Traffic Noise Presentation

1.- Basic Noise Concepts

2.- The Nature and Measurement of Traffic Noise

3.- Measurement Definition and Noise Units

4.- Acceptable Noise Levels

5.- Variables that Contribute to Highway Noise

6.- Traffic Noise Reduction and Management

7.- Motor Vehicle Noise Reduction Options

8.- Roadway Planning and Design

9.- Land Use Planning

10.- Building Design Standards

11.- Noise Attenuation Scenarios

12.- Noise Shielding

13.- Roadway Traffic Noise Studies

14.- Summary
1.- Basic Noise Concepts

• Sound is a sensation caused by fluctuations in air pressure detected by the human ear. When the sound is unwanted it is described as noise.

• Noise can affect people in a variety of ways from damage to hearing to general annoyance.

• Reaction to the same noise intensity and source varies considerably from person to person.

• One’s environment affects what is considered excessive: noise as a factory is much different than a hospital.

• Addressing the noise problem is based on the average reaction for the situation i.e. a residential area.

• Noise is generally described in measurement of loudness and in terms of annoyance ranging from acceptable to very annoying and disrupting of human activities such as sleep.

• Traffic noise can be reduced but only at a price.
2.- The Nature and Measurement of Traffic Noise

- Noise from road traffic fluctuates throughout the day.

- There are 3 broad elements in noise evaluation
  - source (vehicles)
  - propagation medium (distance, barriers)
  - receiver environment (dwelling office)

- The more distant a person is from the source the lower the noise level; similarly the closer the person is, the higher the average level and the more obvious the noise peaks become.

- Improvements to reduce vehicle noise are often offset by increasing traffic volumes

- Sound pressure levels are measured in terms of decibels (dB), a logarithmic function of the pressure

- The range of levels most frequently encountered in evaluating traffic generated noise is 50 – 90 dB.

- Since the dB is measured on a logarithmic scale note that an increase of 10 dB doubles the noise level (loudness) and a reduction of 10 dB halves the noise level (loudness).
3.- Measurement Definitions of Noise Units

• Basic Unit is dBA:
  - dB condenses intensity of traffic noise into a single number that can be read with a Sound Meter.
  - “A” is the weighting scale for the pitch component of noise
  - the “A” weighted level has been found to correlate well with people’s judgment of loudness or annoyance as it incorporates such factors as loudest events, repetitiveness of these loud noise levels, and the sustained or continuous nature of noise.
  - L eq is the constant, average sound level, which over a period of time contains the same amount of energy as the ranging levels of traffic noise. Leq is accepted as the standard noise descriptor.

• Hourly Unit:
  - L eq condenses hours worth of fluctuations into a single number

• Daily Unit:
  - L dn and L eq 24 condenses 24 hourly volumes into 2 single numbers, the first for sleep impacts and the latter for all other activities.
  - dBA L eq is the single number indicator most often used to describe the noise intensity level over a specific period of time which the sound level fluctuated
  - the value of L eq can be evaluated continuously or over very small intervals of time
  - L eq is an effective way to compare or combine noises over different time histories
4.- Acceptable Noise Levels

- Residential land use
  - design level varies from 55 dBA to 75 dBA, the variance is generally attributed to cost, technical and public reactions variance

- Maximum acceptable traffic noise levels for residential dwelling and outdoor yard areas
  - bedrooms 35 dBA
  - living areas 40 dBA
  - kitchen 45 dBA
  - outdoor yards 55 dBA
  - the equivalent 24 hour, L eq (24), sound level
  (Ref: NHA/CMHC Road and Rail Noise Effects in Housing)

- The City of Edmonton’s noise policy strives to attain a maximum 24 hour L eq noise level of 60 dBA on roadways in residential areas.
  (Ref: Whitemud/Terwillegar Drive Planning Study, 2001)

- Traffic Noise relationships with changes in volume or distance to recipient
  - doubling traffic volumes at source increases the noise levels by 3 dBA
  - a tenfold increase in traffic volume would increase noise levels by about 10 dBA; twice the loudness of the original noise level
  - if distance from the source is doubled the noise level will decrease by 3-4 dBA;
  - if distance from source is increased by 8 times the noise level will decrease by about 10 dBA; the loudness of the noise will be reduced by approximately half (1/2)
  - traffic traveling 110 kph will be twice as loud as traffic traveling 55 kph.
  - One truck traveling at 80 kph will sound as loud as 28 cars traveling at 80kph
Apparent Loudness

Loudness Scale

dB
80
70
60
50
40
30

A 10 dB increase in level appears to double the loudness while a 10 dB decrease halves the apparent loudness.
Acceptable —
noise exposure both indoors and outdoors is unobtrusive

