Steps 1-3 Recap

- ✓ Project Understanding Complete
- ✓ Individual Noise Levels Calculated, as Appropriate, for
  - ✓ Aircraft,
  - ✓ Roadways,
  - ✓ Railroads, and
  - ✓ Loud Impulsive Sounds

Step 4: Combine Findings and Assess

- Find the Numerical Difference between Two Levels to be Combined
- Look Up Difference in Table 1
- Add Factor to the Larger (Louder) Sound Level
- Repeat as Necessary

Table 1—Combining Sound Levels

Difference in Sound Levels	Factor to Add to Larger Level
0	3.0
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
6	1.0
7	0.8
8	0.6
9	0.5
10	0.4
12	0.3
14	0.2
16	0.1
Greater Than 16	0

Council Bluffs Preliminary Findings

- Aircraft: 65 dB
- Roadway: 46 dB
- Railway: 65 dB
- Impulse: 0

✓ Acceptable with Construction Typical for the Area to Reduce Interior Noise to 45dB as Required.

What if it Wasn't Acceptable?

- Pick Another Site
- Consider Exterior Mitigation
  - Revise the Site Design
  - Construct a Barrier
  - Remove Balconies from Noise-exposed Facades
- Consider Interior Mitigation
  - Move Noise-sensitive Uses to Interior Portions of the Building
  - Use Wall Sections with Appropriate Sound Transmission Classifications

What Do You Do?

- Your Responsibility as HUD Staff or RE
  - Make Sponsor or Developer Aware of the Attenuation Requirements
  - Make Decision-makers Aware of the Options Available
  - Review Attenuation Proposals to Assure They are Adequate

What Don't You Do?

It Is ***Not*** Your Responsibility to Design Barriers.

However…

You Should

- Have a Basic Understanding of What Can be Done
- Know What will Work and What will Not
- Provide Site Planning Options that will Achieve the Desired Result without Additional Cost
- Remember that an Alternative Site may be the Best Solution

Step 5: Noise Attenuation

- Three Options Available for Attenuating Noise
  - **Site Design** (Moving Noise-Sensitive Uses away from the Noise Source)
  - **Barriers or Berms** (Constructing Physical Barricades to Noise)
  - **Special Acoustical Construction** in the Building (Least Preferred because it does Nothing to Mitigate Exterior Noise)

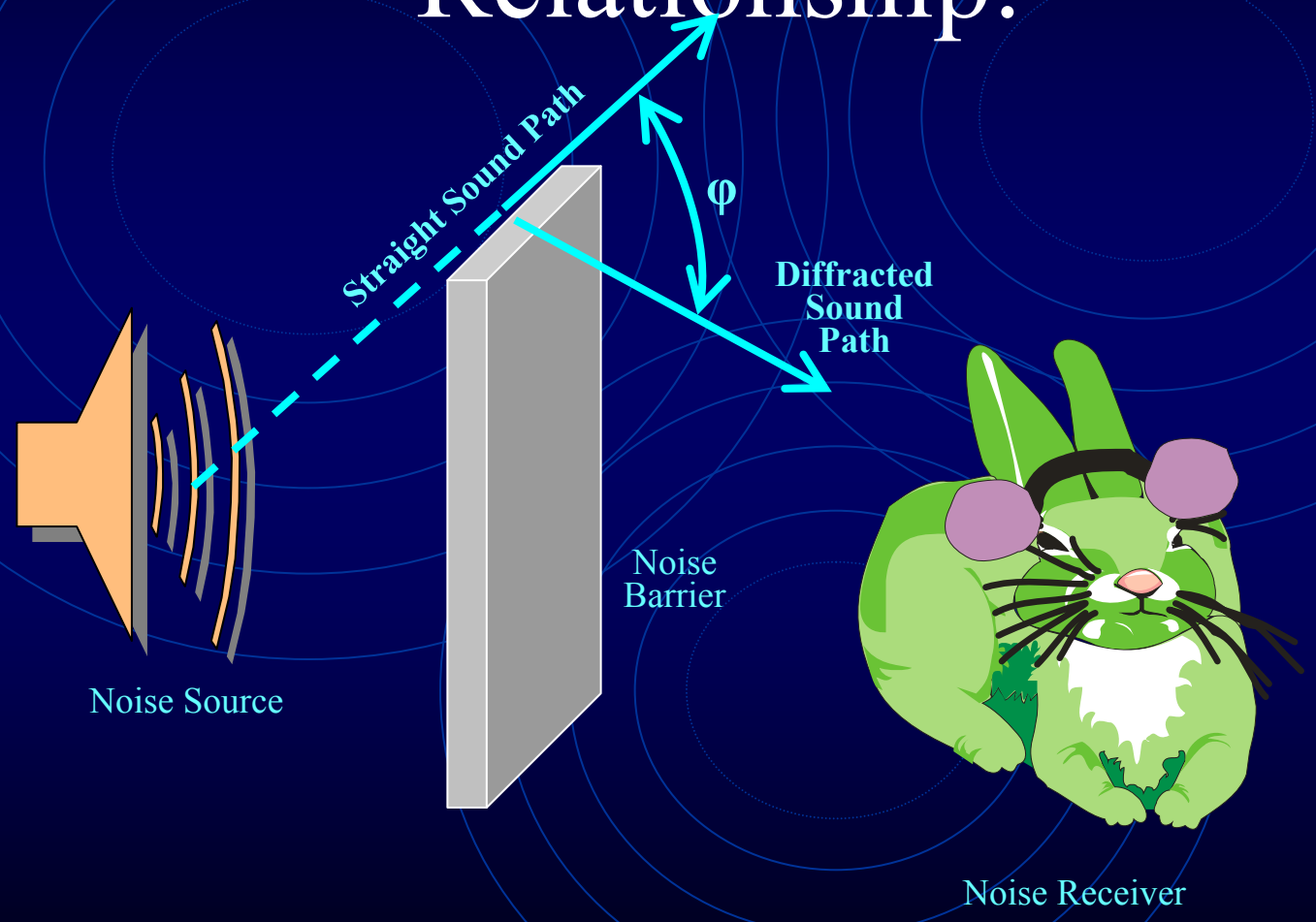
Site Design Issues

- Distance
  - Doubling the Distance from a Sound Source can Reduce its Intensity by as much as 6 dB
  - This is an Important consideration for the Upper Levels of Multi-story Buildings too
- Noise-compatible Land Uses as Buffers
  - Parking, Maintenance Facilities, and Utility Structures
- Buildings as Shields
  - Structures with Noise-tolerant Uses (Offices, Retail, etc.) can Block the Sound Energy from More Sensitive Uses Behind Them
- Building Orientation
  - Windows can be Removed or Reinforced along the most Impacted Wall
  - Site Buildings to Use Topography (Hills and Depressions) as Barriers

How Do Barriers Work?

