APPENDIX: NOISE

THE CHARACTERISTICS OF TYPICAL NOISE SOURCES

MOBILE SOURCES

Vehicular Traffic

Vehicular traffic includes automobiles, buses, and trucks. The noise generated by these vehicles comes from the operation of engines and the sound of tires passing over the roadbed. Buses and trucks are similar in their respective noise generating characteristics, while cars have unique characteristics.

Automobile noise is a function of vehicle speed and engine noise. With changing gears, the noise levels tend to increase in a sawtooth kind of pattern as vehicular speed increases. The interaction of the road surface with the tires generates noise that increases with vehicle speed. At vehicular speeds below 30 miles per hour, the typical automobile noise spectrum is dominated by engine noise. At speeds higher than 30 miles per hour, the automobile noise signature is composed of a combination of lower frequency engine noise and higher frequency tire noise. The engine and tire noise for vehicular speeds above 30 miles per hour are comparable in noise level.

Noise generated by buses and heavy trucks is also composed of engine and tire noise, but tire noise tends to dominate the noise signature at vehicular speeds above 30 miles per hour in trucks and buses. Cargo load normally does not significantly affect noise levels because increased load usually results in decreased vehicular speed and the effects cancel each other out. Because individual trucks and buses are noisier than individual automobiles, the concept of passenger car equivalents (PCEs) is used within the CEQR Technical Manual.

Aircraft Operations

The principal noise sources from conventional aircraft (airplanes and helicopters) using New York City airspace are the propulsion system and aerodynamic noise. There are generally three types of engines in use on contemporary airplanes —turbojet, turbofan, and propeller. For turbojets and turbofans, the dominant noise source is the exhaust, generating the characteristic low frequency roar of the jet engine. Propeller aircraft have combinations of engine exhaust noise and propeller noise, with the propeller component usually dominating. This produces the typical whining sound of propeller-driven aircraft.

Aerodynamic noise is generated by airflow around the fuselage, cavities, control surfaces, and landing gear of the aircraft. Aerodynamic noise is usually only dominant during cruise conditions (frequencies above 600 Hz). Conditions during takeoff and landing normally cause propulsion system noise to dominate the aerodynamic component.

Helicopter noise is generated by the engine and main rotor system. The engine noise is similar to that discussed for airplanes, but on a smaller scale. Rotor noise is characterized by slaps or cracks caused by the sharp variations in pressure encountered by the rotating rotor blades as they pass through the aerodynamic wake produced by each adjacent blade. For rotor noise, the frequency of the rotor noise is proportional to the tip speed and the number of blades in the rotor system.

Train Operations

In general, the principal noise sources of train systems are the interaction between wheels and rails, the propulsion system of the railcars, brakes, and auxiliary equipment (ventilation and horns). The dominant cause of railcar noise over most of the typical speed range is the interaction between the wheels and rails. In general, noise increases with train speed and train length.

Noise levels are dependent upon the rail guideway configuration (*i.e.*, whether the track is at-grade, a welded rail, a joined track, an embedded track on grade, or an aerial structure with slab track) and whether there are any noise barriers or berms in place.

When railcars travel on tight curves, the dominant noise emitted may be a high-pitched squeal or screech. This is usually caused by metal wheels sliding on the rail and scraping metal on metal when the train negotiates a curve.

Other concerns relating to rail transit operations that may need to be addressed include noise from train crossovers and switches, as well as noise from train warning horns. In some limited situations, noise from new or increased rail yard operations may also have to be examined.

STATIONARY SOURCES

The principal stationary noise sources encountered in the City are mechanical equipment associated with industrial and manufacturing operations and building ventilating systems. Other stationary sources worth noting are crowd noise related to playgrounds or spectator events, and noise from amplification systems. The basic characteristics of these sources are described below.