Normally acceptable —
noise exposure may cause some concern but construction complying with ‘Residential Standards’ should provide acceptable indoor conditions

Normally unacceptable —
noise exposure is significantly more severe. Indoor conditions are unacceptable unless adequate sound insulation is provided. Outdoor recreational space may have to be sheltered

Unacceptable —
noise exposure so severe that sound insulation costs would be prohibitive and outdoor environment would be excessively noisy
<table>
<thead>
<tr>
<th>Sound Source</th>
<th>Noise Level</th>
<th>Apparent Loudness</th>
<th>Typical Reaction</th>
<th>CIMHC Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Military jet</td>
<td>135 dB</td>
<td>Painfully loud</td>
<td>Limit amplified speech</td>
<td>Maximum Acceptable Levels</td>
</tr>
<tr>
<td>Jet takeoff at 50 m</td>
<td>120 dB</td>
<td>Thirty-two times as loud</td>
<td></td>
<td>Unacceptable</td>
</tr>
<tr>
<td>Jet takeoff at 500 m</td>
<td>100 dB</td>
<td>Eight times as loud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight train at 15 m</td>
<td>95 dB</td>
<td>Sixteen times as loud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy truck at 15 m</td>
<td>90 dB</td>
<td>Four times as loud</td>
<td>Very annoying – Hearing damage (8 hours)</td>
<td></td>
</tr>
<tr>
<td>Busy city street</td>
<td>80 dB</td>
<td>Twice as loud</td>
<td>Annoying</td>
<td></td>
</tr>
<tr>
<td>Highway traffic at 15 m</td>
<td>70 dB</td>
<td>Base reference</td>
<td>Telephone use difficult</td>
<td>Unacceptable</td>
</tr>
<tr>
<td>Light car traffic at 15 m</td>
<td>60 dB</td>
<td>Half as loud</td>
<td>Intrusive</td>
<td></td>
</tr>
<tr>
<td>Noisy office</td>
<td>50 dB</td>
<td>Quieter as loud</td>
<td>Speech interference</td>
<td>Normally acceptable</td>
</tr>
<tr>
<td>Public library</td>
<td>40 dB</td>
<td>Eighth as loud</td>
<td>Quiet</td>
<td></td>
</tr>
<tr>
<td>Soft whisper at 5 m</td>
<td>30 dB</td>
<td>Sixteenth as loud</td>
<td>Very quiet</td>
<td></td>
</tr>
<tr>
<td>Threshold of hearing</td>
<td>0 dB</td>
<td>Sixty-four times as loud</td>
<td>Just audible</td>
<td>Acceptable</td>
</tr>
</tbody>
</table>

**NOTE:** The minimum difference in noise level noticeable to the human listener is 3 dBA. A 10 dB increase in level appears to double the loudness, while a 10 dB decrease halves the apparent loudness.
## 1.1 Common Noise Levels and Typical Reactions

<table>
<thead>
<tr>
<th>Sound Source</th>
<th>dB</th>
<th>Typical Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Military Jet</td>
<td>140</td>
<td>Painfully loud.</td>
</tr>
<tr>
<td>Jet Takeoff - 60 Metres</td>
<td>130</td>
<td>Limit amplified sound</td>
</tr>
<tr>
<td>Jet Takeoff - 600 Metres</td>
<td>120</td>
<td>Maximum vocal effort</td>
</tr>
<tr>
<td>Heavy Truck - 15 Metres</td>
<td>110</td>
<td>Very annoying hearing damage (8 hours)</td>
</tr>
<tr>
<td>Highway Traffic - 15 Metres</td>
<td>100</td>
<td>Annoying</td>
</tr>
<tr>
<td>Light Car Traffic - 15 Metres</td>
<td>90</td>
<td>Telephone use difficult</td>
</tr>
<tr>
<td>Noisy Office</td>
<td>80</td>
<td>Intrusive</td>
</tr>
<tr>
<td>Average Residence</td>
<td>70</td>
<td>Speech interference</td>
</tr>
<tr>
<td>Public Library</td>
<td>60</td>
<td>Quiet</td>
</tr>
<tr>
<td>Soft Whisper - 5 Metres</td>
<td>50</td>
<td>Very quiet</td>
</tr>
<tr>
<td>Studio for sound recording</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Threshold of hearing</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Threshold of hearing</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Threshold of hearing</td>
<td>10</td>
<td>Just audible</td>
</tr>
</tbody>
</table>

*Continued exposure in workplace*
### Table 1: Relations Between Decibels, Energy, And Loudness