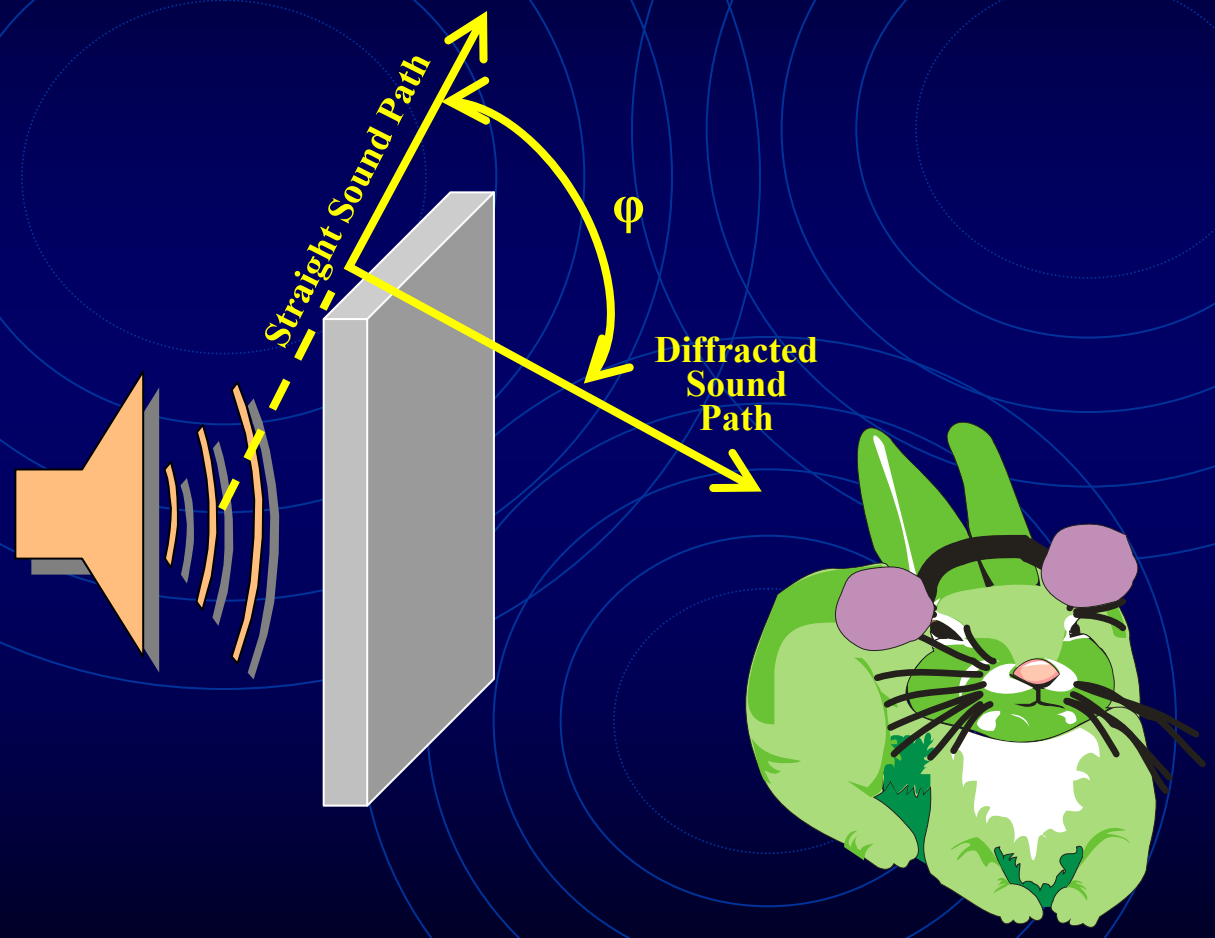
Barriers Block the Sound Energy that Travels on a Line-of-Sight between the Source and Receiver

Barrier Design Basic Relationship:



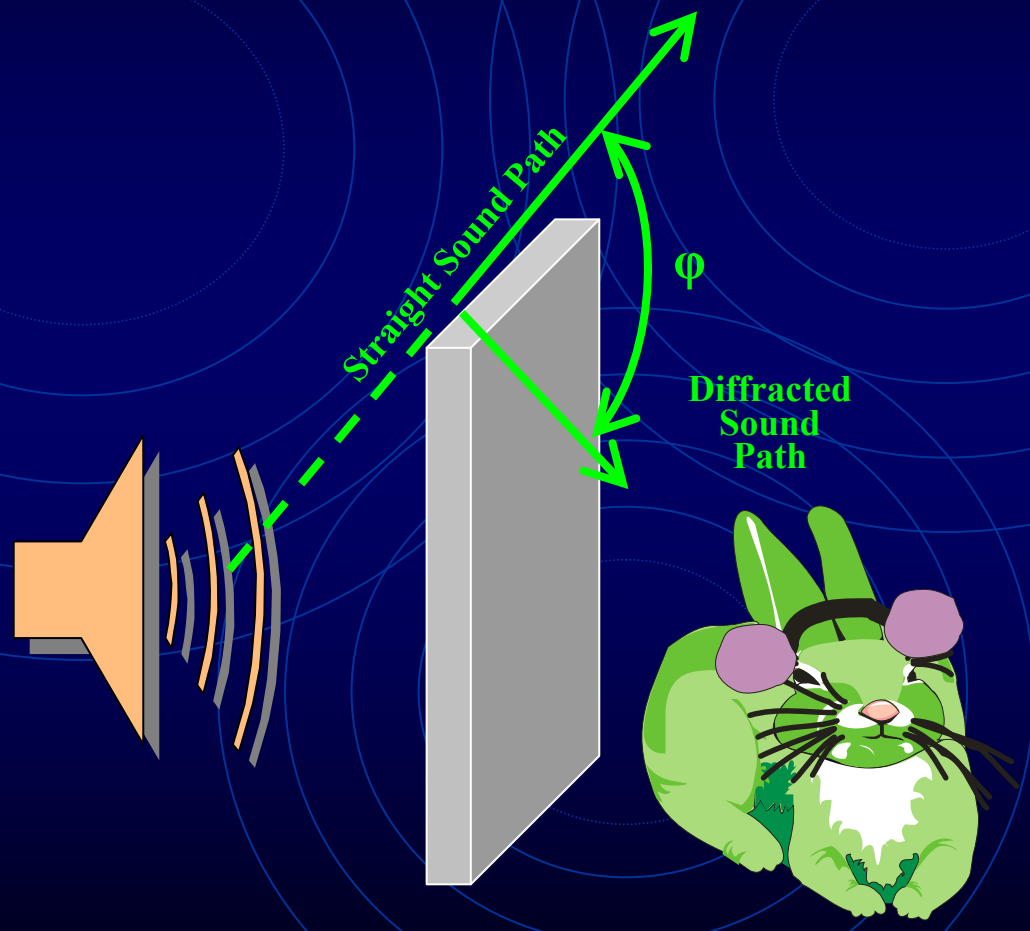
How Do You Make Barriers More Effective?

