Appendix F.
Noise Worksheets

Appendix F. Noise Background and Modeling Data

Characteristics of Sound

Sound is a pressure wave transmitted through the air. When an object vibrates, it radiates part of its energy as acoustical pressure in the form of a sound wave. Sound can be described in terms of amplitude (loudness), frequency (pitch), or duration (time). The standard unit of measurement of the loudness of sound is the decibel (dB). The human hearing system is not equally sensitive to sound at all frequencies. Sound waves below 16 Hz are not heard at all and are "felt" more as a vibration. Similarly, while people with extremely sensitive hearing can hear sounds as high as 20,000 Hz, most people cannot hear above 15,000 Hz. In all cases, hearing acuity falls off rapidly above about 10,000 Hz and below about 200 Hz. Since the human ear is not equally sensitive to sound at all frequencies, a special frequency-dependent rating scale is usually used to relate noise to human sensitivity. The A-weighted decibel scale (dBA) performs this compensation by discriminating against frequencies in a manner approximating the sensitivity of the human ear.

Because of the physical characteristics of noise transmission and noise perception, the relative loudness of sound does not closely match the actual amounts of sound energy. Table 1, Change in Sound Pressure Level, dB, presents the subjective effect of changes in sound pressure levels. Typical human hearing can detect changes of approximately 3 dBA or greater under normal conditions. Changes of 1 to 3 dBA are detectable under quiet, controlled conditions and changes of less than 1 dBA are usually indiscernible. A change of 5 dBA or greater is typically noticeable to most people in an exterior environment and a change of 10 dBA is perceived as a doubling (or halving) of the noise.

Table 1
Change in Sound Pressure Level, dB

Change in Apparent Loudness	
± 3 dB	Threshold of human perceptibility
± 5 dB	Clearly noticeable change in noise level
± 10 dB	Half or twice as loud
± 20 dB	Much quieter or louder

Source: Bies and Hansen, Engineering Noise Control, 1988.

Point and Line Sources

Noise may be generated from a point source, such as a piece of construction equipment, or from a line source, such as a road containing moving vehicles. Because noise spreads in an ever-widening pattern, the given amount of noise striking an object, such as an eardrum, is reduced with distance from the source. This is known as "spreading loss." The typical spreading loss for point source noise is 6 dBA per doubling of the distance from the noise source.

A line source of noise, such as vehicles proceeding down a roadway, would also be reduced with distance, but the rate of reduction is affected by of both distance and the type of terrain over which the noise passes. Hard sites, such as developed areas with paving, reduce noise at a rate of 3 dBA per doubling of the distance while soft sites, such as undeveloped areas, open space and vegetated areas reduce noise at a rate of 4.5 dBA per doubling of the distance. These represent the extremes and most areas would actually contain a combination of hard and soft elements with the noise reduction placed somewhere in between these two factors. Unfortunately the only way to actually determine the absolute amount of attenuation that an area provides is through field measurement under operating conditions with subsequent noise level measurements conducted at varying distances from a constant noise source.

Objects that block the line of sight attenuate the noise source if the receptor is located within the "shadow" of the blockage (such as behind a sound wall). If a receptor is located behind the wall, but has a view of the source, the wall would do little to reduce the noise. Additionally, a receptor located on the same side of the wall as the noise source may experience an increase in the perceived noise level, as the wall would reflect noise back to the receptor compounding the noise.

Noise Metrics

Several rating scales (or noise "metrics") exist to analyze adverse effects of noise, including traffic-generated noise, on a community. These scales include the equivalent noise level (L_{eq}), the community noise equivalent level (CNEL). L_{eq} is a measurement of the sound energy level averaged over a specified time period.

The CNEL noise metric is based on 24 hours of measurement. CNEL differs from L_{eq} in that it applies a time-weighted factor designed to emphasize noise events that occur during the evening and nighttime hours (when quiet time and sleep disturbance is of particular concern). Noise occurring during the daytime period (7:00 AM to 7:00 PM) receives no penalty. Noise produced during the evening time period (7:00 to 10:00 PM) is penalized by 5 dB, while nighttime (10:00 PM to 7:00 AM) noise is penalized by 10 dB.