<table>
<thead>
<tr>
<th>Sound Level Change</th>
<th>Acoustic Energy Loss</th>
<th>Relative Loudness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 dBA</td>
<td>0</td>
<td>Reference</td>
</tr>
<tr>
<td>-3 dBA</td>
<td>50%</td>
<td>Perceptible Change</td>
</tr>
<tr>
<td>-10 dBA</td>
<td>90%</td>
<td>Half as Loud</td>
</tr>
<tr>
<td>-20 dBA</td>
<td>99%</td>
<td>1/4 as Loud</td>
</tr>
<tr>
<td>-30 dBA</td>
<td>99.9%</td>
<td>1/8 as Loud</td>
</tr>
<tr>
<td>-40 dBA</td>
<td>99.99%</td>
<td>1/16 as Loud</td>
</tr>
</tbody>
</table>

As mentioned earlier, sound intensity decreases with distance from a source. Noise from a line source, such as a continuous stream of vehicles, varies differently with distance because sound pressure waves originate all along the line and converge at the point of measurement. The wave front approximates an expanding cylinder. As a result, the noise level will decrease from 3 to 4.5 dBA for each doubling of distance from the source. The amount of decrease depends on the absorptive characteristics of the ground.
2. Typical Noise Exposure

Each noise situation is unique

There exists a wide range of noises to which individuals are exposed in their day to day lives. As can be imagined, every road or railway generates different levels of noise. Similarly, each industrial use and airport produces varied levels of noise. It is not possible to specifically identify all the situations which may occur; however, by considering some of the following example of typical situations one should be able to apply the principles illustrated to specific cases.

Roadways

Where a freeway, arterial, major road or street is in close proximity to a proposed residential development, there will be the potential for a noise problem. The extent of that problem may be determined by direct measurements with a sound level meter or as a result of applying a noise prediction model.

2.1 Roadway Noise

Noise levels depend on the number, speed and mix of cars and trucks; the type, elevation, gradient, surface and distance of the road.
5. Variables That Contribute to Roadway Noise

- hourly volumes of cars
- hourly volumes of trucks
- number of travel lanes
- average operating speeds of vehicles
- projected traffic volumes
- vehicle features such as tire type, brakes, mufflers, etc.
- pavement surface texture
- elevation of roadway relative to noise recipients
- positive and negative gradients of roadway
- distance from edge of roadway to noise recipient
- noise attenuation devices between vehicle noise source and noise recipient (i.e. berms, walls, vegetation, etc.)
- building construction
Noise Calculation

24 HOUR'S WORTH OF $L_{eq}$'s

A-LEVEL (dBA $L_{eq}$)

- MIDNIGHT
- 3 AM
- 6 AM
- 9 AM
- NOON
- 3 PM
- 6 PM
- 9 PM
- MIDNIGHT
Noise Calculation

\[ L_{\text{eq}(24)} = 10 \log \left[ \left( \frac{1}{24} \right) \sum_{0000 \text{ hours}}^{2400 \text{ hours}} 10^{(L_{\text{eq}}/10)} \right] \]
Noise Calculation

• Example
  – Average running speed 50 mph
  – Cars - 2000 vehicles per hour
  – Medium trucks – 100 vehicles per hour
  – Heavy trucks – 115 vehicles per hour
  – Distance from source to observer – 200 feet
  – Height of observer – 5 feet
  – Ground is absorptive
Noise Calculation

- Equations
- Cars $L_{eq} = 20 + 20 \log S + 10 \log (V/D)$
- Med trucks $L_{eq} = 30 + 20 \log S + 10 \log (V/D)$
- Heavy trucks $L_{eq} = 62 + 5 \log S + 10 \log (V/D)$
Noise Calculation

- **Cars**
  - \( L_{eq} = 20 + 20 \log S + 10 \log (V/D) \)
  - \( L_{eq} = 20 + 20 \log (50) + 10 \log (2000/200) \)
  - \( L_{eq} = 20 + 20(1.7) + 10(1) \)
  - \( L_{eq} = 20 + 34 + 10 \)
  - \( L_{eq} = 64 \text{ dBA} \)
Noise Calculation