Move the Barrier Closer to the Source:



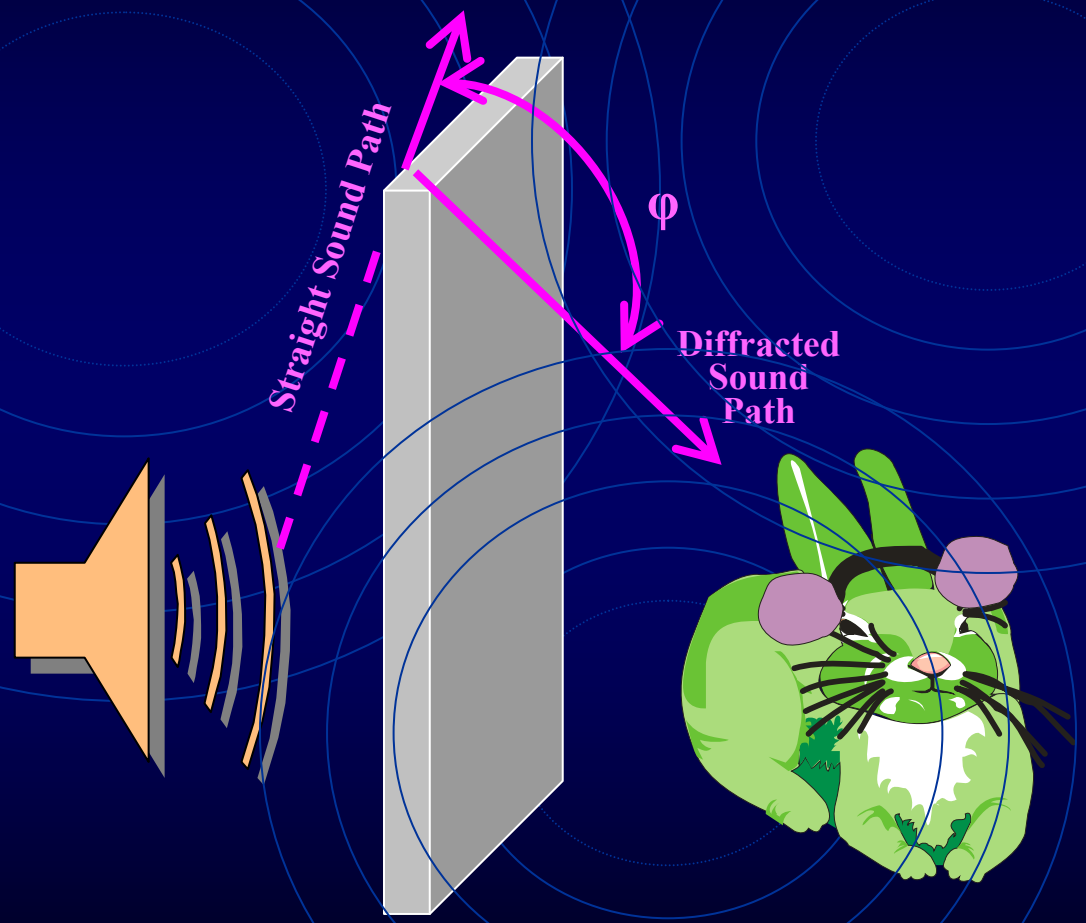
Larger Diffraction Angle (φ) Equals Better Attenuation

Move the Barrier Closer to the Receiver :



Larger Diffraction Angle (φ) Equals Better Attenuation

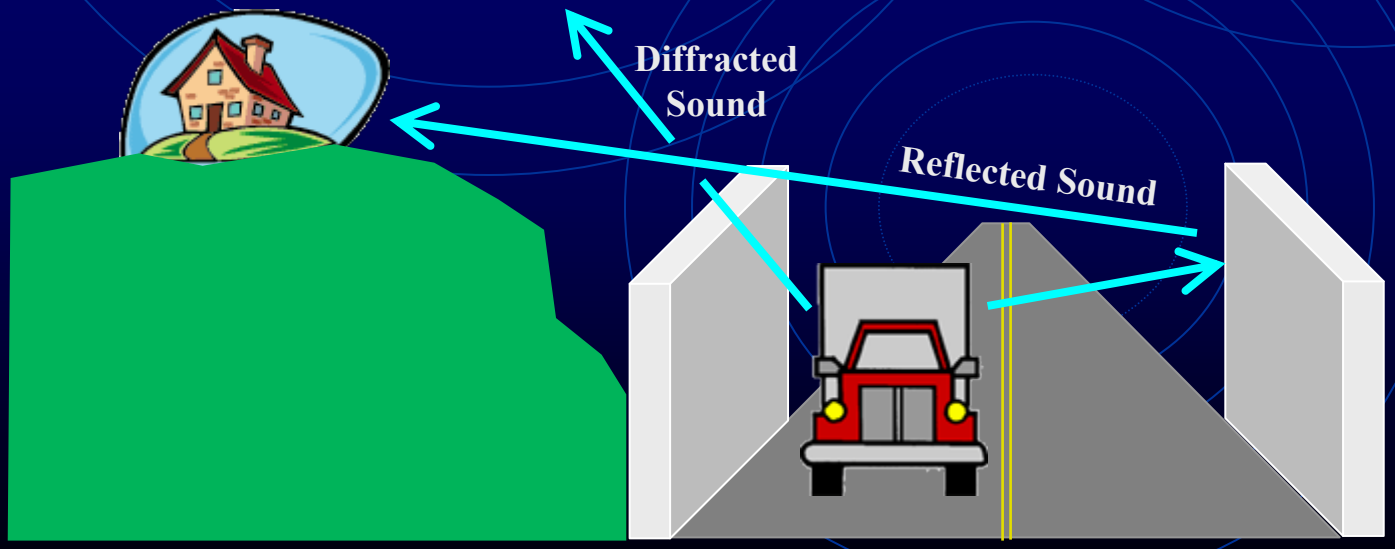
Increase the Barrier Height :



