 35+50	(OB)	Office** (3)	65	140	65	45	24-30	--	--	--
42+90 to 43+60	(IB)	Hall of Records	70	70	60	40-45	29-35	--	--	--
43+40 to 44+90	(IB)	Hall of Administ.	70	70	60	40-45	29-35	--	--	--
49+00 to 51+10	(IB)	Law Library	55	85 (Sta.)	45	35-40	22-28	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
49+00 to 50+40	(IB)	County Court House	55	30 (Sta.)	45	35	38-44	60	29-35	24-30
52+80 to 54+00	(IB)	State Office Building	45	60	50	40-45	29-35	--	--	--
52+80 to 57+30	(IB)	Planned Office and Resid. Complex	40	50 (Est.)	60	45	39-45	--	--	--
58+00 to 68+30	(IB)	Commercial (11)	40	60	65	50	31-37	--	--	--
61+40 to 62+30	(IB)	Apartment (1)	45	60	65	45	36-42	--	--	--
63+30 to 66+50	(IB)	Angeles Plaza Elderly Housing	45	80	65	45	32-38	--	--	--
67+00 to 70+00	(IB)	Planned California Plaza	45	50 (Est.)	55	40-45	39-45	--	--	--
72+10 to 73+60	(IB)	Subway Terminal/VA Building	45	25 (Sta.)	45	40-45	37-45	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
72+20 to 73+90	(IB)	Clark Hotel	45	10 (Sta.)	45	45	47-53	25	38-44	33-39
74+00 to 75+30	(IB)	Commercial (3)	40	10 (Sta.)	45	50	51-57	25	42-48	37-43
75+50	(IB)	Theater	40	10 (Sta.)	45	35-40	51-57	60	42-48	37-43
75+70 to 76+70	(IB)	Pershing Square Building	35	10 (Sta.)	50	45	50-56	40	41-47	36-42
76+00 to 76+70	(IB)	401 Hill Street Building	35	25 (Sta.)	50	45	41-47	40	34-39	28-34
80+60 to 82+70	(IB)	International Jewelry Center	45	75	50	40	31-37	--	--	--
83+50 to 87+00	(IB)	Mixed Office/ Commercial (2)	55	0	50	45	44-50	50	35-41	31-37
83+80 to 85+50	(OB)	Mixed Office/ Commercial (1)	80	20	50	45	37-43	--	--	--

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
87+70 to 88+70 (OB)	Commercial (1)	75	0	50	50	38-44	--	--	--
88+30 to 93+30 (IB/OB)	Mixed Office/ Commercial (9)	65	0	50	45	41-47	20	32-38	28-34
94+20 to 95+20 (OB)	Wilshire Grand Building	55	20	50	45	50-56 (crossover)	80	NA	37-43
94+50 to 97+70 (IB)	Robinson's Dept. Store	55	20	50	50	50-56 (crossover)	60	NA	37-43
95+80 to 97+70 (OB)	Parson's Building	50	25	50	45	51-57 (crossover)	85	NA	38-44
98+60 to 99+70 (IB)	Hyatt Regency Hotel	50	30 (Sta.)	50	40	38-44	45	30-36	25-31
98+60 to 99+40 (OB)	Hong Kong Bank	50	15 (Sta.)	50	40-45	45-51	40	36-42	31-37
99+50 to 102+00 (OB)	Roosevelt Building	50	15 (Sta.)	45	45	44-50	40	35-41	30-36

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
						Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
100+80 to 102+00 (IB)	Broadway Plaza	50	30 (Sta.)	45	45	38-44	--	--	--
103+00 to 106+20 (IB)	Barker Bros.	55	15 (Sta.)	45	45-50	48-54	30	39-45	34-40
102+80 to 104+40 (OB)	Global Marine	50	15 (Sta.)	45	40-45	44-50	25	35-41	30-36
104+60 to 106+20 (OB)	Home Savings & Loan	55	15 (Sta.)	45	40-45	48-54	45	39-45	34-40
107+20 to 111+00 (OB)	Hilton Hotel	75	30	50	40	38-44	45	30-36	25-31
119+00 to 120+10 (IB)	Office** (2)	100	15	70	45-50	30-36	--	--	--
120+50 to 127+00 (IB/OB)	Mixed Office/ Commercial (6)	95	15	70	45-50	36-42	--	--	--
122+10 to 124+60 (OB)	Motel (2)	95	40	70	40	33-39	--	--	--

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Ground-Borne Noise in Nearest Occupied Areas of Building: Criterion for Allowable Noise Levels (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
127+00 to (IB/OB) 152+60	Mixed Office/ Commercial (37)	85	15	70	45-50	38-44	--	--	--
150+00 (IB)	Travelodge Motel	85	15	70	40	38-44	50	30-36	28-32
152+60 to (IB/OB) 156+70	Commercial (4)	65	0	60	45-50	42-48	--	--	--
158+80 (IB)	Commercial (1)	55	10	50	45-50	44-50	--	--	--
156+50 (IB/OB)	Mid Wilshire Conval. Hosp.	50	0	55	40	38-44	70	29-35	24-30
158+80 to (IB) 159+50	Commercial/ Office	50	0	50	45-50	46-52	25	37-43	32-38
164+50 (OB)	Commercial/ Office	50	20 (Sta.)	45	45-50	46-52	25	37-43	32-38
178+70 to (IB) 189+70	Office (5)	85 (Est.)	20	70	40-45	35-41	--	--	--
178+70 to (OB) 180+20	Art Gallery	85 (Est.)	50	70	40	34-40	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
182+10 to 186+10 (OB)	Commercial (2)	85 (Est.)	40	70	50	34-40	--	--	--
187+10 to 188+20 (OB)	Apartments	85 (Est.)	40	70	45	34-40	--	--	--
188+90 to 190+00 (OB)	Apartments	85 (Est.)	70	70	45	32-38	--	--	--
200+00 to 201+00 (OB)	Sheraton West Hotel	85 (Est.)	30	70	40	36-42	40	28-34	23-29
200+00 to 205+50 (IB/OB)	Commercial/ Office (6)	85 (Est.)	30	70	45-50	37-43	--	--	--
202+20 to 209+00 (OB)	Office (3)	85 (Est.)	30	70	40-45	35-41	--	--	--
206+80 to 209+50 (IB)	Bullock's Wilshire Dept. Store	70	40	55	50	35-41	--	--	--
209+50 to 212+50 (IB/OB)	Commercial (2)	55	20 (Sta.)	50	50	47-53	30	38-44	33-39

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

					Ground-Borne Noise in Nearest Occupied Areas of Building				
						Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
212+60 to 214+00 (IB)	Wilshire Shatto Building	50	20 (Sta.)	45	45	44-50	35	39-41	30-36
213+30 to 217+80 (IB/OB)	Commercial/ Office (3)	45	20 (Sta.)	45	45-50	47-53	30	38-44	33-39
216+50 to 217+70 (OB)	Bank of America	45	20 (Sta.)	45	40-45	44-50	35	39-41	30-36
218+70 to 220+00 (IB)	Chubb/Pacific Indemnity Tower	45	30	50	40-45	42-48	40	33-39	29-35
219+50 (OB)	Gas Station	50	35	55	55	43-49	--	--	--
220+10 to 221+50 (IB)	I. Magnin Dept. Store	45	30	60	50	44-50	--	--	--
222+50 to 223+70 (IB/OB)	Office (2)	50	30	65	45	43-49	40	34-40	30-36
224+00 to 230+00 (IB/OB)	Mixed Commercial/ Office (5)	60	30	70	45-50	43-49	35	34-40	30-36

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
						Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
226+70 to 227+90 (IB)	Immanuel Presbyterian Church	70	30	65	35	33-39	55	24-30	19-25
230+30 to 233+50 (IB/OB)	Mixed Commercial Office (3)	70	30	70	45-50	41-47	--	--	--
234+00 to 237+50 (IB)	Ambassador Hotel	75	400	60	35-40	<20 (Crossover)	--	--	--
235+00 to 236+60 (OB)	Gaylord Hotel	75	40	60	40	43-49 (Crossover)	115	NA	31-37
239+10 to 241+70 (OB)	Equitable Building	60	80 (Sta.)	50	40-45	27-33	--	--	--
239+80 to 240+60 (IB)	IBM Building	60	25 (Sta.)	45	40-45	43-49	35	35-41	30-36
241+50 to 245+70 (IB)	Tishman Building	60	60 (Sta.)	45	40-45	32-38	--	--	--
243+00 to 244+40 (OB)	Atlantic Richfield Building	60	25 (Sta.)	45	40-45	43-49	35	35-41	30-36

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
						Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
244+40 to 245+60 (IB)	Wilshire Christian Church	60	25 (Sta.)	45	35	37-44	45	29-35	24-30
246+50 to 247+50 (IB)	Glendale Federal Savings	75	30	55	40-45	35-41	--	--	--
248+00 to 249+10 (OB)	Wilshire-Hyatt Hotel	80	70	60	40	33-39	--	--	--
249+80 to 257+00 (IB/OB)	Office (4)	100	25	70	40-45	34-40	--	--	--
253+80 to 255+00 (OB)	St. Basil Catholic Church	90	90	70	35	22-28	--	--	--
259+30 to 260+40 (OB)	Wilshire Boulevard Temple	80	50	70	35	29-35	--	--	--
262+00 (IB)	Commercial/ Office (2)	70	20	65	45-50	42-48	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

						Ground-Borne Noise in Nearest Occupied Areas of Building				
							Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
262+80 to 264+50	(OB)	Office	60	40	60	45	39-45	--	--	--
265+00 to 268+00	(OB)	Ahmanson Plaza	55	60	55	40-45	35-41	--	--	--
265+00 to 268+00	(IB)	Beneficial Plaza	55	280	55	40-45	<20	--	--	--
260+80 to 270+30	(OB)	McKinley Bldg	45	20 (Sta.)	45	40-45	44-50	35	39-41	30-36
268+80 to 271+80	(IB)	Wiltern Theater	45	20 (Sta.)	45	35	44-50	60	39-41	30-36
270+30 to 271+80	(OB)	Commercial	45	20 (Sta.)	45	50	44-50	--	--	--
272+70 to 274+00	(IB)	Union Bank	45	30	50	40-45	42-48	40	33-39	29-35
272+70 to 273+80	(OB)	Pierce Nat'l Life Bldg.	45	25	50	40-45	42-48	40	33-39	29-35

TABLE 8 (CONTINUED)

						Ground-Borne Noise in Nearest Occupied Areas of Building			
						Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
274+60 to 276+80 (IB)	Commercial (2)	45	25	60	50	44-50	--	--	--
276+40 to 277+80 (OB)	Christ Church	45	110	65	35	24-30	--	--	--
277+50 to 279+20 (OB)	Wilshire Professional Bldg.	45	40	70	40-45	43-49	75	35-41	31-37
277+50 to 279+80 (IB)	Commercial/ Office (7)	45	25	70	45-50	50-56	50	41-47	37-43
279+90 to 282+40 (OB)	St. James Episcopal Church/School	40	40	70	35-40	40-46	90	32-38	28-34
279+80 to 295+70 (IB/OB)	Commercial/ Office (10)	40	25	70	45-50	50-56	55	41-47	37-43
281+20 to 295+70 (IB/OB)	Commercial/ Office (11)	40	40	70	45-50	47-53	55	38-44	34-40
292+40 to 294+20 (IB)	Office	45	25	70	40-45	46-52	60	37-43	33-39

WILSON, IHRIG & ASSOCIATES, INC. 1982e

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Ground-Borne Noise in Nearest Occupied Areas of Building: Criterion for Allowable Noise Levels (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
295+50 to 296+30 (OB)	Perinos Restaurant	50	40	70	45	43-49	60	34-40	30-36
296+30 to 297+60 (OB)	Los Altos Apartments	50	40	70	40	42-48	80	34-40	30-36
296+90 to 298+20 (IB)	Theater of Arts	55	25	70	35	46-52	100	37-43	33-39
301+40 to 304+60 (OB)	Swett & Crawford Group Bldg.	60	40	70	40	40-46	75	32-38	28-34
301+30 to 304+00 (IB)	Commercial (2)	55	30	70	50	46-52	35	37-43	33-39
306+50 to 309+00 (IB)	Commercial/ Office (3)	45	25	70	45-50	49-55	50	39-45	36-42
309+60 to 311+10 (OB)	Aames Home Loan	45	40	70	40-45	45-51	65	36-42	32-38
310+00 to 311+10 (IB)	Wilshire Dunes Motel	45	25	70	45	49-55	65	39-45	36-42

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
311+90 to 312+90 (OB)	Great Western Savings	45	50	70	40-45	43-49	60	34-40	30-36
314+00 to 316+90 (OB)	Scottish Rite Temple	45	50	70	35	36-42	80	28-34	24-30
314+10 to 315+20 (IB)	Wilshire United Methodist Church	45	30	70	35	40-46	85	32-38	28-34
318+40 to 319+80 (OB)	Office	45	50	70	40-45	43-49	60	34-40	30-36
318+60 to 320+00 (IB)	Wishire Ebell Theater	45	250	70	35	<20	--	--	--
320+00 to 324+50 (IB)	Apartments (2)	45	30	70	40	47-53	90	38-44	34-40
323+20 to 324+00 (OB)	Office	50	50	70	40-45	41-47	60	32-38	28-34
324+20 to 326+70 (OB)	Apartment	50	50	70	40	42-48	90	34-40	30-36

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
329+40	(IB)	Office	50	30	70	40-45	46-52	60	37-43	33-39
329+30 to 336+60	(OB)	Residential (3)	45	180	70	35	<20	--	--	--
339+10 to 340+30	(IB)	Farmers Insurance Building	45	40	70	40-45	45-51	65	36-42	32-38
338+80 to 341+30	(OB)	Residential (2)	50	120	70	35	24-30	--	--	--
342+60 to 344+20	(OB)	Office	55	50	70	40-45	42-48	60	33-39	29-35
346+80 to 352+00	(OB)	Residential (2)	60	150	70	35	18-24	--	--	--
353+80	(IB)	Residential (1)	55	40	70	35	37-43	85	29-35	25-31
354+70 to 355+60	(IB)	Leona School	50	40	70	40	38-44	65	30-36	26-32
359+00	(OB)	Residential (1)	45	150	70	35	19-25	--	--	--
357+00 to 360+70	(IB)	Office	45	60	70	40-45	42-48	60	33-39	29-35

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
360+00 to 361+50 (OB)	Imperial Savings	40	60	70	40-45	41-47	65	32-38	28-34
362+00 to 363+00 (IB/OB)	Commercial/ Office (3)	45	40	70	45-50	46-52	45	37-43	33-39
363+00 to 365+00 (IB/OB)	Commercial/ Office (3)	50	25	70	45-50	56-62 (crossover)	85	NA	44-50
366+00 to 367+10 (OB)	Office	50	30	70	40-45	45-51	60	36-42	32-38
366+50 to 370+50 (IB/OB)	Commercial/ Office (4)	50	25	65	45-50	46-52	40	37-43	33-39
372+50 to 373+50 (IB)	Time Oil Bldg.	55	40	55	40-55	46-52 (crossover)	90	NA	37-43
372+50 to 374+00 (OB)	Lou Ehler Cadillac	55	25	50	50	43-49	--	--	--
375+70 to 378+20 (OB)	Mutual of Omaha	55	10 (Sta.)	45	40-45	49-55	35	39-45	35-41
377+50 to 378+50 (IB)	Southwest Savings	55	35	45	40-45	42-48	35	33-39	29-35

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
							Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
379+70	(OB)	Commercial (1)	50	20	50	50	44-50	--	--	--
380+00	(IB)	Bank of Amer.	50	35	50	40-45	43-49	55	34-40	30-36
380+90 to 381+90	(IB)	Commercial (1)	50	35	60	50	44-50	--	--	--
382+40 to 385+00	(OB)	Commercial (4)	50	20	65	50	46-52	40	37-43	33-39
383+00 to 385+30	(IB)	Commercial	50	35	65	50	43-49	--	--	--
385+70 to 393+80	(OB)	Commercial/ Office (8)	50	20	70	45-50	47-53	45	38-44	34-40
385+60 to 387+80	(IB)	Dominguez Wilshire Bldg.	50	35	70	45-50	44-50	--	--	--
393+60	(OB)	El Rey Theater	60	20	70	35	44-50	100	35-41	30-36
393+80 to 400+00	(OB)	Commerical/ Office (6)	60	50	70	45-50	41-47	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to *Top-of* Rail (ft)	Horizontal Distance from Tunnel ℄ to *Nearest* Building (ft)	Maximum *Train* Speed (mph)	Criterion for Allowable *Noise* Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted *Noise* Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for *Criterion* Compliance (ft)	Resiliently Supported Ties — Predicted *Noise* Levels (dBA)	Floating Slab Trackbed — Predicted *Noise* Levels (dBA)
400+00 to 402+50 (IB)	Commercial/ Office (3)	50	50	70	45-50	42-48	--	--	--
402+50 to 404+90 (IB)	Office (1)	50	100	65	40-45	31-37	--	--	--
403+00 to 405+00 (IB)	Commercial (1)	50	20	65	50	46-52	40	37-43	33-39
405+00 to 407+00 (IB)	Prudential Building	50	25	60	40-45	43-49	50	35-41	31-37
407+00 to 409+00 (IB)	Prudential Building	50	80	55	40-45	32-38	--	--	--
409+00 to 411+00 (IB)	Prudential Building	50	25 (Sta.)	45	40-45	41-47	30	33-39	28-34
407+00 to 408+50 (IB)	Commercial/ Office (1)	50	40	55	45-50	41-47 (crossover)	--	--	--
410+00 to 418+50 (IB)	Commercial/ Office (4)	45	30 (Sta.)	45	45-50	41-47	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
415+50 to 416+50	(IB)	Commercial/ Office (1)	40	40	50	45-50	44-50	--	--	--
418+80 to 424+30	(IB)	L.A. County Art Museum	45	150	55	40	<20	--	--	--
421+30 to 424+50	(IB)	Mutual Benefit Life Ins. Plaza	50	50	55	40-45	39-45	--	--	--
425+00 to 426+90	(IB)	Office (2)	50	120	55	40-45	27-33	--	--	--
426+50 to 428+50	(IB)	Commercial (1)	50	0	55	50	44-50	--	--	--
428+50 to 431+90	(IB)	May Company Dept. Store	55	10	55	50	43-40	--	--	--
433+80 to 435+00	(IB)	Commercial (3)	60	60	55	50	36-42	--	--	--
435+50 to 439+50	(IB)	Commercial (6)	60	10	55	50	43-49	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
437+20 to 440+00	(OB)	Apartments (9)	75	30	55	40	37-43	55	29-35	24-30
439+50 to 443+10	(IB)	Commercial (5)	60	10	60	50	44-50	--	--	--
443+00 to 444+50	(IB)	Guardian Convalescent Hospital	60	15	65	40	44-50	80	36-42	31-37
440+10 to 443+30	(OO)	Apartments (7)	75	30	60	40	38-44	65	30-36	25-31
443+10 to 461+50	(IB)	Commercial (23)	65	10	70	50	44-50	--	--	--
443+20 to 450+00	(OB)	Apartments (7)	75	30	70	40	39-45	75	31-37	26-32
450+80 to 453+30	(OB)	Hancock Park School	75	50	70	40	37-43	75	29-35	24-30
453+70 to 459+00	(OB)	Commercial (3)	75	30	70	50	39-45	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
460+50 to 461+50	(OB)	Farmer's Market (6)	70	70	65	50	34-40	--	--	--
461+50 to 466+20	(OB)	Farmer's Market (6)	60	0	60	50	44-50	--	--	--
461+50 to 465+40	(IB)	Commercial (4)	65	10	60	50	42-48	--	--	--
466+00 to 468+50	(IB)	Farmer's Daughter Motel	50	80	55	45	34-40	--	--	--
468+50 to 471+50	(IB)	Commercial (3)	50	110	50	50	27-33	--	--	--
468+50 to 470+90	(OB)	CBS Television City	45	160	50	25	18-24	--	--	--
470+90 to 472+30	(OB)	CBS Television City	45	150 (Sta.)	45	25	14-20	--	--	--
471+50 to 474+60	(IB)	American Savings and Crocker Banks	45	100 (Sta.)	45	40-45	24-30	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

						Ground-Borne Noise in Nearest Occupied Areas of Building				
							Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
477+60 to 479+50	(IB)	Commercial (3)	50	60	55	50	37-43	--	--	--
478+10 to 479+30	(OB)	Great Western Savings Bank	50	0	55	40-45	47-53	55	37-43	32-38
477+80 to 479+50	(IB)	Fairfax Movie Theater	50	100	60	35	28-34	--	--	--
479+30 to 491+10	(OB)	Commercial (18)	45	30	70	50	47-53	50	38-44	34-40
480+70 to 496+50	(IB)	Commercial (26)	45	15	70	50	51-57	50	42-48	37-43
497+00	(IB)	King Solomon Home for the Elderly	35	15	70	40	53-59	100	44-50	39-45
496+70 to 501+00	(OB)	Fairfax High School	35	140	70	40	27-33	--	--	--
470+40 to 515+30	(IB)	Commercial/ Office (21)	35	15	70	50	53-59	50	44-50	39-45
505+10 to 523+20	(OB)	Commercial/ Office (12)	35	60	70	45-50	42-48	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
515+70	(IB)	Country Villa Wilshire Convalescent Hosp.	35	10	70	40	55-61	100	46-52	41-47
516+70 to 520+60	(IB)	Mixed Comm./ Resid. (10)	35	10	70	40-45	55-61	60	46-52	41-47
520+60 to 522+10	(IB)	Garden of Palms Rest Home	35	10	70	40	55-61	95	46-52	41-47
522+30 to 524+50	(IB)	Commercial (3)	35	10	65	50	54-60	50	45-51	40-46
523+20 to 524+50	(OB)	Commercial (2)	35	60	65	50	42-48	--	--	--
524+50 to 526+00	(IB)	Apartments (3)	40	10	60	40	60-66 (crossover)	130	NA	46-52
524+50 to 526+00	(OB)	Commercial (3)	40	60	60	50	49-55 (crossover)	85	NA	37-43
526+00 to 528+00	(IB)	Commercial (2)	45	20	55	50	47-53	40	37-43	32-38
526+00 to 528+00	(OB)	Commercial (4)	45	60	55	50	38-44	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 8 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
528+00 to 529+30 (IB)	Commercial (1)	50	10	50	50	46-52	25	37-43	32-38
528+00 to 529+30 (OB)	Commercial (1)	50	60	50	50	36-42	--	--	--
530+80 to 534+50 (IB)	Mixed Comm./Resid. (4)	55	10 (Sta.)	45	45- 50	51-57	25	42-48	37-43
532+10 to 534+00 (OB)	Commercial (4)	55	15 (Sta.)	45	50	48-54	25	39-45	34-40
534+00 to 535+00 (OB)	Fairfax Tower Elderly Housing	60 (Sta.)	50	45	40	34-40	--	--	--
534+50 to 535+00 (IB)	Apartment (1)	60	15 (Sta.)	45	40	48-54	50	39-45	34-40

(OB) = Out-bound
(IB) = In-bound
(N)* = Number of Buildings ±10%
** = Adjacent to freeway (<300' away)

TABLE 9 GROUND-BORNE NOISE PROJECTIONS FOR THE METRO RAIL SYSTEM SUBWAY (ALTERNATIVE A)

							Ground-Borne Noise in Nearest Occupied Areas of Building			
							Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
535+00 to 537+50	(IB)	Mixed Comm./Resid. (5)	30	10	70	45-50	55-61	60	46-52	41-47
535+00 to 537+50	(OB)	Commercial (3)	30	60	70	50	44-50	--	--	--
537+50 to 539+00	(IB)	Apartments (6)	35	10	65	40	63-69 (crossover)	135	NA	49-55
537+50 to 539+50	(OB)	Commercial (3)	35	60	65	50	50-56 (crossover)	90	NA	37-43
539+00 to 540+70	(IB)	Garden of Palms Rest Home	35	10	65	40	63-69 (crossover)	135	NA	49-55
541+00 to 543+00	(IB)	Apartments (7)	40	10	60	40	60-66 (crossover)	130	NA	47-52
541+00 to 543+00	(OB)	Commercial (3)	40	60	60	50	49-55 (crossover)	80	NA	37-43
543+50 to 548+30	(IB)	Commercial (2)	45	10 (Sta.)	45	50	51-57	25	41-47	37-43

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Ground-Borne Noise in Nearest Occupied Areas of Building: Criterion for Allowable Noise Levels (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
542+50 to 547+80	(OB)	Commercial (4)	45	50 (Sta.)	45	50	35-41	--	--	--
548+80 to 551+10	(IB)	Commercial (5)	60	10	55	50	43-49	--	--	--
550+20 to 552+00	(OB)	Commercial (4)	60	60	55	50	35-41	--	--	--
551+70 to 554+90	(IB)	Mixed Comm./Resid. (7)	65	10	60	45-50	43-49	--	--	--
552+10 to 553+10	(OB)	Fairfax Tower Elderly Housing	65	60	60	40	36-42	65	27-33	23-29
553+10 to 554+90	(OB)	Apartments (4)	70	60	60	40	35-41	65	26-32	22-28
555+00 to 556+60	(IB)	Apartments (4)	75	10	70	40	40-46	60	32-38	28-34
555+10 to 558+50	(OB)	Residential (11)	70	60	70	35-40	36-42	70	27-33	23-29

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
556+60 to 559+70 (IB)	St. Ambrose School	85	10	65	40	37-43	65	28-34	24-30
558+60 to 560+40 (OB)	Apartments (4)	85	60	65	40	34-40	--	--	--
561+10 to 564+20 (IB)	Residential (7)	90	10	55	35-40	35-41	60	26-32	22-28
561+50 to 564+30 (OB)	Residential (6)	90	60	55	35-40	30-36	--	--	--
564+50 to 566+50 (IB)	Apartments (3)	100	20	50	40	31-37	--	--	--
564+70 to 567+00 (IB)	Residential (2)	100	20	50	35-40	31-37	--	--	--
567+00 to 574+00 (IB/OB)	Residential (8)	100	0	50	35-40	31-37	--	--	--
575+00 to 576+00 (IB/OB)	Commercial (1)	110	0	50	50	29-35	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
577+00 to 578+00 (IB)	Apartments (2)	110	0	50	40	29-35	--	--	--
579+00 to 580+20 (OB)	Commercial (1)	110	20	50	50	29-35	--	--	--
580+80 to 582+00 (IB)	Commercial (1)	110	20	55	50	30-36	--	--	--
581+10 to 582+00 (OB)	Residential (1)	110	50	55	35-40	29-34	--	--	--
582+20 to 583+50 (IB/OB)	Commercial (2)	100	40	60	50	30-37	--	--	--
584+20 to 587+50 (IB/OB)	Commercial (9)	95	20	60	50	34-40	--	--	--
587+50 to 592+00 (IB/OB)	Mixed Resid./Comm. (9)	90	20	70	45-50	36-42	--	--	--
592+00 to 595+00 (IB)	Mixed Resid./Comm. (5)	80	20	70	45-50	39-45	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
							Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
592+00 to 595+00	(OB)	Mixed Resid./Comm. (5)	80	40	70	45-50	37-43	--	--	--
595+00 to 598+50	(IB)	Commercial (2)	70	20	70	50	42-48	--	--	--
595+00 to 598+50	(OB)	Commercial (3)	70	40	70	50	39-45	--	--	--
598+50 to 601+00	(IB)	Commercial (3)	60	20	70	50	44-50	--	--	--
598+50 to 601+00	(OB)	Commercial (4)	60	40	70	50	42-48	35	--	--
601+00 to 612+00	(IB)	Commercial (5)	55	20	70	50	45-51	35	36-42	32-38
601+00 to 612+00	(OB)	Commercial (10)	55	40	70	50	42-48	--	--	--
612+00 to 614+30	(IB)	Commercial (3)	50	20	70	50	47-53	40	38-44	34-40

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

							Ground-Borne Noise in Nearest Occupied Areas of Building			
							Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
612+00 to 614+00	(OB)	Commercial (1)	50	40	70	50	44-50	--	--	--
614+00 to 618+50	(IB)	Commercial (5)	50	20	65	50	46-52	40	37-43	33-39
615+00 to 618+50	(OB)	Commercial (4)	50	40	65	50	42-48	--	--	--
619+20 to 621+00	(IB)	Commercial (2)	45	30	55	50	45-51	40	36-42	32-38
610+50 to 621+00	(OB)	Commercial (3)	45	40	55	50	43-49	--	--	--
621+00 to 625+50	(IB)	Commercial (4)	45	20 (Sta.)	45	50	46-52	25	37-43	32-38
621+00 to 625+50	(OB)	Commercial (2)	45	20 (Sta.)	45	50	46-52	25	37-43	32-38
625+50 to 629+00	(IB)	Commercial (6)	45	20	55	50	47-53	40	37-43	32-38

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

						Ground-Borne Noise in Nearest Occupied Areas of Building				
							Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
625+50 to 629+00	(OB)	Commercial (2)	45	40	55	50	43-49	--	--	--
632+00 to 638+50	(IB)	Hollywood High School	35	70	70	40	39-45	95	30-36	26-32
630+20 to 632+00	(OB)	Commercial (3)	35	40	65	50	46-52	55	37-43	33-39
632+00 to 652+50	(OB)	Mixed Comm./Resid. (15)	35	40	70	45-50	47-53	55	38-44	34-40
638+50 to 650+30	(IB)	Commercial (9)	35	20	70	50	53-59	50	44-50	39-45
650+30 to 652+70	(IB)	Blessed Sacrament School	35	20	70	40	53-59	100	44-50	39-45
652+50 to 656+20	(OB)	Mixed Comm./Resid. (7)	35	40	65	45-50	47-53	50	38-44	33-39
655+00 to 657+20	(IB)	Commercial (2)	35	20	60	50	51-57	45	43-49	38-44

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure ([illegible])*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
656+60 to 659+20 (OB)	Commercial (6)	30	40	50	50	46-52	45	37-43	32-38
657+30 to 658+50 (IB)	Commercial (2)	30	10	50	50	55-61	45	46-52	41-47
659+20 to 676+00 (IB/OB)	Commercial (15)	30	0	50	50	55-61	45	46-52	41-47
676+00 to 681+30 (IB)	Commercial (1)	35	70 (Sta.)	45	50	29-35	--	--	--
681+30 to 685+00 (IB/OB)	Commercial (9)	40	0	55	50	53-59	45	44-50	40-46
687+40 to 692+00 (IB/OB)	Commercial (6)	45	0	60	50	51-57	40	43-49	38-44
(Note: Station Equation here 698+40BK = 695+00 AHD)									
692+50 to 698+00 (IB/OB)	Residential (20)	70•	0	70	35-40	42-48	80	33-39	29-35

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building			
						Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
						Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
698+00 to (IB/OB) 699+00	Residential** (4)	85	0	70	40	34-40	--	--	--
699+00 to (IB) 700+00	Residential** (2)	100	0	70	40	29-35	--	--	--
700+00 to (IB/OB) 709+00	Residential** (15)	>120	0	70	40	<30	--	--	--
722+50 to (IO) 726+50	Hollywood Bowl Band Shell	65	250	70	35	<25	--	--	--
738+00 to (IB/OB) 819+00	Residential (approx. 75)	>120	0	70	35	<30	--	--	--
819+00 to (IB/OB) 823+00	Residential (6)	110	0	70	35-40	27-33	--	--	--
823+00 to (IB/OB) 830+00	Commercial** (3)	95	0	70	50-55	37-43	--	--	--
830+00 to (OB) 831+00	Restaurant (1)	90	0	70	45-50	37-43	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 GROUND-BORNE NOISE PROJECTIONS FOR THE METRO RAIL SYSTEM SUBWAY ALTERNATIVE A (NORTH HOLLYWOOD)