• Medium trucks

\[ L_{eq} = 30 + 20 \log S + 10 \log \left( \frac{V}{D} \right) \]

\[ L_{eq} = 30 + 20 \log (50) + 10 \log \left( \frac{100}{200} \right) \]

\[ L_{eq} = 30 + 20 \times 1.7 + 10 \times (-.3) \]

\[ L_{eq} = 30 + 34 - 3 \]

\[ L_{eq} = 61 \text{ dBA} \]
Noise Calculation

• Heavy trucks

\[ L_{eq} = 62 + 5 \log S + 10 \log \left( \frac{V}{D} \right) \]
\[ L_{eq} = 62 + 5 \log 50 + 10 \log \left( \frac{115}{200} \right) \]
\[ L_{eq} = 62 + 5 \left( 1.7 \right) + 10 \left( -0.24 \right) \]
\[ L_{eq} = 62 + 8.5 - 2.4 \]
\[ L_{eq} = 68 \text{ dBA} \]
Noise Calculation

- Ground Absorption
  - $10 \log \left[ \frac{D}{(H_o + 8)} \right] - 5.3$
  - $10 \log \left[ \frac{200}{(5+8)} \right] - 5.3$
  - $10 \log [15.38] - 5.3$
  - $10(1.18) - 5.3$
  - $11.8 - 5.3 = 6.5$
# Noise Calculation

<table>
<thead>
<tr>
<th>Step</th>
<th>Traffic</th>
<th>Example #3</th>
<th>Example #4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vehicle</td>
<td>A</td>
<td>MT</td>
</tr>
<tr>
<td>2</td>
<td>Veh. Volume (vph)</td>
<td>2000</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Veh. Average Speed (mph)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Roadway Gradient (%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Surface Type (Normal, Rough, Smooth)</td>
<td>R</td>
<td>S</td>
</tr>
<tr>
<td>3</td>
<td>Observer-Roadway Distance, D (ft)</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Observer height less than 0.30 + B ?</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>Ground absorptive?</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>4</td>
<td>Line-of-Sight Distance, L/5 (ft)</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Barrier Position Distance, P (ft)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Break in L/5, B (ft)</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Angle Subtended, φ (degrees)</td>
<td>170</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Leg from Nerngrof (dBA)</td>
<td>64</td>
<td>61</td>
</tr>
<tr>
<td>5</td>
<td>Barrier Attenuation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Vegetation Attenuation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Row-of-building Attenuation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Sum of these three attenuations</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Ground-effect Attenuation</td>
<td>6½</td>
<td>6½</td>
</tr>
<tr>
<td></td>
<td>Most negative of these two</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gradient Adjustment</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Surface-type Adjustment</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>Prediction of Leq</td>
<td>57½</td>
<td>51½</td>
</tr>
<tr>
<td>7</td>
<td>Leq at Observer, by Vehicle Class (dBA)</td>
<td>63½</td>
<td>63½</td>
</tr>
<tr>
<td></td>
<td>Total Leq at Observer (dBA)</td>
<td>63½</td>
<td>63½</td>
</tr>
<tr>
<td></td>
<td>L_up (24) - Leq</td>
<td>-1½</td>
<td>-1½</td>
</tr>
<tr>
<td></td>
<td>Resulting Leq (24) (dBA)</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>L_dn - Leq</td>
<td>+3</td>
<td>+3</td>
</tr>
<tr>
<td></td>
<td>Resulting L_dn (dBA)</td>
<td>66½</td>
<td>66½</td>
</tr>
</tbody>
</table>
Noise Calculation

### TABLE I.9 dB-ADDITION TABLE
(also included on the $L_{eq}$ Nomograph)

<table>
<thead>
<tr>
<th>$L_{\text{high}} - L_{\text{low}}$</th>
<th>Add to $L_{\text{high}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to $\frac{1}{2}$</td>
<td>3</td>
</tr>
<tr>
<td>1 to $1\frac{1}{2}$</td>
<td>$2\frac{1}{2}$</td>
</tr>
<tr>
<td>2 to 3</td>
<td>2</td>
</tr>
<tr>
<td>$3\frac{1}{2}$ to $4\frac{1}{2}$</td>
<td>$1\frac{1}{2}$</td>
</tr>
<tr>
<td>5 to 7</td>
<td>1</td>
</tr>
<tr>
<td>$7\frac{1}{2}$ to 12</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>$12\frac{1}{2}$ and up</td>
<td>0</td>
</tr>
</tbody>
</table>
Noise Calculation

- Ground absorption – take off 6.5 dBA
- $57.5 - 54.5 = 3$ dBA difference
- Add 2 dBA to 57.5 get 59.5 dBA
- $61.5 - 59.5 = 2$ dBA
- Add 2 dBA to get to 63.5 dBA
- Another way $61.5 - 54.5 = 7$ dBA
- Add 1 to 61.5 get to 62.5 dBA
- $62.5 - 57.5 = 5$ dBA
- Add 1 to 62.5 to get to 63.5 dBA
6.- Traffic Noise Reduction and Management

- There are many variables that contribute to traffic noise. Traffic noise reduction programs require a shared responsibility. Highway agencies, land use planners, vehicle manufacturers, developers and builders must work together through joint effort to attain overall cost effective noise management and reduction goals. The following are the main areas where noise reduction can be systematically approached.