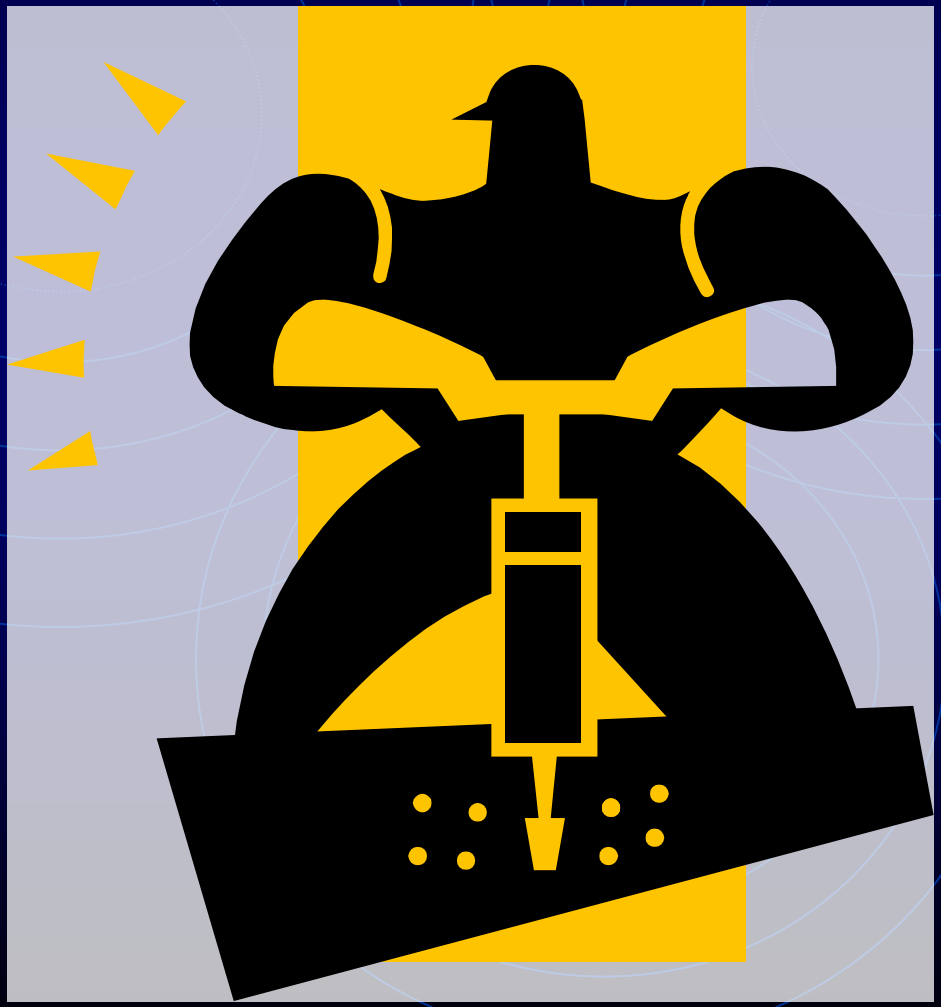
Larger Diffraction Angle (φ) Equals Better Attenuation

Barrier or Berm Design Issues

- Openings Totaling More than 10% of the Barrier Area will Remove All Attenuation Value
- Diffracted Sound (Over the Wall) is Usually More Important than Reflected Sound (Bounced Off an Opposite Wall), But Not Always



Special Acoustical Construction Issues



Sound Transmission Basics

- Building Materials Transmit Sound at Different Rates
- Walls are Composed of Various Components and Spaces
  - Single- or Multi-pane Windows
  - Concrete Masonry Units or Wood Frame
  - Cavities (Double Brick with an Airspace) or Solid
- Wall Systems can be Specially Constructed to Insulate Against Noise
  - Allowed by 24CFR51.104(a)(1)

Sound Transmission Classifications

- Sound Transmission Classification (STC) is a Number of Decibels a Sound is Reduced as It Passes Through a Specific Combination of Materials and Construction
  - Developed Through Laboratory Testing
  - Ratings for Various Wall Configurations are in the Noise Guidebook (page 38, Table 3)
- Windows and Doors are Less Effective Components of the Wall
  - Ratings in the 20s versus 40s and 50s for the Rest of the Wall (See page 38, Table 3)

Noise Assessment Review

The Elements to Review are:

- Site Design
- Barriers or Berms
- Special Acoustical Construction

Site Design Review

- Is the Separation between the Source and the Receiver Adequate?
- If Noise-compatible Buildings are being Used as Barriers, are They Adequate?
  - Are They Long Enough?
  - Are They High Enough?
  - If They Contain Noise-sensitive Uses, have They been Appropriately Soundproofed?