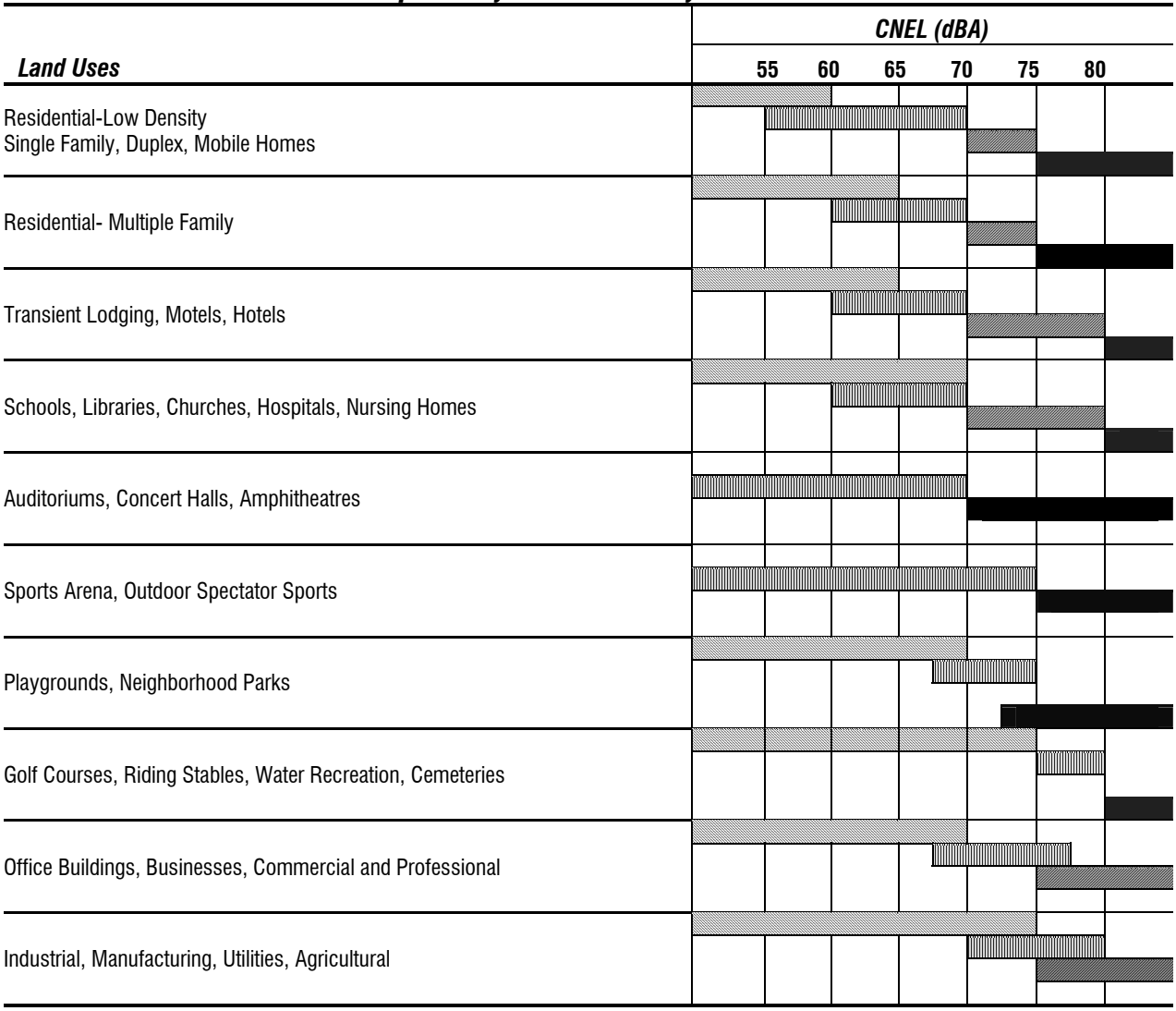
Regulatory Environment

State of California

Noise Compatibility Standards

Land use noise compatibility standards were developed by the California Office of Noise Control, and are now included as part of the Governor's Office of Planning and Research's *2003 General Plan Guidelines*. Since the project is under the jurisdiction of the Poway Unified School District (PUSD), and the PUSD does not have specific criteria to evaluate noise impacts, the state of California land use noise compatibility standards are used as the basis for defining land use compatibility impacts for placement of the District's service facilities. Table 2, presents the land use compatibility chart for community noise. This table provides urban planners with a tool to gauge the compatibility of new land uses relative to existing and future noise levels. It identifies normally acceptable, conditionally acceptable, normally unacceptable, and clearly unacceptable noise levels for various land uses.

Table 2
Land Use Compatibility for Community Noise Environments



Normally Acceptable:
Specified land use is satisfactory based upon the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.

Conditionally Acceptable:
New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and the needed noise insulation features included in the design. Conventional construction, but with closed windows and fresh air supply systems or air conditioning will normally suffice.

Normally Unacceptable:
New construction or development should generally be discouraged. If new construction does proceed, a detailed analysis of the noise reduction requirements must be made and needed noise insulation features included in the design.

Clearly Unacceptable:
New construction or development generally should not be undertaken.

Source: California Office of Noise Control. Guidelines for the Preparation and Content of Noise Elements of the General Plan. February 1976. Adapted from the US EPA Office of Noise Abatement Control, Washington D.C. Community Noise. Prepared by Wyle Laboratories. December 1971.

California Building Code

Title 24 of the *California Code of Regulations* (California Building Standards Code) requires that residential structures, other than detached single-family dwellings, be designed to prevent the intrusion of exterior noise so that the interior CNEL with windows closed, attributable to exterior sources, shall not exceed 45 dBA in any habitable room.