- Motor vehicle noise
- Roadway planning and design
- Land use and development control
- Building design and standards
Noise Calculation

dB Addition Table

<table>
<thead>
<tr>
<th>High-Low</th>
<th>Add 10 High</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1/2</td>
<td>3</td>
</tr>
<tr>
<td>1 to 1 1/2</td>
<td>2 1/2</td>
</tr>
<tr>
<td>2 to 3</td>
<td>2</td>
</tr>
<tr>
<td>3 1/2 to 4 1/2</td>
<td>1 1/2</td>
</tr>
<tr>
<td>5 to 7</td>
<td>1</td>
</tr>
<tr>
<td>7 1/2 to 12</td>
<td>1/2</td>
</tr>
<tr>
<td>12 1/2 and up</td>
<td>0</td>
</tr>
</tbody>
</table>

Leq NOMOGRAPH (English Units)

Start

Heavy Trucks
Medium Trucks
Autos

Speed (mph)

Rail Cars

Turn

Pivot

Distance (ft)

Volume (veh/hr)

Example
Noise Calculation

FIG. II.12 $L_{eq}$ NOMOGRAPH, EXAMPLES 3 AND 4
7.- Motor Vehicle Noise Reduction

- operational control of vehicles on roadways
- restricted hours of truck operations
- designated truck routes
- regulation on height of exhaust stacks on trucks
- better design and insulation of engine compartments for quieter operation
- limitation on use of truck brake retarders in residential areas
- better design of sound reduction for mufflers, fans, etc
- better tire design to reduce pavement noise
- noise standards for motor cycles and street hot rod vehicles
- restrict hours of operation and maximum dBA for “loud” vehicles
7- Motor Vehicle Noise Reduction (con’t)

• Regulations limiting truck noise through proper specifications, operations and maintenance can be expected to decrease the noise level by 5 to 10 dBA. Truck engine noise is more dominant at lower speeds whereas tire noise becomes more dominant at higher speeds. The same principle applies to car noise. On cars, the engine noise under power only contributes about 2 additional dBA as compared to coasting.

• The most effective approaches to minimize traffic noise are to legally reduce noise emissions from motor vehicles and enforce the lower limits. Highway agencies (departments) generally have no control over noise emanating from vehicles. Help and co-operation is needed from vehicle manufacturers, drivers, regulatory and enforcement agencies and community support.
8.- Roadway Planning and Design

- Traffic noise generation is an important consideration in the location and design of highway facilities.

- Highway agencies (departments) are generally in a position to exert some influence and control over the magnitude of vehicle noise impacts through their planning and design responsibility.

- Roadway location:
  - A new road can be located away from noise sensitive areas and placed near non-sensitive areas (business or industrial) or through undeveloped areas.

- Roadway Right-of-way:
  - Extra right-of-way may be purchased to act as a buffer zone which is an undeveloped open space bordering a roadway so that future dwelling cannot be constructed close to the roadway; also increases spatial separation with existing developments.

- Depressed vs. Elevated Roadway:
  - Depressed section is generally more effective in noise reduction and least expensive as compared to elevated roadways.

- At-grade, stop and go, intersections:
  - Elimination of at-grade intersections on high volume roadways and replacing them with alternative means of access such as interchanges with free flow characteristics is effective in noise reduction if it can be incorporated into the roadway planning and design.
8.- Roadway Planning and Design (con’t)

- Roadway gradients
  - minimize design grades when technically and economically feasible; positive grades increase engine noise; negative grades increase brake and tire noise.

- Pavement design
  - select most appropriate pavement type and texture that will minimize tire noise when technically and economically feasible

- Interchange location
  - have ramp location and grades that will minimize noise impacts relative to residential developments, etc.

- Noise attenuation structures
  - may be incorporated into highway design (Refer to later section on this topic)

- Ultimate capacity, traffic projections, growth rate, expansion plans, etc. for each particular roadway section must be considered in the planning and design stage so as to meet future noise attenuation needs.