						Ground-Borne Noise in Nearest Occupied Areas of Building			
						Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
838+80 to 842+50 (OB)	Commercial (3)	65	0	70	50	44-50	--	--	--
847+70 to 848+50 (IB)	Commercial (4)	50	100	70	50	39-45 (crossover)	--	--	--
863+60 to 864+00 (IB/OB)	Residential (2)	50	0	50	35-40	46-52	75	43	32-38
867+30 to 868+30 (IB/OB)	Residential (3)	65	0	60	35-40	42-48	70	34-40	29-35
876+70 to 878+00 (OB)	Howard Johnson's Motel	80	100	60	45	27-33	--	--	--
887+40 to 888+80 (OB)	Rio Vista School**	75	100	70	40	30-36	--	--	--
890+00 (OB)	Residential (1)	70	40	70	35-40	39-45	80	31-37	26-32
890+30 to 895+05 (OB)	Residential (3)	60	50	70	35-40	39-45	85	31-37	26-32

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
901+40 to 903+50	(IB)	Office (1)	65	50	70	40	37-43	80	29-35	24-30
911+20 to 914+00	(IB)	Residential (4)	60	90	70	35-40	29-35	--	--	--
910+80	(OB)	Residential** (1)	60	50	70	40-45	34-40	--	--	--
911+00 to 921+90	(OB)	Mixed Comm./Apts. (12)	55	30	70	45-50	45-51	35	36-42	31-37
914+00 to 920+40	(IB)	Residential (4)	55	90	70	35-40	34-40	--	--	--
921+20 to 922+80	(IB)	Office (1)	50	90	70	40	33-39	--	--	--
925+50 to 950+00	(OB)	Mixed Comm./Resid. (38)	40	30	70	45-50	49-55	50	40-46	35-41
934+60 to 936+10	(IB)	Residential (2)	35	80	70	35-40	37-44	100	29-35	25-31

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 9 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
937+50 to 946+00	(IB)	Residential (5)	35	80	70	35-40	37-44	100	29-35	25-31
957+40 to 958+80	(IB)	Commercial (1)	45	30	50	50	42-48	—	—	—
988+80 to 995+50	(OB)	Mixed Comm./Resid. (7)	35	120	65	45-50	28-34	—	—	—
995+90 to 1000+60	(OB)	Mixed Comm./Resid. (16)	20	60	70	45-50	44-50	—	—	—

(OB) = Out-bound
(IB) = In-bound
(N)* = Number of Buildings ±10%
** = Adjacent to freeway (<300' away)

TABLE 10 GROUND-BORNE NOISE PROJECTIONS FOR THE METRO RAIL SYSTEM SUBWAY (ALTERNATIVE B)

						Ground-Borne Noise in Nearest Occupied Areas of Building			
						Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
535+00 to 537+00 (IB)	Mixed Comm/Resid (5)	30	10	70	45-50	55-61	60	46-52	41-47
535+00 to 537+00 (OB)	Commercial (3)	30	60	70	50	44-50	--	--	--
537+00 to 539+00 (IB)	Apartments (3)	35	10	65	40	63-69 (crossover)	135	NA	49-55
537+00 to 540+00 (OB)	Commercial (3)	35	60	65	50	50-56 (crossover)	90	NA	37-43
539+00 to 540+20 (IB)	Garden of Palms Rest Home	35	10	65	40	63-69 (crossover)	135	NA	49-55
540+50 to 542+50 (IB)	Apartments (4)	40	10	60	40	60-66 (crossover)	130	NA	47-52
540+50 to 542+50 (OB)	Commercial (3)	40	60	60	50	49-55 (crossover)	80	NA	37-43
542+50 to 547+80 (IB)	Mixed Comm/Resid (3)	45	10 (Sta.)	45	45-50	51-57	25	41-47	37-43

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 10 (CONTINUED)

					Ground-Borne Noise in Nearest Occupied Areas of Building					
						Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
542+50 to 547+80 (OB)	Commercial (4)	45	50 (Sta.)	45	50	35-41	--	--	--
548+80 to 551+10 (IB)	Commercial (5)	60	10	55	50	43-49	--	--	--
550+20 to 552+00 (OB)	Commercial (4)	60	60	55	50	35-41	--	--	--
551+70 to 554+90 (IB)	Mixed Comm/Resid (5)	60	10	60	45-50	43-49	--	--	--
552+10 to 553+10 (OB)	Fairfax Tower Elderly Housing	60	60	60	40	37-43	75	28-34	24-30
553+10 to 554+90 (OB)	Apartments (4)	60	60	60	40	37-43	75	28-34	24-30
555+00 to 556+60 (IB)	Apartments (4)	60	10	70	40	45-51	85	37-43	32-38
555+10 to 558+50 (OB)	Residential (11)	65	60	70	35-40	37-43	80	28-34	24-30

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 10 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
556+60 to 559+70	(IB)	St. Ambrose School	65	10	70	40	44-50	80	35-41	30-36
558+60 to 560+40	(OB)	Apartments (4)	70	60	70	40	37-43	80	29-35	24-30
561+10 to 564+20	(IO)	Residential (5)	80	30	70	35-40	38-44	70	30-36	25-31
561+50 to 564+30	(OO)	Residential (6)	80	30	70	35-40	38-44	70	30-36	25-31
564+40 to 566+50	(IO)	Apartments (3)	90	30	70	40	36-42	55	27-33	23-29
564+50 to 566+40	(OO)	Residential (4)	90	30	70	35-40	36-42	55	27-33	23-29
564+50 to 566+40	(OB)	Residential (4)	90	30	70	36-40	36-42	55	27-33	23-29
566+60 to 568+10	(IO)	Apartments (3)	100	30	70	40	33-39	--	--	--
566+50 to 567+90	(OB)	Residential (3)	100	30	70	35-40	33-39	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 10 (CONTINUED)

					Ground-Borne Noise in Nearest Occupied Areas of Building				
						Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
568+20 to 569+50 (IB)	Apartments (2)	110	30	70	40	31-37	--	--	--
568+20 to 571+60 (OB)	Apartments (6)	110	30	70	40	31-37	--	--	--
571+50 TO 575+10 (IB)	Commercial (2)	110	30	70	50	30-36	--	--	--
571+70 to 575+20 (OB)	Commercial (1)	110	30	70	50	30-36	--	--	--
575+40 to 579+80 (OB)	Residential (8)	120	40	70	35-40	29-35	--	--	--
576+50 to 579+80 (IB)	Residential (6)	120	40	70	35-40	29-35	--	--	--
580+30 to 723+00 (IB/OB)	Residential (approx. 115)	>120	0	70	35	<30	--	--	--
723+00 to 725+50 (IB/OB)	Residential (9)	100	0	70	35	29-35	--	--	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 10 (CONTINUED)

					Ground-Borne Noise in Nearest Occupied Areas of Building				
						Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
725+50 to (IB/OB) 726+50	Residential** (4)	75	0	70	40	42-48 (crossover)	80	NA	30-36
726+50 to (IB/OB) 727+50	Residential** (6)	50	0	60	40	51-57 (crossover)	100	NA	37-43
ALTERNATIVE B-LANKERSHIM									
773+00 to (IB/OB) 774+00	Residential (2)	100	0	65	35	20-34	--	--	--
774+00 to (IB/OB) 776+00	Residential (9)	85	0	65	35	33-39	45	24-30	19-25
776+00 to (IB/OB) 778+50	Residential (8)	70	0	70	35-40	42-48	70	34-40	29-35
778+50 to (IB/OB) 779+20	Mixed** Comm/Resid (3)	60	0	70	45-50	45-51	25	37-43	32-38

(OB) = Out-bound
(IB) = In-bound
(N)* = Number of Buildings ±10%
** = Adjacent to freeway (<300' away)

TABLE 11 GROUND-BORNE NOISE PROJECTIONS FOR THE METRO RAIL SYSTEM SUBWAY (ALTERNATIVE C)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
535+00 to 537+00	(IB)	Mixed Comm./Resid. (5)	30	10	70	45-50	55-61	60	46-52	41-47
535+00 to 537+00	(OB)	Commercial (3)	35	60	70	50	42-48	--	--	--
537+00 to 539+00	(IB)	Apartments (2)	35	10	65	45	54-60	75	46-52	40-46
537+00 to 539+00	(OB)	Commercial (3)	35	60	65	50	41-47	--	--	--
539+00 to 540+20	(IB)	Garden of Palms Rest Home	35	10	65	40	63-69 (crossover)	135	NA	49-55
539+00 to 540+00	(OB)	Commercial (1)	35	60	65	50	50-56 (crossover)	90	NA	37-43
540+50 to 544+50	(IB)	Apartments (5)	40	10	55	40	59-65 (crossover)	125	NA	46-51
540+50 to 544+50	(OB)	Commercial (2)	40	60	55	50	48-54 (crossover)	75	NA	36-42

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 11 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
						Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
544+50 to 547+80 (IB)	Commercial (2)	60	10 (Sta.)	45	50	51-57	25	41-47	37-43
544+50 to 547+80 (OB)	Commercial (4)	60	50 (Sta.)	45	50	35-41	--	--	--
548+80 to 551+10 (IB)	Commercial (5)	60	10	50	50	42-48	--	--	--
550+20 to 551+50 (OB)	Commercial (1)	70	20	50	50	39-45	--	--	--
551+70 to 552+70 (IB)	Apartments (10)	70	80	50	40	30-36	--	--	--
552+10 to 553+30 (OB)	Fairfax Tower Elderly Housing	70	0	50	40	39-45	55	31-37	26-32
553+30 to 555+50 (IB/OB)	Residential (7)	70	0	50	35-40	39-45	55	31-37	26-32
555+50 to 557+50 (IB/OB)	Residential (8)	75	0	50	35-40	38-44	50	30-36	25-31

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 11 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
557+50 to (IB/OB) 565+00	Residential (16)	80	0	50	35-40	36-42	45	28-34	23-29
565+00 to (IB) 571+00	Residential (6)	75	10	60	35-40	39-45	60	31-37	27-33
565+00 to (OB) 571+00	Residential (8)	75	30	60	35-40	38-44	60	30-36	26-32
571+00 to (IB) 575+50	Residential (13)	70	10	65	35-40	41-47	70	33-39	29-35
571+00 to (OB) 575+50	Residential (9)	70	30	65	35-40	40-46	70	32-38	28-34
575+50 to (IB) 585+50	Residential (15)	60	10	70	35-40	45-51	80	36-42	32-38
575+50 to (OB) 585+50	Residential (18)	60	30	70	35-40	41-47	80	32-38	28-34
586+00 to (IB) 588+50	Residential (3)	50	30	65	35-40	44-50	90	35-41	31-37

TABLE 11 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
589+00 to 591+00 (IB)	Residential (5)	45	10	55	35-40	49-55	75	40-46	35-41
591+00 to 594+50 (IB)	Residential (5)	40	0	55	35-40	51-57	80	42-48	37-43
591+00 to 594+50 (OB)	Residential (6)	40	30	55	35-40	47-53	80	38-44	33-39
594+50 to 600+00 (IB/OB)	Residential (8)	35	0	55	35-40	53-59	85	44-50	39-45
594+50 to 600+00 (IB/OB)	Residential (3)	35	30	55	35-40	49-55	85	40-46	35-41
600+00 to 612+60 (IB/OB)	Residential (19)	30		55	35-40	56-62	85	47-53	42-48
600+00 to 612+60 (IB/OB)	Residential (31)	30	30	55	35-40	51-57	85	42-48	37-43
613+50 to 617+50 (IB/OB)	Mixed Comm./Resid. (10)	30	0	55	45-50	56-62	85	47-53	41-47

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 11 (CONTINUED)

Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners — Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners — Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties — Predicted Noise Levels (dBA)	Floating Slab Trackbed — Predicted Noise Levels (dBA)
618+20 to 619+30 (OB)	Commercial (1)	40	50 (Sta.)	45	50	35-41	--	--	--
620+00 to 621+20 (IB)	Apartment (1)	45	40 (Sta.)	45	50	38-44	--	--	--
622+00 to 622+60 (IB)	Theater	45	10 (Sta.)	45	35	51-57	70	41-47	37-43
623+30 to 625+80 (IB/OB)	Commercial (2)	50	0	55	50	47-53	40	38-44	33-39
626+00 to 627+00 (OB)	Commercial/ Office (3)	55	20	55	45-50	43-49	--	--	--
628+20 to 629+00 (IB)	Apartment (1)	60	30	60	45	42-48	45	34-40	29-35
627+00 to 630+10 (OB)	Mixed Comm./Resid. (3)	65	10	60	45-50	42-48	--	--	--
630+20 to 632+50 (IB/OB)	Apartment (5)	70	20	65	40	41-47	70	33-39	28-34

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 11 (CONTINUED)

						Ground-Borne Noise in Nearest Occupied Areas of Building			
						Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment	Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
632+50 to 634+00 (OB)	Apartment (3)	75	20	65	40	40-46	65	32-38	27-33
635+00 to 636+00 (OB)	Apartment (2)	80	30	70	40	38-44	60	30-36	25-31
636+00 to 638+00 (IB/OB)	Residential (4)	95	10	70	35-40	36-42	30	32-38	23-29
638+20 to 640+00 (IB/OB)	Apartment (2)	120	0	70	40	29-35	--	--	--
640+00 to 740+00 (IB/OB)	Residential (approx. 55)	>150	0	70	35	<30	--	--	--

(OB) = Out-bound
(IB) = In-bound
(N)* = Number of Buildings ±10%

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 12 GROUND-BORNE NOISE PROJECTIONS FOR THE METRO RAIL SYSTEM SUBWAY LANKERSHIM ALTERNATIVE (NORTH HOLLYWOOD)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Ground-Borne Noise in Nearest Occupied Areas of Building: Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
Continuation of ALT. A:										
760+00 to 763+20	(IB/OB)	Residential (3)	85	0	60	35-40	37-43	45	28-34	24-30
763+20 to 770+00	(IB/OB)	Residential (6)	70	0	50	35-40	34-40	--	--	--
770+00 to 778+50	(IB/OB)	Residential (5)	60	0	50	35-40	37-43	35	28-34	24-30
ALT. C:										
773+50 to 774+70	(IB/OB)	Residential (3)	105	0	70	35-40	29-35	--	--	--
775+50 to 777+70	(IB/OB)	Residential (4)	70	0	70	35-40	37-43	40	28-34	24-30
778+80 to 779+60	(IB)	Commercial** (1)	65	0	65	55	44-50	--	--	--
789+40 to 792+00	(IB)	Residential (4)	55	10	50	40	44-50	75	35-41	31-3[illegible]

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 12 (CONTINUED)

							Ground-Borne Noise in Nearest Occupied Areas of Building			
							Standard Invert with Resilient D.F. Rail Fasteners		Resiliently Supported Ties	Floating Slab Trackbed
Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Noise Levels (dBA)	Predicted Noise Level (dBA)	Distance Required for Criterion Compliance (ft)	Predicted Noise Levels (dBA)	Predicted Noise Levels (dBA)
789+80 to 791+40	(OB)	Hewlett Packard Building	55	10	50	40	42-48	70	33-39	29-35
797+50 to 800+30	(IB/OB)	Hotel (1)	35	0	55	40	51-57	85	42-48	37-43
799+50 to 800+50	(OB)	Technicolor Corp. Building	35	175	55	35-45	<20	--	--	--
800+50 to 864+50	(OB)	Commercial (40)	40	30	70	50	49-55	50	40-46	35-41
800+50 to 824+20	(IB)	Commercial (12)	40	30	70	50	49-55	50	40-46	35-41
827+20 to 829+50	(IB)	Office (1)	40	30	70	40	47-53	95	38-44	29-35
832+40 to 835+00	(IB)	Commercial (5)	40	30	70	50	49-55	50	40-46	35-41
836+40 to 837+00	(IB)	Office (1)	40	30	70	40	47-53	95	38-44	29-35

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 12 (CONTINUED)

Location of Structures Adjacent to Subway Alignment		Type of Structure (N)*	Depth to Top-of Rail (ft)	Horizontal Distance from Tunnel ℄ to Nearest Building (ft)	Maximum Train Speed (mph)	Ground-Borne Noise in Nearest Occupied Areas of Building: Criteria for Allowable Noise Levels (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Predicted Noise Level (dBA)	Standard Invert with Resilient D.F. Rail Fasteners: Distance Required for Criterion Compliance (ft)	Resiliently Supported Ties: Predicted Noise Levels (dBA)	Floating Slab Trackbed: Predicted Noise Levels (dBA)
843+10 to 845+40	(IB)	Office** (1)	40	30	70	45-50	47-53	50	38-44	29-35
849+10 to 864+50	(IB)	Commercial (4)	40	30	70	45-55	47-53	--	--	--

(OB) = Out-bound
(IB) = In-bound
(N)* = Number of buildings ±10%
** = Adjacent to freeway (<300' away)

WILSON, IHRIG & ASSOCIATES, INC. 1982e

For Alternative A: Cahuenga Bend, the only other location where a floating slab trackbed may not reduce the ground-borne noise from transit train operations to an acceptable level is at the Blessed Sacrament School, located between stations 650+30 and 652+70. For Alternative B: Fairfax Extended, the other locations where a floating slab trackbed may not reduce the ground-borne noise from transit train operations to an acceptable level are at the apartments located between stations 555+00 and 556+60, and at the apartments located between stations 726+50 and 727+50. For Alternative C: La Brea Bend, the other location where a floating slab trackbed may not reduce the ground-borne noise from transit train operations to an acceptable level is at the residences located between stations 600+00 and 612+60. As detailed in the previous discussion, these locations along the finally adopted alternative will be reanalyzed during final design to determine the specific measures which should be used to further reduce the ground-borne noise.

Table 12 indicates the expected ground-borne noise levels from transit train operations in buildings along the North Hollywood Segment, Lankershim Alternative. As with the other alternatives, there are sections where the use of resiliently supported ties or floating slab trackbeds will be needed to reduce the ground-borne noise levels from transit train operations. From station 797+50 to 800+30, there is a hotel where the ground-borne noise from transit train operations may exceed the appropriate criterion even with the use of a floating slab trackbed. The St. Charles Borromeo Church is also located along this segment and may require the use of a floating slab trackbed and resiliently supported ties in order to comply with the maximum single event noise criterion of 35 dB(A) for a church (Wilson, Ihrig & Associates, Inc., 1982g). If this alternative is adopted, this location will be reanalyzed during final design to determine the specific measures as previously discussed which should be used to further reduce the noise.

With the use of resilient direct fixation fasteners and resiliently supported ties and/or floating slab trackbeds where required, the ground-borne noise from transit train operations with the current alignment configuration will not be intrusive to occupants in the buildings which are adjacent to the Metro Rail alignment except possibly at those few locations detailed above. At those specific locations which have been identified, a reanalysis during final design will determine what additional measures, if any, are necessary to further reduce the ground-borne noise from transit train operations. These measures include minor alignment relocation, crossover relocation, subway structure modification, train speed modification and non-standard floating slab design.

Noise Levels From Surface and Aerial Structure Operations

To provide a basis for evaluating the expected acoustical impact of the Metro Rail system transit train operations, levels of the expected wayside noise from the train operations have been determined. The background information providing the basis for the expected performance is based on measured data for a variety of conditions at several operating systems: BART, WMATA, MARTA, and TTC. The predictions, therefore, are based on the information available from the latest advancements in technology, from data obtained from the newest systems, and from research studies on wheel/rail noise and aerial structure noise.

In the evaluation and control of wayside noise created by steel wheel/rail rapid transit system operations, for surface and aerial way structures, the use of low sound barrier walls at the side of the way structure has been found to be an effective means for reducing wayside noise exposure due to the transit train operations. Evaluations which have been made at several of the newest systems indicate that a substantial noise reduction, typically on the order of 9 to 10 dB(A), can be achieved with sound barrier walls. The predictions which are part of this chapter include determination of the expected noise level performance with the inclusion of sound barrier walls as part of the transit system facilities.

The predictions of wayside noise levels to be expected from the Metro transit trains take into account the operational characteristics such as train length, speed, auxiliary equipment noise and other features which can affect the wayside noise. It has been assumed that solid wheels with either steel or aluminum hubs will be used on all the vehicles and that the maximum operational speed will be 70 mph. It should also be noted that rail transit train noise is strictly a function of speed. There is no variation in the noise produced for different operating modes, i.e., acceleration, deceleration, coasting, or constant speed.

For surface ballast and tie track installations, one of the most important design features of the Metro Rail system, which contributes to quieter operation than may be expected based on experience with older steel wheel/rail systems, is the use of continuous welded rail. With the continuous welded rail eliminating the rail joints, which are one of the major sources of noise in a steel wheel/rail system, and considering all of the features included on the transit cars for noise reduction, the overall result is a considerably lower wayside noise level than for older systems which have noisier or jointed rail and which have vehicle equipment that generates higher noise levels.

Figure 31 indicates the expected wayside noise as a function of speed for Metro Rail trains operating on an at-grade track as observed 50 feet from track centerline. The data on the chart is for operations of the vehicles using rail and wheels which are maintained in a smooth condition using rail and wheel grinding equipment. Experience with the BART equipment indicates that the 2 dB(A) range shown on the chart is the normal variation in performance which can be expected from the transit trains with normal maintenance of the wheels and rails.

One of the noisiest modes of operation of rail rapid transit systems in the past has been operation on elevated or aerial structures. The lightweight steel structures of the Chicago and New York elevated, with direct or rigidly attached rails, produce very intense noise due to mechanical vibration of the structure as the transit trains pass by. This noise has resulted in considerable impact on the neighboring areas and buildings and is one of the factors which has resulted in the general public view that rail rapid transit systems are noisy. The noise generated by the steel aerial structure also results in high noise levels in the transit car, decreasing the quality of the environment presented to the transit system patrons.

For many years it has been known that concrete deck and all-concrete aerial structures result in much less structure-radiated wayside noise and in-car noise for aerial structure operations. At BART, WMATA Metro and MARTA, the use of concrete aerial structures or concrete/steel structures with resilient direct fixation rail fasteners has been demonstrated to be very effective in reducing wayside and in-car noise. The noise radiated by the mechanical vibration of the concrete or composite steel/concrete aerial structure is less than the noise radiated by the car and the noise produced during aerial structure operations is primarily due to the characteristics of the car. The concrete

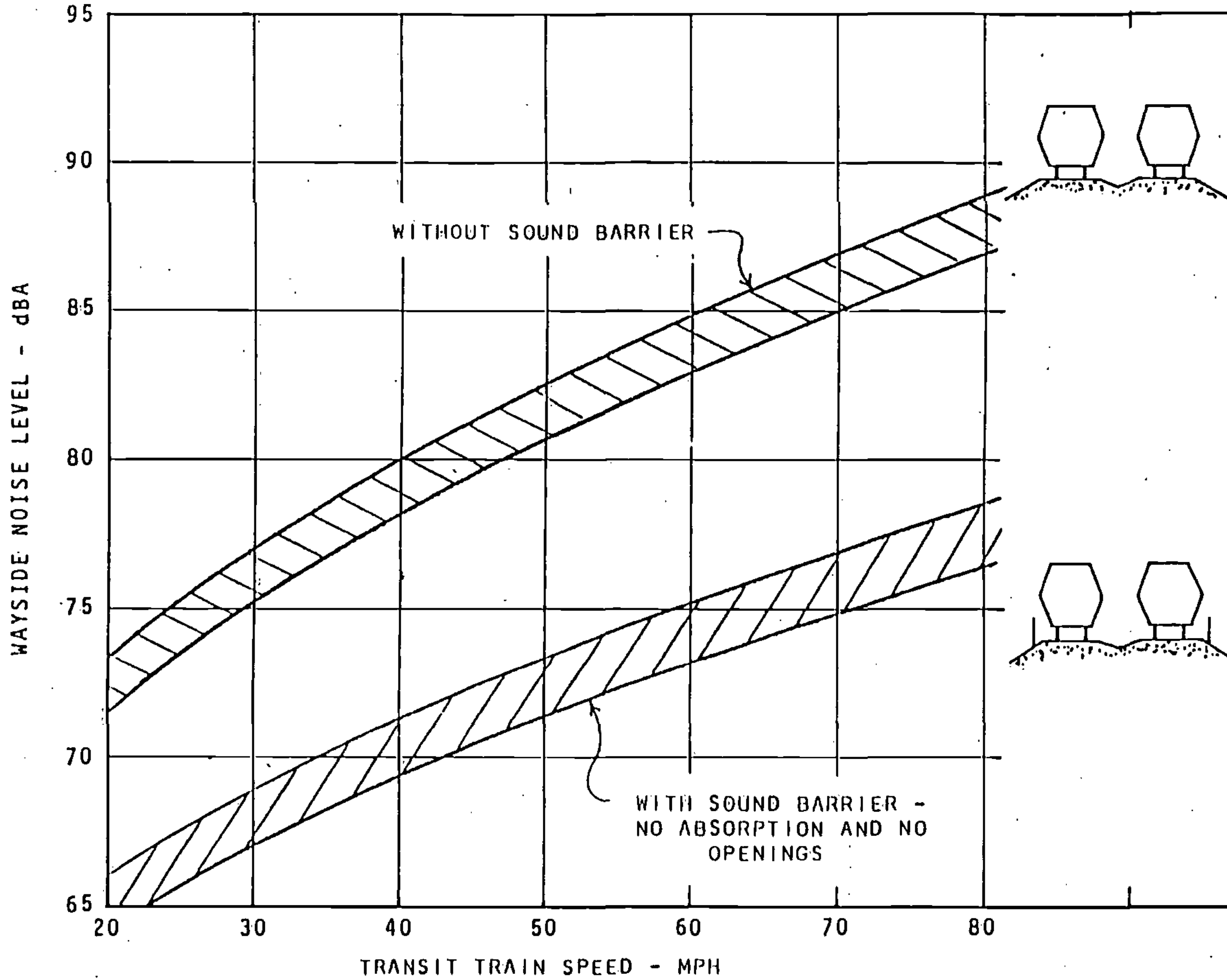


FIGURE 31 MAXIMUM WAYSIDE PASSBY NOISE LEVELS EXPECTED AT 50 FT FROM TRACK CENTERLINE FOR SIX-CAR METRO TRAINS OPERATING ON BALLAST AND TIE TRACK

structure is so effective, in fact, that it is possible to use a sound barrier wall for further reduction of the wayside noise since the noise is primarily radiated from the transit car and rails. With a sound barrier wall it is possible to reduce the wayside noise to levels 9 to 12 dB(A), less than the levels produced by the car alone, thus further reducing the noise of aerial structure operations on the neighboring communities (without significantly affecting car interior noise).

With concrete aerial structures there is a small increase in the wayside and in-car noise compared to ballast and tie operations; however, this increase is primarily due to the sound reflective characteristics of the concrete trackbed compared to the absorptive characteristics of the ballast and tie trackbed. The wayside noise for operation on an all-concrete aerial structure is only 2 to 4 dB greater than for operation on ballast and tie tracks. Similarly, the in-car noise is about 3 dB greater on concrete aerial structures than for ballast and tie tracks. These higher noise levels on the concrete aerial structure are primarily due to the reflection of the middle frequency range sound from the concrete trackbed and are not due to mechanical vibration of the aerial structure.

With steel aerial structures the noise radiated from the structure is greater than the noise from the transit cars and wayside sound levels of 100 to 110 dB(A) are typical at distances of about 50 feet from the track centerline. With a concrete aerial structure, levels of 80 to 88 dB(A) at 50 feet are typical for even higher speed operation than is characteristic of the systems using steel aerial structures. With sound barrier walls the levels can be further reduced to the range of 70 to 78 dB(A) at 50 feet for concrete aerial structures whereas the noise from a steel structure cannot be reduced at all with a simple sound barrier.

Figure 32 indicates the expected wayside noise level at 50 feet from track centerline as a function of train speed for Metro Rail trains operating on aerial structures. As with the ballast and tie track wayside noise, the continuous welded and ground rail is of considerable benefit in reducing the wayside noise expected from the aerial structure. Further, where the trackbed is concrete as on an aerial structure, the use of resilient direct fixation rail fasteners of the same type as used in subways contributes to the lowering of vibration and noise levels. These rail fasteners are to be used on the Metro Rail aerial structures.

In regions where special trackwork is included, such as at crossovers, the wheel impact against the frogs, switch points or other discontinuities can significantly increase the radiated noise levels. As such, a correction factor must be added to Figures 31 and 32 in order to project the maximum train operations. A correction factor of +6 dB(A) has been added to account for the added wheel/rail noise at the discontinuities at special trackwork sections.

To derive the impact for the community noise exposure from the wayside noise level data given on Figures 31 and 32 it is necessary to provide information on the decrease of the noise level with distance away from the track centerline. Figure 33 indicates the maximum wayside noise levels as a function of distance from track centerline for locations perpendicular to the center of the train as the train passes by, assuming open level terrain. The chart is plotted in a manner to give a correction factor to be applied to the levels on Figures 31 and 32 for different distances from track centerline and for different lengths of trains.