City of Lake Forest Noise Standards

The City applies the Noise Control Ordinance standards (Lake Forest Municipal Code Chapter 11.16), summarized in Table 3, to non-transportation, stationary noise sources. These standards do not gauge the compatibility of developments in the noise environment, but provide restrictions on the amount and duration of noise generated at a property, as measured at the property line of the noise receptor. These noise standards do not apply to noise generated by vehicle traffic, because the state, counties, and cities are preempted from controlling vehicle noise under federal law. The City's Noise Ordinance is designed to protect people from objectionable non-transportation noise sources such as music, machinery, pumps, and air conditioners.

Table 3
City of Lake Forest Exterior Noise Standards[1,2]
(L_{eq})

Noise Zone	Time Interval	Maximum Permissible Noise Level				
		L_{50}	L_{25}	L_8	L_2	L_{max}
All Residential Property	7:00 AM to 10:00 PM	55	60	65	70	75
	10:00 PM to 7:00 AM	50	55	60	65	70

Source: City of Lake Forest Municipal Code, Chapter 11.16.040, *Exterior Noise Standards*.

[1] In the event the ambient noise level exceeds any of the L_n set forth in this section, the cumulative period applicable to said category shall be increased to reflect said ambient noise level. In the event the ambient noise level exceeds the L_{max}, the maximum allowable noise level under said category shall be increased to reflect the maximum ambient noise level.

1.1.2 Construction Noise

According to Section 11.16.060 D, noise sources associated with construction, repair, remodeling, or grading of any real property, provided said activities do not take place between the hours of eight p.m. and seven a.m. on weekdays, including Saturday, or at any time on Sunday or a Federal holiday are exempt from the Noise Ordinance standards above.

Federal Transit Administration

The human reaction to various levels of vibration is highly subjective. The FTA provides criteria, shown in Table 4, for acceptable levels of groundborne vibration for various types of land uses that are sensitive to vibration based on the relative perception of a vibration event.