Mechanical Equipment

Mechanical equipment generally includes machinery used for industrial purposes, such as motors, compressors, boilers, pumps, transformers, condensers, generators, cooling towers, and ventilating equipment. Such machinery commonly generates noise mechanically (through gears, bearings, belts, fans, or other rotating components), aerodynamically (through air or fluid flow), and magnetically (through magnetostriction or periodic forces between rotors and stators).

Assuming proper maintenance, mechanical machinery noise is usually characterized by discrete mid- to high-frequency tones. These tones are usually caused by friction, vibration of components, and aerodynamic flow generation. Even when large machinery is properly maintained, noise levels may exceed 100 dB(A) within 10 feet of the equipment. Badly maintained machinery may increase mechanical noise levels by as much as 20 dB(A); this represents a quadrupling of the perceived loudness.

Ventilating systems are also common mechanical stationary noise sources in the City. These systems usually have fans that generate tones at high operating speeds. These tones may propagate through ducts in a building and produce noise in rooms far away from the original source. Air conditioning units may generate noise that could affect adjacent buildings. If not isolated from the building structure by properly tuned springs or resilient materials, ventilating systems and other machinery may generate vibrations that may be sensed throughout a building and possibly a neighborhood.

Aerodynamic noise usually becomes an issue when the air (or other fluid) flows through ducts in a restrictive, unsmooth path, and turbulence is generated. Boilers and steam turbines have liquids and steam flowing through them at high speeds, generating a hissing noise or roaring noise.

M E M O R A N D U M

TO:	Julie Geisler	**FROM:**	James P. Cowen Stephen J. Holley
RE:	**SCA Playground Noise Study**	**DATE:**	October 23, 1992

Introduction

Between October 1 and 14, 1992, eight New York City public schools—consisting of early childhood (P.S. 52R), elementary (P.S. 299, P.S. 52R, P.S. 57, and P.S. 69), intermediate (I.S. 7, I.S. 72, and I.S. 75), and high (Tottenville High School)—were monitored for noise emissions from playground activities. The purpose of this monitoring was to provide updated noise level values, that will accurately reflect existing school playground noise levels, for use in future environmental assessments of new school projects.

The levels currently used in environmental noise assessments are 75 dBA $L_{eq(1)}$ at the playground boundary, 73 dBA $L_{eq(1)}$ 15 feet away from the playground boundary, 70 dBA $L_{eq(1)}$ 30 feet away from the playground boundary, and a 4.5 dBA drop-off rate per doubling of distance for locations farther than 30 feet away. Additionally, $L_{10(1)}$ levels are presently assumed to be 2 dBA greater than $L_{eq(1)}$ levels.

Noise Monitoring

Three sound level meters were used for the measurements. Two of the instruments were Larson Davis Labs (LDL) Model 700 meters (serial numbers 2216 and 1362) and the third was a Bruel & Kjaer (B&K) Type 4427 noise level analyzer (serial number 1167006). All of these instruments meet ANSI Standard S1.4-1983 tolerances for Type 1 specification. The LDL instruments were mounted on tripods at heights of 5 feet above the ground and the B&K 4427 was supported with its microphone fixed at a height of approximately 4 feet above the ground. All instruments were calibrated before and after each measurement session with an LDL Model CA250 Precision Acoustic Calibrator (serial number 1894) and the appropriate microphone adapter. Windscreens were used for all measurements. The weather conditions were clear to partly cloudy with winds under 10 miles per hour and temperatures in the 45 to 55 degree Fahrenheit range. All monitoring methods conformed with industry-accepted practices for measuring sound pressure levels.

Background noise levels, without playground activity, were recorded at each location. All school playgrounds monitored, except P.S. 299 in Brooklyn, were in Staten Island because the Staten Island schools provided the lowest background noise levels of any schools in the New York City area.

The lowest possible background noise levels were desirable for this study to ensure that all readings recorded were clearly generated by the playground sources and not by other sources (e.g., vehicles, trains, airplanes, or manufacturing sources). As long as measured levels with playground activity exceed background levels without playground activity by more than 9 dBA, the measured levels are clearly indicative of those associated with the playground activity only.