Barriers or Berms Design Review

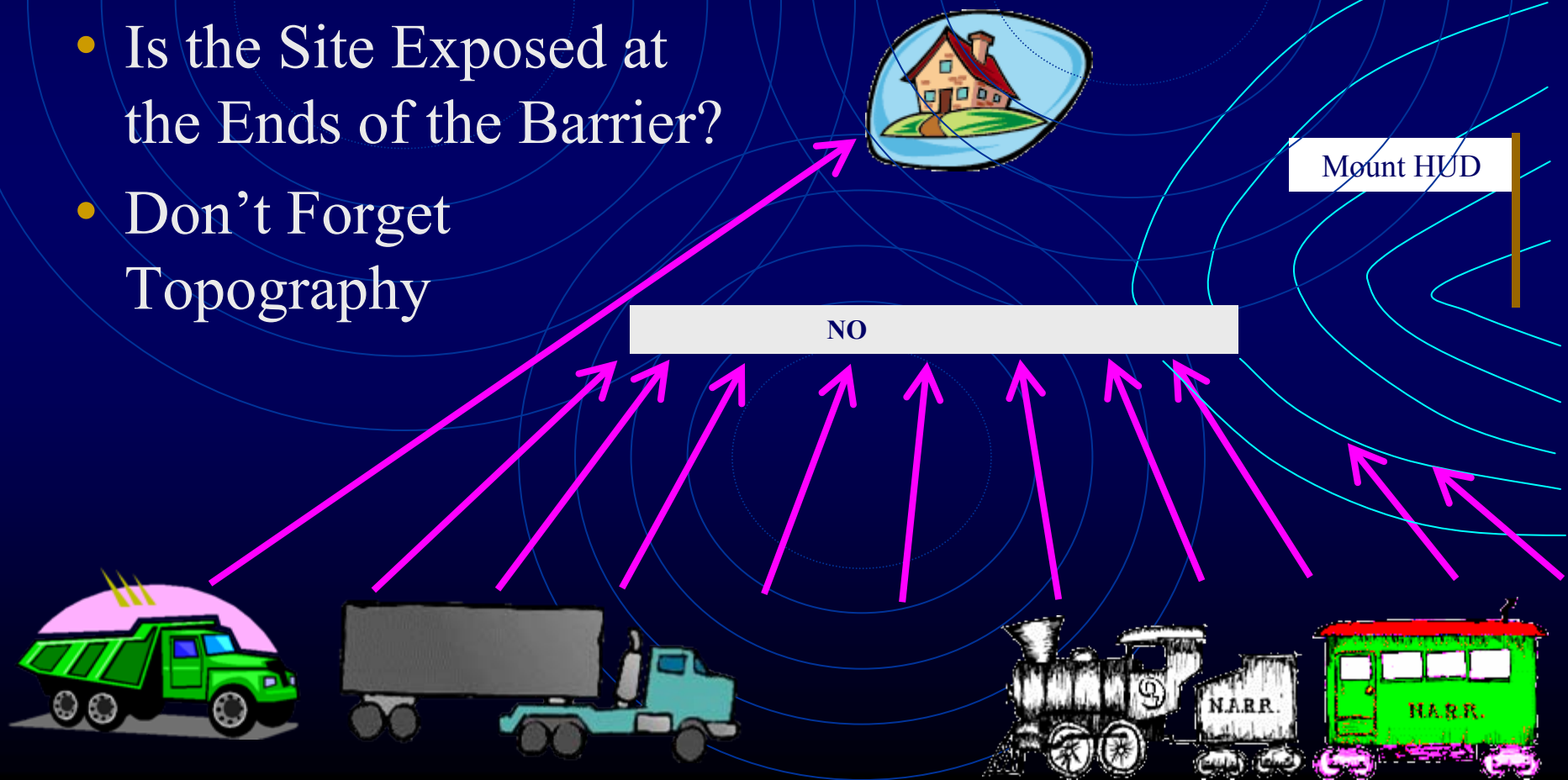
- Is It High Enough?
- Is It Long Enough?
- Is It Made of the Right Materials?
- Is It Properly Constructed?

Barriers or Berms Design Review

- Is It High Enough?
  - Does it Break the Line-of-Sight between the Source and the Receiver?
    - Look for Surfaces that might Reflect the Sound
  - Generally Not Effective for Units Above the Second Floor
    - Can Still Improve Outdoor Recreation Areas
    - Upper Floors Benefit from Increased Distance from the Source

Barriers or Berms Design Review

- Is It Long Enough?
  - Is the Site Exposed at the Ends of the Barrier?
  - Don't Forget Topography



Barriers or Berms Design Review

- Is It Made of the Right Materials?
  - Lightweight Materials Transmit Sound
    - *Remember the STC Discussion?*
  - If the Transmission Loss Value for the Barrier Material is not at least 10dB higher than the Barrier's Size and Location Provide, there is Little or No Attenuation.
    - In Most Cases, Barrier Material Choice Reduces Barrier Design Effectiveness

Barriers or Berms Design Review

- Is It Properly Constructed?
  - Barriers with Openings Totaling 50% or More of the Total Area Provides No Attenuation
  - Barriers with Openings Totaling 10% of the Total Area Provides 4dB Attenuation Maximum
  - Specifications Should Call for:
    - Openings No More Than 1% of Total and
    - All Joints Tightly Sealed

Special Acoustical Construction Review

- STC Ratings can Guide the Choice of Wall Materials and Construction
  - Remember if Exterior Noise Level is 65dBs, 24CFR51.103(c)(2) Accepts that Interior Noise Level will be 45dB with Typical Construction for the Area
    - CAUTION: STC Ratings Typically Overstate a Wall's Ability to Reduce Transportation Noise by 2-3 Decibels

Special Acoustical Construction* Review

- Generally: Denser, Thicker, or Stiffer are Ways to Improve Sound Insulation in Walls
  - All Dramatically Influence Construction Costs

*Acoustical Construction, Figure 19, page 39

Special Acoustical Construction Review

- There are Many Cost Effective Strategies for Improving Sound Insulation
  - Cavities Improve Wall Performance without Huge Cost Increases
    - A 6” Airspace Provides 5dB Additional Attenuation
  - Increase Spacing Between Studs
    - An Increase from 16” to 24” Yields 2-5dB Additional Attenuation
  - Stagger the Studs
    - Attaching Each Stud to Only One Wall Panel Provides Approximately 4dB Additional Attenuation
  - Use Resilient Materials and Fasteners
    - Fiberboard Sheathing and Resilient Clips can Provide 2-5dB Additional Attenuation