Table 4
Groundborne Vibration and Noise Impact Criteria – Human Annoyance

Land Use Category	Max L_v (VdB)[1]	Description
Workshop	90	Distinctly felt vibration. Appropriate to workshops and nonsensitive areas
Office	84	Felt vibration. Appropriate to offices and non-sensitive areas.
Residential – Daytime	78	Barely felt vibration. Adequate for computer equipment.
Residential – Nighttime	72	Vibration not felt, but groundborne noise may be audible inside quiet rooms.

Source: United States Department of Transportation Federal Transit Administration (FTA), *Transit Noise and Vibration Impact Assessment,* May 2006
[1] As measured in 1/3 octave bands of frequency over the frequency ranges of 8 to 80 Hz.

In addition to the vibration annoyance standards presented above, the FTA also applies standards for construction vibration damage, as shown in Table 5. Structural damage is possible for typical residential construction when the peak particle velocity (PPV) exceeds 0.2 inch per second. This criterion is the threshold at which there is a risk of damage to normal dwelling houses.

Table 5
Groundborne Vibration and Noise Impact Criteria – Structural Damage

Building Category	PPV (in/sec)	VdB
I. Reinforced concrete, steel, or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Nonengineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Source: FTA, *Transit Noise and Vibration Assessment,* May 2006.
RMS velocity calculated from vibration level (VdB) using the reference of one microinch/second.

REFERENCES

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Thalheimer, E. 2000. Construction Noise Control Program and Mitigation Strategy as the Central Artery/Tunnel Project. *Noise Control Engineering Journal*, 48(5), Sep–Oct. 2000, Indianapolis, IN: Institute of Noise Control Engineering (INCE).

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Table F1

Noise Contours for Existing Conditions

Roadway	Segment	Daily Traffic Volumes	Noise level at 50 feet (dBA CNEL)	Distance to noise contour (feet)		
				70 dBA CNEL	65 dBA CNEL	60 dBA CNEL
Trabuco Rd.	Bake Pkwy. to Peachwood	23,300	67.4	67	144	309
Trabuco Rd.	Peachwood to Lake Forest Dr.	25,300	67.7	70	152	327
Trabuco Rd.	south of Lake Forest Dr.	24,800	67.6	69	150	322
Peachwood	north of Tamarisk	2,300	54.2	9	19	41
Peachwood	Tamarisk to Calle Pradera	3,100	55.5	11	23	50
Peachwood	Calle Padrera to Palmwood Dr.	3,400	55.9	11	25	53
Peachwood	Palmwood Dr. to Trabucco Rd.	7,900	59.5	20	43	93
Lake Forest Dr.	north of Trabucco Rd.	27,400	68.1	74	160	345
Lake Forest Dr.	south of Trabucco Rd.	25,300	67.7	70	152	327
Bake Pkwy.	north of Trabucco Rd.	41,400	69.9	98	211	454
Bake Pkwy.	south of Trabucco Rd.	38,800	69.6	94	202	434

Table F2

Noise Contours for Existing With Project Conditions

Roadway	Segment	Daily Traffic Volumes	Noise level at 50 feet (dBA CNEL)	Distance to noise contour (feet)		
				70 dBA CNEL	65 dBA CNEL	60 dBA CNEL
Trabuco Rd.	Bake Pkwy. to Peachwood	26,800	68.0	73	158	340
Trabuco Rd.	Peachwood to Lake Forest Dr.	25,700	67.8	71	153	330
Trabuco Rd.	south of Lake Forest Dr.	25,000	67.7	70	150	324
Peachwood	north of Tamarisk	2,700	54.9	10	21	46
Peachwood	Tamarisk to Calle Pradera	3,500	56.0	12	25	54
Peachwood	Calle Padrera to Palmwood Dr.	4,400	57.0	14	29	63
Peachwood	Palmwood Dr. to Trabucco Rd.	8,700	60.0	21	46	100
Lake Forest Dr.	north of Trabucco Rd.	27,500	68.1	74	160	345
Lake Forest Dr.	south of Trabucco Rd.	25,000	67.7	70	150	324
Bake Pkwy.	north of Trabucco Rd.	38,900	69.6	94	202	435
Bake Pkwy.	south of Trabucco Rd.	41,600	69.9	98	211	455