- Noise reduction measures that are possible on new roads are more or less restricted to noise attenuation strutures on existing roadways. Roads that are being rebuilt are somewhat less restrictive but usually its location and right-of-way is fixed. Changes to gradients, access locations, pavement design and minor changes to alignment in combination with noise attenuation structures are most often considered when improving or expanding existing roadways.
9.- Land Use Planning

- An effective noise control program must encourage compatible land uses adjacent to the roadway. Controlling motor vehicle noise cannot provide an overall and cost-effective solution by itself. Problems arise when noise sensitive developments are constructed next to roadways. These problems can be minimized by local governments exercising their power to control land use through regulations. Land use planning is the art of arranging land uses in a compatible manner with respect to noise generating uses as well as the many other factors that go into land use planning generally. It applies to any new development or redevelopment and focuses primarily on residential and other institutional uses. Two main principles of land use planning at the community, subdivision and lot scale are the following:

- Spatial separation
  - insertion of buffers (noise insensitive space)
  - open space
  - orientation of outdoor space

- Intervening structures (development) acting as barriers
  - apartments
  - linked town houses

- Other factors which may be considered but with lower priority are acoustic barriers (earth berms and walls) and building design

- Provincial Planning Acts provide local governments (municipalities) the authority to control land use and building structures for lands within their jurisdiction and often adjacent to public roadways. Highway agencies are encouraged to work closely with the jurisdictions that have authority over land use planning. There is legislation and regulations where the municipality may become involved in the various stages of land use, planning and development control.
9.- Land Use Planning (con’t)

Official Plans
- Determines development patterns best for municipality
- Develops policies related to noise control to ensure a comprehensive uniform approach
- Noise is only one factor among many other social economic and environmental factors that is included in an Official Plan
- Develops noise receiver orientated polices needed to protect new residential developments against the impact of noise created by existing sources or new sources projected for the future
- Develops source-orientated policies aimed at controlling new potential source of noise
- Addresses all sources of noise:
  - major roadways including freeways, highways, major arterials, aircraft, railway
  - air craft
  - railways
  - industrial plants
  - large commercial
- addresses both indoor and outdoor noise with equal priority
- distributes land uses in consideration of major noise source

Neighbourhood Area Structure Plans
- Second level of municipal planning with more detailed concept of land use distribution
- May try to locate intervening land uses or barrier type structures for noise control
- Spatial separation is the most direct measure in dealing with noise at the neighbourhood plan level with respect to residential development
- Open space as noise mitigation is relatively limited as large distances are required to have effect.
9.- Land Use Planning (con’t)

Neighbourhood Area Structure Plans (con’t)

- Cost of land for spatial separation (buffer) in urban areas can be excessive unless it can be used to accommodate other uses i.e. utility lines or uses that are not sensitive to noise i.e. a baseball park

- Spatial separation must be addressed very early in the planning process prior to any development occurring.

- Spatial separation gives rise to loss of development opportunity and maintenance costs

- In urban situations the result of using developable land for spatial noise mitigation can become very expensive and other noise attenuation methods need to be considered (usually as second priority)

- The use of open space or good land arrangement will likely result in a high level of acceptance by the general public.

Subdivision Plans

- Municipalities are generally the subdivision approving authority with referral to and input from other agencies

- Subdivision is the third level in land use planning and involves Zoning By-laws and a Site Plan Approval Process

- Noise study may be a requirement to recommend noise control features

- Noise controls can be included in a zoning by-law if a noise problem has been identified at a site-specific location. If re-zoning is necessary the municipality may specify what noise mitigation measures should be included.
3.10 Subdivision Layout

Row of continuous townhouses are designed to buffer the interior of the subdivision and their own recreational areas.
3.11 Key Lot Plan

The "key lot" plan allows the houses themselves to form quiet outdoor recreational areas.
Building regulations and codes are also administered by local municipalities and can also help in noise reduction but has less influence than facility design and land use planning. It is also restricted to noise reduction inside buildings. Factors to be considered in building design are:

- Exposure of dwelling to noise sources
- Orientation of rooms within a dwelling floor plan
- Limiting the number and size of wall openings on the side of dwelling exposed to noise
- Acoustical sound insulation in exterior walls
- Double glazed windows
- Insulated exterior doors
- Proper ventilation and air conditioning so that windows and doors may remain closed
- Outdoor landscaping near dwelling
11.- Noise Attenuation Screening

- Totally undeveloped area
  - May use combination of roadway design, right of way width and land use planning to attain the desired noise attenuation.