Barrier Calculations

- Workchart 5 is How to Prove a Barrier Works
  - You will Need the Dimensions Listed and Diagrammed at the Top of the Sheet
  - A Sketch Showing the Relationship of the Barrier to the Source and Receiver would be Very Useful
    - Ask the Designer for a “Section View” (or “Profile”) through the Receiver
    - Make sure it is Drawn to Scale
  - Get a Topographic Map (one showing contours) to Evaluate Gaps

Barrier Calculations – Workchart 5

Workchart 5
Noise Barrier
To find R, D and h from Site Elevations and Distances

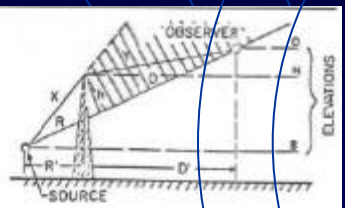
Enter the values for:

H = _____ R = _____

S = _____ D = _____

O = _____

Fill out the following worksheet (all quantities are in feet):



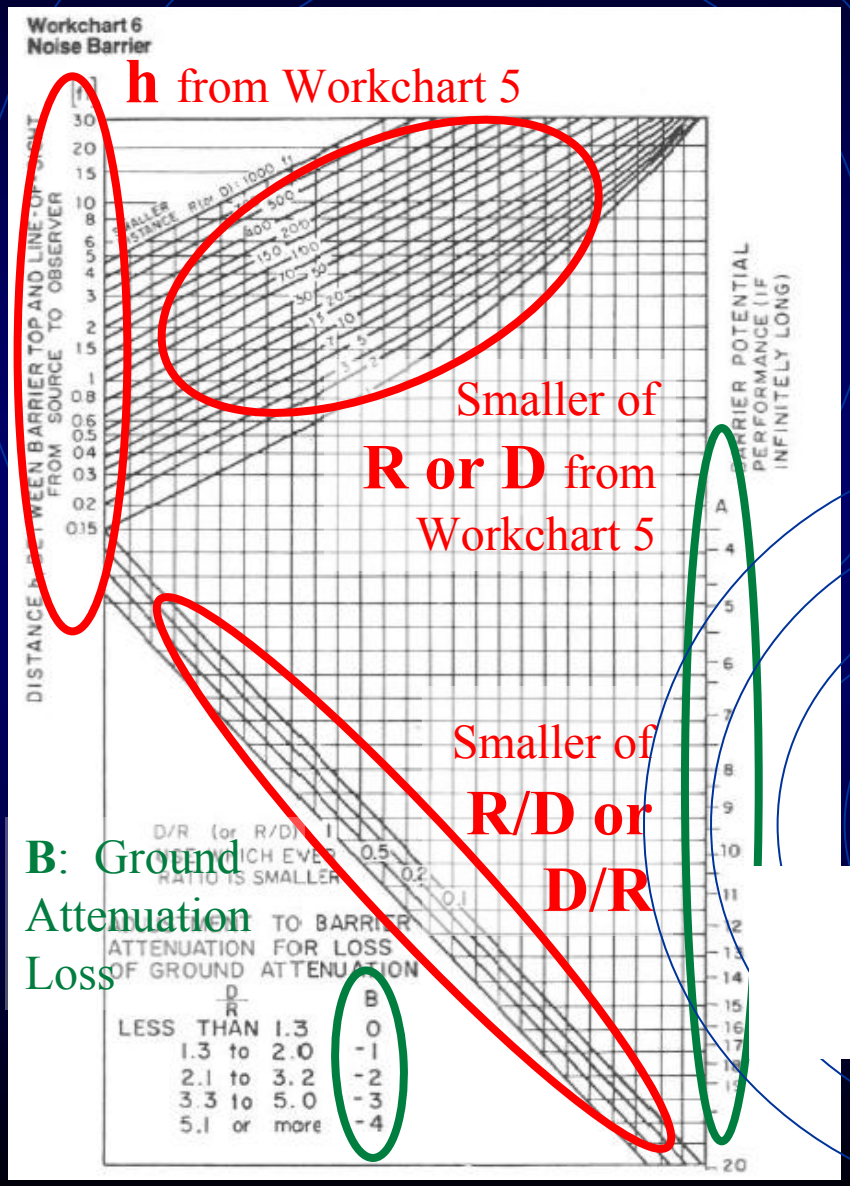
1. Elevation of barrier top minus elevation of source	[H	] − [S	] = [1	]		
2. Elevation of observer minus elevation of source	[O	] − [S	] = [2	]		
3. Map distance between source and observer (R′ + D′)			[3	]		
4. Map distance between barrier and source (R′)			[4	]		
5. Line 2 divided by line 3	[2	] ÷ [3	] = [5	]		
6. Square the quantity on line 5 (i.e., multiply it by itself); always positive	[5	] × [5	] = [6	]		
7. 40% of line 6	[	0.4	] × [5	] = [7	]	
8. One minus line 7	[	1.0	] − [7	] = [8	]	
9. Line 5 times line 4 (will be negative if line 2 is negative)	[5	] × [4	] = [9	]		
10. Line 1 minus line 9	[1	] − [9	] = [10	]		
11. Line 10 times line 8	[10	] × [8	] = [11	]	= h	
12. Line 5 times line 10	[5	] × [10	] = [12	]		
13. Line 4 divided by line 8	[4	] ÷ [8	] = [13	]		
14. Line 13 plus line 12	[13	] + [12	] = [14	]	= R	
15. Line 3 minus line 4	[3	] − [4	] = [15	]		
16. Line 15 divided by line 8	[15	] ÷ [8	] = [16	]		
17. Line 16 minus line 12	[16	] − [12	] = [17	]	= D	

[**Note:** the value on line 2 may be negative, in which case so will the values on lines 5,9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: $x+(-y)=x-y$. And subtracting a negative number is like adding: $x-(-y)=x+y$.

Round off R and D to nearest tenth of a decimal place.