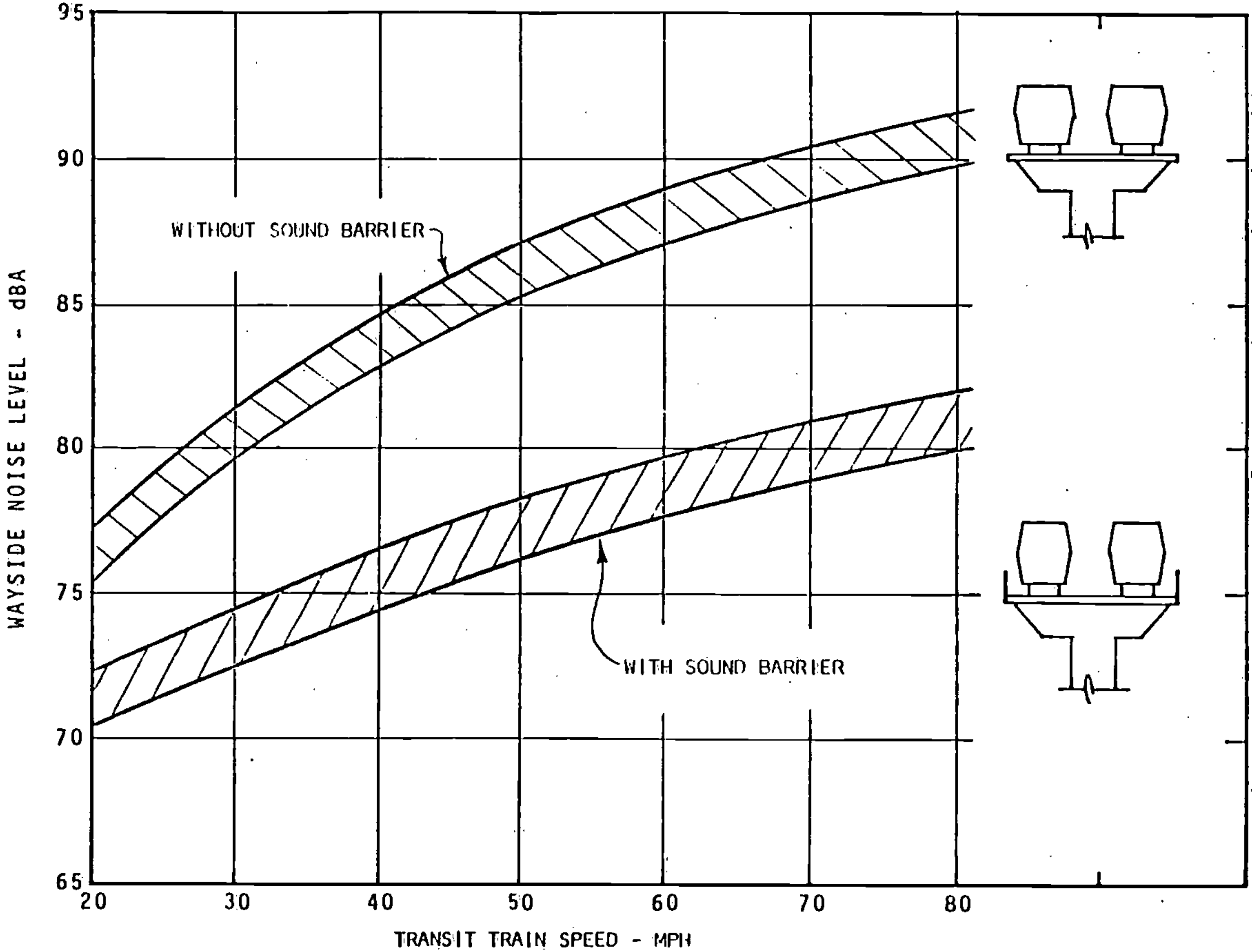


FIGURE 32 MAXIMUM WAYSIDE PASSBY NOISE LEVELS EXPECTED AT 50 FT FROM TRACK CENTERLINE FOR SIX-CAR METRO TRAINS OPERATING ON CONCRETE AERIAL STRUCTURE WITH AND WITHOUT SOUND BARRIER WALLS

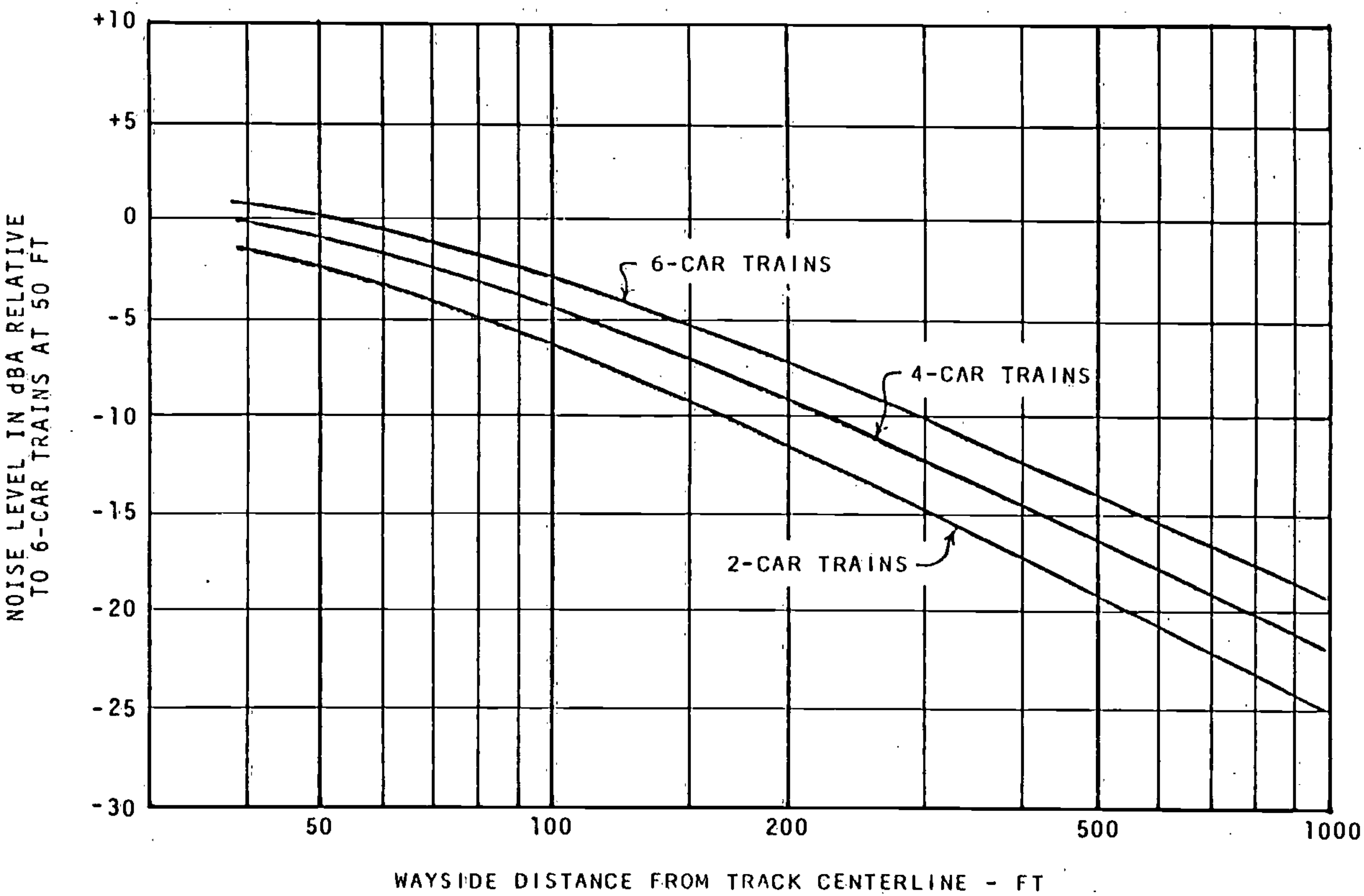


FIGURE 33 MAXIMUM WAYSIDE NOISE LEVELS AS A FUNCTION OF DISTANCE FROM TRACK CENTERLINE FOR OPEN LEVEL TERRAIN - METRO TRANSIT TRAINS OPERATING ON AERIAL STRUCTURE OR BALLAST AND TIE TRACK

WILSON, IHRIG & ASSOCIATES, INC. 1982e

The curves of decreasing sound level with distance on Figure 33 are for application to both aerial structure and at-grade operations in open terrain. If there are rows of buildings along the transit structure alignment, the sound levels at large distances from the track may be somewhat less than given by Figure 33. For at-grade ballast and tie track the sound level beyond the first row of buildings or first row of houses will be 10 to 15 dB(A) less than indicated on the chart because of the shadowing effect created by the buildings. This shadowing effect is only present when the sound waves from the transit train are directly shadowed by intervening buildings and only the first row of buildings provides any noise reduction. The subsequent rows of buildings or homes do not create any additional or additive noise reduction beyond that created by the first row of shadowing buildings. At those locations along an aerial structure where the first row of buildings is of two stories or more in height, additional attenuation of the train noise will be provided behind these buildings for locations which are lower than the building closest to the transit alignment. Having the aerial structure at high elevation relative to grade in order to traverse the Hollywood and Ventura Freeways will be essentially the same as for a standard height aerial structure at an equivalent distance. The only potential difference would be the lack of shielding that would normally be provided behind tall buildings adjacent to the structure.

A basic and effective procedure available for abatement of the transit system wayside noise in critical areas is the use of a sound barrier wall such as that shown on Figure 34 for an aerial structure installation on a MARTA concrete aerial structure. A low sound barrier or shadow wall located at the side of the way structure is in an ideal location to shield all of the sound sources present on a transit car and, thus, can be used as a very effective means of producing extra sound abatement in critical areas. All of the noise generated by a transit car in operation originates in the area beneath the car. The main sources are the noise radiated by vibration of the wheels and rails due to wheel/rail interaction and the noise radiated by the propulsion system. The auxiliary equipment and vibration of other undercar components also contribute to the noise, but aerodynamic noise and vibration of the upper parts of the car body do not contribute significantly to the wayside noise. Therefore, a sound barrier wall shielding or shadowing the noise from beneath the car is a very effective noise abatement technique.

One of the most important features of the barrier wall design is the height of the wall relative to the transit car wheels and side skirt. Another important feature is that the wall must have no holes or slots which would allow transmission of sound through the wall. In special cases, the provision of sound-absorbing material on the interior face of the wall can be considered for maximizing the efficiency of the wall as a noise reduction element.

For ballast and tie installations the sound barrier walls can be constructed in a variety of configurations. The basic requirement is the provision of a solid wall with sufficient height to shadow the noise transmitted from the transit trains to the wayside. No sound absorption is necessary on a ballast and tie track sound barrier wall for full effectiveness because of the sound absorption provided by the ballast. For example, a retaining wall which extends above the top-of-rail elevation or an earth berm or earth cut which extend above the top-of-rail will serve as a wayside sound barrier for reducing the wayside noise level from operations on surface ballast and tie tracks.

Figures 31 and 32 include the expected wayside noise level as a function of speed for operations on the ballast and tie track and aerial structure, respectively, with sound barrier wall in place. Figure 32 for the sound barrier wall on aerial structure indicates

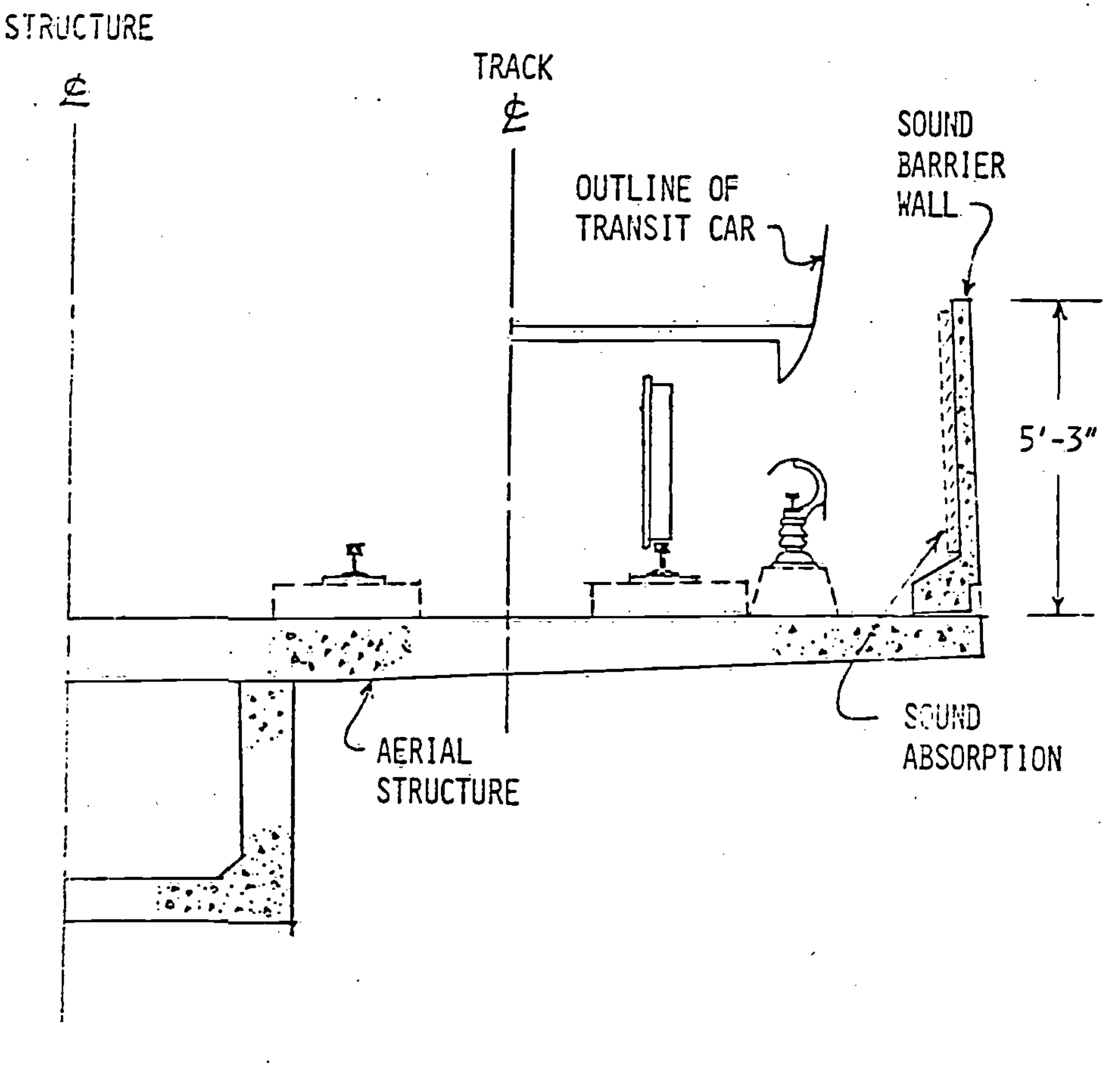


FIGURE 34 CROSS-SECTION OF MARTA AERIAL STRUCTURE SHOWING THE CONFIGURATION FOR SOUND BARRIER WALLS

WILSON, IHRIG & ASSOCIATES, INC. 1982e

the results expected with a typical non-absorptive barrier wall. A sound barrier wall with absorption can be used in the most critical areas to obtain 2 to 3 dB(A) more reduction. However, for most areas the sound barrier without absorption will give adequate noise reduction to give satisfactory results.

As with other aspects of the Metro Rail system, strict design criteria have been adopted for wayside airborne noise from transit train operations (Wilson, Ihrig & Associates, Inc., 1982b). Tables 13 and 14 indicate a comparison of the expected wayside noise levels from 6-car transit train passbys with the criteria. These comparisons indicate where sound barrier walls should be used to reduce the noise to the appropriate level and are based on the simple concept of single event passby noise. The data shown on these tables provide information on the noise levels of an individual passby but do not account for the duration of each passby or the number of events per hour or day. These factors are, however, accounted for when evaluating the noise exposure levels for the transit trains utilizing the energy equivalent noise level, Leq.

The aerial heavy rail sections of the alternative under study occur in the North Hollywood area. The Metro Rail trains will travel at the maximum speed of 70 mph along much of these alternatives except in the vicinity of stations. For evaluation of potential impact, projections of the maximum expected wayside noise at a number of buildings along the alignment have been determined. The predicted noise levels have been calculated using the procedures and techniques described for determination of maximum wayside noise levels and determination of the areas where sound barrier walls are needed.

Tables 13 and 14 present the results of calculations of the expected maximum wayside noise levels due to transit train operations for the two aerial structure alternatives proposed for North Hollywood. The data presented include the location along the alignments by civil station number and direction from the alignment, the type of building structure, the distance from the near track centerline to the nearest buildings under consideration, the maximum train speed for the area, the criteria for allowable levels and the expected maximum wayside noise levels with and without sound barrier walls for 6-car trains. The noise levels for 6-car trains are used since the majority of Metro Rail train operations will be with 6-car trains.

The noise and vibration surveys (Wilson, Ihrig & Associates, Inc., 1982d) in conjunction with the identification of land usage indicate that the areas along the North Hollywood alternatives are best characterized as average residential, high density residential and commercial. The commercial areas consist of office buildings and retail stores, consisting primarily of buildings with daytime occupancy. Most of the areas along Lankershim Boulevard, Vineland Avenue and Chandler Boulevard are best characterized as high density urban residential. Table 7.4.1 of the Criteria document (Wilson, Ihrig & Associates, Inc., 1982b) gives the criteria for maximum airborne noise from Metro Rail train operations. Without repeating the specific criteria for all situations, the basic criteria are that the maximum airborne noise from transit train operations should not exceed 75 dB(A) at single-family residences, 80 dB(A) at multi-family residences and 85 dB(A) at commercial buildings. In addition, the criteria indicate that the maximum airborne noise from transit train operations should not exceed 75 dB(A) at any churches, theaters, schools, hospitals, museums or libraries.

Review of Tables 13 and 14 indicate that there are significant portions of the proposed aerial structure alignments which will require the use of barrier walls to reduce the noise level to less than that required by the criterion. At some locations an absorptive barrier wall could be considered to further reduce the wayside passby noise. The following summarizes the projections of Tables 13 and 14 and is based on the maximum wayside passby noise levels with typical non-absorptive barrier wall for aerial structure operations and non-absorptive barrier wall for at-grade operations.

For the Vineland Aerial Alternative, from the north slope of the Santa Monica Mountains to the Hollywood Freeway on Chandler Boulevard, the maximum airborne noise criteria are exceeded at approximately 27 single-family residences by up to 7 dB(A) with an average exceedance of approximately 3 dB(A), and at approximately 22 apartment buildings by up to 2 dB(A) with an average exceedance of approximately 1 dB(A), which (considering its location with respect to Vineland Avenue and the Hollywood Freeway) is insignificant.

For the Chandler Extension, the maximum airborne noise criteria for aerial structure operations is exceeded at approximately 18 single-family residences by 1 to 4 dB(A), with an average exceedance of approximately 3 dB(A). If the at-grade option is constructed, the levels on Table 13 for a barrier will be reduced by approximately 3 to 4 dB(A) which will then make the wayside noise level acceptable at all of the nearest wayside buildings.

For the Lankershim Aerial Alternative, the maximum airborne noise criteria are exceeded at approximately 28 single-family residences by 2 to 6 dB(A), with an average exceedance of approximately 4 dB(A), and at approximately 7 apartment buildings by up to 3 dB(A), with an average exceedance of approximately 1 dB(A). All of these exceedances occur between the portal location and the Universal City station.

Thus, even with the use of a typical barrier wall there are certain locations where the maximum expected wayside noise from transit train operations will exceed the noise level goal. These locations are primarily single-family residential dwellings which are located within 125 to 150 feet of the proposed aerial structure where the trains will be operating up to the maximum speed of 70 mph.

As previously discussed, the single-event passby noise does not account for the cumulative effect of noise since the noise level from an individual passby does not account for the duration of each passby or the number of events per hour or day. This is because a loud noise occurring very seldom may be less annoying or intrusive than a moderate noise occurring many times.

The noise exposure due to heavy rail transit train operations on aerial structures is presented in Table 15 in terms of the day-night average Level (Ldn) for two train speeds and at distances of 50, 100 and 200 feet. This measure allows an assessment of the expected long-term noise exposure that individuals living or working near the transit route will experience for an entire day without taking into account the effects of existing ambient noise. This estimate of noise exposure is based on the passby sound levels, the duration of the sound and the number of passbys per hour. The number of passbys per hour is based upon the proposed 2000 weekday operating schedule. Table 15 also indicates the noise exposure levels with the use of sound barrier walls attached to the sides of the aerial structure (as discussed previously). The sound barrier walls result in a noise exposure level reduction of up to 10 dB(A).

TABLE 13 AIRBORNE NOISE PROJECTIONS FOR THE METRO RAIL SYSTEM AERIAL STRUCTURE ALTERNATIVE A (NORTH HOLLYWOOD)

					No Sound Barrier Wall		Sound Barrier Wall	
Station Number and Direction From Alignment	Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	Predicted Maximum Noise 6-car Train (dBA)	Required Distance for Criterion Compliance (ft)	Predicted Maximum Noise 6-car Train (dBA)	Required Distance for Criterion Compliance (ft)
828+00 to 852+00 (IB)	Residential (6)	50	70	75	89-91	650	79-81	150
828+00 to 852+00 (IB)	Residential (7)	150	70	75	83-85	650	73-75	--
828+00 to 852+00 (IB)	Residential (98)	225	70	75	80-82	650	70-72	--
828+00 to 852+00 (IB)	Apartments (23)	150	70	80	83-85	325	73-75	--
828+00 to 852+00 (IB/OB)	Commerical** (28)	30	70	85	91-93	150	81-83	--
828+00 to 852+00 (IB/OB)	Commercial** (9)	75	70	85	87-89	150	77-79	--
834+00 to 847+00 (OB)	Office (3)	600	70	85	73-77	--	63-67	--
856+00 to 860+00 (IB)	Residential (14)	650	55	75	76-78***	900	67-69***	--
857+00 to 860+00 (OB)	Apartments** (3)	30	55	85	94-96***	225	85-87***	50

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 13 (CONTINUED)

Station Number and Direction From Alignment		Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
858+00 to 860+00	(IB)	Commercial (4)	275	55	85	82-84***	--	73-75***	--
859+00 to 860+00	(OB)	Residential** (2)	200	55	80	84-86***	500	75-77***	--
862+00 to 865+00	(OB)	Apartments** (12)	125	50	85	80-82	--	71-73	--
863+00 to 874+00	(IB/OB)	Apartments (14)	40	55	80	87-89	200	77-79	--
870+00 to 875+00	(IB)	Apartments (5)	150	55	80	81-83	200	72-74	--
875+00 to 877+00	(IB)	Apartments (4)	125	60	80	82-84	225	72-74	--
875+00 to 879+50	(OB)	Motel**	150	65	80-85	82-84	275	72-74	--
878+50 to 879+50	(IB)	Residential (3)	175	70	75	82-84	650	72-74	--
878+50 to 879+50	(IB)	Residential (5)	225	70	75	80-82	650	70-72	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 13 (CONTINUED)

Station Number and Direction From Alignment		Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
879+50 to 880+50	(IB)	Apartments (5)	125	70	80	84-86	325	74-76	—
881+00 to 882+00	(IB)	Apartments** (2)	100	70	85	86-88	150	76-78	—
886+50 to 888+80	(OB)	School**	125	70	75	84-86	650	74-76	150
887+00 to 888+50	(OB)	Apartments** (3)	80	70	85	87-89	150	77-79	--
889+50 to 903+50	(IB/OB)	Residential (11)	40	70	75	90-92	650	80-82	150
889+50 to 903+50	(IB/OB)	Residential (4)	150	70	75	83-85	650	73-75	--
889+50 to 903+50	(IB/OB)	Residential (37)	225	70	75	80-82	650	70-72	—
890+00 to 904+50	(IB/OB)	Commercial (20)	40	70	85	90-92	150	81-83	—
890+50 to 897+00	(IB/OB)	Apartments (7)	40	70	80	90-92	325	80-82	75

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 13 (CONTINUED)

Station Number and Direction From Alignment	Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
890+50 to 897+00 (IB/OB)	Apartments (23)	100	70	80	81-33	325	75-77	--
893+00 to 905+00 (IB)	Residential** (4)	325	70	80	78-80	--	68-70	--
909+50 to 911+00 (IB)	Apartments** (2)	100	70	85	86-88	150	76-78	--
910+80 (OB)	Residential** (1)	50	70	80	89-91	325	80-82	75
911+00 to 924+50 (IB/OB)	Residential (6)	125	70	75	84-86	650	74-76	150
911+00 to 924+50 (IB/OB)	Residential (5)	150	70	75	83-85	650	73-75	--
911+00 to 924+50 (IB/OB)	Residential (51)	225	70	75	80-82	650	70-72	--
911+00 to 924+50 (IB/OB)	Apartments (14)	40	70	80	88-90	325	78-80	--
911+00 to 924+50 (IB/OB)	Apartments (17)	100	70	80	81-83	325	75-77	--

TABLE 13 (CONTINUED)

Station Number and Direction From Alignment		Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
913+00 to 924+50	(IB/OB)	Commercial (13)	40	70	85	90-92	150	82-83	--
925+00 to 949+50	(IB/OB)	Residential (3)	125	70	75	84-86	650	74-76	150
925+00 to 949+50	(IB/OB)	Residential (23)	150	70	75	83-85	650	73-75	--
925+00 to 949+50	(IB/OB)	Residential (114)	225	70	75	80-82	650	70-72	--
925+00 to 949+50	(IB/OB)	Apartments (12)	40	70	80	90-92	325	80-82	75
925+00 to 949+50	(IB/OB)	Apartments (41)	100	70	80	81-83	325	75-77	--
925+00 to 949+50	(OB)	Commercial (43)	40	70	85	90-92	150	80-82	--
925+00 to 949+50	(IB/OB)	Commercial (24)	75	70	85	87-89	150	77-79	--
949+50 to 954+00	(IB/OB)	Apartments (2)	75	60	85	85-87	100	75-77	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 13 (CONTINUED)

Station Number and Direction From Alignment		Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
949+50 to 954+00	(IB/OB)	Commercial (9)	40	60	85	88-90	100	78-80	--
954+00 to 960+00	(IB/OB)	Commercial (3)	50	50	85	85-87	75	76-78	--
955+50 to 958+50	(IB/OB)	Commercial (1)	20	50	85	88-90	75	79-81	--
CHANDLER EXTENSION:									
989+00 to 990+20	(IB)	Commercial (2)	20	70	85	92-94	150	82-84	--
990+00 to 1000+00	(OB)	Residential (10)	325	70	75	78-80	650	68-70	--
990+00 to 1000+00	(OB)	Apartments (3)	60	70	80	88-90	325	78-80	--
990+00 to 1000+00	(OB)	Apartments (22)	100	70	80	85-87	325	75-77	--
990+00 to 1000+00	(OB)	Commercial (5)	60	70	85	88-90	150	78-80	--
1000+00 to 1001+00	(OB)	Residential (2)	100	70	75	86-88	650	76-78	150

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 13 (CONTINUED)

Station Number and Direction From Alignment	Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
1000+00 to 1001+00 (OB)	Residential (12)	225	70	75	80-82	650	70-72	--
1000+00 to 1001+50 (OB)	Residential** (3)	50	70	80	87-89	325	75-77	--
1000+00 to 1002+50 (OB)	Residential** (7)	200	70	80	81-83	325	71-73	--
1005+00 to 1007+00 (IB)	Apartments** (5)	80	70	85	86-88	150	76-78	--
1004+00 to 1006+50 (IB)	Residential** (4)	225	70	80	80-82	325	70-72	--
1006+70 to 1009+00 (OB)	Residential** (3)	60	70	80	87-89	325	75-77	--
1007+50 to 1013+00 (IB)	Apartments (9)	80	70	80	86-88	325	76-78	--
1009+00 to 1010+00 (IB/OB)	Apartment** (1)	50	70	85	87-89	150	77-79	--
1010+50 to 1032+50 (OB)	Apartments (11)	50	70	80	87-89	325	77-79	--

TABLE 13 (CONTINUED)

Station Number and Direction From Alignment		Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
1007+50 to 1013+00	(OB)	Residential (31)	225	70	75	80-82	650	70-72	--
1014+00 to 1035+00	(OB)	Residential (19)	50	70	75	87-89	650	77-79	150
1014+00 to 1035+00	(OB)	Residential (22)	150	70	75	83-85	650	73-75	--
1014+00 to 1022+00	(IB)	School	425	70	75	76-78	650	66-68	--
1014+00 to 1035+00	(OB)	Residential (84)	225	70	75	80-82	650	70-72	--
1022+00 to 1035+00	(IB)	Apartments (15)	80	70	80	86-88	325	76-78	--
1035+00 to 1040+50	(IB/OB)	Commercial (4)	70	55	85	85-87	100	76-78	--
1035+00 to 1040+50	(OB)	Residential (14)	125	55	75	81-83	425	72-74	--
1040+50 to 1045+00	(IB/OB)	Commercial (4)	60	45	85	83-85	--	74-76	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 13 (CONTINUED)

Station Number and Direction From Alignment	Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall		Sound Barrier Wall	
					Predicted Maximum Noise 6-car Train (dBA)	Required Distance for Criterion Compliance (ft)	Predicted Maximum Noise 6-car Train (dBA)	Required Distance for Criterion Compliance (ft)
1050+00 to 1062+00 (IB/OB)	Residential (5)	70	60	75	86-88	500	77-79	125
1050+00 to 1062+00 (IB/OB)	Residential (15)	175	60	75	80-82	500	71-73	--
1050+00 to 1062+00 (IB/OB)	Apartments (8)	70	60	80	86-88	225	76-78	--

(OB) = Out-bound
(IB) = In-bound
(N)* = Number of buildings ±10%
** = Adjacent to freeway (<300')
*** = Due to increased noise from crossover

TABLE 14 AIRBORNE NOISE PROJECTION FOR THE METRO RAIL SYSTEM AERIAL STRUCTURE LANKERSHIM ALTERNATIVE (NORTH HOLLYWOOD)

Station Number and Direction From Alignment		Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
Continuation of Alt. A:									
760+00 to 766+00	(IB/OB)	Residential (4)	50	65	75	88-90	575	78-80	125
760+00 to 766+00	(IB)	Residential (6)	125	65	75	83-85	575	73-75	--
760+00 to 766+00	(IB)	Residential (27)	200	65	75	80-82	575	70-72	--
760+00 to 766+00	(IB)	Apartment (1)	30	65	80	90-92	300	80-83	100
760+00 to 766+00	(IB)	Apartment (1)	250	65	80	78-80	--	68-70	--
760+00 to 765+00	(IB)	Commercial (3)	100	65	[illegible]	85-87	125	75-77	--
765+00 to 778+50	(IB/OB)	Residential (12)	40	50	75	86-88	375	77-79	100
765+00 to 778+50	(IB)	Residential (8)	100	50	75	82-84	375	73-75	--
765+00 to 778+50	(IB)	Residential (23)	150	50	75	79-81	375	70-72	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 14 (CONTINUED)

Station Number and Direction From Alignment	Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
765+00 to 778+50 (OB)	Apartments (5)	30	50	80	87-89	175	77-79	--
765+00 to 778+50 (OB)	Apartments (3)	75	50	80	83-85	175	73-75	--
765+00 to 779+00 (OB)	Commercial (4)	30	50	85	87-89	75	78-80	--
Alt C:								
773+00 to 778+50 (IB/OB)	Residential (12)	50	70	75	89-91	650	79-81	150
773+00 to 778+50 (IB/OB)	Residential (9)	150	70	75	83-85	650	73-75	--
773+00 to 778+50 (IB/OB)	Residential (47)	225	70	75	80-82	650	70-72	--
777+50 to 778+50 (OB)	Apartment** (2)	30	70	80	91-93	325	81-83	75
778+50 to 779+60 (IB)	Commercial** (1)	30	65	85	90-92	125	80-82	--
779+00 (OB)	Commercial** (1)	70	65	85	87-89	100	77-79	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 14 (CONTINUED)

Station Number and Direction From Alignment		Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
789+00 to 790+20	(IB)	Apartments (1)	250	50	80	78-80	--	69-71	--
789+40 to 792+00	(IB)	Apartments (4)	30	55	80	88-90	275	80-82	50
789+80 to 791+40	(OB)	Commercial (1)	20	55	85	89-91	100	81-83	--
796+50 to 800+00	(IB)	Residential (6)	200	55	75	72-74***	--	70-72***	--
797+50 to 800+30	(IB)	Hotel*** (1)	50	55	80	86-88	200	77-79	--
799+50 to 800+50	(OB)	Office (1)	175	55	85	79-81	--	69-71	--
800+50 to 808+00	(IB/OB)	Commercial (3)	40	55	85	87-89	100	78-80	--
810+00 to 811+50	(IB/OB)	Commercial (3)	30	65	85	90-92	125	80-82	--
811+50 to 834+00	(OB)	Residential (9)	150	70	75	83-85	650	73-75	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 14 (CONTINUED)

Station Number and Direction From Alignment		Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall		Sound Barrier Wall	
						Predicted Maximum Noise 6-car Train (dBA)	Required Distance for Criterion Compliance (ft)	Predicted Maximum Noise 6-car Train (dBA)	Required Distance for Criterion Compliance (ft)
811+50 to 834+00	(OB)	Residential (44)	225	70	75	81-83	650	70-72	--
811+50 to 834+00	(OB)	Apartments (22)	150	70	80	83-85	325	73-75	--
811+50 to 834+00	(OB)	Commercial (20)	30	70	85	91-93	150	81-83	--
811+50 to 838+00	(IB)	Residential (12)	150	70	75	83-85	650	73-75	--
811+50 to 838+00	(IB)	Residential (45)	225	70	75	81-83	650	70-72	--
811+50 to 838+00	(IB)	Apartments (17)	150	70	80	83-85	325	73-75	--
811+50 to 839+50	(IB)	Commercial (21)	50	70	85	89-91	150	79-81	--
842+00 to 853+50	(OB)	Residential (20)	225	70	75	81-83	650	70-72	--
842+00 to 853+50	(OB)	Apartments (11)	150	70	80	83-85	325	73-75	--

WILSON, IHRIG & ASSOCIATES, INC. 1982e

TABLE 14 (CONTINUED)

Station Number and Direction From Alignment		Type of Structure (N)*	Distance Near track to Nearest Building (ft)	Maximum Train Speed (mph)	Criterion for Allowable Levels (dBA)	No Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	No Sound Barrier Wall: Required Distance for Criterion Compliance (ft)	Sound Barrier Wall: Predicted Maximum Noise 6-car Train (dBA)	Sound Barrier Wall: Required Distance for Criterion Compliance (ft)
844+00 to 853+00	(OB)	Commercial (14)	30	70	85	91-93	150	81-83	--
843+00 to 853+00	(IB)	Commercial (4)	50	70	85	89-91	150	79-81	--
843+00 to 853+00	(IB)	Apartments (3)	175	70	80	82-84	325	72-74	--
853+00 to 858+00	(OB)	Residential (7)	150	60	75	81-83	500	72-74	--
853+00 to 858+00	(OB)	Apartments (5)	150	60	80	81-83	225	72-74	--
853+00 to 858+00	(IB/OB)	Commercial (7)	30	60	85	85-87	50	76-78	--
858+00 to 864+50	(OB)	Residential (3)	150	50	75	79-81	375	71-73	--
858+00 to 864+00	(OB)	Apartments (4)	150	50	80	79-81	175	71-73	--
858+00 to 864+00	(OB)	Commercial (7)	40	50	85	85-87	75	77-79	--

(OB) = Out-bound
(IB) = In-bound
(N)* = Number of buildings ± 10%
** = Adjacent to freeway (<300')
*** = Assumes part of existing hotel will be retained

WILSON, IHRIG & ASSOCIATES, INC. 1982e

Table 15 presents the projected noise exposure that will be created by the heavy rail transit trains on aerial structures and thus represents only the transit train noise and

Table 15

EXPECTED OUTDOOR NOISE EXPOSURE LEVELS FOR METRO RAIL TRANSIT TRAINS OPERATING ON AERIAL STRUCTURE - L_{DN} IN DB(A)

Train	At 50 ft		At 100 ft		At 200 ft	
Speed	No SBW	SBW	No SBW	SBW	No SBW	SBW
50 mph	71-75	62-66	68-72	59-63	63-67	54-58
70 mph	74-78	64-68	71-75	61-65	66-70	56-60

Source: Wilson, Ihrig & Associates, Inc., 1982e.