With playground activity, noise levels were recorded at the playground boundaries and, wherever practical considering traffic and other extraneous sources, at distances away from the playground boundaries simultaneously. Simultaneous readings were used to estimate a drop-off rate of noise from the playground with distance.

Table 1, below, summarizes the monitored data by listing the most relevant L_{eq} and L_{10} values obtained. The complete set of monitored data is listed in Attachment A. The data is divided according to the type of school, (i.e., early childhood, elementary, junior high, or high) and activity (i.e., line-up, PE class, or recess).

It was originally planned that 10 schools would be monitored; however, P.S. 52R was used for both its early childhood and elementary school sources and neither I.S. 61 nor I.S. 24 could be monitored with reliable results for this study's purpose because of high background noise levels. Therefore, eight school sites are listed below.

Of all the data used in the analysis, the only monitored L_{eq} value that was less than 9 dBA greater than the background was the 60' recess reading at I.S. 72. This value was used only for drop-off rate analysis and the actual level due to playground noise alone, after the background noise is subtracted from the reading, is 1.7 dBA less than the recorded value (which was a composite of background and playground noise).

Analysis Methodology

New York City regulations, standards, and guidelines used for environmental noise assessments are based on hourly noise levels, specifically $L_{eq(1)}$ and $L_{10(1)}$ (where the number 1 in parentheses denotes a 1-hour value). However, each school monitored had different playground usage periods for activities such as morning lineups, physical education (PE) classes, or lunch recesses. To account for these different usage durations, noise levels during active playground use were recorded separately from the background levels and the two sets of data were combined into $L_{eq(1)}$ levels by utilizing the standard mathematical definition of the L_{eq}, which is:

$$L_{eq(T)} = 10 \log_{10} \left(\frac{1}{T} \int_0^T \left(\frac{p}{p_{ref}} \right)^2 dt \right)$$

where T is the measurement time period (1 hour in this case), p is the measured acoustic pressure, and pref is the pressure at the threshold of hearing ($2x10^{-5}$ N/m²). All logarithmic references are to the base 10. Attachment B shows the specific use of this equation in the determination of the values quoted herein.

Table 1

Measured Noise Levels (in dBA)

School	Grade	Activity	Distance from Playground (feet)	Duration (minutes)	L_{10}	L_{eq}
Early Childhood/Elementary Schools:						
P.S. 52R	K-2	Recess	0	15	77.5	74.6
	K-2	Recess	30	15	67.5	65.3
	3-5	Recess	0	25	78.0	77.3
P.S. 299	K-5	Line-up	0	17	79.5	78.9
P.S. 57	K-5	Line-up	0	25	74.5*	77.9*
	4,5	Recess	0	20	72.0	71.8
P.S. 69	K-5	Line-up	0	20	71.5	68.4
	1,3	Recess	0	20	76.0	73.8
	1,3	Recess	20	20	70.8	68.2
	1,3	Recess	40	20	66.5	64.0
	2,5	Recess	0	21	77.0	73.4
	2,5	Recess	20	21	72.7	69.5
	2,5	Recess	40	21	68.0	65.0
Intermediate Schools						
I.S. 7	6-8	Line-up	0	10	79.0*	87.1*
	6-8	Line-up	30	10	76.5	74.5
	8	PE Class	0	25	67.5	66.1
	8	PE Class	30	25	63.0	59.6
	7	Recess	0	30	78.0	74.8
I.S. 72	6-8	Line-up	0	15	73.5	70.9
	8	Recess	0	17	78.0	76.9
	8	Recess	30	17	73.8	70.8
	8	Recess	60	17	66.0	63.4
I.S. 75	6-8	Line-up	0	26	68.5	67.4
	6-8	Line-up	30	26	65.0	62.3
	8	PE Class	0	20	67.5	64.8
	8	PE Class	30	20	63.0	60.3
	8	Recess	0	15	69.5	68.2
	8	Recess	30	15	65.7	63.0
High Schools:						
Tottenville HS	9-12	Line-up	0	20	76.5	73.5
	9-12	Recess	0	20	71.5	69.7
	9-12	Recess	30	20	63.3	62.8

Note: * High-level discrete events biased these measurements. These values were not used in the analysis.