- Developed roadway in undeveloped area
  - Land use planning for future development to get desired noise attenuation with consideration of future traffic volumes.
  - Buffers may be considered
  - Shielding structures considered only if other methods become very cost prohibitive

- Undeveloped roadway in developed area
  - Roadway design and right of way width most important in getting desired noise attenuation
  - Shielding structures considered only if other methods becomes very cost prohibitive

- Developed roadway and adjacent to developed lands
  - Due to space restrictions in retrofit situations where it is not possible to change the roadway design or land use and extra right of way is not easily available the use of shielding structures is sometimes the only option for noise attenuation
  - Buffer zones require an extra wide tract of land to have a noticeable effect on noise attenuation. Unless the space can be used for other non-sensitive land uses, buffers have practical and financial limits.
12.- Noise Shielding

There are several types of barriers that can be considered useful in noise reduction. A solid, acoustically opaque roadside barrier can reduce the noise exposure of a property by 10 to 15 dBA. For maximum effectiveness, a barrier should be close to either the source or the receiver and it should be high enough and long enough to cast a large sound shadow; and it must be constructed with a dense material with no allowance of air paths through or under the barrier.

• Earth berms:

  Usually most aesthetically pleasing; natural appearance
  Can be incorporated with roadway grading
  Can be incorporated with roadway/development landscaping
  Can be combined with a wall
  Generally most cost effective if right of way cost reasonable
  Slightly more attenuation than a wall
  Requires more right of way than walls
  Requires more frequent maintenance
  May cause drainage problems

• Barrier walls:

  Noise walls can be constructed of wood, concrete, stucco, masonry, metal or other material and can range from relatively simple to rather complex designs
  Material chosen should be rigid, dense and acoustically opaque
  Cost of material, foundation, fabrication, erection and maintenance must be considered
  Requires less right of way and less maintenance than berms
  Not considered as aesthetically pleasing as berms
  Provides a strong psychological separation between noise generator and receiver
  Openings in walls for access more apt to cause a problem than berms
12.- Noise Shielding (con’t)

- Vegetation:
  
  Must be high enough, wide enough and dense enough to decrease traffic noise  
  (a 200 foot width that cannot be seen through and sufficiently high can reduce  
  noise by 10 dBA)  
  Relatively cheap, low maintenance and aesthetically pleasing  
  Narrow width of sporadic plantings will not provide effective noise reduction  
  (only psychological)

- All noise barriers must be high enough and long enough to block line of sight to the  
  road; noise barriers do very little good for homes on a hillside. The ends of the  
  barrier should extend well beyond the area to be shielded from the noise

  Barrier designs have a noise reduction goal and focus generally on acoustical  
  comparison and economy. However, there are other considerations such a  
  safety, drainage, maintenance and visual quality that need to be included.
3.2 Principles of Noise Mitigation

Noise mitigation measures can be categorized as either utilizing distance or introducing a barrier, to reduce noise levels. Usually measures combine both principles.
Sound Reflections: Berms vs Walls

Both sides of a noise source should be considered when analysing noise problems. Reflections of sound in the illustration would be worse with barrier walls than utilizing earth berms.
Berm Barrier

The berm acts as a noise barrier to reduce sound levels in the recreational area. It is not effective for upper storeys.
3.4 Land Use Planning: Neighbourhood Scale

Land uses grouped so that noise producers (railway/industry/major road) are away from residential areas with office/commercial/recreational uses between.
### 3.1 Noise Control Measures

#### LAND USE PLANNING

**SPATIAL SEPARATION**
- Insertion of Noise Insensitive Buffers
- Orientation of Outdoor Recreational Space
- Open Space

**BARRIERS**
- Topographic Considerations
- Intervening Structures
  - Apartments
  - Townhouses and linked units

Mitigation measures may be considered at:
- Community Scale
- Neighbourhood Scale
- Subdivision Scale
- Lot Scale

#### OTHER NOISE CONTROL MEASURES

**ACOUSTIC BARRIERS**
- Earth Berms
- Walls and Fences

Mitigation measures may be considered at:
- Neighbourhood Scale
- Subdivision Scale

**BUILDING DESIGN**
- Room Arrangement
- Orientation of Windows

Mitigation measures relate to Indoor Noise levels

**CONSTRUCTION TECHNIQUES**
13.- Roadway Traffic Noise Studies

- Objective of a noise study for new roadway construction or roadway improvements.
  - Define areas of potential noise impact
  - Evaluate measures to mitigate these impacts
  - Compare alternatives on the basis of potential noise impact and the associated mitigation costs

- Different audiences
  - Roadway agencies responsible for roadway planning and design
  - Government decision makers responsible for vehicle regulation and land use planning and development
  - Lay public who are impacted by noise

- Key elements of a roadway noise study
  - Definition of noise impact criteria and identification of noise-sensitive land uses
  - Determination of existing noise levels (noise meters, field measurements, calculations)
  - Projection of noise impacts for study alternatives using traffic noise projection models which can handle many variations of traffic parameters
  - Identification and evaluation, including feasibility, of mitigation measures; a cost-effective noise reduction goal at a specified location at the lowest cost
  - Evaluation of construction noise impact; since noise is temporary it is usually accepted by the public as a necessary part of construction and is not a problem
  - Documentation of the traffic study discussions and coordination with local governments whose jurisdictions are affected
  - Primary purpose of coordination is to promote compatibility between land development and roadways; the roadway agency should provide local officials with the Noise Study report including estimated future noise levels caused by the roadway and noise criteria for various land use activities to assist land use planning
14.- Summary

- Noise is generally described in measurement of loudness and in terms of annoyance.