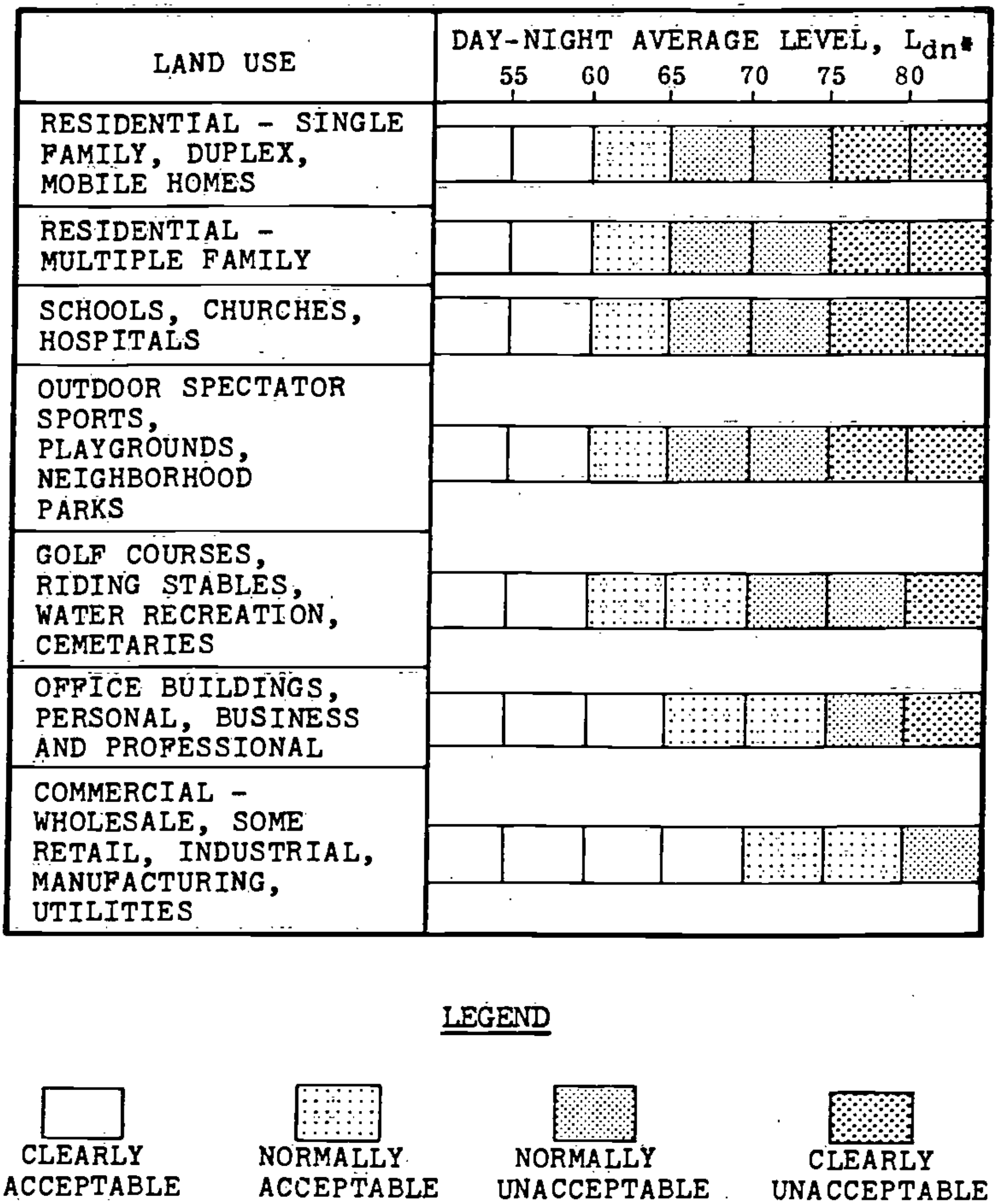
does not account for any other noise sources. Comparison of the transit train noise exposure with the existing noise exposure indicates the degree to which the transit train operations will affect the total noise exposure levels.

Based on the ambient noise measurements made in 1981 and 1982 the day-night equivalent level, Ldn that has been measured and estimated is presented in Table 16 along with the operation of the transit trains on aerial structures. The measurement location numbers refer to the location numbers in the previously referenced noise survey reports.

Table 16 indicates that without the use of sound barrier walls the noise from the operation of Metro Rail trains on aerial structures would raise the Ldn levels by 0 to 10 dB(A), with an average value of 4 to 5 dB(A). With the use of sound barrier walls the noise from operation of the Metro Rail trains on aerial structures would raise the Ldn levels at the noise measurement locations by 0 to 3 dB(A), with an average value of less than 1 dB(A). Although a 4 to 5 dB(A) increase in Ldn is considered significant, a 1 dB(A) increase is considered insignificant.

Although there are no noise regulations of the City of Los Angeles which directly affect the operation of transit trains, it is understood that the Los Angeles City Planning Department uses the "Guidelines for Environmental (Exterior) Noise Compatible Land Use" which is presented in Figure 35. Comparison of Table 15 and Figure 35 indicates that with the use of sound barrier walls the transit train operations will comply with the normally acceptable guidelines of Figure 35 for even the most critical land use categories at distances of 100 feet or more. However, the data in Table 16 indicate that even without transit train operations the existing noise levels exceed the Ldn of 65 dB(A) by as much as 5 dB(A). Hence, in the community areas along Vineland Avenue and Lankershim Boulevard, the noise abatement measures (i.e., sound barrier walls) will not reduce the total noise exposure unless steps are taken to reduce the existing noise.

As part of the Fairfax Extended and La Brea Bend alternatives analysis, special studies were undertaken to determine noise and vibration characteristics of alternative transit technologies, i.e., an Intermediate Capacity Transit System (ICTS) on an aerial



Source: City of Los Angeles EIR Manual

Guidelines for Environmental Noise Land Use Compatability

FIGURE 35

Table 16

ESTIMATED AND MEASURED DAY-NIGHT EQUIVALENT LEVELS ALONG THE PROPOSED METRO RAIL AERIAL ALIGNMENTS

Measurement Location	L_{dn} - no trains	L_{dn} with trains	
		No SBW	SBW
40	64-66 dB(A)	70-72 dB(A)	65-66 dB(A)
41	66-68	74-76	68-70
42	68*	72-75	68-70
43	68-70	75-77	70-72
44	57-59	62-64	58-60
45	66-68	73-75	68-70
	(if yard here)	68-70	66-68
119	64-66	65-67	64-66
120	58-60	64-66	59-61
121	58-60	61-63	58-60
122	54-56	61-63	55-57
123	56-58	65-67	58-60
124	66-68	66-68	66-68
125	64*	64-66	64-65
126	56-58	64-66	58-60
127	59-61	61-63	59-61
128	55-57	60-62	56-58
129A	61*	62-64	61-62
130	55-57	59-61	56-58
131	56-58	59-61	56-58
132	68*	68-70	68-69
133	55-57	57-59	55-57

*Measured in 24-hour survey
SBW = sound barrier wall
Source: Wilson, Ihrig and Associates, Inc. (1982e).

structure and a Light Rail Transit (LRT) system at grade. The results of the noise and vibration analysis are contained in the Special Analysis documents (Special Analysis Task Force, 1982). In summary, the ICTS will be audible outdoors, having an Ldn of 64-66 dB(A) at a distance of 50 feet for maximum travel rates of 45 mph. With absorptive barriers the level could fall as low as an Ldn of 38-40 dB(A). Those levels are below community ambients and could increase ambient Ldns by less than 1 dB(A). The LRT system could create noise as high as 54-56 dB(A) Ldn for the 35 mph maximum speed without side barrier walls. This is noisier than either the subway heavy rail or the ICTS. There could be an increase in the community ambient of 1 dB(A) for locations 50 feet from the centerline. Side barrier walls would cause the ambient to be exceeded by less than 1 dB(A), which is considered insignificant.

Storage and Maintenance Yard Noise

The activities in storage and maintenance yards result in noise due to a number of sources, as given in the following listing of the major sources.

- Wheel squeal on curves,
- Clicks and pings as wheels pass over rail joints and through switches,
- Train rolling noise,
- Transit car auxiliary equipment operation,
- Coupling and decoupling of cars,
- Train horns,
- Workmen shouting, and
- Telephone or warning buzzers or horns, announcement or call loudspeakers and noise created by maintenance work.

There are two additional sources of noise that have been encountered in yard operations but that are not included in the above list and will not occur with the Metro Rail cars: the sound of brakes squealing and the sound of air release frequently encountered with air brakes or dumping cycles of air compressor and air brake systems. Neither of these sources of noise is present as a significant noise source on modern transit vehicles because of the use of quiet operating brakes and the use of systems which do not require dumping of air in the operating cycle, thus eliminating the characteristic air release sound.

The principal noises which have been found to create annoyance in residential areas near transit system yards are:

- The noise from auxiliary equipment on the transit cars,
- The noise from car propulsion systems and the wheel and rail interaction when the cars are moving on the track,

- The pings, clicks and bangs which occur as wheels pass through switches and over frogs and joints in the special trackwork included in the yard, and

- The wheel squeal which results when the cars move on short radius tracks entering the yard or on the turnaround track.

These sources produce randomly occurring noises which are of considerably different character than typical community background noise and, therefore, if of sufficient level they can be noticeable and intrusive. Most of the noise produced by the transit vehicles themselves is controlled (due to the specification requirements for in-car noise and subway station platform noise) to a level that will avoid impact on adjacent areas unless the separation distance from the yard and the residential or other noise critical areas is very small.

All auxiliary equipment on modern transit cars is required to meet a specification of 68 dB(A) at 15 feet from each individual item. With all equipment operating, the maximum allowable noise level is 60 dB(A) 50 feet from the center of the vehicle. With older vehicles it has been found that air compressors and other items which operate either constantly or cyclicly can typically produce noise levels as high as 75 to 80 dB(A) at 15 feet from the car. The noise limit specifications on auxiliary equipment for the Metro Rail transit vehicles will eliminate these noises as sources of impact in the community near the system yards.

Train speeds in yards are generally limited to the range of 15 to 20 mph maximum so that noise from the trains rolling is generally a maximum of 70 dB(A) at 50 feet and usually is considerably less - in the range of 60 to 65 dB(A) at 50 feet. Because of the noise limit specifications on vehicle auxiliary and propulsion equipment and because of low speeds of operation in yards, the general rolling noise due to train operations does not result in any impact in adjacent communities and is comparable with and compatible with typical community background noise.

Table 17 indicates the noise levels expected at 50, 100, 300 and 600 feet from 2-car trains stopped or moving on the yard tracks. Included are the expected levels when the noise is shielded by either a sound barrier or deep cut.

Storage yards have been proposed in various locations at the North Hollywood end of the alignment. These include an aerial yard on Chandler west of the original North Hollywood station, an at-grade and subway yard in the same location and a subway yard on Chandler east of Lankershim. Yard location and configuration for the present Locally Preferred Alternative have not been established although it will probably be below ground and not have an impact on the surrounding community. Aerial yards along Chandler are as close as 80 feet from buildings, and could have significant noise impacts if not shielded as considered in Table 17. It should be noted that wheel squeal which results when the cars move on short radius tracks is not anticipated since North Hollywood yards will be used primarily for storage, are not large and do not have any short radius curves. If aerial or surface yards are put into a deep cut, the resulting wayside noise levels will be lower and lower still if covered by a parking lot.

Noise generation at any of the four possible downtown yard locations will not be significant in light of the high ambients and industrial land uses which occur.

Table 17

NOISE LEVELS FROM 2-CAR TRAINS OPERATING ON YARD TRACKS

Noise Source	Distance From Track Centerline			
	50 Feet	100 Feet	300 Feet	600 Feet
Car Stationary				
Auxiliaries Operating	61 dB(A)	57 dB(A)	47 dB(A)	41 dB(A)
Train Moving at 20 mph				
Aerial Structure				
No Shielding	73	69	60	54
With Sound Barrier Wall	68	64	55	49
Ballast and Tie				
No Shielding	70	66	57	51
With Sound Barrier Wall	62	58	49	43
Deep Cut	55	51	42	36

Source: Wilson, Ihrig & Associates, Inc. (1982e).

Fan and Vent Shaft Noise Levels

Transit system facilities or operations which can create noise intrusion or annoyance include fan and vent shafts. At ventilation shafts, the train noise transmitted to the surface gratings and thence to the surrounding community areas depends on the speed of the transit trains and the presence or absence of sound absorption material in the shafts or in the tunnels in the area near the vent shaft. At fan shafts the main noise is from the fans, but the noise from the transit trains can also transmit through the shafts. It has been found that the attenuation required for the fan noise provides more than adequate attenuation for the transit train noise. In general, the noise from the fan shafts is dependent upon the number of fans required in the shaft, i.e., the total volume of air to be handled by the shaft. The noise from the subway ventilation fan units is limited by a specification requiring certified maximum sound power levels which is included in the contract documents. This specification of maximum sound power level from the fans determines the maximum noise level which can be expected from operation of fans at each fan shaft in the absence of any attenuation treatment.

In the absence of acoustical treatment in the shafts, both measurements and calculations or estimates of the sound transmission through the various configurations of fan and vent shaft show that there will be very little attenuation of the transit train noise or the fan noise as it is transmitted through the ducts to the surface. This is because the shafts are of concrete, which has a negligible sound absorption coefficient, and because the shafts are of large cross-sectional area.

Reduction of the noise from the transit trains and from the ventilation fans can be achieved through: 1) the use of sound absorption treatment applied to the wall and ceiling surfaces of the shafts, and 2) the use of sound attenuators on the ventilation fans. In general, the sound absorption treatment applied to vent shaft walls and ceilings is a 2-inch to 4-inch nominal thickness panel material of expanded cellular glass or mineral fiber. The sound absorption coefficient will be at least 0.75 in the middle frequency range (the range included in the 500 Hz and 1000 Hz octaves) where the maximum reduction of noise is needed to give appropriate noise reduction to reduce the noise in accordance with the requirements of the design criteria.

At this time, the exact locations of only a few fan and vent shafts have been determined, thus a general discussion follows which indicates the design criteria which will be applied to achieve noise levels which are comparable to or less than the existing typical ambient noise levels and, therefore, will not contribute significantly to the noise environment.

The design criteria for fan and vent shafts are given to Table 7.7.1 of the Design Criteria document (Wilson, Ihrig & Associates, Inc., 1982b) and are repeated here for convenience as Table 18. As with other aspects of the design criteria, the appropriate noise level design goal limit depends on the activities of occupants as well as the background noise in the area. The acceptable levels of noise from vent shafts and fan shafts are different. This is because the noise from a vent shaft is transient in nature while that from a fan shaft is continuous. Transient noises are acceptable at higher levels than continuous noises. Thus the transient noise design goals apply to the train passby noise transmitted from vent shaft openings and the continuous noise design goals apply to the fan noise from fan shaft openings.

Table 18

DESIGN CRITERIA FOR NOISE FROM TRANSIT SYSTEM
FAN AND VENT SHAFTS

Community Area Category		Maximum Noise Level, dB(A)	
		Vent Shaft	Fan Shaft
I	Low Density Residential	50	40
II	Average Residential	55	45
III	High Density Residential	60	50
IV	Commercial	65	55
V	Industrial/Highway	75	65

The criteria shall be applied at a distance of 50 feet from the shaft outlet or shall be applied at the setback line of the nearest building or occupied area, whichever is closer.

Source: Wilson, Ihrig & Associates, Inc. (1982e).

The design criteria in terms of community category area are indicated below for locations where fan and vent shafts have been determined. These apply to subway alternatives primarily.

Location	Community Category Area
Union Station	V
First/Hill Station	IV
Fifth/Hill Station	IV
Seventh/Flower Station	IV
Alvarado/Wilshire Station	IV
Vermont/Wilshire Station	IV
Normandie/Wilshire Station	IV
Western/Wilshire Station	IV
Western/Wilshire Station	IV
Crenshaw/Wilshire Station	IV
La Brea/Wilshire Station	IV
Fairfax/Wilshire Station	IV
Beverly/Fairfax Station	IV
Santa Monica/Fairfax Station	IV
La Brea/Sunset Station	IV
Hollywood/Cahuenga Station	IV
Universal City Station	IV
North Hollywood Station	IV, V

Ancillary Facility Noise

The location of all ancillary facilities has not been defined at the time of this study; however, a general discussion of the noise from ancillary facilities follows. As with the noise from fan and vent shaft openings, the noise from ancillary facilities is subject to the Metro Rail design criteria for maximum permissible noise levels.

Ancillary facilities include such items as power sub-stations, emergency power generation equipment and chiller plants. The criterion for noise from these ancillary facilities is essentially the same as that shown for fan shafts in Table 18, except that sub-station and emergency power generation noise shall be limited to 5 dB(A) less sound level than given in Table 18. This is due to the fact that transformer noise and continuous noise with tonal components can be more obtrusive due to their tonal nature, which is accounted for by making the criteria more restrictive. It is noted that most power transformers will be located below ground which mitigates noise impact.

The specification of a maximum permissible noise level from ancillary facilities is intended to control the level of sound to minimize or eliminate annoyance due to noise from the facilities. The design of each facility is required to incorporate noise reduction features sufficient to achieve the appropriate noise level for the site. The noise reduction features of typical facilities include sound barrier walls surrounding the noise sources; complete enclosures around the noise sources; sound attentuators on fans, blowers or cooling towers; and the use of sound absorption material, both inside enclosures and on the noise source side of sound barriers.

The net effect of the provisions in the Metro Rail design procedures for reducing noise generated by these facilities is that, regardless of the final location chosen for the ancillary facilities, the noise generated will be compatible with the ambient noise of the surrounding area. In most cases the noise will be comparable to the pre-existing background noise. In some cases the noise will be audible but will not be intrusive nor will it be of a higher level than is appropriate for the land use and type of buildings nearby. The criteria are generally a more severe requirement than is placed on typical residential air conditioning systems and other mechanical equipment found in residential and semi-residential/commercial areas.

Noise Level Changes Due to Changes in Traffic Patterns

With the implementation of the Metro Rail System, traffic analysis shows that there will be some reduction in traffic (from the year 2000 base condition) since a certain number of trips will be accomplished using the transit system instead of automobiles. The reduction is most apparent on freeways (especially the Hollywood Freeway) and major arterials. Traffic reductions of between 1 and 15 percent are projected in some locations. These traffic reductions will not significantly affect noise levels since the reduction in traffic flow would have to be 50 percent or more before a reduction in the noise exposure level from traffic will be noticeable.

The changes in traffic patterns around the proposed stations will primarily consist of an increase in bus traffic due to feeder buses, and an increase in the local traffic due to park-and-ride and kiss-and-ride trips. Stations most affected by increased traffic are at North Hollywood, Universal City, Beverly/Fairfax, Wilshire/Curson and Union Station. The resulting total change in automobile traffic (up to a 20 percent increase) will not be sufficient to cause significant changes in the noise exposure levels. The full extent of bus traffic changes is not known, thus impacts cannot be quantified.

Construction Noise Levels

One of the impacts associated with a rail rapid transit system project is the short-term noise and vibration impact of construction activities. As with any large project, the construction of a rapid transit system involves the use of machines and procedures which, in the past, have resulted in intense noise levels and, occasionally, high vibration levels in and around the construction site. The construction activities include demolition, clearing, grading, excavating, pile driving, drilling, materials handling and placement, erection and finish work and will involve the use of all the various kinds of machines and procedures which are associated with these activities. It is also possible that blasting will be used for excavation and tunneling in rock.

In recent years considerable progress has been made in the reduction and control of construction noise through modifications of the equipment to reduce noise generated at the source, through modifications of construction procedures and by selection of those construction procedure alternates which are less noisy. Also, in many areas and for many types of construction projects there have been noise limits or noise standards included in the construction contracts or applied by governmental agencies in order to limit the noise impact from the construction. These efforts at reducing construction noise have produced considerable success and with new construction projects the work can be and is accomplished with considerably less noise impact than is traditionally expected.

The three general configurations of transit way structures, subway, aerial and at-grade, have different construction techniques involved and, hence, produce somewhat different noise and vibration.

For at-grade construction the impact will be due to demolition; clearing and grading; placement of materials, including any retaining walls and the ballast and ties and rails; plus any finishing activities such as fencing and landscaping.

For the aerial structure configuration the activities will include demolition; ground clearing and grading; erection of foundations including, possibly, pile driving; construction of the aerial structure columns; erection of girders and the finishing.

For subway construction the acoustical impacts can be of two different characters. In the areas where tunneling is used the only impact due to the construction activities (except at access shafts) will be the ground-borne vibration due to the excavation process, either the tunnel boring machine or blasting. Also, there may be some ground-borne vibration due to the vehicles used to remove material. For cut-and-cover subway there will be impacts due to ground clearing, excavation, erection and finishing activities.

Construction Equipment Noise Levels. There is considerable information available on the typical noise levels created by modern construction equipment and there is a growing body of information on lower noise levels which can be achieved with modified equipment or equipment which is designed with noise reduction and control as one of the design parameters.

Measurements made at transit system construction project sites provide the best information relative to expected noise levels from the type of construction activities which are associated with the Metro Rail system.

Table 19 presents a series of noise levels observed for various types of machines and activities associated with the WMATA Metro construction project. These data are for early construction activities using standard present-day equipment without noise control or noise reduction modifications to the equipment. The data were obtained before noise restrictions and limits had been applied to the construction activities on the Metro project.

Typical noise levels at construction sites, as indicated by Table 19, do result in substantial acoustic impact on neighboring communities and in new and future projects such noise levels are considered unacceptable. There are many techniques available for reducing the noise, some of which involve little or no cost and some of which involve considerable cost. In some instances modifications of procedures or use of different procedures and equipment can result in much lower noise levels and impact. For the Metro Rail project one of the procedures, a very effective procedure, will be to include noise limit specifications in the construction contracts in order to reduce or limit acoustic impact due to construction activities. Examples of other noise reduction measures include:

- Replacement of individual operations and techniques by less noisy ones -- e.g., using drilled piles or vibratory pile drivers instead of impact pile drivers, using welding instead of riveting, mixing concrete offsite instead of onsite, and employing prefabricated structures instead of assembling them onsite.

Table 19

TYPICAL NOISE LEVELS OBSERVED AT RAIL TRANSIT SYSTEM CONSTRUCTION PROJECTS

Equipment or Process	Distance (feet)	Noise Levels dB(A)
Air Hammer Cutting Concrete	50	85-90
Crane & Pile Drilling Rig	50	
Crane & Pile Moving Drill		90
Crane & Pile Emptying Auger		86
Crane & Pile Idling		82
Crane & Pile Drilling		83-88
Crane & Pile Placing Pile		74
Crane & Pile Setting Pile		88
Concrete Mix Truck Placing Concrete	50	81-85
Diesel Hammer Pile Driver	24	95-106
Compressor	24	83-90
Hydraulic Cranes	24	88-90
Derrick Crane	50	88
Tamper	50	88
Scraper	50	88
Rock Drill	50	98
Trucks	50	85-91
Paver	50	89

Source: Wilson, Ihrig and Associates, Inc. (1982e).

- Selecting the quietest of alternative items of equipment — e.g., electric instead of diesel-powered equipment, hydraulic tools instead of pneumatic impact tools.
- Scheduling of equipment operations to keep average levels low, to have noisiest operations coincide with times of highest ambient levels, and to keep noise levels relatively uniform in time; also turning off idling equipment.
- Keeping noisy equipment as far as possible from site boundaries.
- Providing enclosures for stationary items of equipment and barriers around particularly noisy areas on the site or around the entire site.

Use of the above techniques can result in a 5 to 15 percent reduction in noise generation from specific construction equipment or operations.

Project construction will require considerable earthwork, including the hauling of spoil material to acceptable disposal sites. Noise from heavy-duty trucks can have a substantial impact on the community in terms of both intrusive and average noise levels. Haul routes for muck disposal have been proposed (Sedway/Cooke, 1982) to mitigate potential noise impacts by avoiding sensitive land uses such as residential areas. Thus, noise from muck disposal truck traffic should not result in significant noise impact.

Ground-Borne Vibration from Construction. Because of the nature of some construction activities, high amplitudes of ground-borne vibration may result in some impact in neighboring community areas. Blasting and impact pile driving are two types of activities traditionally associated with high levels of ground-borne vibration. It is also possible that some types of heavy vehicles and excavation activities can generate sufficient ground-borne vibration levels to be perceptible or noticeable in nearby buildings.

The vibration levels created by the normal movement of vehicles including graders, loaders, dozers, scrapers and trucks generally are of the same order of magnitude as the ground-borne vibration created by heavy vehicles running on streets and highways. Large trucks and buses operating on city streets and on highways generate ground-borne vibration due to wheel/roadway interaction and particularly high vibration levels can be associated with truck and bus operations on rough or pock-marked streets. In general, the ground-borne vibration from vehicle operations on streets, even very rough streets, is not sufficient to create noticeable impact on adjacent community areas. This vibration is of a level that is generally imperceptible or barely perceptible and is considered acceptable, producing little or no impact. Thus, it can be expected that the normal vehicle activities at the construction sites will not generate sufficient ground-borne vibration to result in significant impact.

Blasting, drilling and excavation procedures for cut-and-cover subways can result in ground-borne vibration levels which are perceptible or noticeable in adjacent community areas. The amplitudes of vibration from such activities are limited for safety reasons by procedural techniques. For example, through the use of time delay charges in blasting, the maximum amplitude of the ground-borne vibration is limited to a level well below the criteria for structural damage to adjacent facilities. Impact pile drivers, which create considerable noise and vibration, also produce vibration levels which are well below the intensity required for structural damage to adjacent buildings and other facilities.

Tunnel boring machines also create ground-borne vibration and noise; however, experience to date indicates that the vibration from the use of such machines is of considerably less intensity than that from blasting or pile driving. Also, ground-borne noise from TBMs is not significantly greater than the vibration created by heavy trucks traveling on city streets.

If the transit line in the San Fernando Valley is to be a subway structure, the probable method of excavation will be with the use of a tunnel boring machine (TBM). With the use of a TBM the potential noise and vibration impact is considerably lower than if traditional blasting techniques are used. Blasting can have a considerable noise and vibration impact on a community. As for transit trains operating in subway, the possibility of noise and vibration impact from the operation of a TBM is to occupants inside buildings adjacent to the new subway alignment. Outside of a building, there is no possibility of noise or vibration impact from TBM operation.

Use of a TBM will create vibration levels which are generally imperceptible at distances greater than 75 to 100 feet from the operating TBM. Even at a distance of 50 feet, the operation of the TBM will create vibration levels which are just perceptible. As stated above, the possibility of noise impact from the TBM will be to occupants inside of buildings, similar to the possible noise impact from operations of transit trains in subway. For the deep tunnel option (approximately 125 feet below grade), the ground-borne noise from the TBM should be unnoticeable in buildings which are 100 feet or more in horizontal distance from the alignment. If the tunnel is approximately 35 feet below grade, then there is some possibility that the ground-borne noise would be noticed by building occupants at buildings which are approximately 100 feet in horizontal distance from the alignment. The relative noise levels would depend on the type of building structure, and type of activities in the building. However, the ground-borne noise and vibration from tunnel boring machines is of very short duration since the machine passes by an area in, at most, a few days, so that there will be no significant impact.

Special study has been undertaken to assess construction vibration impact on the St. Charles Borromeo Church located at the corner of Lankershim Boulevard and Moorpark Street, North Hollywood (Wilson, Ihrig & Associates, Inc., 1982g). At a distance of 50 feet, which is the approximate distance between the near subway centerline and the nearest part of the church, the operation of the TBM will create vibration levels which may be just perceptible to people in the church. During boring of the far tunnel, the ground noise should be considerably less noticeable and perhaps unnoticeable. The relative impact will be minor at most since the time of operation of the TBM in close proximity to the church will be a few days at most. During construction, arrangements can be made with the contractor to ensure that the TBM will not be operated in close proximity to the church during any scheduled service or function.

MITIGATION OPTIONS

The general approach that has been used by the Metro Rail design team to avoid adverse noise and vibration impact from construction and operation has been to specify them away, i.e., to incorporate into the system plans any one or combination of several presently available very effective noise and vibration design features wherever the "standard" system design would cause problems. Each of these features raises the cost of construction and some may, in fact, also raise maintenance costs and therefore are not contemplated to be incorporated carte blanche system-wide. The design criteria and specific impact mitigation measures are detailed in a Noise and Vibration Design Criteria document (Wilson, Ihrig & Associates, Inc., 1982a). Most of the criteria from the aforementioned publication are also contained in Attachment 1 of this report for easy reference.

As noted in previous sections, even with incorporation of the available proven and practical noise and vibration mitigation measures there will still be a number of locations which will experience adverse impacts. Therefore, additional methods beyond system engineering noise and vibration control must be employed to ameliorate the impacts. There are several strategies available: local area speed limits, i.e., speed reduction of transit trains to reduce impacts since both noise and vibration radiation increase dramatically with speed; conversion of the adversely impacted land use to a noise and vibration compatible use through condemnation proceedings and/or purchase; shielding of impacted areas using berms or walls; adjustment of the transit system alignment to avoid the close proximity to the sensitive use; and improve the exterior building shell of the noise impacted habitable structures to increase the structures' ability to exclude outdoor noise. The last item will usually require both structural upgrades of the impacted building and that the doors and windows be closed to shut out noise. Sealing a habitable structure will result in fresh air ventilation and summer heat buildup problems which can only be solved by the use of mechanical air conditioning equipment.

Mitigation of noise and vibration impact through incorporation of design features is the responsibility of SCRTD. Enforcement of operational noise criteria which are consistent with city standards will be accomplished by City of Los Angeles. Enforcement of operational standards more stringent than city standards rests with SCRTD.

Responsibility for enforcement of noise standards during project construction rests with the construciton contractor through response to design criteria built into project construction specifications. Secondarily, complaints about construction noise may be made to local agencies such as the City of Los Angeles, the Department of Health, or SCRTD which may result in follow-up enforcement activities.

REFERENCES

Los Angeles Department of Transportation (LADOT) 1982, 1980 Traffic Volumes Working Paper.

Sedway/Cooke, 1982, Muck Disposal Study, SCRTD Metro Rail Project.

Wilson, Ihrig & Associates, Inc., 1982a, Noise and Vibration Survey for the Metro Rail Project, Draft Report (April).

Wilson Ihrig & Associates, Inc., 1982b, Noise and Vibration Design Criteria for the Metro Rail Project (April.

Wilson, Ihrig & Associates, Inc., 1982c, Noise and Vibration Survey for the Metro Rail Project, Final Report (July).