Playground usage durations for the different school types and activities were developed based on field observations and verified by school principals and other school officials of the New York City Board of Education. These playground usage durations (which were the same or longer than the observed usage durations), rather than the measured durations, were used in the analysis to derive the recommended levels. Table 2 shows these usage durations by school type.

Table 2

Duration of Outdoor Playground Activities

Time	Activity		
Early Childhood/Elementary Schools (Grades K-2/3-5)			
7-8 AM	30-minute line-up		
8-9 AM	30-minute line-up	or	30-minute PE class
9-10 AM			40-minute PE class
10-11 AM	30-minute recess	or	40-minute PE class
11-12 PM	40-minute recess	or	40-minute PE class
12-1 PM	40-minute recess	or	40-minute PE class
1- 2 PM			40-minute PE class
2- 3 PM			40-minute PE class
Intermediate Schools (Grades 6-8):			
6-7 AM	15-minute line-up		
7-8 AM	30-minute line-up		
8-9 AM	30-minute line-up	or	50-minute PE class
9-10 AM			50-minute PE class
10-11 AM	30-minute recess	or	50-minute PE class
11-12 PM	40-minute recess	or	50-minute PE class
12-1 PM	40-minute recess	or	50-minute PE class
1-2 PM	30-minute recess	or	50-minute PE class
2-3 PM			50-minute PE class
High Schools (Grades 9-12)			
6-7 AM	15-minute line-up		
7-8 AM	30-minute line-up	or	30-minute PE class
8-9 AM	30-minute line-up	or	50-minute PE class
9-10 AM			50-minute PE class
10-11 AM	45-minute recess	or	50-minute PE class
11-12 PM	45-minute recess	or	50-minute PE class
12-1 PM	45-minute recess	or	50-minute PE class
1-2 PM		or	50-minute PE class
2-3 PM			50-minute PE class

Note: Worst-case assumptions include the longest duration of activity that would normally happen during each hour. Note that during some hours, a 40-minute lunch recess is indicated; this may not be a continuous recess but could include two 20-minute recess periods occurring within the same hour.

All calculations performed are in terms of L_{eq} values. Because L_{10} values cannot be combined mathematically the way L_{eq} values can be, L_{10} values can only be estimated through their relationship to the L_{eq} values.

Analysis Results

Table 3 shows the maximum hourly noise levels at the playground boundary for each type of school based on the duration of outdoor playground activities shown in Table 2, above. Table 4, below, shows the maximum noise levels at the playground boundary for specific activities. There does not seem to be a clear relationship between noise levels measured and the number of students in the playground or the total number of students at any given school. The average difference between L_{eq} and L_{10} measured values was 2.8 dBA. [1]

Table 3

Maximum Hourly Playground Boundary Noise Levels for Environmental Assessments

Early Childhood Schools (Grades K-2)		Elementary Schools (Grades 1-5)		Intermediate Schools (Grades 6-8)		High Schools (Grades 9-12)	
Time	**$L_{eq(1)}$ (dBA)**	**Time**	**$L_{eq(1)}$ (dBA)**	**Time**	**$L_{eq(1)}$ (dBA)**	**Time**	**$L_{eq(1)}$ (dBA)**
				6-7 AM	61.5	6-7 AM	63.5
7- 8 AM	63.8	7-8 AM	63.8	7-8 AM	64.9	7-8 AM	68.2
8- 9 AM	69.3	8-9 AM	69.3	8-9 AM	64.9	8-9 AM	68.2
9-10 AM	62.9	9-10 AM	62.9	9-10 AM	64.3	9-10 AM	64.3
10-11 AM	69.3	10-11 AM	69.3	10-11 AM	68.9	10-11 AM	67.6
11-12 PM	71.5	11-12 PM	71.4	11-12 PM	71.0	11-12 PM	67.6
12-1 PM	71.5	12-1 PM	71.4	12-1 PM	71.0	12-1 PM	67.6
1-2 PM	62.9	1-2 PM	62.9	1-2 PM	68.9	1-2 PM	64.3
2-3 PM	62.9	2-3 PM	62.9	2-3 PM	64.3	2-3 PM	64.3

Note: Noise data from intermediate schools were used for PE class activities for all school types.