- The three elements in noise evaluation are the source (vehicles); propagation medium (space) and receiver (dwelling)

- The decibel (dA) is a measure of sound pressure and is shown on a logarithmic scale of 0 to 140; note that an increase of 10 dB doubles the noise level (loudness)

- The dBA unit is a weighting of the sound pressure level for each frequency band and most closely represents the range of human hearing and it’s response to traffic noise

- The A-weighted sound level (leq dBA) is intended as a single number indicator to describe the intensity level over a period of time (usually 1 hr.) during which the sound level fluctuated. Leq is the constant, average sound level, which over a period of time contains the same amount of sound energy as the varying levels of the traffic noise.

- Maximum acceptable noise levels for outdoor back yards is 55 – 60 dBA and for indoor dwelling is 35 – 45 dBA for most jurisdictions in Canada.

- Key variables that affect vehicle noise are type of vehicle (trucks vs. cars) traffic volumes, speed, pavement, vehicle tires and brakes and distance from edge of roadway to the noise recipients.

- Traffic noise reduction can be achieved through various means; better motor vehicle noise emissions and control; roadway planning and design, land use planning, better building design and standards.
14.- Summary (con’t)

• Most noise reduction with motor vehicles can be achieved through better design of vehicle components (tires, brakes, mufflers, etc.) and with regulation of vehicle operation (restricted routes, hours of operation, etc. for truck, noise emissions, etc.)

• The key factors that affect traffic noise with respect to roadway location and design are roadway location, right of way width, grade lines, access management (removal of “stop” conditions), pavement design and noise barriers

• Good land use planning establishes land use adjacent to roadways that are compatible with traffic noise; provides separation of noise-sensitive land uses from close proximity to roadways, i.e. schools, churches, libraries, residential homes, etc.; provides for adequate noise reduction through spatial separation, noise insensitive buffers, building patterns and orientation (apartments and townhouses are noise barriers) and acoustic barriers (berms, walls) where noise sensitive activities have no option but to locate close to roadways (usually cost related).

• There are generally four (4) levels of land use planning: Official Plan (regional or city); Neighbourhood or Area Structure Plan; Subdivision Plan and Zoning By-laws and sometimes Site Plans.

• Building design and standards can be used to reduce noise inside dwellings through acoustically insulated exterior walls, windows and doors.
14.- Summary (con’t - 2)

• Noise attenuation scenarios vary with the degree that the roadway and adjacent land is developed. In planning a new roadway facility through undeveloped lands there are many noise mitigation options available. In the retro-fit situation when a roadway is in existence and land is developed on both sides, the mitigation measures available for solving a noise problem becomes very limited. Noise barriers may be the only option available.

• Noise shielding can be achieved by noise barriers that include earth berms, vertical walls and vegetation plantings. Generally noise barriers are expensive to construct if needed for a considerable distance. Selection of type of barrier depends on such factors as how much noise reduction is require, available space, maintenance, aesthetic qualities and costs.

• Good roadway traffic noise studies on the part of the roadway agency are very important in identifying noise impacts and evaluating alternative mitigation measures; coordination of information contained in the study needs to be provided to local jurisdictions who are responsible for land use planning. The study should estimate future noise levels caused by the roadway and recommend noise criteria for various land use activities to assist in land use planning. Noise attenuation solutions can only be achieved through a systems approach where road agencies, traffic regulators, roadway designers, land use planners work together towards a common goal.
Figure 3: Example of Wooden Noise Barrier Along Freeway.
**SHADOW Effect of Acoustic Barrier**

![Diagram showing the effect of an acoustic barrier]

- **UNSHIELDED DWELLING**
- **SHIELDED DWELLING**
- **SHADOW ZONE**
- **NOISE BARRIER**

**SHADOW ZONE RELATIVELY QUIET**

**Figure 1**
Fig. 2 — Need for detailed calculations

Distance from buildings to centreline of road

Average number of vehicles per day

Detailed calculations necessary

Calculations not necessary
97 St. & 153 Ave. Looking NE
Yellowhead and 89 St.
50 Street & Yellowhead – Looking SE
106 St & Whitemud