Table F3

Noise Contours for 2015 No Project Conditions

Roadway	Segment	Daily Traffic Volumes	Noise level at 50 feet (dBA CNEL)	Distance to noise contour (feet)		
				70 dBA CNEL	65 dBA CNEL	60 dBA CNEL
Trabuco Rd.	Bake Pkwy. to Peachwood	27,600	68.1	75	161	346
Trabuco Rd.	Peachwood to Lake Forest Dr.	26,800	68.0	73	158	340
Trabuco Rd.	south of Lake Forest Dr.	26,000	67.8	72	154	333
Peachwood	north of Tamarisk	2,100	53.8	8	18	39
Peachwood	Tamarisk to Calle Pradera	2,900	55.2	10	22	48
Peachwood	Calle Padrera to Palmwood Dr.	3,800	56.4	12	27	57
Peachwood	Palmwood Dr. to Trabucco Rd.	8,400	59.8	21	45	97
Lake Forest Dr.	north of Trabucco Rd.	28,900	68.3	77	166	357
Lake Forest Dr.	south of Trabucco Rd.	26,600	67.9	73	157	338
Bake Pkwy.	north of Trabucco Rd.	41,100	69.8	97	210	451
Bake Pkwy.	south of Trabucco Rd.	43,700	70.1	101	218	470

Table F4

Noise Contours for 2015 With Project Conditions

Roadway	Segment	Daily Traffic Volumes	Noise level at 50 feet (dBA CNEL)	Distance to noise contour (feet)		
				70 dBA CNEL	65 dBA CNEL	60 dBA CNEL
Trabuco Rd.	Bake Pkwy. to Peachwood	28,000	68.2	75	162	350
Trabuco Rd.	Peachwood to Lake Forest Dr.	27,200	68.0	74	159	343
Trabuco Rd.	south of Lake Forest Dr.	26,200	67.9	72	155	334
Peachwood	north of Tamarisk	2,900	55.2	10	22	48
Peachwood	Tamarisk to Calle Pradera	3,700	56.3	12	26	56
Peachwood	Calle Padrera to Palmwood Dr.	4,600	57.2	14	30	65
Peachwood	Palmwood Dr. to Trabucco Rd.	9,200	60.2	22	48	103
Lake Forest Dr.	north of Trabucco Rd.	29,000	68.3	77	166	358
Lake Forest Dr.	south of Trabucco Rd.	26,800	68.0	73	158	340
Bake Pkwy.	north of Trabucco Rd.	41,200	69.8	97	210	452
Bake Pkwy.	south of Trabucco Rd.	43,900	70.1	102	219	472

Table F5

Existing Conditions Project Off-Site Contributions

Roadway	Segment	CNEL at 50 feet (dBA)			
		No Project	With Project	Project Contribution	Potential Impact?
Trabuco Rd.	Bake Pkwy. to Peachwood	67.4	68.0	0.6	no
Trabuco Rd.	Peachwood to Lake Forest Dr.	67.7	67.8	0.1	no
Trabuco Rd.	south of Lake Forest Dr.	67.6	67.7	0.1	no
Peachwood	north of Tamarisk	54.2	54.9	0.7	no
Peachwood	Tamarisk to Calle Pradera	55.5	56.0	0.5	no
Peachwood	Calle Padrera to Palmwood Dr.	55.9	57.0	1.1	no
Peachwood	Palmwood Dr. to Trabucco Rd.	59.5	60.0	0.5	no
Lake Forest Dr.	north of Trabucco Rd.	68.1	68.1	0.0	no
Lake Forest Dr.	south of Trabucco Rd.	67.7	67.7	0.0	no
Bake Pkwy.	north of Trabucco Rd.	69.9	69.6	-0.3	no
Bake Pkwy.	south of Trabucco Rd.	69.6	69.9	0.3	no