- It's Not as Bad as It Looks
  - The Blanks are Labeled
  - The Operations are Described
- The Goal is Values for h, R, and D

Barrier Calculations



- Workchart 6 Provides an Interim Value that Feeds into the Barrier Performance
- Let's Map it Out First

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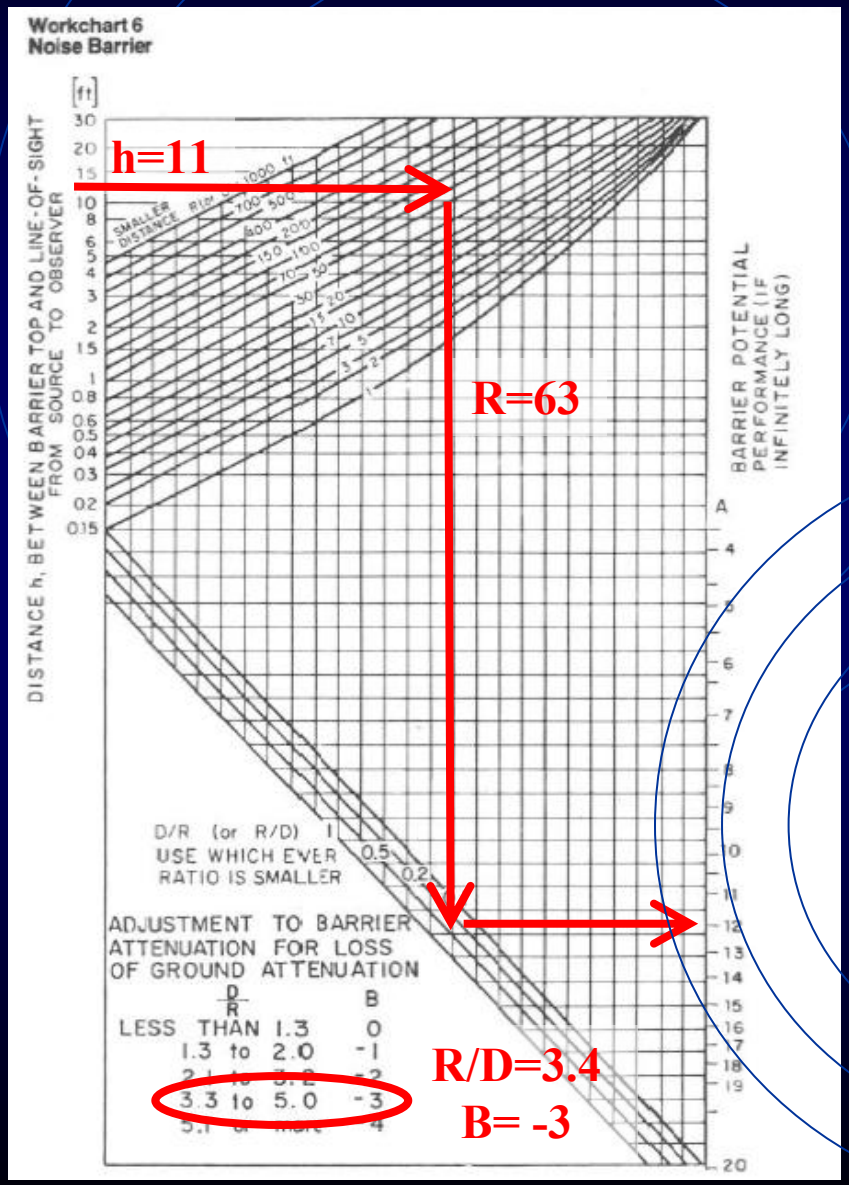
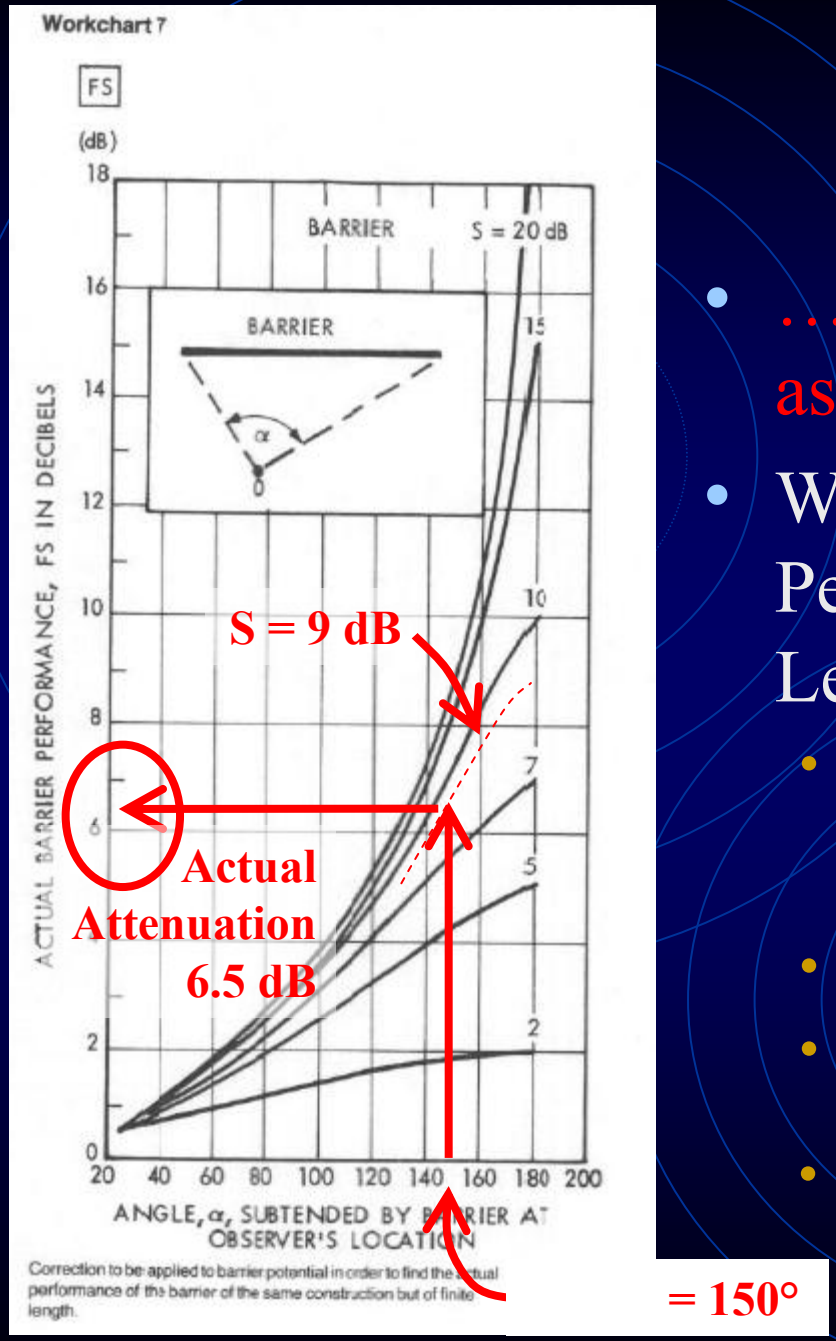
Infinite Barrier Calculations