1 In calculating this average, all measured differences less than 1.5 dBA were not used because they were associated with readings where extraneous peak levels from such sources as sirens, trucks, buses, and children yelling into the microphones contaminated the measurements.

Table 4

Maximum Playground Boundary Noise Levels for Specific Activities

Grades	Activity	Duration (minutes)	$L_{eq(1)}$ (dBA)
Early Childhood (Grades K-2)			
K-2	Line-up	30	63.5
K-2	Recess	40	71.5
K-2	PE class	40	62.9
Elementary Schools (Grades K, and 1-5)			
K-5	Line-up	30	63.5
1-5	Recess	40	71.4
K-5	PE class	40	62.9
Intermediate Schools (Grades 6-8):			
6-8	Line-up	30	64.9
6-8	Recess	40	71.0
6-8	PE class	50	64.3
High Schools (Grades 9-12)			
9-12	Line-up	30	68.2
9-12	Recess	45	67.6
9-12	PE class	50	64.3

Note: Noise data from intermediate schools was used for PE class activities for all school types.

Average drop-offs were 4.8 dBA at 20 feet, 6.2 dBA at 30 feet, 9.1 dBA at 40 feet, and 15.2 dBA (the only reading) at 60 feet. Beyond 30 feet from the playground borders, drop-off rates were generally 6 dBA per doubling of distance from the noise source (in this case the playground boundary). This corresponds with generally accepted rule-of-thumb for other typical outdoor applications. However, if the new playground were to be located near any large reflective buildings, a lower drop-off rate per doubling of distance from the playground boundary could exist. In such cases, the actual drop-off rates can only be verified by field measurements, which should be performed, because of the complexity of the acoustical environment that is created by the buildings. However, if field measurements are not possible, a more conservative drop-off rate per doubling of distance from the playground boundary should be assumed (on the order of 4.5 dBA).

Recommendations

Based on the measurements and calculations derived from measurements in this study, the following values, shown in Table 5, are recommended to be used as a preliminary estimate of the noise levels generated by students in a New York City school playground. Applying these levels to all operating hours for a new school would result in a conservative analysis, and are based on the maximum levels calculated for Table 4, above, to provide worst-case values.

Table 5

Recommended Playground Boundary Noise Levels for Preliminary Environmental Assessments

School Type	$L_{eq(1)}$ (dBA)
Early Childhood Center	71.5
Elementary School	71.4
Intermediate School	71.0
High School	68.2

If, after a preliminary analysis the potential for significant project impacts exists, a more refined analysis may be warranted. For this type analysis, noise levels for playground related noise should be added on an hour-by-hour basis. Appropriate levels for this purpose are shown above in Table 3, by school type.

$L_{10(1)}$ levels should be estimated, whenever measured values are not available, as approximately 3.0 dBA higher than $L_{eq(1)}$ values. Unless the proposed playground is near (within 100 feet of) any large buildings, hourly noise levels can be expected to decrease by the following values at the specified distances from the playground boundary: 4.8 dBA at 20 feet, 6.8 dBA at 30 feet, and 9.1 dBA at 40 feet. The general rule of a 6 dBA drop-off per doubling of distance from the playground boundary for all distances between 40 and 300 feet appears to be appropriate for analytical purposes. Atmospheric absorption, terrain, and meteorological conditions would affect noise levels beyond 300 feet away from the playground, and should be considered on a case-by-case basis. However, for most areas of New York City, background noise levels and building densities are high enough to make most playgrounds inaudible beyond distances of 300 feet away.

cc: Ed Applebome

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