Wilson, Ihrig & Associates, Inc., 1982d, Supplemental Noise and Vibration Survey for the Metro Rail Project, Preliminary Draft Report (October).

Wilson, Ihrig & Associates, Inc., 1982e, Noise and Vibration Study, Alternative Route Alignments for the Metro Rail Project, Draft Report (November).

Wilson, Ihrig & Associates, Inc., 1982f, Review of Regulations and Industry Practice Affecting Control of Noise and Vibration From Construction and Operations of the Metro Rail System (May).

Wilson, Ihrig & Associates, Inc., 1982g, Letter Report on Noise and Vibration Levels at St. Charles Borromeo Church.

ATTACHMENT 1

NOISE AND VIBRATION DESIGN CRITERIA

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

NOISE AND VIBRATION DESIGN CRITERIA

Introduction

To ensure that the community surrounding the Metro Rail system is not adversely impacted by noise and vibration and provide compliance with all legal statutes and guidelines pertaining to noise and vibrations, the SCRTD has adopted Noise and Vibration Design Criteria (Wilson, Ihrig & Associates, Inc., 1982b). The criteria require control of airborne and ground-borne noise and vibration from transit train operations, and from transit ancillary areas and facilities such as yard operations, vent and fan shafts of the ventilation system, electrical substations, emergency service buildings, and air conditioning chiller plants. In addition, the noise from construction operations is also limited by specifications. In the establishment of transit system noise and vibration criteria, for the protection of the surrounding community, which it serves, there are several factors that must be included: numeric limits to the allowable impacts; a standardized, appropriate, well-documented metric specification; and a set of measurement methodology criteria for determining compliance with standards. In the following sections, the metrics, measurement methodologies, and criteria levels established for the Metro Rail project (Wilson, Ihrig & Associates, Inc., 1982b) will be discussed.

Noise and Vibration Metrics

The noise criteria developed for the Metro Rail project is based upon scales that most closely correlate with subjective evaluation of noise. For most typical noise sources, it has been found that the A-weighted sound level gives good correlation with subjective evaluation of response to noise. Thus, the A-weighted sound level, which can be read directly from a sound level meter, is best for evaluating the response of people to the noise created by transit system operation and construction.

As for the subjective response to noise, the human sensitivity to vibration varies with frequency. Therefore, the frequency must be taken into consideration in assessing annoyance due to vibration. A number of studies have indicated that at frequencies above approximately 12 to 16 Hz, sensitivity to vibration is primarily determined by the velocity amplitude and is relatively independent of frequency. Since the frequency range over which human sensitivity is approximately proportional to velocity amplitude covers the range of principal vibration components from transit trains and since the noise level generated by the vibration of buildings' surfaces is approximately proportional to vibration velocity level, it is appropriate to present vibration criteria and data in terms of velocity level.

A curve of human response to vibration has evolved from the studies which have been done and has been documented in the International Standards Organization document 2631 and Draft ANSI Standard S3.29-198X. Additional information on human sensitivity to vibration is contained in the CHABA Publication, "Guidelines for Preparing Environmental Impact Statements on Noise," which has utilized much of the information contained in the ISO Standard. These standards and publications do indicate that below about 12 to 16 Hz the sensitivity to vibration velocity is somewhat lower. The curves of human response to building vibrations based on the CHABA data show graphically the vibrations perception level ranges in decibels (dB) re 1.0 micro inch/second as a function of frequency in Hertz (Hz). The amount in dB that this response deviates from a linear response as a function of frequency is defined to be the CHABA weighting for the frequency in question. Although the CHABA weighting is not a standardized measurement, the resultant weighted velocity level is a good single-number indication of the human response to vibration, and is used as a basis for specification of the ambient conditions to which the system levels are compared.

Measurement Procedures and Assumptions

General. Unless otherwise indicated, all noise levels or measurements refer to the use of A-weighting and "slow" response of an instrument complying with the Type 2 requirements of the latest revision of American National Standards Institute (ANSI) S1.4-1971, "Specification for Sound Level Meters" (ANSI, 1971).

All noise levels are expressed in decibels referenced to 20 x 10^{-6} Pa (0.0002 microbar) as measured with the A-weighting network of a standard sound level meter, abbreviated dB(A).

Transit System Wayside Noise and Vibration Measurements. Transit wayside noise guidelines are based on measurements taken at appropriate distances and performed in essentially a free-field or open space environment away from reflective or shielding surfaces. Unless otherwise indicated, vibration guidelines are based on measurements of vibration in the vertical direction on the ground surface or on building floors.

Construction Noise and Vibration Measurements.

- Measure construction noise in accordance with Section 2.1. In addition, all impulsive or impact noise levels or measurements refer to use of an impulsive sound level meter complying with the criteria of IEC 179 (IEC, 1973) for impulse sound level meters. As an alternative procedure, a Type 2 General Purpose sound level meter on C-weighting and "fast" response may be used to estimate peak values of impulsive or impact noises.

- Noise levels at buildings affected acoustically by the Contractor's operations refer to measurements at points between 3 feet and 6 feet from building facades or building setback lines or a distance of 200 feet from the Construction Limits, whichever is closer.

- Vibration levels at buildings affected by construction operations refer to vertical direction vibration on the ground surface or building floor, or 150 feet from the Construction Limits, whichever is closer.

- Vibration levels at buildings affected by blasting operations refer to the 3-axis vector sum of vibration velocity on the ground surface or building floor, or 200 feet from the Construction Limits, whichever is closer.

Community Categories and Relation to Criteria for Wayside Noise and Vibration

A wayside community noise impact criterion provides a basis from which to determine the type and extent of noise reduction measures necessary to avoid annoyance in the community. The wayside noise criteria must be related to the type of activity taking place in the building or community and the ambient noise levels in the absence of transit system noise. Obviously, a passby noise level of a given magnitude is more objectionable in a quiet residential area at night than in a busy commercial area during the day.

The typical existing ambient or background noise and vibration levels vary significantly from one type of community to the next. Therefore, it is necessary to make a judgment as to the nature of the community in which the transit system is to be located before determining the appropriate criteria for permissible noise or vibration levels from the transit system in that community.

Table 1-1 indicates the five generalized categories of wayside areas into which the communities along the transit corridors can be categorized for the purpose of assigning appropriate noise and vibration criteria. The table indicates the description of the areas and the normal expected range of ambient noise levels. These categories and noise levels are based, in part, on the information developed from several studies of rail transit corridor environments along with data presented in the 1974 U.S. Environmental Protection Agency (EPA) document, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," usually referred to as the "Levels Document" (EPA, 1974), and other field data obtained in many community areas in the USA.

The categories defined in Table 1-1 are used in determining appropriate design criteria for the Metro Rail system noise and vibration. The land use or area categories presented above are similar to those used for other transit properties and presented in the APTA Publication, "Guidelines for Design of Rapid Transit Facilities" (APTA, 1979). In most cases, experience with the new systems now in operation has indicated that these categories and the associated criteria provide for adequate results and most of the neighbors of the transit facility find the noise and vibration acceptable.

Wayside Noise and Vibration Due to Transit Operations

Airborne Noise from Above-Ground Train Operations. Table 1-2 presents design criteria for single-event maximum noise levels for airborne noise from transit trains for various types of buildings in each of the land use or area categories listed in Table 1-1. These criteria are generally applied to nighttime operations because the sensitivity to noise is greater at night than during daytime. The maximum levels are based on the maximum level that will not cause significant intrusion or alteration of the pre-existing noise environment and represent noise levels which are considered acceptable for the type of land use in each area. The criteria presented in Table 1-2 are generally applicable at the nearside of the nearest dwelling or occupied building under consideration or at 50 feet from the track centerline, whichever is closer.

For some types of buildings or occupancies maximum noise level limits should be applied regardless of the community area category. The design should reflect careful consideration of noise control when the transit line is near auditoriums, TV studios, schools, theatres, amphitheatres, and churches. Table 1-3 lists design goals for maximum airborne noise from transit operations in these areas.

Ground-Borne Noise from Train Operations. Table 1-4 presents the pertinent criteria for maximum ground-borne noise due to transit train operations for various types of residential communities. It is noted that ground-borne noise and ground-borne vibration are exactly the same phenomenon up to the point of perception at the dwelling.

Table 1-1

GENERAL CATEGORIES OF COMMUNITIES ALONG METRO RAIL SYSTEM CORRIDORS

Category	Area Description	Typical (Average or L_{50}*) Ambient Noise Level - dB(A)	Typical Day/Night Exposure Levels - L_{dn}
I	Low Density urban residential, open space park, suburban residential or quiet recreational area. No nearby highways or boulevards.	40-50 - day 35-45 - night	Below 50
II	Average urban residential, quiet apartments and hotels, open space, suburban residential, or occupied outdoor areas near busy streets.	45-55 - day 40-50 - night	50-60
III	High Density urban residential, average semi-residential/commercial areas, parks, museum, and non-commercial public building areas.	50-60 - day 45-55 - night	55-65
IV	Commercial areas with office buildings, retail stores, etc., primarily daytime occupancy. Central Business Districts.	60-70	Over 60
V	Industrial areas or Freeway and Highway Corridors.	Over 60	Over 65

*L_{50} is the long-term statistical median noise level.

Table 1-2

CRITERIA FOR MAXIMUM AIRBORNE
NOISE FROM METRO TRAIN OPERATIONS

Community Area Category		Maximum Single Event Noise Level: Single Family Dwellings dB(A)	Multi-Family Dwellings dB(A)	Commercial Buildings dB(A)
I	Low Density Residential	70	75	80
II	Average Residential	75	75	80
III	High Density Residential	75	80	85
IV	Commercial	80	80	85
V	Industrial/Highway	80	85	85

Table 1-3

CRITERIA FOR MAXIMUM AIRBORNE NOISE FROM
METRO TRAIN OPERATIONS NEAR SPECIFIC TYPES OF BUILDINGS

Building or Occupancy Type	Maximum Single Event Noise Level
Amphitheatres	65 dB(A)
"Quiet" Outdoor Recreation Areas	70 dB(A)
Concert Halls, Radio and TV Studios	70 dB(A)
Churches, Theatres, Schools, Hospitals, Museums, Libraries	75 dB(A)

Table 1-4

CRITERIA FOR MAXIMUM GROUND-BORNE NOISE FROM METRO TRAIN OPERATIONS

	Community Area Category	Maximum Single Event Noise Level		
		Single-Family Dwellings dB(A)	Multi-Family Dwellings dB(A)	Hotel/Motel Buildings dB(A)
I	Low Density Residential	30	35	40
II	Average Residential	35	40	45
III	High Density Residential	35	40	45
IV	Commercial	40	45	50
V	Industrial/Highway	40	45	50

Ground-borne vibration describes waves in the ground which can be measured using vibration pickups mounted on sidewalks, foundations, basement walls, or stakes in the ground and which can be perceived as mechanical motion. Ground-borne noise describes sound generated when the same waves in the ground reach room surfaces in buildings, causing them to vibrate and radiate sound waves into the room.

Wayside impact due to transit vibration is normally described in terms of ground-borne noise because in most situations the noise produced by the vibration of room surfaces is audible at ground-borne vibration levels below those which are perceptible to tactile senses. Thus, in most, but not every case, a criterion limiting audible noise levels will provide adequate protection against tactile ground-borne vibration levels.

In most cases for surface or aerial transit operations the airborne noise is significantly louder than the ground-borne noise and the ground-borne noise is not perceived separately from the airborne noise. Thus, assessment of the acoustic noise levels due to vibration instead of ground vibration levels facilitates comparison with expected interior airborne noise.

As with airborne noise, there are some types of buildings for which specific design criteria should be applied, regardless of area category. Table 1-5 presents design criteria for generally acceptable levels of transient ground-borne noise levels in occupied spaces of various types of buildings and occupancies. This table is not intended to be all inclusive but may be a convenient general guide to the designer.

Table 1-5

CRITERIA FOR MAXIMUM GROUND-BORNE NOISE FROM METRO TRAIN OPERATIONS NEAR SPECIFIC TYPES OF BUILDINGS

Type of Building or Room	Maximum Single Event Noise Level
Concert Halls and TV Studios	25 dB(A)
Auditoriums and Music Rooms	30 dB(A)
Churches and Theatres	35 dB(A)
Hospital Sleeping Rooms	35-40 dB(A)
Courtrooms	35 dB(A)
Schools and Libraries	40 dB(A)
University Buildings	35-40 dB(A)
Offices	35-45 dB(A)
Commercial Buildings	45-55 dB(A)

Ground-borne noise which meets the design criteria listed above will not be inaudible in all cases; however, the level will be sufficiently low that no significant intrusion or annoyance should occur. In most cases, there will be noise from street traffic, other occupants of a building, or other sources, which will create intrusion that is equivalent to or greater in level than the noise from transit trains passing by.

A range for the maximum ground-borne noise limit is given in some cases to permit the designer to adjust the design criterion to be suitable for the environment and location of the building. For example, at offices in a quiet, landscaped industrial park area the limit should be at the low end of the range, 35 dB(A), whereas for offices located at a busy intersection or in a noisy central business district the limit can be at the upper end of the range, 45 dB(A).

Ground-Borne Vibration from Train Operations. Table 1-6 presents the appropriate criteria for maximum ground-borne vibration for various types of residential buildings. The criteria apply to measurements of vertical vibration of floor surfaces within the buildings.

Table 1-6

CRITERIA FOR MAXIMUM GROUND-BORNE VIBRATION FROM METRO TRAIN OPERATIONS

	Community Area Category	Maximum Single Event Ground-borne Vibration Velocity Level (dB re 10^{-6} in/sec) Single Family Dwellings	Multi-Family Dwellings	Hotel/ Motel Buildings
I	Low Density Residential	70	70	70
II	Average Residential	70	70	75
III	High Density Residential	70	75	75
IV	Commercial	70	75	75
V	Industrial/Highway	75	75	75

As with ground-borne noise, there are some types of buildings for which specific design criteria for ground-borne vibration should be applied, regardless of area category. Table 1-7 presents design goals or generally acceptable levels of transient ground-borne vibration levels in occupied spaces of various types of buildings and occupancies. This table is not intended to be all inclusive.

Table 1-7

CRITERIA FOR MAXIMUM GROUND-BORNE VIBRATION FROM TRAIN OPERATIONS

Type of Building or Room	Maximum Single Event Vibration Velocity Level (dB re 10^{-6} in/sec)
Concert Halls and TV Studios	65
Auditoriums and Music Rooms	70
Churches and Theatres	70
Hospital Sleeping Rooms	75
Courtrooms	75
Schools and Libraries	75
University Buildings	75-80
Offices	75-80
Commercial Buildings	75-85

Ground-borne vibration which meets the design criteria listed above will not be imperceptible in all cases; however, the level will be sufficiently low that no significant intrusion or annoyance should occur. In most cases, there will be vibration from street traffic, other occupants of a building, or other sources, which will create intrusion that is equivalent to or greater in level than the vibration from the metro trains.

A range for the maximum ground-borne vibration limit is given in some cases to permit the designer to adjust the design criterion to be suitable for the environment and location of the building. For example, at offices in a quiet, landscaped industrial park area the limit should be at the low end of the range, 75 dB, whereas for offices located at a busy intersection or in a noisy central business district the limit can be at the upper end of the range, 80 dB.

Airborne Noise from Transit Ancillary Facilities

General Introduction. There are sources of community noise in a subway or above-grade transit system other than trains. The two basic types of airborne noise from ancillary facilities are transient and continuous. For example, transient noise occurs during train passbys as noise is transmitted from vent shaft openings. Power substations, chiller plants and fan noise may be characterized as continuous ancillary equipment noise. These noises can be obtrusive due to their tonal and continuous nature. The appropriate noise level design goal limit depends on the activities of occupants as well as background noise in the area. The acceptable levels of transient and continuous noises are different. Transient noises are acceptable at higher levels than continuous noises, particularly continuous noises containing pure tones.

Table 1-8 presents the design goals for the transit system ancillary facility noises in each of the community area categories listed in Table 1-1. This should result in general community acceptance.

Table 1-8

DESIGN CRITERIA FOR CONTINUOUS NOISE
FROM TRANSIT SYSTEM ANCILLARY FACILITIES

Community Area Category		Maximum Noise Level, dB(A) Transient	Continuous
I	Low Density Residential	50	40
II	Average Residential	55	45
III	High Density Residential	60	50
IV	Commercial	65	55
V	Industrial/Highway	75	65

The criteria in Table 1-8 shall be applied at a distance of 50 feet from the shaft outlet or other ancillary facility or shall be applied at the setback line of the nearest building or occupied area, whichever is closer.

As stated previously, transient noise design goals apply to short time duration events such as train passby noise transmitted from vent shaft openings. Continuous noise design goals apply to noises such as fans, cooling towers or other long-duration noises except electrical transformer hum. The design goals for transformer noise, or other sources with tonal components, should be 5 dB(A) less than given in the Table 1-8. Sound attenuation is not required on the outlet of emergency exhaust fans except in cases where the emergency exhaust fans are used as part of a station ventilation system.

<u>Fans and Vent Shafts</u>. For fan and vent shafts with surface gratings or openings the noise shall be limited in accordance with the criteria for exterior noise from ancillary facilities, Table 1-8.

Vent shaft noise reduction shall be achieved by absorption treatment in the shafts - applied to the walls and ceilings. Fan shaft noise reduction shall be achieved by use of standard duct attenuators in shafts where the fans are near the surface gratings. For shafts with fans located remotely from the grating the noise reduction shall be achieved by the use of standard attenuators and sound absorption treatment applied to the fan room and shaft walls and ceilings with the combination to achieve the total attenuation required. Sound absorption treatment shall consist of 2- to 4-inch-thick mechanically attached panels, e.g. expanded cellular glass foam blocks.

<u>Substations and Emergency Power Generation</u>. Substation and emergency power generation equipment noise shall be limited to 5 dB(A) less sound level than listed for continuous noise in Table 1-8. Reduction of noise from these sources shall be achieved by barriers, enclosures, sound absorption materials and mufflers, as applicable to the individual facility or unit design.

<u>Chiller Plant Noise</u>. Chiller plant noise levels shall comply with design criteria listed for continuous noise in Table 1-8. Reduction of noise from chiller plants shall be achieved by barriers, enclosures and sound absorption materials, as applicable to the individual facility or unit design (AMCA, n.d.).

<u>Noise in Subway Tunnels</u>

High-speed train operations in tunnels can generate excessive noise levels and noise abatement techniques shall be used to reduce the noise to an acceptable level. The maximum interior car noise at maximum tunnel operating speeds shall not exceed 80 dB(A). An acoustical absorption system may be employed in the tunnel or additional sound insulation may be provided on the cars to meet this design goal. Tunnel sound absorption treatment can, for instance, provide 5 dB(A) or more reduction of noise levels inside the car. Reducing tunnel noise by a sound absorption system improves the acoustical environment for system employees and aids in complying with the statutory noise limits set by the Occupational Safety and Health Administration.

Shop Equipment Noise

To avoid excessive noise exposure for employees and to comply with existing and proposed standards and requirements of the Occupational Safety and Health Administration, shop equipment noise should not exceed 85 dB(A) at operator stations and should not exceed 90 dB(A) at any point 3 feet from the equipment.

Vibration Isolation of Subway Structures

Scope. Vibration isolation shall be provided at any point where the subway structure is in very close proximity to or directly against a building structure or building foundation elements.

General Considerations. Vibration isolation in the form of a resilient element shall be provided between the subway structure elements and building structure elements to prevent direct transmission of noise and vibration to buildings.

Isolation Elements.

- The resilient element between the two structures shall consist of intervening soil of at least 2 feet thickness or depth, or shall be an elastomer pad between the subway structure and building.
- The elastomer pad shall be a 1- or 2-inch thickness closed-cell expanded neoprene, selected to give proper support of hydraulic or structural loads with deflection of the elastomer pad not exceeding 10 percent to 20 percent of pad thickness.

Construction Noise and Vibration Control

General. Perform construction operations in a manner to minimize noise and vibration. Provide working machinery and equipment with efficient noise suppression devices and employ other noise and vibration abatement measures necessary for protection of both employees and the public. In addition, restrict working hours and schedule operations in a manner that will minimize to the greatest extent feasible the disturbance to the public in areas adjacent to the work and to occupants of buildings in the vicinity of the work. Protect employees and the public against noise exposure in accordance with the requirement of the Occupational Safety and Health Act of 1970 and the current statutory noise limits set by the Occupational Safety and Health Administration (1972). Compliance with the requirements of this Section will not relieve the Contractor from responsibility for compliance with state and local ordinances, regulations, and other Sections of this criteria document.

Special Requirements. Compliance with the requirements of this Section will require the use of machines with effective mufflers or enclosures and selection of quieter alternative procedures. Compliance may also require the use of completely closed enclosures (tongue-and-groove plywood sheathing) around work sites or a combination of closed boarding and effective mufflers or enclosures. It will also be necessary to arrange haul routes to minimize noise and vibration at residential sites and it may be necessary to place operating limitations on machines and trucks. Shop drawings of work sites and haul routes showing provisions for control of construction noise shall be submitted to the Engineer for approval.

Monitoring. Monitor noise and vibration levels of work operations to assure compliance with the noise and vibration limitations contained herein and retain records of noise and vibration measurements for inspection by the Engineer. Promptly inform the Engineer of any complaints received from the public regarding noise and vibration. Describe the action proposed and the schedule for implementation and subsequently inform the Engineer of the results of the action.

Definitions.

- Daytime refers to the period from 7:00 a.m. to 8:00 p.m. local time daily except Sundays and legal holidays. Nighttime refers to all other times including all day Sunday and legal holidays.
- Construction Limits are defined for the purpose of these noise and vibration control requirements as the Right-of-Way lines, Construction Easement Boundary or property lines as indicated on the drawings.
- Special Zones or Special Construction Sites, outside of Construction Limits, may be designated by the agency having jurisdiction to be considered as being within the Construction Limits.

Noise Level Restrictions.

Noise Level Restrictions in All Areas. In no case expose the public to construction noise levels exceeding 90 dB(A) (slow) or to impulsive noise levels with a peak sound pressure level exceeding 140 dB as measured on an impulse sound level meter or 125 dBC maximum transient level as measured on a general purpose sound level meter on "fast" meter responses.

Noise Level Restrictions at Affected Structures. Conduct construction activities in such a manner that the noise levels 200 feet from the Construction Limits or at the nearest affected building, whichever is closer, do not exceed the levels listed below.

- Continuous Noise: Prevent noises from stationary sources, parked mobile sources or any source or combination of sources producing repetitive or long-term noise lasting more than a few hours from exceeding the limits of Table 1-9.
- Intermittent Noise: Prevent noises from non-stationary mobile equipment operated by a driver or from any source of non-scheduled, intermittent, non-repetitive, short-term noises not lasting more than a few hours from exceeding the limits of Table 1-10.

Special Zone or Special Construction Site. In areas outside of Construction Limits but for which the Contractor has obtained designation as a Special Zone or Special Construction Site from the agency having jurisdiction, the noise limitations for buildings in industrial areas apply.

In zones designated by the local agency having jurisdiction as a special zone or special premise or special facilities, such as hospital zones, the noise level and working time restrictions imposed by the agency shall apply. These zones and work hour restrictions shall be obtained by the Contractor from the local agency.

Table 1-9

LIMITS FOR CONTINUOUS CONSTRUCTION NOISE

Affected Structure or Area	Maximum Allowable Continuous Noise Level, dB(A)	
Residential	Daytime	Nighttime
single family residence	60	50
along an arterial or in multi-family residential areas, including hospitals	65	55
in semi-residential/commercial areas, including hotels	70	60
Commercial	At All Times	
in semi-residential/commercial areas, including schools	70	
in commercial areas with no nighttime residency	75	
Industrial		
all locations	80	

Table 1-10

LIMITS FOR INTERMITTENT CONSTRUCTION NOISE

Affected Structure or Area	Maximum Allowable Continuous Noise Level, dB(A)	
Residential	Daytime	Nighttime
single family residence	75	60
along an arterial or in multi-family residential areas, including hospitals	80	65
in semi-residential/commercial areas, including hotels	85	70
Commercial	At All Times	
in semi-residential/commercial areas, including schools	85	
in commercial areas with no nighttime residency	85	
Industrial		
all locations	90	

More Than One Limit Applicable. Where more than one noise limit is applicable, use the more restrictive requirement for determining compliance.

Noise Emission Restrictions. Use only equipment meeting the noise emission limits listed in Table 1-11, as measured at a distance of 50 feet from the equipment in substantial conformity with the provisions of the latest revisions of SAE J366b, SAE J88, and SAE J952b (SAE, 1973a,b, 1979) or in accordance with the measurement procedures specified herein.

Table 1-11

NOISE EMISSION LIMITS ON CONSTRUCTION NOISE

TYPE OF EQUIPMENT	MAXIMUM NOISE LIMIT	
	Date Equipment Acquired	
	Before January 1, 1982	On or After January 1, 1982
All equipment other than highway trucks; including hand tools and heavy equipment	90 dB(A)	85 dB(A)
Highway trucks in any operating mode or location	83 dB(A)	80 dB(A)

Vibration Level Restrictions.

Vibration Limits in All Areas. Conduct construction activities in such a manner that vibration levels at a distance of 150 feet from the Construction Limits or at the nearest affected building, whichever is closer, do not exceed root-mean-square (rms) vibration velocity levels of 0.01 inches per second in any direction over the frequency range of 1 to 100 Hz.

Special Zones. In zones designated by the local agency having jurisdiction as a special zone or special premise or special facilities, the vibration level and working time restrictions imposed by the agency shall apply. These zones and work hour restrictions shall be obtained by the Contractor from the local agency.

Noise and Vibration Control Requirements. Notwithstanding the specific noise and vibration level limitations specified herein, utilize the noise and vibration control measures listed below to minimize to the greatest extent feasible the noise and vibration levels in all areas outside the Construction Limits.

- Utilize shields, impervious fences or other physical sound barriers to inhibit transmission of noise.
- Utilize sound-retardant housings or enclosures around noise-producing equipment.
- Utilize effective intake and exhaust mufflers on internal combustion engines and compressors.
- Line or cover hoppers, storage bins and chutes with sound-deadening material.
- Do not use air- or gasoline-driven saws.
- Conduct truck loading, unloading and hauling operations so that noise and vibration are kept to a minimum.

- Route construction equipment and vehicles carrying spoil, concrete or other materials over streets and routes that will cause the least disturbance to residents in the vicinity of the work. Advise the engineer in writing of the proposed haul routes prior to securing a permit from the local government.

- Site stationary equipment to minimize noise and vibration impact on the community, subject to approval of the Engineer.

- Use vibratory pile drivers or augering for setting piles in lieu of impact pile drivers. If impact pile drivers must be used, their use is restricted to the hours from 8:00 a.m. to 5:00 p.m. weekdays in residential and semi-residential/commercial areas.

Blasting Noise and Vibration Control

General. Perform blasting operations in a manner to minimize noise and vibration. Use blasting procedures and covers providing effective suppression of noise and vibration and employ other abatement measures necessary for protection of both employees and the public. In addition, restrict working hours and schedule operations in a manner that will minimize to the greatest extent feasible the disturbance to the public in areas adjacent to the work and to occupants of buildings in the vicinity of the work. Compliance with the requirements of this Section will not relieve the Contractor from responsibility for compliance with state and local ordinances, regulations, and other Sections of this criteria document.

Monitoring. Monitor noise and vibration levels of work operations to assure compliance with the limitations contained herein and retain records of measurements for inspection by the Engineer. Promptly inform the Engineer of any complaints received from the public regarding noise or vibration. Describe the action proposed and the schedule for implementation and subsequently inform the Engineer of the results of the action.

Time of Blasting.

General. Restrict blasting to daytime hours, 7:00 a.m. to 8:00 p.m. daily except Sundays and legal holidays.

Emergency. In the event that safety or emergency considerations require blasting during nighttime hours, 8:00 p.m. to 7:00 a.m., and Sundays and legal holidays, blasts may be fired at such times subject to prior notice to and approval by the Engineer and subject to the restrictions of Section 7.12.4.B.

Special Considerations. In addition to the restrictions of Section 7.12.3.A, if situations and circumstances require, restrict blasting to within reasonably safe distances of noise and vibration sensitive premises or facilities to specific daytime periods determined by the Engineer and schedule and coordinate each shot with the Engineer.

Ground Vibration Due to Blasting.

General. Conduct blasting operations to avoid damage to structures or buildings and to prevent peak particle velocity of blast-induced motion from exceeding 2.0 inches per second on or in the nearest structure or on the ground at the nearest structure or 200 feet from the Construction Limits, whichever is closer.

Peak particle velocity is defined as the instantaneous maximum vector sum of the velocity vectors in three mutually perpendicular directions at the point of interest.

Emergency Blasting. Emergency blasting required to protect the safety of the project during the nighttime period will be controlled to prevent peak particle velocity of ground vibration at the nearest building having nighttime occupancy or 200 feet from the Construction Limits, whichever is closer, from exceeding 0.2 inches per second. Notwithstanding the above, if the emergency arises from inability of Contractor to fire loaded holes within the daytime period solely due to unavoidable conditions, peak particle velocity of ground vibration may exceed 0.2 inches per second but will not exceed 2.0 inches per second.

New Concrete. Conduct blasting operations to prevent peak particle velocity of ground vibration from exceeding 1.0 inch per second at concrete less than 3 days old or 2.0 inches per second at concrete less than 7 days old. Do not blast within 25 feet of concrete less than 7 days old unless a satisfactory plan has been submitted in writing and accepted by the Engineer.

Noise (Overpressure) Due to Blasting.

General. Conduct daytime blasting in such a manner as to limit instantaneous peak overpressure to 0.01 psi at the nearest building or 200 feet from the Construction Limits, whichever is closer. All instrumentation must be linear in response with a range of at least 5 Hz to 200 Hz.

Emergency. Conduct nighttime blasting in such a manner as to limit instantaneous peak overpressure to 0.0004 psi at the nearest building or 200 feet from the Construction Limits, whichever is closer.

Overpressure Control Measures. Notwithstanding the specific limitations specified herein, utilize control measures such as listed below to minimize to the greatest extent feasible the blasting overpressure in all areas outside the Construction Limits.

- Utilize weighted covers on vertical and inclined shafts to contain blasting overpressure.
- Utilize blasting mats at the excavation where feasible.
- Minimize charge per delay.
- Arrange covers and excavation to maximize underground volume exposed to blast pressure.

Test Blasts. Perform at least one small charge test blast at each new drill and blast excavation site prior to commencement of production blasting. The purpose is to establish local ground-borne vibration and airborne overpressure propagation characteristics and anomalies to aid in determination of efficient charges that will not cause the ground-borne vibration and airborne overpressure limits to be exceeded. Coordinate scheduling of each test blast with the Engineer.

General Precautions in Blasting Operations.

- Notify all parties owning or operating subsurface utilities 72 hours before commencing blasting operations.
- Coordinate and obtain the Engineer's approval for the daily blasting schedule.
- Use controlled blasting techniques to minimize fracturing the rock outside the neat lines of the excavation.
- Use such sizes and arrangement of explosive charges and such method of detonation that will reduce the magnitude of vibration resulting from the explosion to the limits specified in previous Sections to prevent damage to the constructed works as well as to services, buildings or property in the neighborhood; and to minimize nuisance to nearby residents.
- Employ all necessary and satisfactory means of protection, such as temporary bridges, staging, chains, rope-nets, mats, timber and the like, to prevent any stones and fragments of rock or other materials from being shot or thrown out of any excavation.
- As the excavation proceeds and immediately after each blast, test the roof and walls and scale loose and shattered rock which is liable to fall. Carry out similar checks of previously excavated sections at least every 48 hours.
- Do not blast in ground which, in the opinion of the Engineer, is loose or liable to slip. Wedging and barring only shall be allowed in such ground.
- Before blasting within 15 feet of an existing line of water, gas or sewer pipes or within 50 feet of any completed part of the works, submit and obtain approval of a plan showing the relative positions of the existing service or completed part of the Works and the area to be blasted and the blasting technique to be employed.