Table F6

2015 Conditions Project Off-Site Contributions

Roadway	Segment	CNEL at 50 feet (dBA)			
		No Project	With Project	Project Contribution	Potential Impact?
Trabuco Rd.	Bake Pkwy. to Peachwood	68.1	68.2	0.1	no
Trabuco Rd.	Peachwood to Lake Forest Dr.	68.0	68.0	0.0	no
Trabuco Rd.	south of Lake Forest Dr.	67.8	67.9	0.1	no
Peachwood	north of Tamarisk	53.8	55.2	1.4	no
Peachwood	Tamarisk to Calle Pradera	55.2	56.3	1.1	no
Peachwood	Calle Padrera to Palmwood Dr.	56.4	57.2	0.8	no
Peachwood	Palmwood Dr. to Trabucco Rd.	59.8	60.2	0.4	no
Lake Forest Dr.	north of Trabucco Rd.	68.3	68.3	0.0	no
Lake Forest Dr.	south of Trabucco Rd.	67.9	68.0	0.1	no
Bake Pkwy.	north of Trabucco Rd.	69.8	69.8	0.0	no
Bake Pkwy.	south of Trabucco Rd.	70.1	70.1	0.0	no

Pinnacle_ConstNoise.txt
Roadway Construction Noise Model (RCNM),Version 1.1

Report date: 01/12/2012
Case Description: Pinnacle Lake Forest

**** Receptor #1 ****

Description	Land Use	Baselines (dBA) Daytime	Evening	Night
Residential (Sonoma Dr.)	Residential	50.0	50.0	50.0

Equipment

Description	Impact Device	Usage (%)	Spec Lmax (dBA)	Actual Lmax (dBA)	Receptor Distance (feet)	Estimated Shielding (dBA)
Dozer	No	40		81.7	500.0	0.0
Dozer	No	40		81.7	500.0	0.0
Scraper	No	40		83.6	500.0	0.0
Scraper	No	40		83.6	500.0	0.0
Grader	No	40	85.0		500.0	0.0
Roller	No	20		80.0	500.0	0.0

Results

Noise Limits (dBA)

Noise Limit Exceedance (dBA)

Equipment	Calculated (dBA) Day Lmax	Day Leq	Evening Lmax	Evening Leq	Night Lmax	Night Leq	Day Lmax	Day Leq	Evening Lmax	Evening Leq	Night Lmax	Night Leq
Dozer	61.7	57.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dozer	61.7	57.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scraper	63.6	59.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scraper	63.6	59.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grader	65.0	61.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Roller	60.0	53.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	65.0	66.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

**** Receptor #2 ****

Description	Land Use	Baselines (dBA) Daytime	Evening	Night
Residential (New Haven)	Residential	50.0	50.0	50.0

Equipment

Description	Impact Device	Usage (%)	Spec Lmax (dBA)	Actual Lmax (dBA)	Receptor Distance (feet)	Estimated Shielding (dBA)
Dozer	No	40		81.7	700.0	0.0
Dozer	No	40		81.7	700.0	0.0
Scraper	No	40		83.6	700.0	0.0
Scraper	No	40		83.6	700.0	0.0
Grader	No	40	85.0		700.0	0.0
Roller	No	20		80.0	700.0	0.0

Results

Noise Limits (dBA)

Noise Limit Exceedance (dBA)

Equipment	Calculated (dBA) Day Lmax	Day Leq	Evening Lmax	Evening Leq	Night Lmax	Night Leq	Day Lmax	Day Leq	Evening Lmax	Evening Leq	Night Lmax	Night Leq
Dozer	58.7	54.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dozer	58.7	54.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scraper	60.7	56.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scraper	60.7	56.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grader	62.1	58.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Roller	57.1	50.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	62.1	63.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE F7

MAXIMUM CONSTRUCTION NOISE LEVELS

Equipment	Distance (feet)		
	50	100	250
Grader	85		
Dozer	85		
Combined	**88**	**82**	**74**