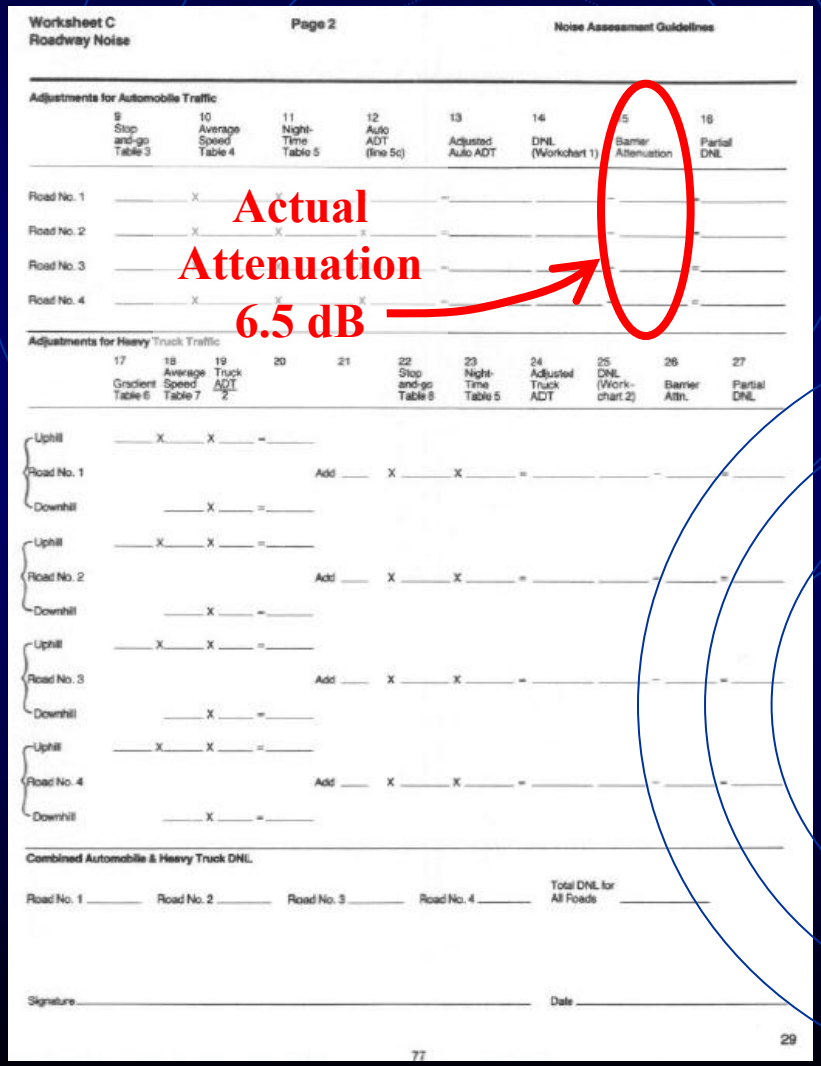
- Begin by Plotting h on the Upper Left Scale
- Draw Horizontally to the Curve that Shows the *Smaller of* R or D
- Draw Vertically to the Line that Shows the *Smaller of* R/D or D/R
- Draw Horizontally to Find an *Infinitely Long* Barrier's Attenuation Value (A)
- D/R Used to Find Loss of Ground Attenuation (B)
- A-B=Barrier Performance (S)

Finite Barrier Calculations



- …But You can only Build a Barrier as Long as the Property Frontage…
- Workchart 7 Adjusts the Performance to Reflect a Finite Length
  - Draw Lines as Shown in the Inset Diagram from the Barrier Ends to the Receiver and Measure the Angle Between Them
  - Enter the Angle on the Horizontal Scale
  - Read Up to the Curve for Infinite Barrier Performance (S)
  - Read Across to Actual Barrier Attenuation for a Finite Length (Our Example is 6.5 dB)

Step 6: Combine and Reassess


Worksheet C
Roadway Noise

Page 2

Noise Assessment Guidelines

Adjustments for Automobile Traffic

	9 Stop and-go Table 3	10 Average Speed Table 4	11 Night-Time Table 5	12 Auto ADT (line 5c)	13 Adjusted Auto ADT	14 DNL (Workchart 1)	15 Barrier Attenuation	16 Partial DNL
Road No. 1								
Road No. 2								
Road No. 3								
Road No. 4								

Actual Attenuation 6.5 dB

Adjustments for Heavy Truck Traffic

	17 Gradient Table 6	18 Average Speed Table 7	19 Truck ADT 2	20	21	22 Stop and-go Table 8	23 Night-Time Table 5	24 Adjusted Truck ADT	25 DNL (Work-chart 2)	26 Barrier Attn.	27 Partial DNL
Uphill Road No. 1											
Downhill Road No. 1											
Uphill Road No. 2											
Downhill Road No. 2											
Uphill Road No. 3											
Downhill Road No. 3											
Uphill Road No. 4											
Downhill Road No. 4											

Combined Automobile & Heavy Truck DNL

Road No. 1 ____ Road No. 2 ____ Road No. 3 ____ Road No. 4 ____ Total DNL for All Roads ____

Signature ____ Date ____

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- Barrier Performance is Recorded on the Worksheets and Combined with Other Noise Levels
- Recalculate for Each Noise Source
- Final Determination Shown on Worksheet A

Summary and Important Points

- Barriers Must Break the Line-of-Sight between the Noise Source and the Receiver
- Noise Traveling Around or Through a Barrier Reduces its Effectiveness
- Detailed Information, Including Maps, Essential (Sketches Helpful)
- Understanding the Design Issues will Save Time and Money

Questions

or

Quiet Reflection