REFERENCES

Air Moving and Conditioning Association (AMCA), Standard 300-67, "Test Code for Sound Rating Air Moving Devices."

American National Standards Institute (ANSI), S1.4-1971, "Specification for Sound Level Meters."

American Public Transit Association (APTA), January 1979, "Guidelines for the Design of Rapid Transit Facilities."

International Electro-technical Commission (IEC), 1973, Publication 179, "Precision Sound Level Meters."

Society of Automotive Engineers (SAE), J366b, 1973, "Exterior Sound Level for Heavy Trucks and Buses."

Society of Automotive Engineers, J952b, 1973, "Sound Levels for Engine Powered Equipment."

Society of Automotive Engineers, J88, 1979, "Exterior Sound Level Measurement Procedure for Earthmoving Machinery."

"Standards for Occupational Noise Exposure," Title 8, Division of Industrial Safety General Safety Orders, Group 15, Noise Control Safety Orders, Article 105, adopted February 5, 1972.

United States Environmental Protection Agency, EPA Technical Document 500/9-74-004, March 1974, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety."

ATTACHMENT 2

NOISE AND VIBRATION REGULATIONS AND GUIDELINES

TABLE OF CONTENTS

NOISE AND VIBRATION REGULATIONS AND GUIDELINES

Introduction

In rapid transit systems, the noise and vibration produced by operation of the vehicles and, in some cases, from ancillary facilities can cause significant environmental impacts. In reaction to this and other community noise sources, there has been considerable legislative action, at the local, state and federal levels, which has produced regulations that may affect the design and operation requirements for a new rail transit facility. Such ordinances in almost all cases address the noise from ancillary facilities and may address the noise from facility construction activities. In addition, some standards or ordinances enacted directly address the noise from rail transit system vehicle operations.

Although some agencies are beginning to consider ground-borne vibration and/or building vibration standards as an adjunct or supplement to noise standards and ordinances, at the present time there are very few standards which specify vibration level limits. Since ground-borne vibration is one of the most significant environmental aspects of a rail transit system, it is appropriate and necessary to consider the effects of ground-borne vibration even though there may be no applicable standards or ordinances which directly address this factor. The material presented in this attachment is divided into two sections: a compendium and review of the legal statutes and guidelines which may pertain to the construction operation and maintenance of the Metro Rail project (Los Angeles County Board of Supervisors, n.d.); and a digest of the Metro Rail Noise and Vibration Design Criteria.

Legal Statutes and Guidelines

Overview. The proposed 18.6-mile route of the Metro Rail project will be located entirely within the County of Los Angeles and, for the most part, within the incorporated area of the City of Los Angeles. Thus, the applicable legislation includes any federal, State of California, or City and County of Los Angeles standards or ordinances which address noise and vibration aspects of the Metro Rail project.

One of the most important pieces of legislation that has had a major impact on noise control and on the issuance of noise regulations in the USA is the Noise Control Act of 1972 (U.S. Congress, 1972). Under this Act, states and municipalities retain primary responsibility for noise control. The Act authorizes the U.S. Environmental Protection Agency (EPA) to provide technical assistance to states and municipalities to facilitate development and implementation of their environmental noise control programs. The Act specifies construction equipment as one of the four categories of equipment to be studied by the EPA.

Pursuant to the California Government Code (1972), Section 65302 (g), both the County and the City have adopted Noise Elements as part of their General Plans. The California Government Code requires (but does not limit) that the General Plan Element include consideration of the following sources of noise generation:

- Highways and freeways
- Primary arterials and local streets
- Passenger and freight on-line railroad operations
- Rapid transit system operations
- Commercial, general aviation, heliport, helistop and military airport operations, aircraft overflights, jet engine test stands, and all other ground facilities and maintenance functions related to airport operations
- Local industrial plants including railroad classification yards
- Other stationary noise sources identified by local agencies as contributing to the community noise environment (California Department of Health; Governor's Office of Planning and Research, 1976).

Both the County and City of Los Angeles have complied with the requirements of the California Government Code Section 65302 (g) by adopting a Noise Element to the General Plan. These Noise Elements in combination with the City and County Noise Ordinances result in some limitations and requirements of the Metro Rail project. Primarily these restrictions apply to construction noise and vibration and to ancillary facility noise during operation. They do not apply to vehicle operation during revenue service.

The State of California has enacted a number of laws intended to control noise. None of these state laws directly affect the Metro Rail project. The California Administrative Code, Title 25, does indirectly establish a noise exposure limit standard for airborne noise from rail transit vehicle operations. None of the federal agencies, EPA, DOT or UMTA, have produced regulations which are applicable to the Metro Rail Project other than some EPA regulations which affect construction equipment noise emission. The general policy of UMTA is to review and comment on environmental impact statements and to assure compliance with commitments of the environmental impact statement.

Transit industry practices generally follow the noise and vibration design limits as outlined in the APTA Publication, "Guidelines for Design of Rapid Transit Facilities." This includes all of the newer system facilities and equipment recently designed and built in Washington, DC, Baltimore, Atlanta, and Buffalo.

<u>Existing General Plan Elements and Local Noise Ordinances</u>

<u>County General Plan Noise Element.</u> The Los Angeles County General Plan Noise Element was adopted in 1974 and is essentially an Action Plan which establishes a list of priority actions to be undertaken by the County to meet Plan objectives (Los Angeles County Department of Regional Planning, 1974). One of these recommendations calls for the passage of "a comprehensive Noise Ordinance" and amendments to the "building code, sub-division, and zoning ordinances... to reflect the latest noise abatement techniques." One result of the Action Plan has been the passage of Ordinance 11,778, the Noise Control Ordinance of the County of Los Angeles (Los Angeles County Board of Supervisors, n.d.).

County Noise Ordinance. The County Noise Ordinance (Los Angeles County Board of Supervisors, n.d.) relates to the control of noise and vibration and states: "It shall be the policy of the County to maintain quiet in those areas which exhibit low noise levels and to implement programs aimed at reducing noise in those areas where noise levels are above acceptable values."

The Ordinance adopted measurement standards, established community noise criteria, defined prohibited actions, provided a variance mechanism, and charged the County Health Officer with the principal role of enforcement (Los Angeles County Board of Supervisors, n.d.). The impact of the County Noise Ordinance on the construction and operation of the transit system is evaluated later in this report.

City General Plan Noise Element. The City of Los Angeles General Plan Noise Element was adopted in 1975 and focuses significant attention upon the transportation sector as a noise generator and places particular emphasis on aviation noise sources (Los Angeles County Department of Regional Planning, 1975). The Noise Element does not suggest a specific action program; rather, it outlines broad conceptual programs and leaves it up to various City Departments to develop the required regulations and/or ordinances.

City Noise Ordinance. The City of Los Angeles' first Noise Ordinance (144,331) (City of Los Angeles, 1973) predates the City General Plan Noise Element (6) and was adopted by the City Council in 1973. It is found, commencing with Section 111.01, in the Los Angeles Municipal Code. The Ordinance was recently submitted to the City Council for amendment in areas which do not affect the construction and operation of the transit system. The City Noise Ordinance establishes standards for ambient noise levels within various land use zones and the criteria for maximum noise levels. The potential impact of the City Noise Ordinance upon the construction and operation of the transit system is discussed below.

Potential Impacts of Local and Federal Agency Regulations

The impacts of local and federal regulations upon the construction and operations of the Metro Rail project are discussed separately herein. Both construction and operations may be affected by either the City and County Noise Ordinances or the EPA noise emission standards, or both.

Construction - Local Regulations. Both the City and County Noise Ordinances prescribe limits for construction noise. Most of the transit alignment is to be located within the municipal boundaries of the City of Los Angeles and will therefore fall under jurisdiction of the Municipal Code (City of Los Angeles, 1973).

First, the City Noise Ordinance prohibits the generation of construction related noise during the hours of 9:00 p.m. to 7:00 a.m. (Slaughter, 1981). Further, Section 112.05(a) of the City Noise Ordinance states that no person shall operate any powered equipment or powered hand tool that exceeds a maximum noise level of 75 dB(A) at a distance of 50 feet. This maximum noise limit applies to all construction and industrial machinery including crawler-tractors, dozers, rotary drills and augers, loaders, power shovels, cranes, derricks, motor graders, paving machines, off-highway trucks, ditchers, trenchers, compactors, scrapers, wagons, pavement breakers, compressors, and pneumatic-powered equipment.

The City Noise Ordinance also states that the noise limits for particular equipment listed above shall be deemed to be superseded and replaced by noise limits for such equipment from and after their establishment by final regulations adopted by the Federal Environmental Protection Agency and publication in the Federal Register.

However, the City Noise Ordinance recognizes the difficulty of achieving the strict noise limits for all the equipment and states that said limitations shall not apply where compliance therewith is technically infeasible (emphasis added). The burden of proving that compliance is technically infeasible shall be upon the person or persons, i.e., the contractor, charged with non-compliance. Technical infeasibility shall mean that said noise limitations cannot be achieved despite the use of mufflers, shields, sound barriers and/or any other noise reduction devices or techniques during operation of the equipment (City of Los Angeles, 1973).

The County Noise Ordinance (Los Angeles County Board of Supervisors, n.d.) also addresses construction-related noise and vibration nuisance. It states (in part): "Notwithstanding any other provisions of this ordinance, the following acts and the causing or permitting thereof are declared to be in violation of this ordinance: Operating or causing the operation of any tools or equipment used in construction, drilling, repair, alteration, or demolition work, between weekday hours of 8:00 p.m. and 7:00 a.m. (note that this should be 8:00 p.m. to be consistent with other provisions of the Ordinance) or at any time on Sundays or holidays, such that the sound therefrom creates a noise disturbance across a residential or commercial real property line, except for emergency work of public service utilities or by variance issued by the Health Officer." The County Noise Ordinance stipulates that the contractor shall conduct construction activities in such a manner that the maximum noise levels at the affected buildings will not exceed the following.

At Residential Structures.

- Mobile Equipment

  Maximum noise levels for nonscheduled, intermittent, short-term operation (less than 10 days) of mobile equipment:

	Single Family Residential	Multi-Family Residential	Semi-Residential/ Commercial
Daily, except Sundays and legal holidays 7 a.m. to 8 p.m.	75 dB(A)	80 dB(A)	85 dB(A)
Daily, 8 p.m. to 7 a.m., and all day Sundays and legal holidays	60 dB(A)	65 dB(A)	70 dB(A)

- Stationary Equipment

  Maximum noise levels for repetitively scheduled and relatively long-term operation (periods of 10 days or more of stationary equipment):

	Single Family Residential	Multi-Family Residential	Semi-Residential/ Commercial
Daily, except Sundays and legal holidays 7 a.m. to 8 p.m.	60 dB(A)	65 dB(A)	70 dB(A)
Daily, 8 p.m. to 7 a.m., and all day Sundays and legal holidays	50 dB(A)	55 dB(A)	60 dB(A)

At Business Structures.

- Mobile Equipment

Maximum noise levels for nonscheduled, intermittent, short-term operation of mobile equipment: daily, including Sundays and legal holidays, all hours; maximum of 85 dB(A).

The County Noise Ordinance also states that in case of a conflict between this ordinance and any other ordinance regulating construction activities, provisions of any specific ordinance regulating construction activities shall control. This statement implies that in areas of the City, the City Noise Ordinance shall apply. The implication is also that any ordinance which has more strict regulations will control; however, this is not explicitly stated.

In addition to the noise limits, the County Noise Ordinance prohibits operating or permitting the operation of any device that creates a vibration which is above the vibration perception threshold of an individual at or beyond the property boundary of the source, if on private property, or at 150 feet (46 m) from the source if on a public space or public right-of-way. The perception threshold shall be a motion velocity of 0.01 in/sec. over the range of 1 to 100 Hertz. The Ordinance fails to clarify whether peak or RMS vibration velocity is to be considered.

Construction - EPA Emission Standards. The pertinent EPA noise emission standards are those relating to portable air compressors and for new wheel and crawler tractors.

On January 14, 1976, EPA published final regulations on newly manufactured portable air compressors (Federal Register, 1976). This document specifies a test procedure involving measurement at five orthogonal positions 7 m from the compressor surface, the measurement positions in the plane horizontal to the (hard) ground being at a height of 1.5 m. The specified operating condition is full load and the results are computed on the basis of energy averaged sound level at 7 m distance. The noise emission standard was set at 76 dB(A).

On July 11, 1977, EPA futher published noise emission regulations for new wheel and crawler tractors having horsepower ratings from 20 hp to 500 hp (Federal Register, 1977). The regulation stipulates the following limits, measured at 15 m.

Machine Type	Horse-power	Not to Exceed A-Weighted Sound Level (dB(A))	Effective Date
Crawler Tractor	20 to 199	77	March 1981
		74	March 1984
Crawler Tractor	200 to 450	83	March 1981
		80	March 1984
Wheel Loader	20 to 249	79	March 1981
		76	March 1984
Wheel Loader	250 to 500	84	March 1981
		80	March 1984
Wheel Tractor	20 plus	74	March 1981

Transit System Operations - Local Regulations. Neither the City nor County of Los Angeles Noise Ordinance establishes specific criteria for transportation vehicle generated noise. This may be partially due to the fact that the federal and state governments have preempted much of this area of law. In the case of transit operations, the pertinent noise and vibration criteria are generally based on the American Public Transit Association document, "Guidelines for Design of Rapid Transit Facilities," usually referred to as the "APTA Guidelines" (APTA, 1979). These criteria are fully considered in the report "Noise and Vibration Design Criteria for the Metro Rail project," dated April 1982. The standards regarding noise and vibration in general use by the transit industry are presented in Section 5 of this report.

While the City and County Noise Ordinances do not specifically address (through prohibitions, establishment of criteria, etc.) transit vehicle noise, they do address transit ancillary facility noise sources associated with the system operations, specifically ventilation and air conditioning equipment noise.

Section 112.02 of the Los Angeles Municipal Code (City of Los Angeles, 1973) is currently under consideration for amendment to read: "It shall be unlawful for any person, within any zone of the City, to operate any air conditioning, refrigeration, or heating equipment for any residence or other structure or to operate any pumping, filtering, or heating equipment for any pool or reservoir in such a manner as to create on the premises of any other occupied property any noise which would cause the noise level to exceed the ambient noise level by more than five (5) decibels."

Article V of the County Noise Ordinance (Los Angeles County Board of Supervisors, n.d.) prohibits the operation of any air conditioning or refrigeration equipment in such a manner as to elevate the ambient noise level on the property line of any adjoining residence beyond 55 dB(A).

Transit System Operations - State Regulations. The California Noise Control Act of 1973 (California Health and Safety Code, 1973) does not specifically address rapid transit system operations or construction. However, it does declare that excessive noise is a serious hazard to the public health and welfare and that it is a policy of the state to provide an environment for all Californians free from noise that may be hazardous to their health or welfare. Thereafter, the Act assigns the Office of Noise Control of the California Department of Health the responsibility for developing criteria and guidelines for use in setting standards for human exposure to noise in cooperation with local governments or the State Legislature. Most of the effect of the California Noise Control Act is via the local noise ordinances and standards, as discussed above. However, there are some state laws or standards which potentially affect the operation of a transit system.

The California Vehicle Code (n.d.) includes a number of sections which provide specific noise limits for motor vehicles subject to registration and off-highway vehicles subject to identification. Because of the definition as motor vehicles and the requirements for registration or identification, these limits do not apply to transit vehicles.

The California Noise Insulation Standards (n.d.) include a provision which indirectly affects noise from rail transit system operations. In Subsection (e) (n.d.) of T25-28, Noise Insulation Standards, the indication is that, where residential buildings or structures will be located within an annual exterior Community Noise Equivalent Level (CNEL) contour of 60 dB(A) adjacent to rapid transit lines, there shall be an acoustical analysis showing that the proposed building has been designed to limit intruding noise to the allowable interior noise levels prescribed in Section (e) (n.d.). An exception is listed for railroads where there are no nighttime operations and daytime operations do not exceed four trains per day. This requirement applies to new residential buildings or structures to be located near the noise source. However, the implication is that when a new noise source, such as a rail transit system, is placed in proximity to residential structures, the noise exposure level created by that new noise source should not exceed a CNEL 60 dB(A) level at the residential structures. While this interpretation is not specifically stated in any of the California Administrative Code Sections, the Standard does provide an appropriate design criterion for airborne noise from transit vehicle operations for a new transit system. Note that many jurisdictions are applying the California Administrative Code standards to any change in use of residential structures, such as conversion of apartments to condominiums.

There are a number of other California laws involving noise including: the California Noise Control Safety Orders (n.d.), the California Airport Noise Standards (n.d.), the California Aircraft Noise Limits Law (1971), the California Law on Freeway Noise Affecting Classrooms (n.d.), and the California Motorboat Noise Law (1973). However, none of these address any of the noise or vibration aspects of a rail transit project.

Transit System Operations - Federal Agency Regulations. While the U.S. EPA provides technical assistance to state and local agencies to facilitate implementation of environmental noise control programs, the EPA has not produced any regulations specific to transit system operations. The only regulations implemented are those which apply to some types of equipment used in construction and trucks used in interstate commerce.

The U.S. Department of Transportation (DOT) and the Urban Mass Transportation Agency (UMTA) of DOT also do not have any specific noise and vibration guidelines or criteria for rapid transit systems. Their activity in this area is limited to review of environmental impact statements and review of design features to assure compliance with the environmental impact statement requirements and standard industry practices.

Transit Industry Practices

There are basically two sets of standards regarding noise and vibration which are in general use by the transit industry. These are:

- The Institute for Rapid Transit (IRT) Guidelines developed in 1970 to 1972 and published in May 1973 (IRT, 1973), entitled: "Guidelines and Principles for Design of Rapid Transit Facilities."

- The revised noise and vibration standards in the American Public Transit Association document, "Guidelines for Design of Rapid Transit Facilities," developed in 1976 to 1978 and published in 1979 (APTA, 1979), usually referred to as the "APTA Guidelines."

The noise and vibration standards indicated in the original IRT Guidelines and in the APTA Guidelines are widely used by the transit industry for determining appropriate design criteria or design goals for noise and vibration produced by various components of a transit system. The guidelines include noise and vibration from transit vehicles for operations both below ground and above ground, design criteria for stations for control of noise from all sources and design criteria for fan and vent shaft noise or other ancillary facility noise. The guidelines also include the noise and vibration limit specifications to be applied to transit vehicles via the purchase contract documents.

The main difference between the noise and vibration guidelines or design goals in the newer APTA 1979 publication, compared to the original IRT specification, is some modification of the transit vehicle noise level limits or design goals. Because of experience with some of the vehicles produced in the 1970s, it was thought that the noise limit specifications for some items of the vehicle equipment were too severe and were causing extra cost and difficulty in producing the cars. As a result, some of the car interior and car exterior noise limits, particularly for auxiliary equipment, were increased by 2 to 5 dB(A). This was in response to criticism and requests from the manufacturers. As it has turned out, evaluation of vehicles and equipment produced by manufacturers have shown that it was, in fact, possible to have produced the equipment within the noise level specifications required with simple designs and at reasonable costs. Thus, it was not necessary to have raised the limits. However, insufficient information on the characteristics of the equipment was available at the time the guidelines were developed.

REFERENCES

Administrative Code of the City of Los Angeles, 1973, "Noise Control Ordinance of the City of Los Angeles (as proposed for amendment)" (Ordinance No. 144,331).

American Public Transit Association (APTA), January 1979, "Guidelines for Design of Rapid Transit Facilities."

California Administrative Code, "California Airport Noise Standards," Title 21, Public Works, Chapter 2.5 - Division of Aeronautics (Department of Transportation), Subchapter 6, as amended through May 26, 1979.

California Administrative Code, "California Noise Control Safety Orders," Title 8, Industrial Relations, Chapter 4 - Division of Industrial Safety, Subchapter 7, Group 15, Article 105, as amended through February 2, 1972.

California Administrative Code, "California Noise Insulation Standards," Title 25, Housing and Community Development, Chapter 1 - State Housing Law Regulations and Earthquake Protection Laws Regulations, Subchapter 1, Article 4, Section 28, as amended through June 16, 1979.

California Department of Health and Governor's Office of Planning and Research, Berkeley, California, February 1976, "Guidelines for the Preparation and Content of Noise Elements of the General Plan."

California Government Code, Division 1, Planning and Zoning, Chapter 3 - Local Planning, Article 5, Section 65302(g), June 1972, "California Noise Planning in Land Use Act," as amended by Senate Bill 860 (Bielenson, 1975) adopted January 1, 1976.

California Harbors and Navigation Code, "California Motor Boat Noise Law," Division 3, Vessels, Chapter 5 - Operations and Equipment of Vessels, Article 1, Sections 654, 654.05, 654.06 and 688, effective July 1, 1973, amended by Laws of 1974, Chapter 1269; Laws of 1976, Chapter 744.

California Health and Safety Code, "California Aircraft Noise Limits Law," Division 20, Miscellaneous Health and Safety Provisions, Chapter 1.5 - Noise Pollution, Sections 24180, 24181, enacted by Laws of 1971, Chapter 1770.

California Health and Safety Code, "California Noise Control Act of 1973," Division 28, Noise Control Act, approved October 2, 1973, Laws of 1973, Chapter 1095, amended by Laws of 1975, Chapters 957, 1124; Laws of 1976, Chapter 1063.

California Streets and Highways Code, "California Law on Freeway Noise Affecting Classrooms," Division 1, State Highways, Chapter 1 - Administration, Article 6, Section 216, amended by Laws of 1973, Chapter 541; Laws of 1974, Chapter 645; Laws of 1975, Chapter 969.

California Vehicle Code, Division 11, Rules of the Road, Chapter 12 - Public Offenses, as amended by Laws of 1974, Chapter 359; Laws of 1975, Chapter 993; and Division 12, Equipment of Vehicles, Chapter 5 - Other Equipment, as amended by Laws of 1974, Chapters 359, 769, 1080; Laws of 1975, Chapters 83, 933; Laws of 1977, Chapter 558;

Laws of 1980, Chapter 382; and Chapter 6 - Equipment of Off-Highway Vehicles, Article 4, as amended by Laws of 1976, Chapter 1093.

Federal Register 41(9), January 14, 1976, "Noise Emissions Standards for Construction Equipment: Portable Air Compressors."

Federal Register 42(132), July 11, 1977, "Noise Emissions Standards for Construction Equipment: New Wheel and Crawler Tractors."

Institute for Rapid Transit, May 1973, "Guidelines and Principles for Design of Rapid Transit Facilities."

Los Angeles County Board of Supervisors, undated, "Noise Control Ordinance of the County of Los Angeles (Ordinance No. 11,778)."

Los Angeles County Department of Regional Planning, October 1974, "Los Angeles County General Plan, Noise Element and Draft Environmental Impact Report."

Los Angeles Department of City Planning, September 1975, "General Plan of the City of Los Angeles, Noise Element."

Noise Control Act of 1972, Public Law 92-574, enacted by Congress October 18, 1972, signed by the President October 27, 1972.

Slaughter, Otis, telephone interview, Los Angeles Department of Building and Safety, November 6, 1981.

ATTACHMENT 3

ENGINEERING LINE STATION REFERENCE MAPS

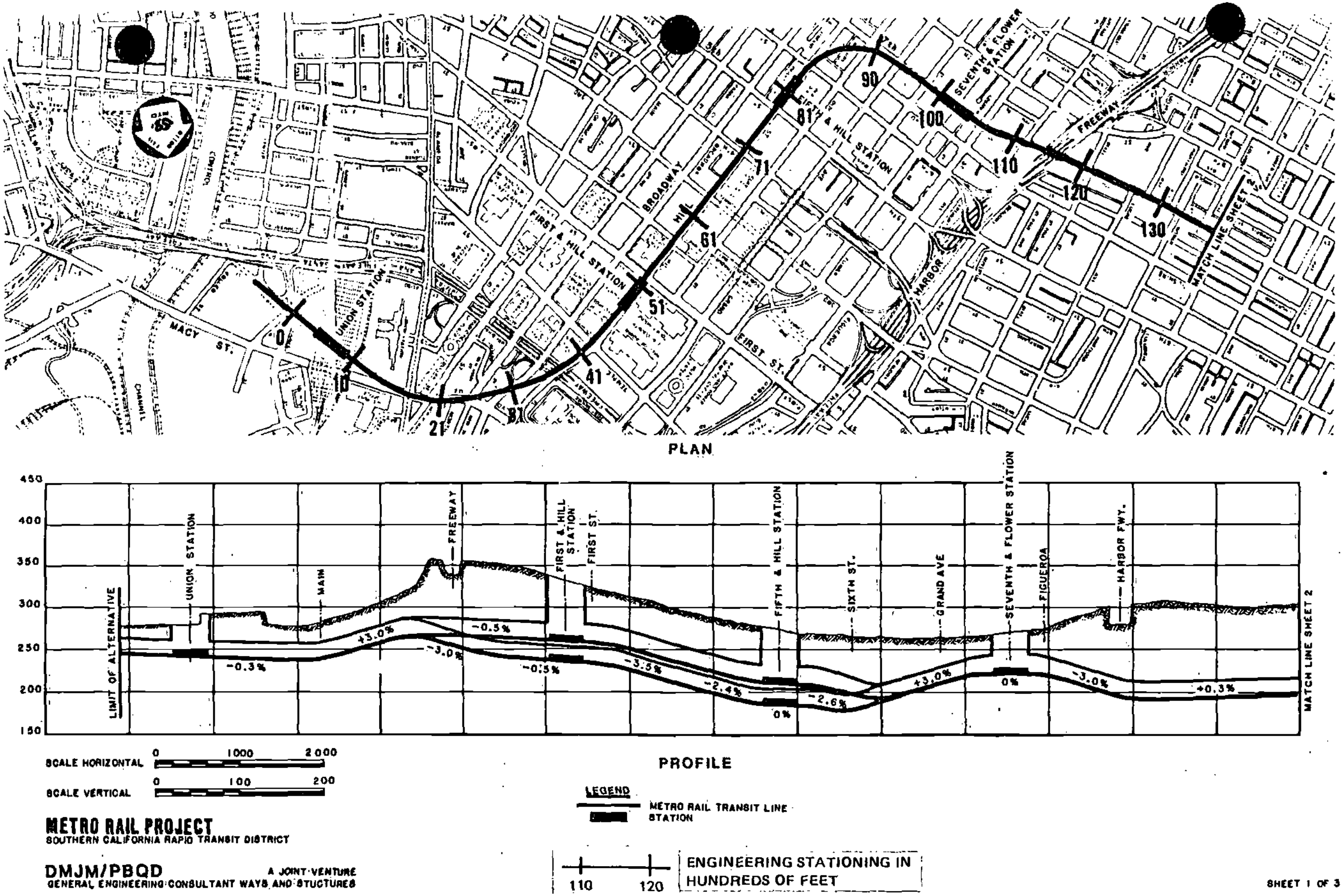
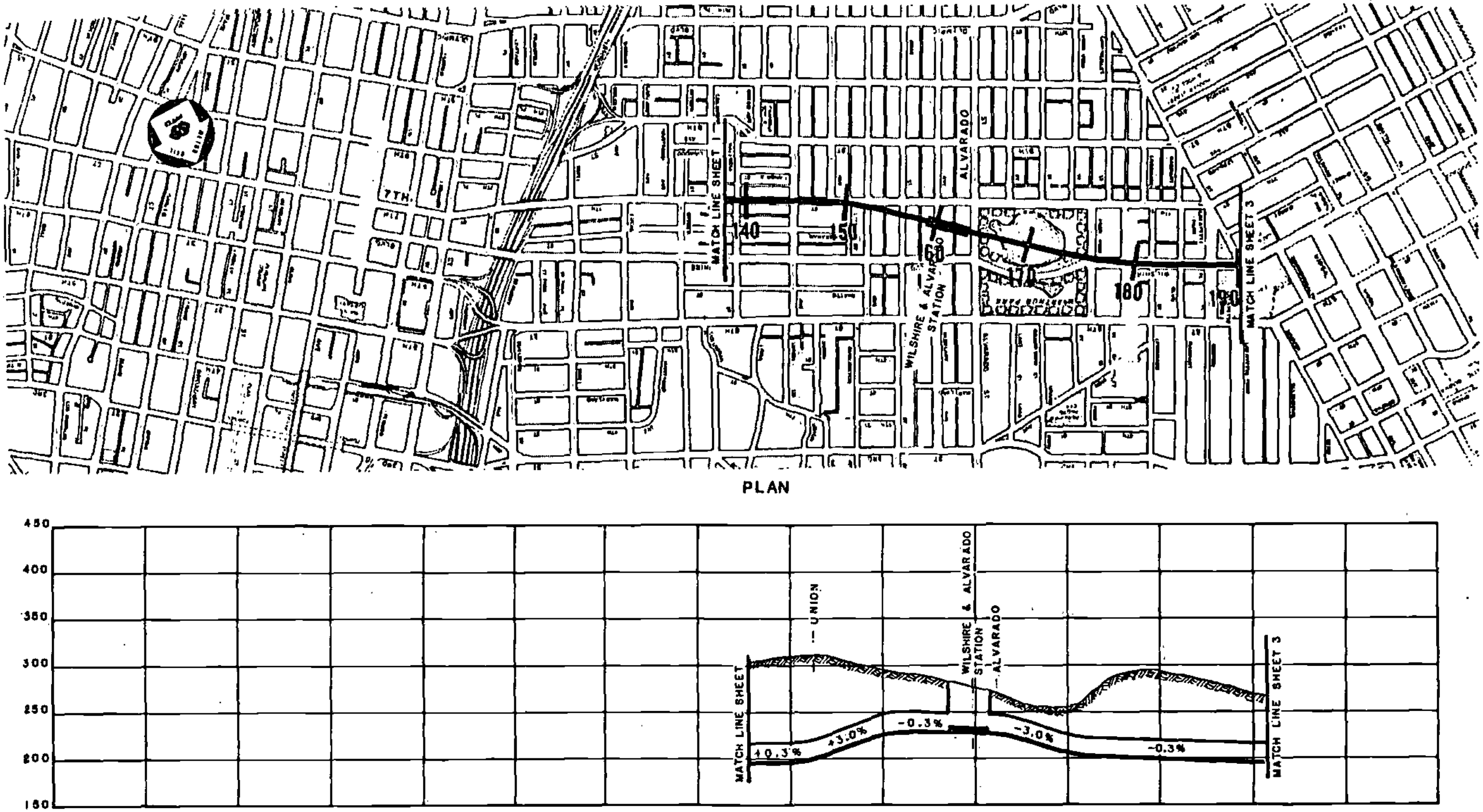


Figure 3-1 Locally Preferred Alternative



SCALE HORIZONTAL 0 1000 2000

SCALE VERTICAL 0 100 200

LEGEND

METRO RAIL TRANSIT LINE

STATION

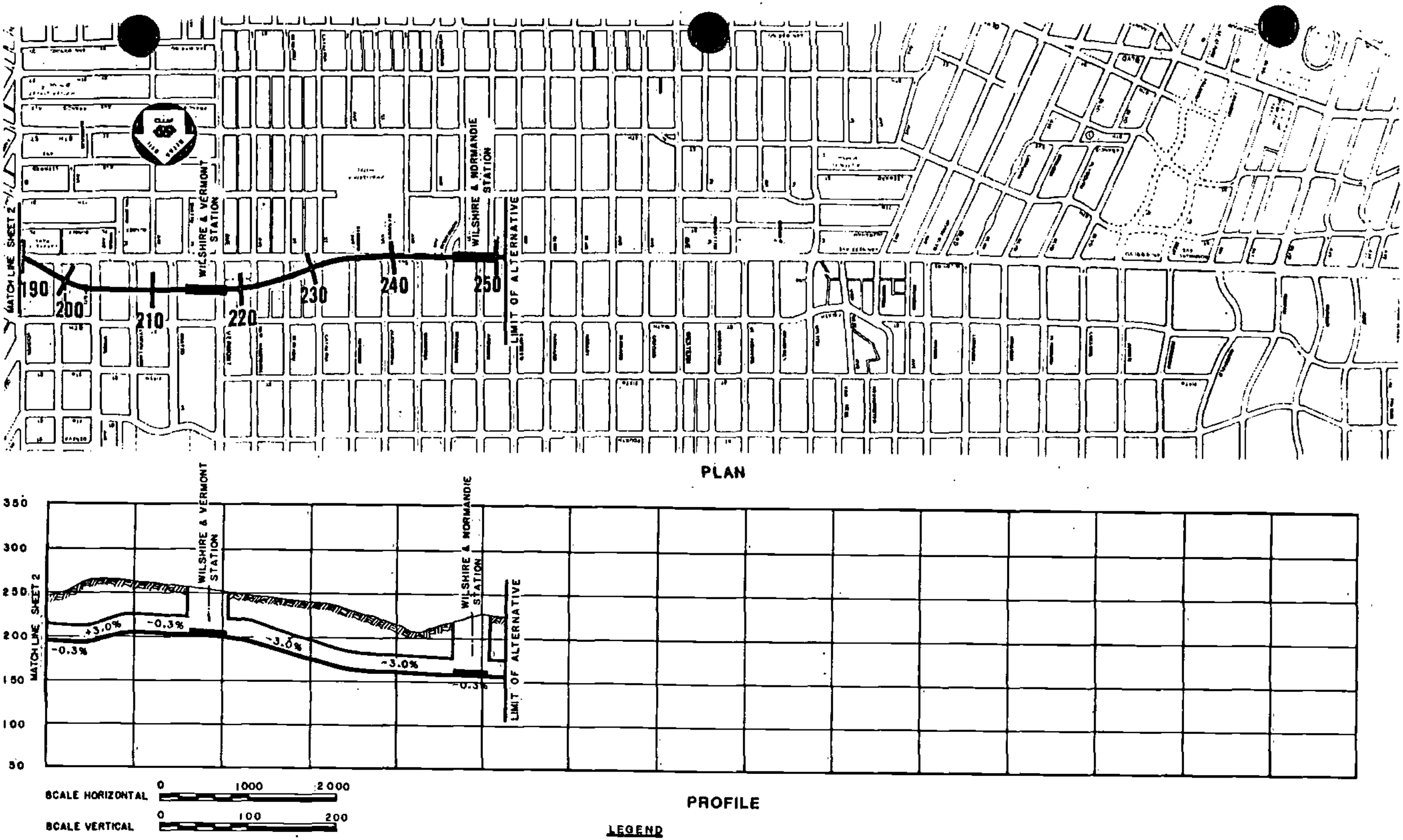
110 120 ENGINEERING STATIONING IN HUNDREDS OF FEET

METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DMJM/PBQD A JOINT VENTURE
GENERAL ENGINEERING CONSULTANT WAYS AND STUCTURES

SHEET 2 OF 3

Figure 3-2 Locally Preferred Alternative



METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DMJM/PBQD A JOINT VENTURE
GENERAL ENGINEERING CONSULTANT WAYS AND STUCTURES

SHEET 3 OF 3

Figure 3-3 Locally Preferred Alternative

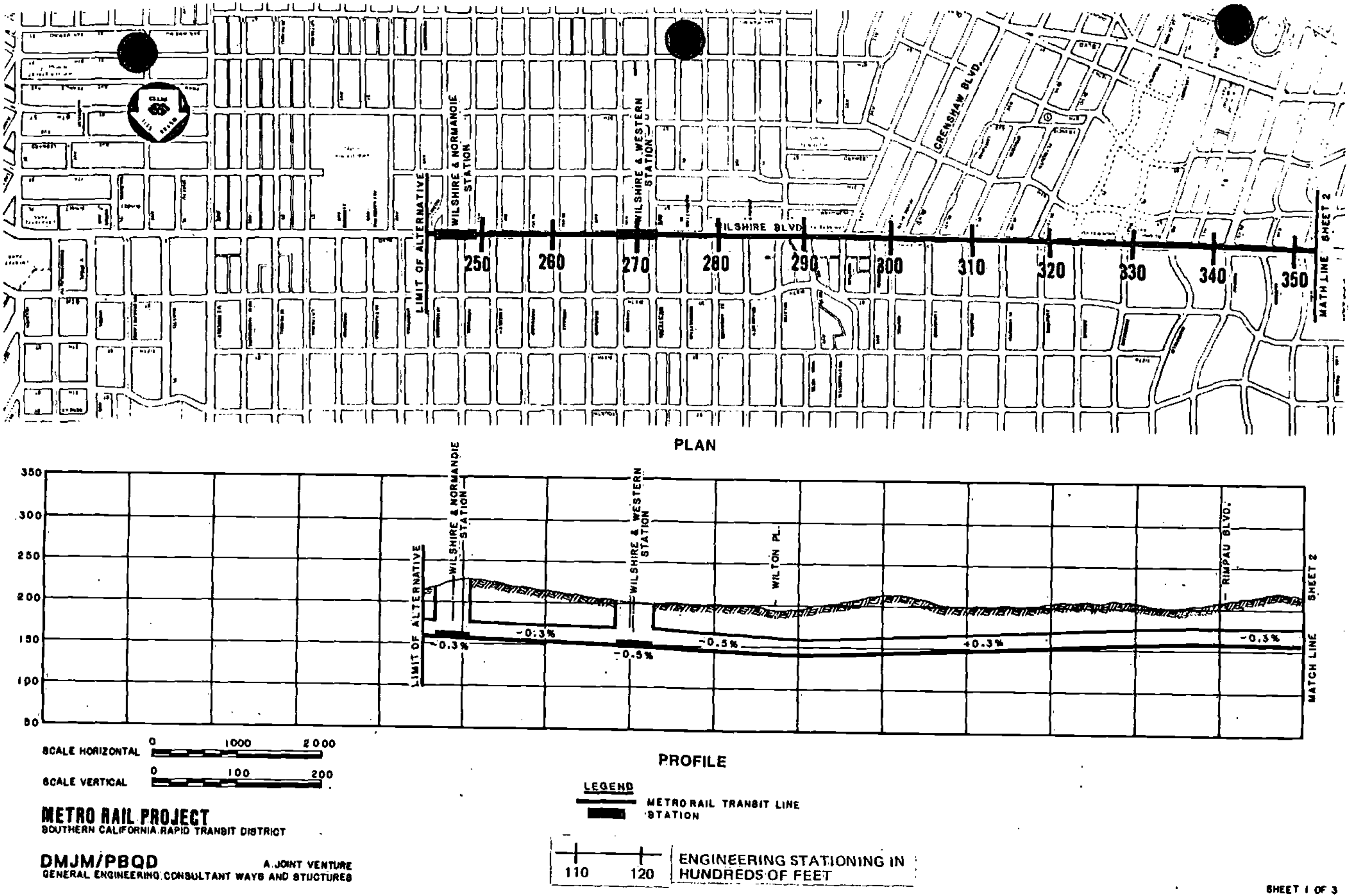


Figure 3-4 Locally Preferred Alternative

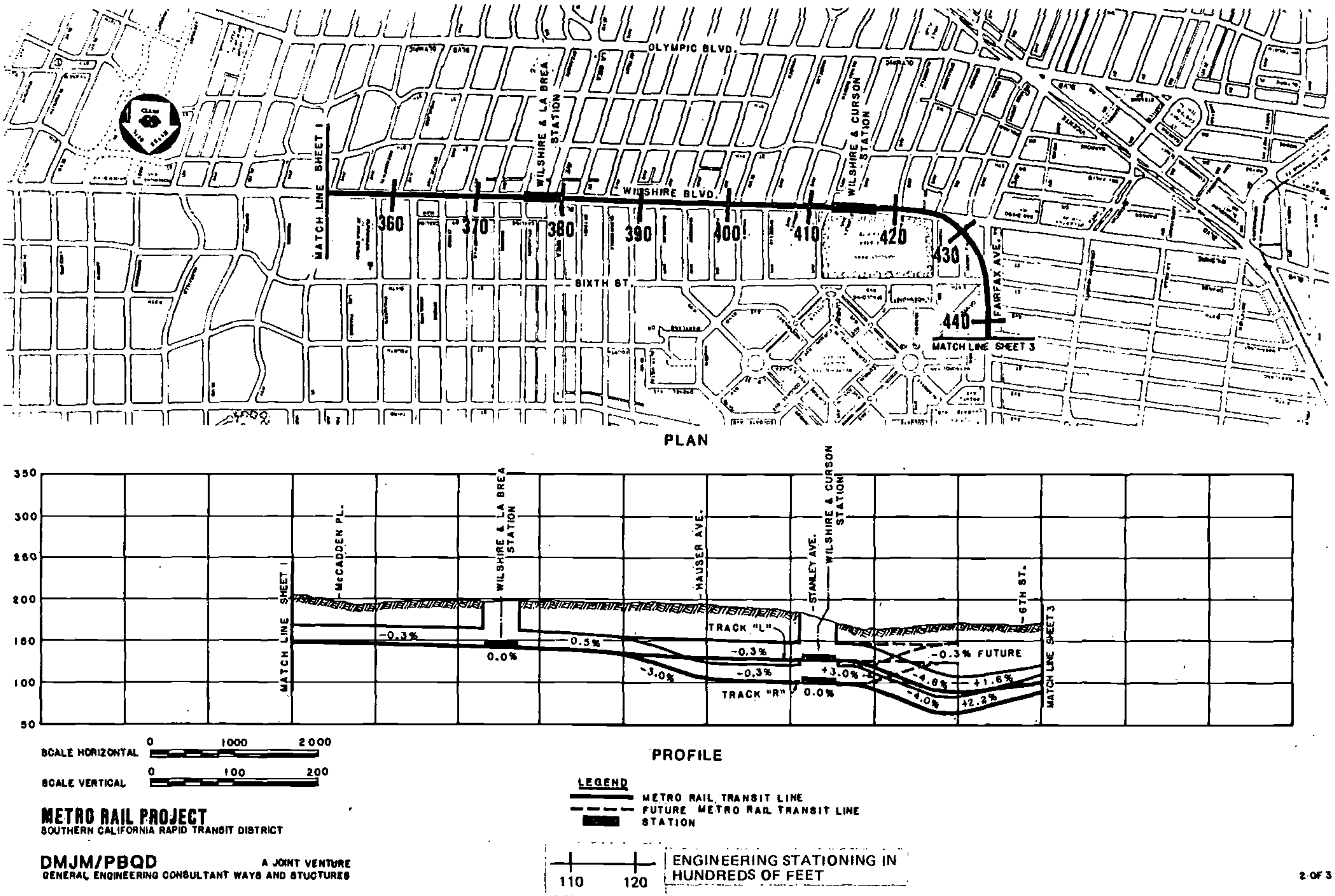


Figure 3-5 Locally Preferred Alternative

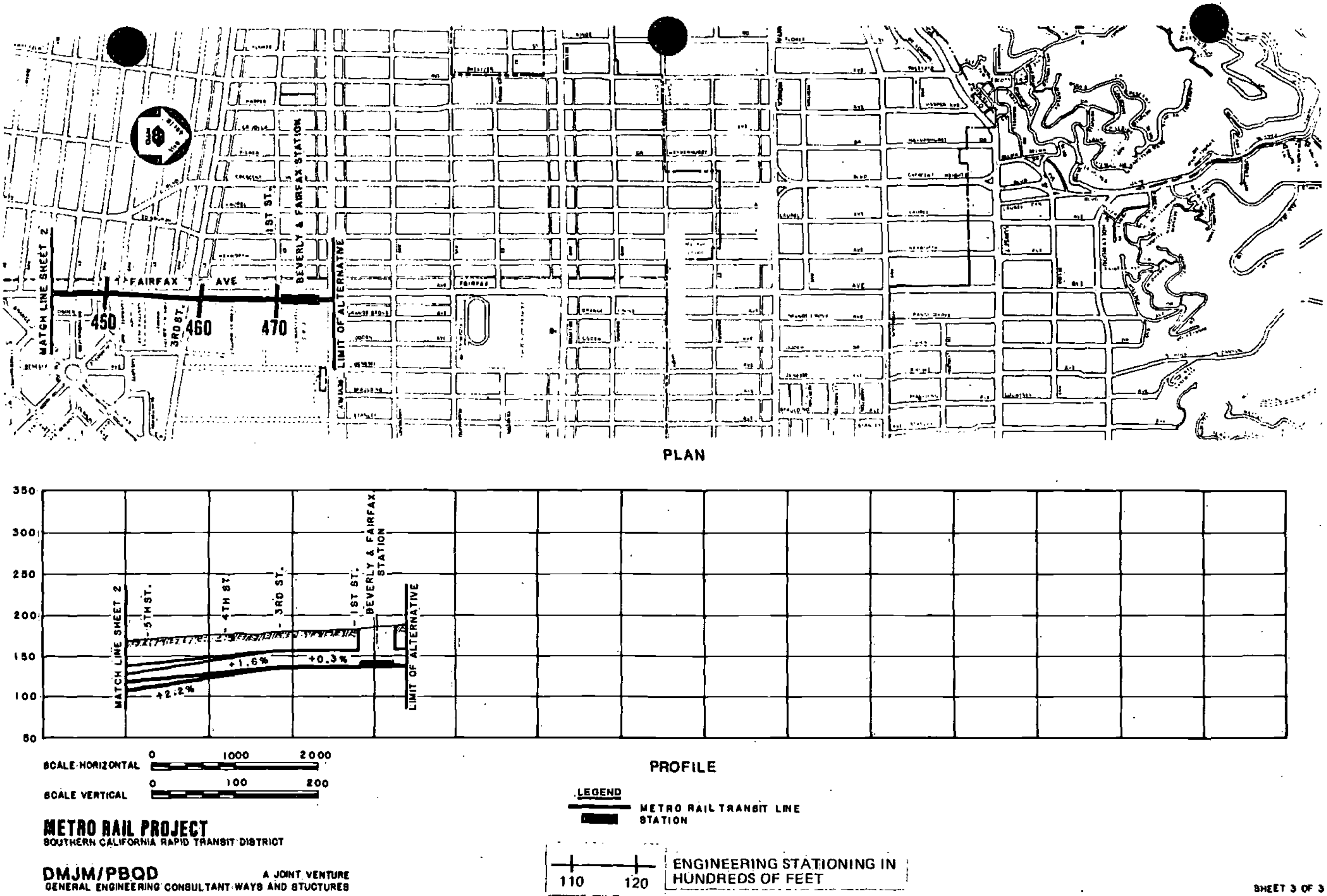


Figure 3-6 Locally Preferred Alternative

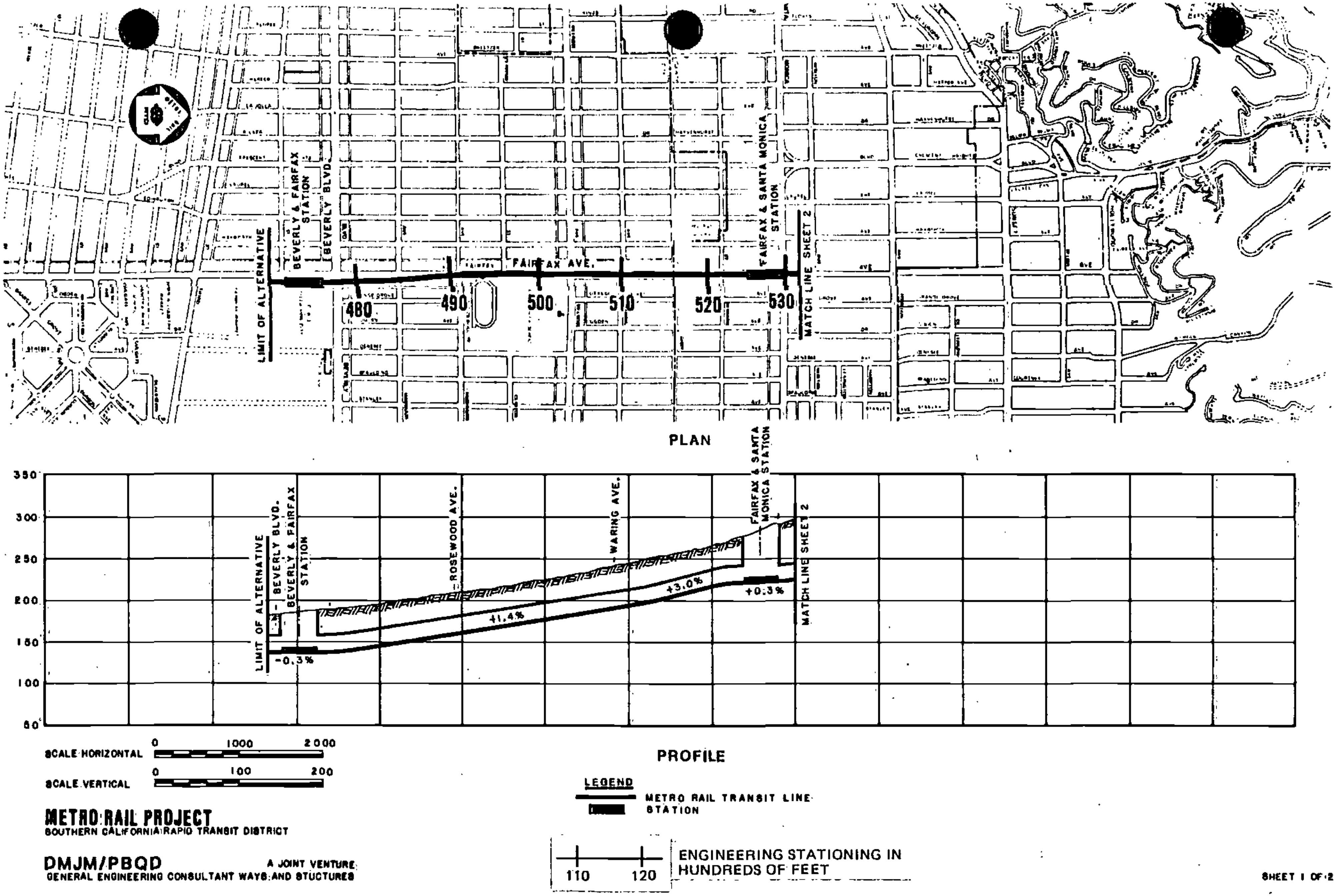


Figure 3-7 Locally Preferred Alternative

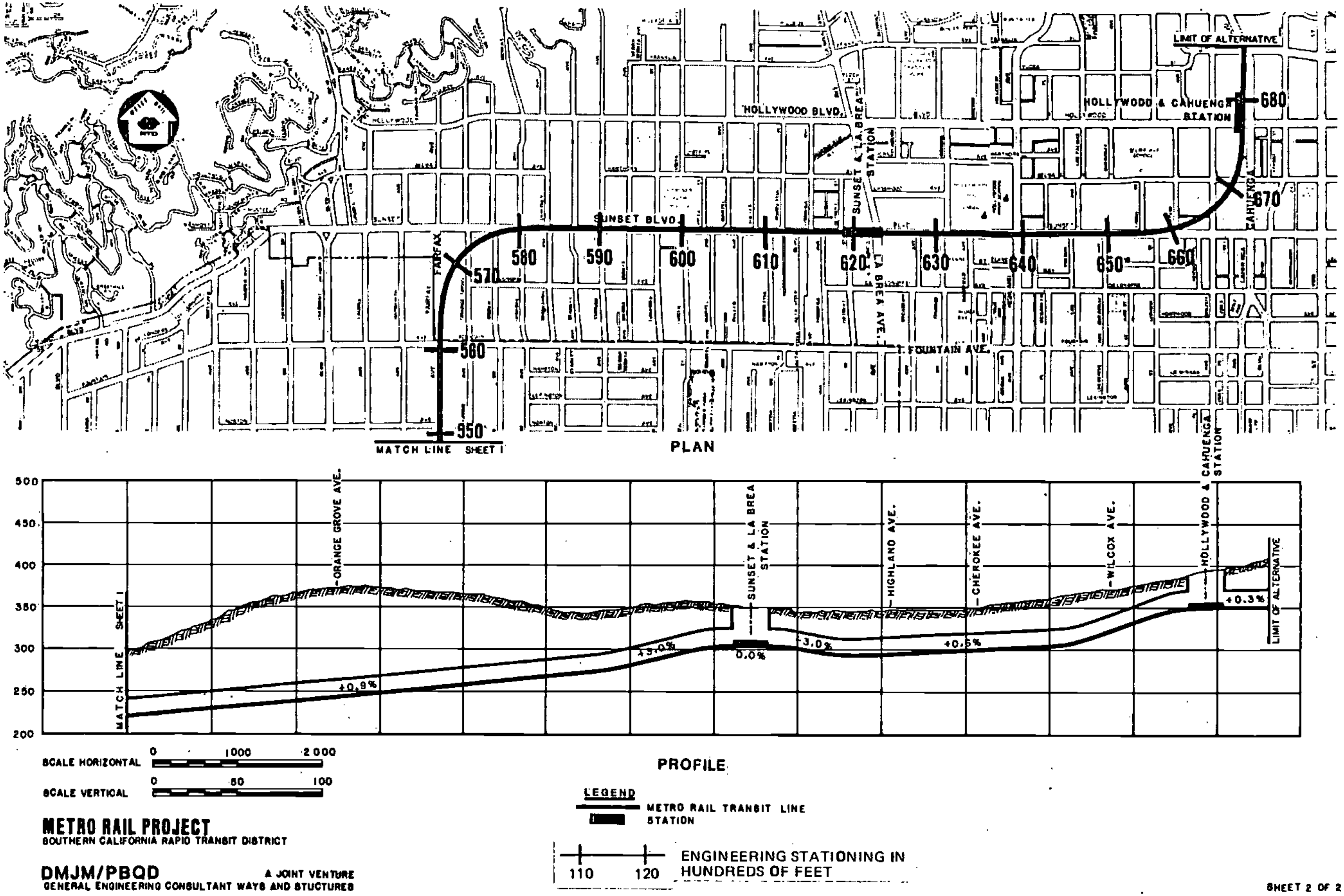
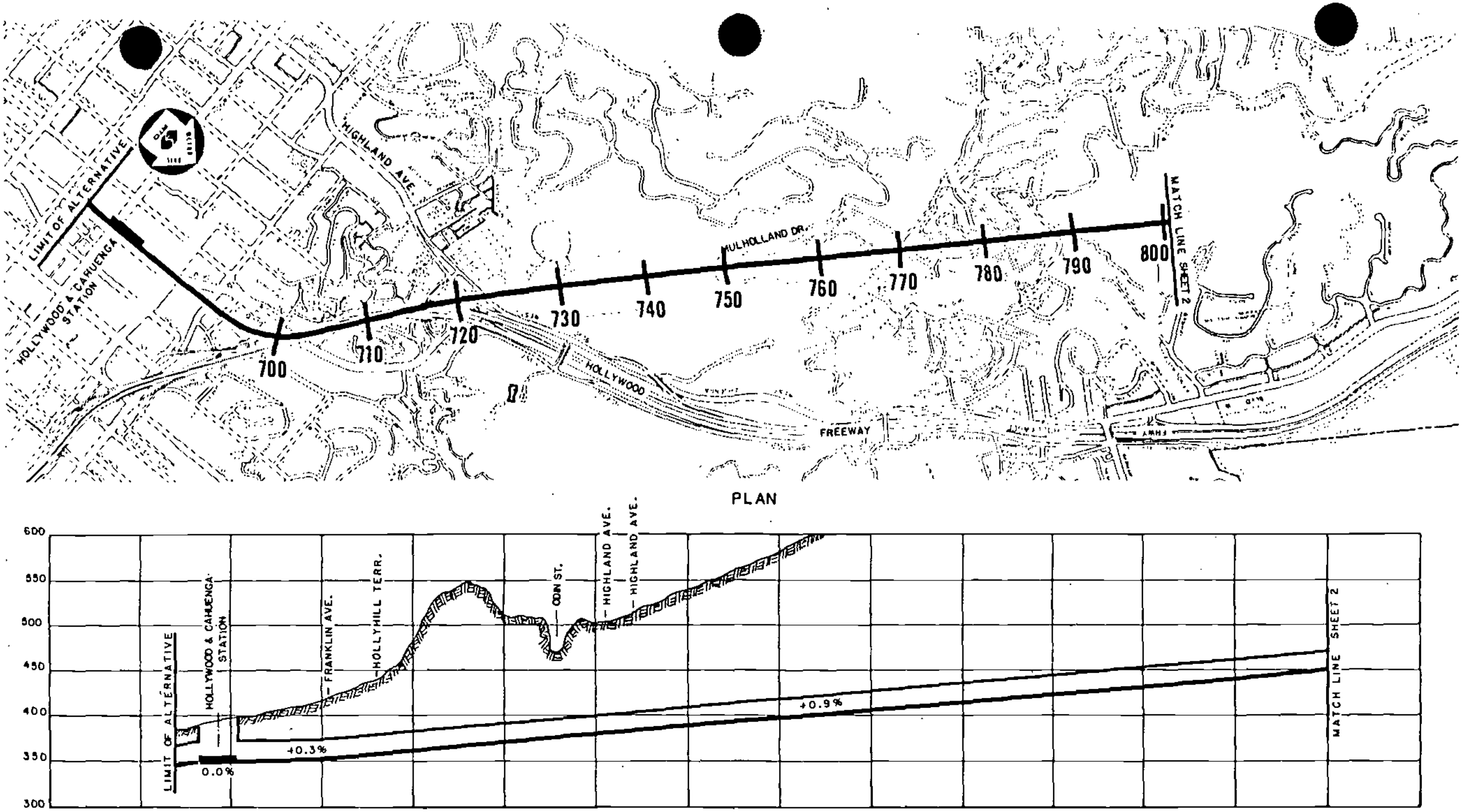


Figure 3-8 Locally Preferred Alternative



PROFILE

SCALE HORIZONTAL 0 1000 2000

SCALE VERTICAL 0 100 200

LEGEND

METRO RAIL TRANSIT LINE

STATION

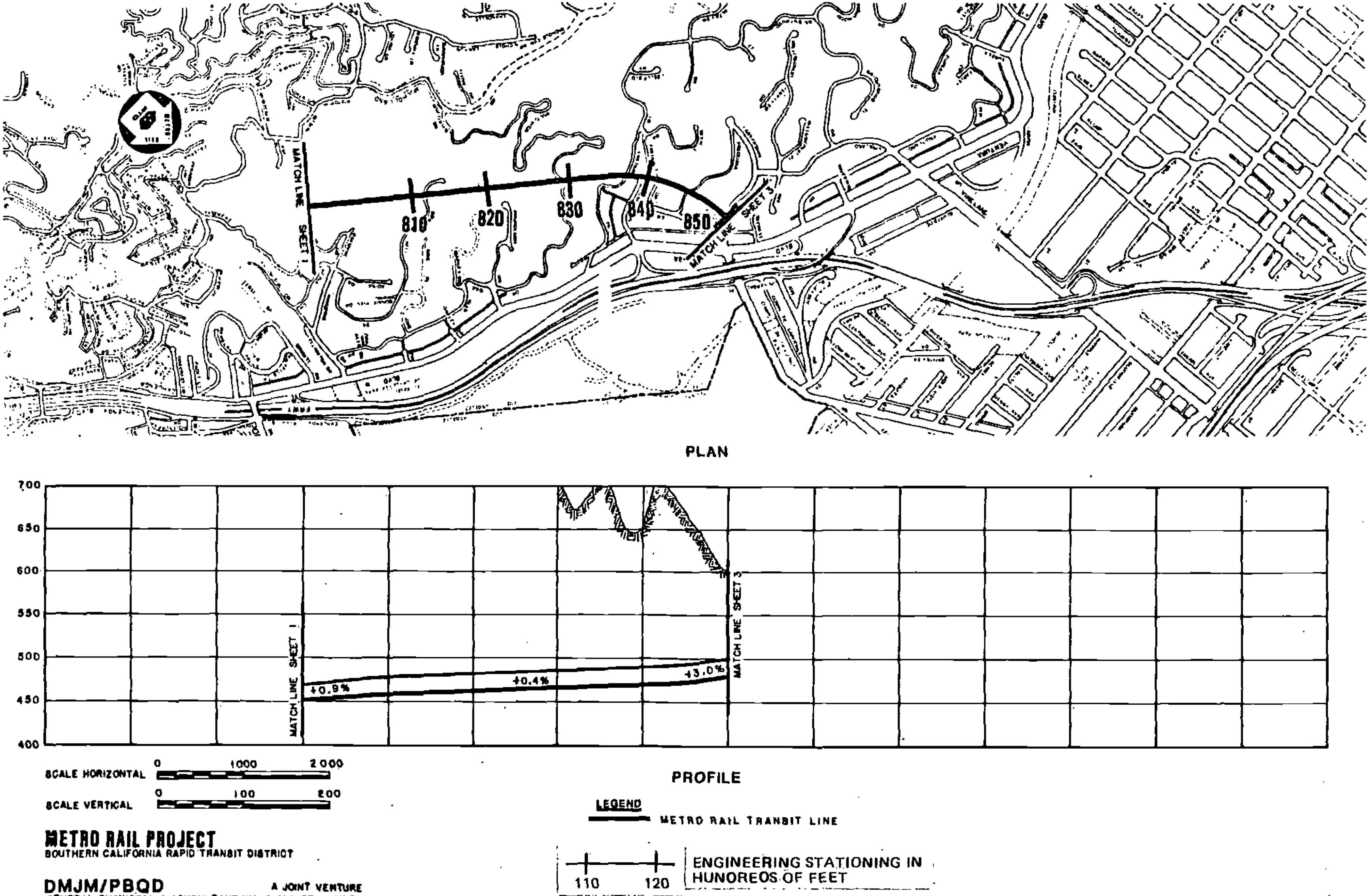
110 120 ENGINEERING STATIONING IN HUNDREDS OF FEET

METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DMJM/PBQD A JOINT VENTURE
GENERAL ENGINEERING CONSULTANT WAYS AND STUCTURES

SHEET 1 OF 3

Figure 3-9 Locally Preferred Alternative



METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DMJM/PBQD A JOINT VENTURE
GENERAL ENGINEERING CONSULTANT WAYS AND STUCTURES

SHEET 2 OF 3

Figure 3-10 Locally Preferred Alternative

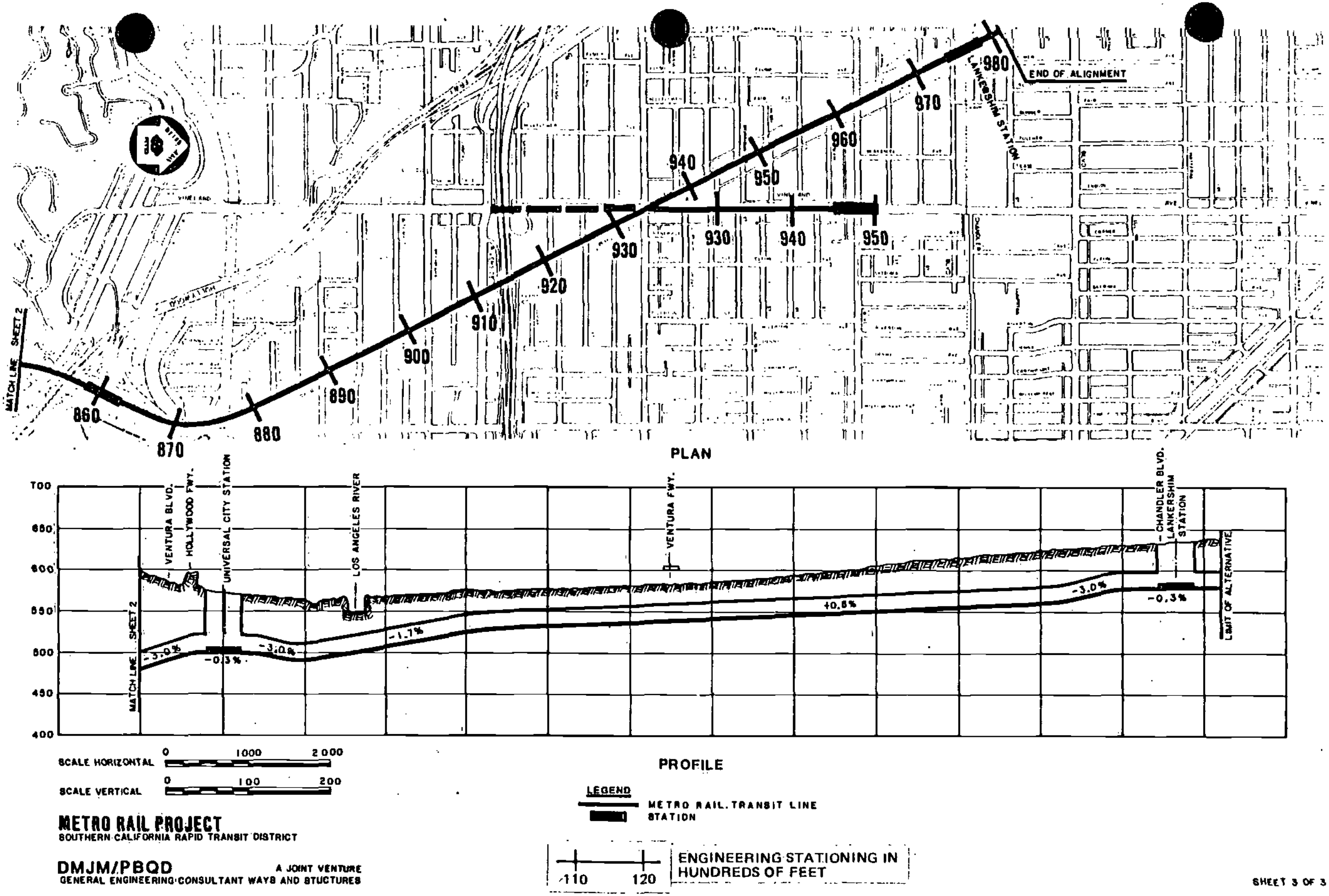
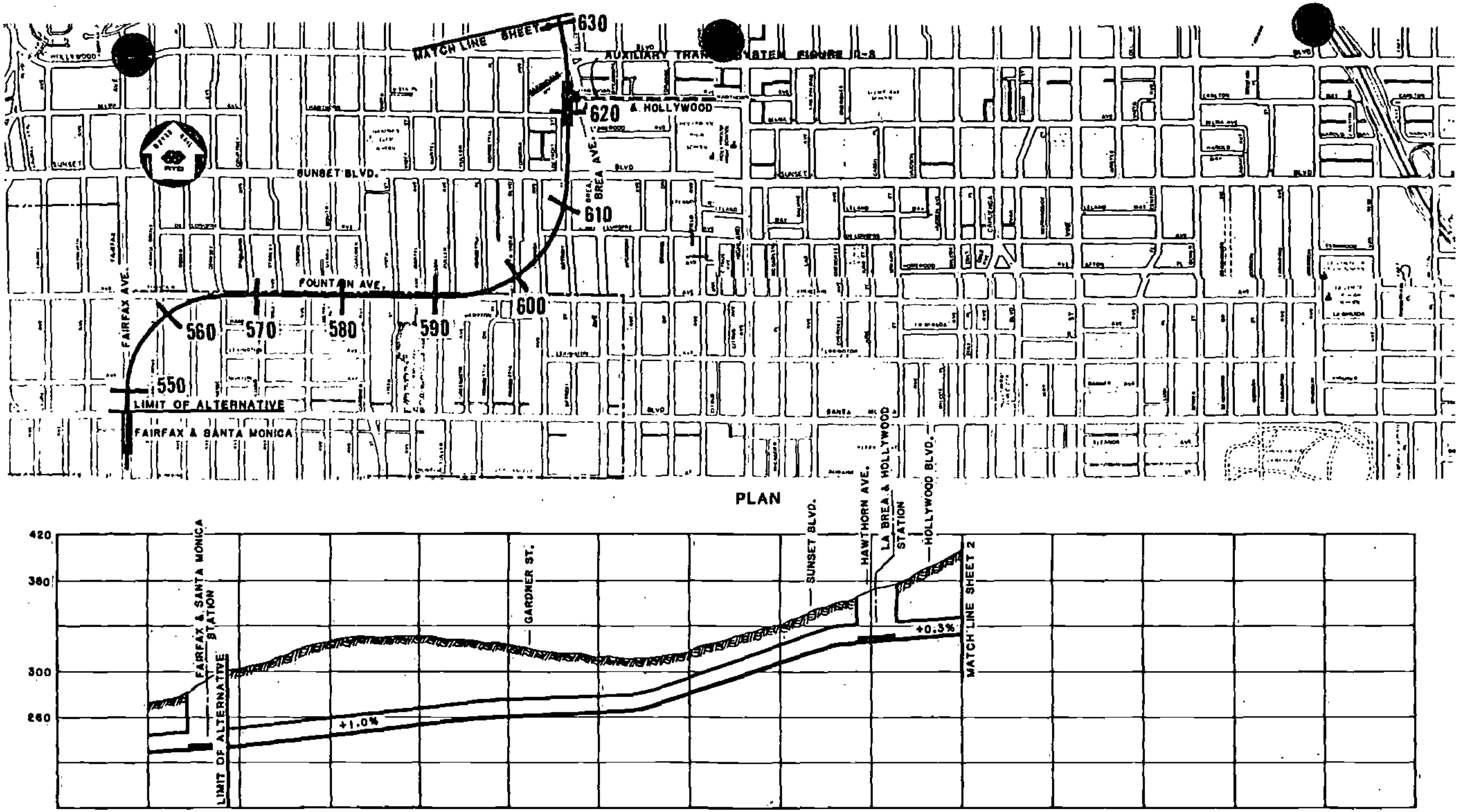


Figure 3-11 Locally Preferred Alternative including Vineland MCA Option



SCALE HORIZONTAL 0 1000 2000

SCALE VERTICAL 0 100 200

LEGEND

- METRO RAIL TRANSIT LINE
- STATION
- AUXILIARY TRANSIT SYSTEM (FIGURE III-3)
- ENGINEERING STATIONING IN HUNDREDS OF FEET (110, 120)

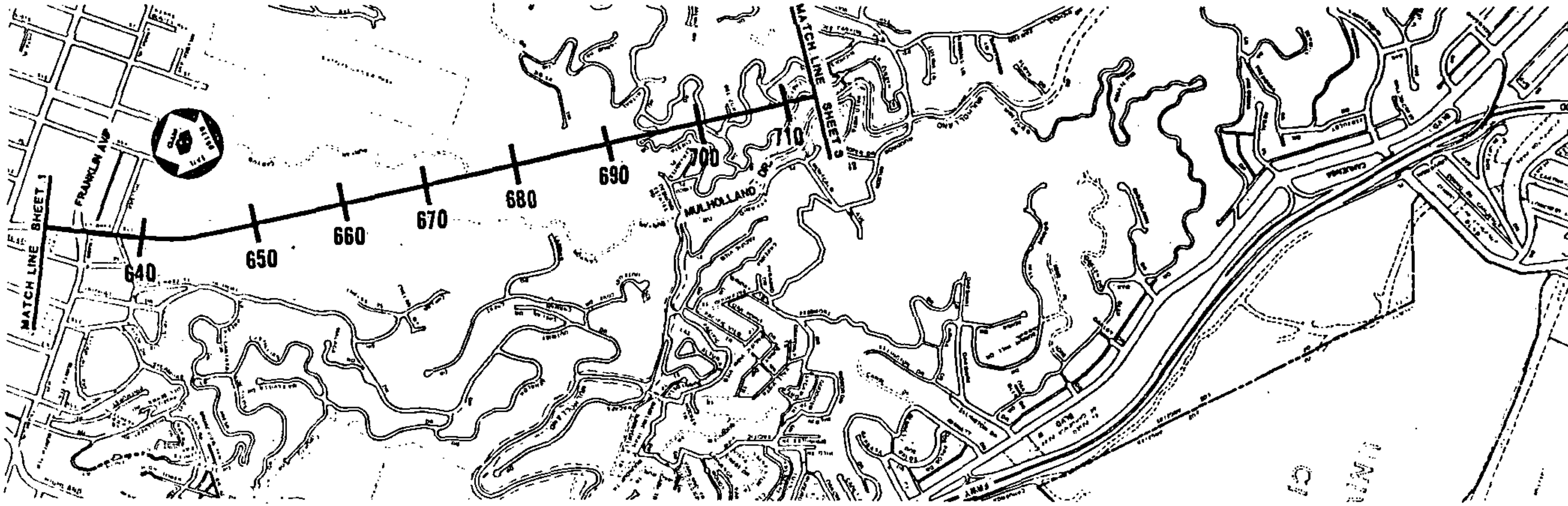
METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DMJM/PBQD A JOINT VENTURE
GENERAL ENGINEERING CONSULTANT WAYS AND STUCTURES

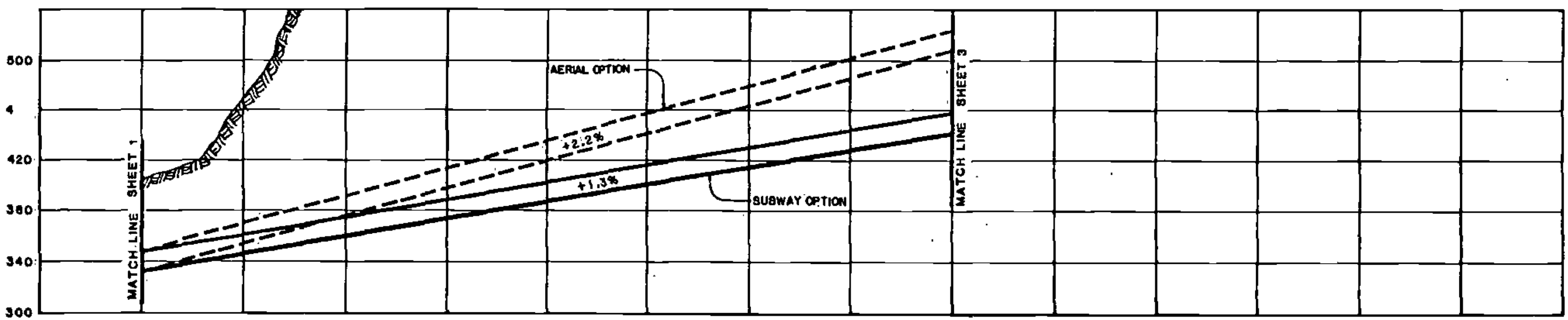
Hollywood Alignment Alternative "C" (La Brea Bend)

FIGURE III-4 SHEET 1 OF 3

Figure 3-12 La Brea Bend Alternative



PLAN



SCALE HORIZONTAL 0 1000 2 000

SCALE VERTICAL 0 100 200

PROFILE

LEGEND

—— METRO RAIL TRANSIT LINE

– – – METRO RAIL TRANSIT LINE (AERIAL)

110 120 ENGINEERING STATIONING IN HUNDREDS OF FEET

METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DMJM/PBQD A JOINT VENTURE
GENERAL ENGINEERING CONSULTANT WAYS AND STUCTURES

Hollywood Alignment Alternative "C" (La Brea Bend)

FIGURE III-4 SHEET 2 OF 3

Figure 3-13 La Brea Bend Alternative

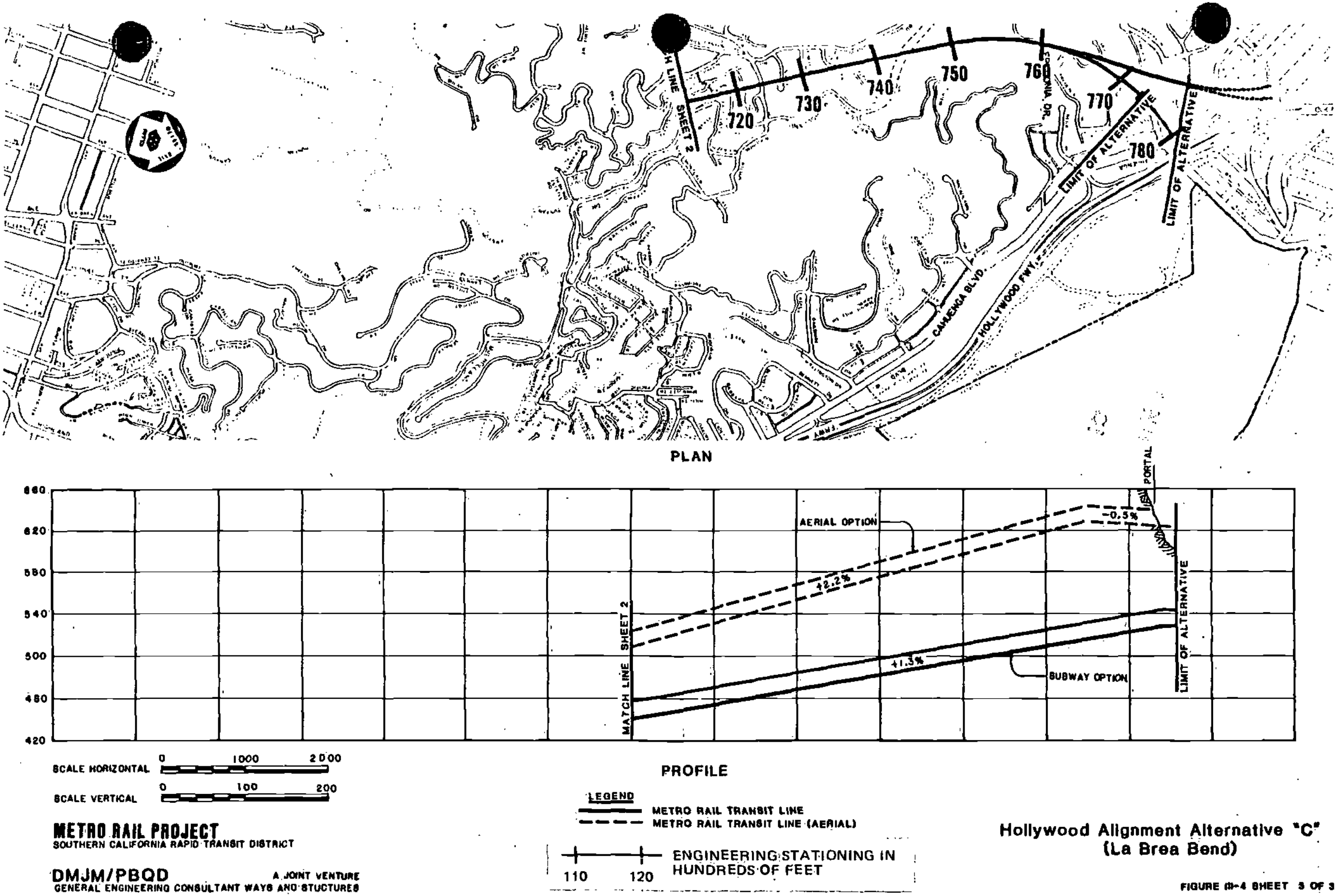


Figure 3-14 La Brea Bend Alternative

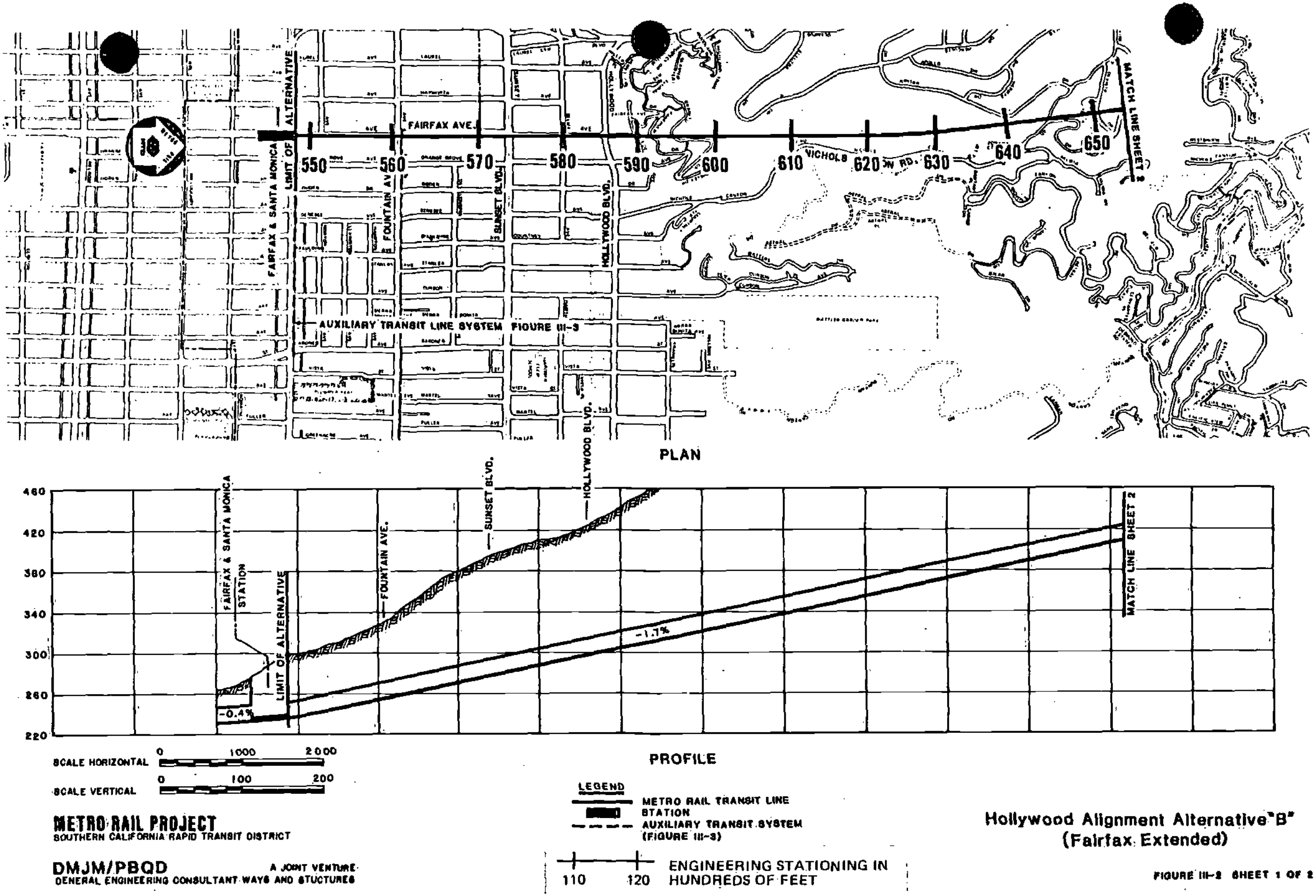
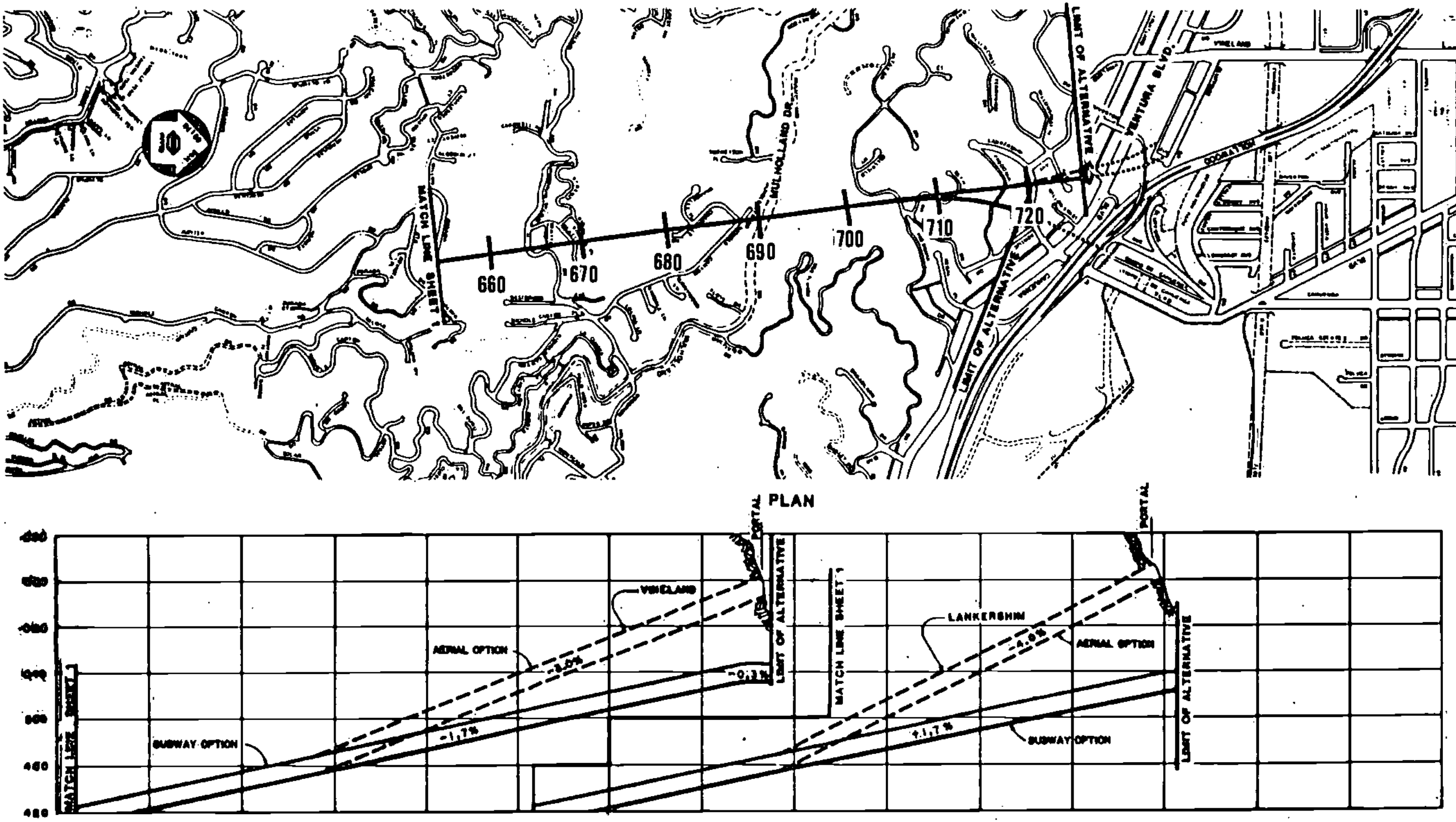


Figure 3-15 Fairfax Extended Alternative



SCALE HORIZONTAL 0 1000 2000

SCALE VERTICAL 0 100 200

PROFILE

LEGEND

METRO RAIL TRANSIT LINE
ADJOINING ALTERNATIVES
METRO RAIL TRANSIT LINE (AERIAL)

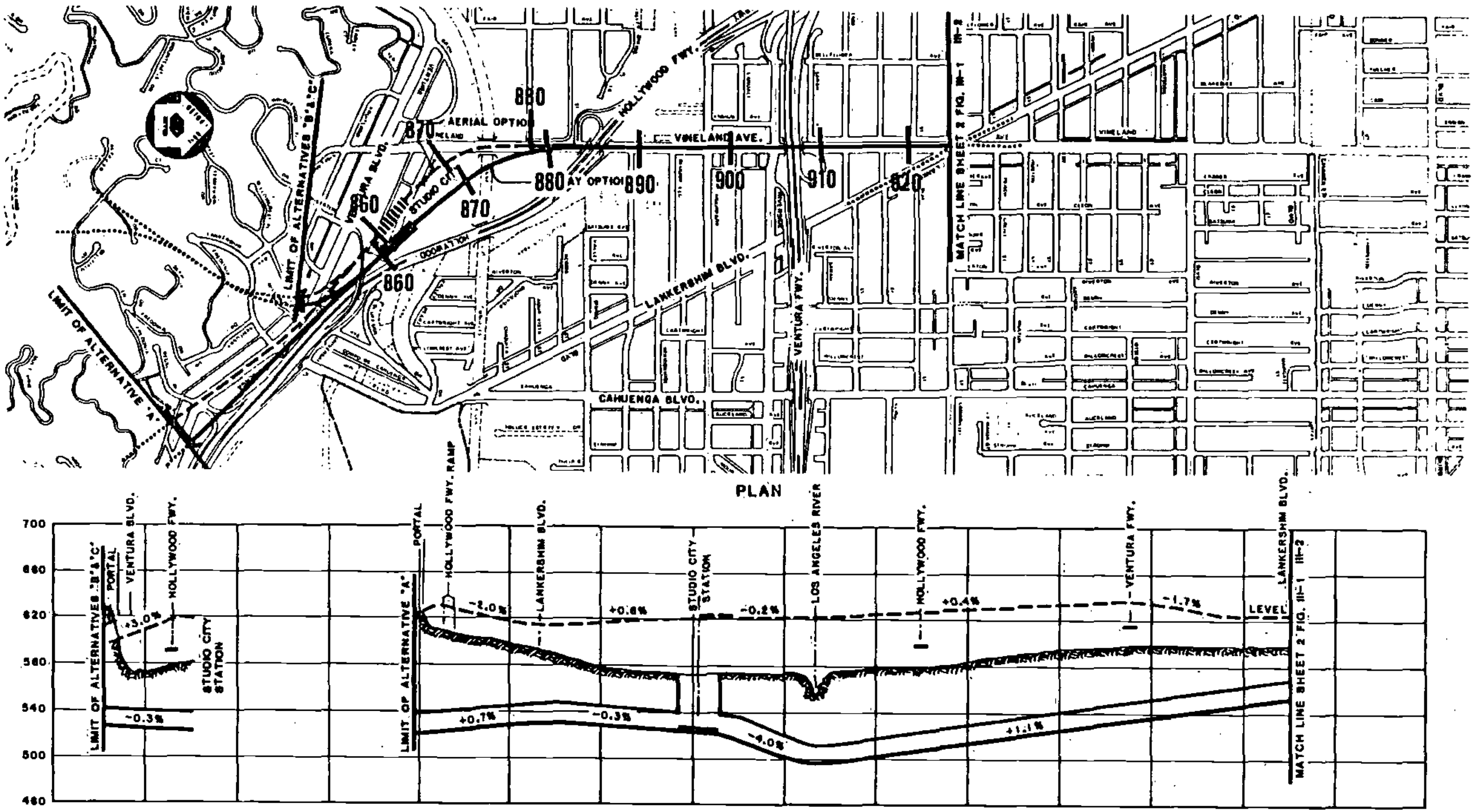
110 120 ENGINEERING STATIONING IN HUNDREDS OF FEET

METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DMJM/PBQD A JOINT VENTURE
GENERAL ENGINEERING CONSULTANT WAYS AND STUCTURES

Hollywood Alignment Alternative "B"
(Fairfax Extended)

Figure 3-16 Fairfax Extended Alternative



SCALE HORIZONTAL 0 1000 2000

SCALE VERTICAL 0 100 200

METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DMJM/PBQD A JOINT VENTURE
GENERAL ENGINEERING CONSULTANT WAYS AND STUCTURES

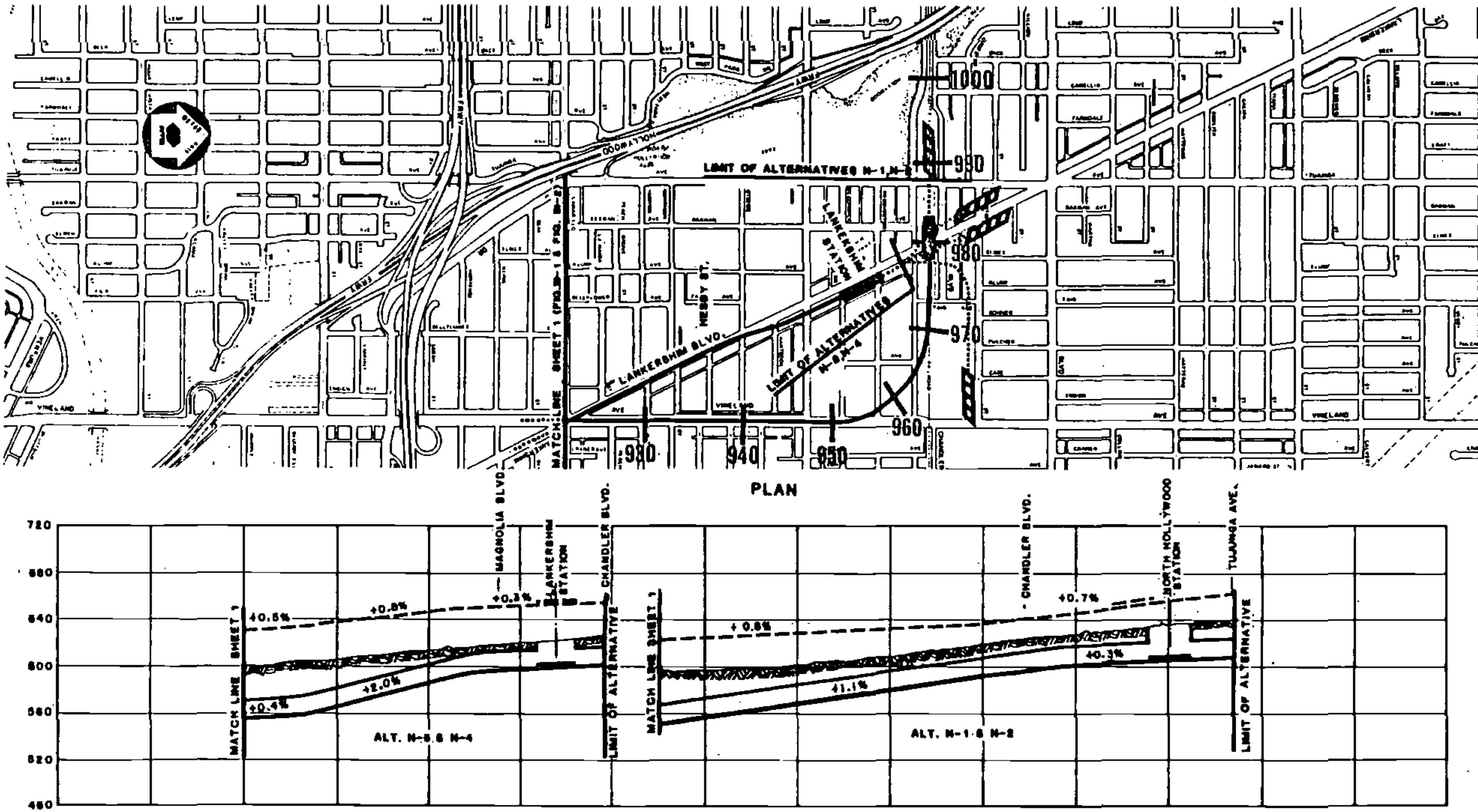
LEGEND
METRO RAIL TRANSIT LINE
STATION
METRO RAIL TRANSIT LINE (AERIAL)
ADJOINING ALTERNATIVES
AERIAL STATION

110 120 ENGINEERING STATIONING IN HUNDREDS OF FEET

North Hollywood Alignment
Alternatives 2, 4, 6, 8, and
S-3 & S-4

FIGURE III-2 SHEET 1 OF 3

Figure 3-17 North Hollywood Vineland Options



SCALE HORIZONTAL 0 1000 2000

SCALE VERTICAL 0 100 200

LEGEND

- METRO RAIL TRANSIT LINE
- METRO RAIL TRANSIT LINE (AERIAL)
- ADJOINING ALTERNATIVES
- STORAGE
- STATION

ENGINEERING STATIONING IN HUNDREDS OF FEET (110, 120)

METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

DMJM/PBQD A JOINT VENTURE
GENERAL ENGINEERING CONSULTANT WAYS AND STUCTURES

North Hollywood Alignment Alternatives N-1,N-2,N-3,N-4,

FIGURE III-6 SHEET 1 OF 2

Figure 3-18 North Hollywood Vineland Options