EARTHEN BERM RESEARCH IN OHIO:

MITIGATION EFFECTIVENESS & PROPERTY VALUE COMPARISONS WITH STRUCTURAL WALLS

ADC40 Transportation-Related Noise & Vibration Committee

2017 Summer Meeting, July 23-26, 2017

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Outline

- Introduction
- Project 1 Highlights & Results:
  - Earthen Berm Noise Reduction Analysis Property Valuation
- Project 2 Highlights & Results:
  - Comparison of Noise-Mitigated Residences Highlights & Results
- Wrap-Up & Questions

Introduction

- Kimberly Burton
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  - Associate Professor of Practice at The Ohio State University in City & Regional Planning
    - Transportation, Resiliency & Sustainability
  - President of Burton Planning Services
    - Planning & environmental projects
  - 18 years of experience working in the public and private sectors
  - Numerous traffic noise analyses and research studies throughout her career
    - Started at ODOT as a Noise & Air Quality Specialist
  - Co-published a chapter in the Guide to Planning in Ohio on “Noise-Compatible Land Use Planning”

Introduction

- State DOTs sponsor noise barrier construction programs to mitigate noise impacts.
- Minimal research has been performed to compare earthen mounds & structural noise walls for:
  - Noise mitigation effectiveness
  - Property value effects
- 2 new research projects in Ohio for Ohio DOT & Ohio Department of Commerce (ODC):
  - ODOT: “Earthen Berm Noise Reduction Analysis” October 2016 (FHWA/OH 2016/17).
  - ODC: “Property Valuation Comparison on Noise-Mitigated Residences,” August 2017.

Earthen Berm
Noise Reduction Analysis

Problem Statement

- Earthen berms cost less to construct & maintain than structural concrete and fiberglass noise walls.
- There is a limited information about comparative mitigation effectiveness of earthen berms.
- Determining the difference is essential to guiding future noise mitigation implementation strategies.

Goals & Objectives

1. Compare the acoustic effectiveness of earthen berms to concrete walls.
2. Determine which is more cost effective – for construction, right-of-way, and maintenance costs.

- The results of this study will be used to assist ODOT in establishing the most effective noise abatement policies and procedures.
- Policy changes could result in significant cost savings over time, in addition to a more effective reduction in noise impacts.

Process

- Step 1: Projects Meetings
- Step 2: Monthly Updates
- Step 3: Literature Search
- Step 4: Acoustic Testing & Field Doc
- Step 5: Field Data Analysis
- Step 6: Snapshot Scenarios
- Step 7: Cost-Benefit Analysis
- Step 8: Draft Report & Executive Summary
- Step 9: Final Report & Executive Summary
- Step 10: Fact Sheet & Presentation

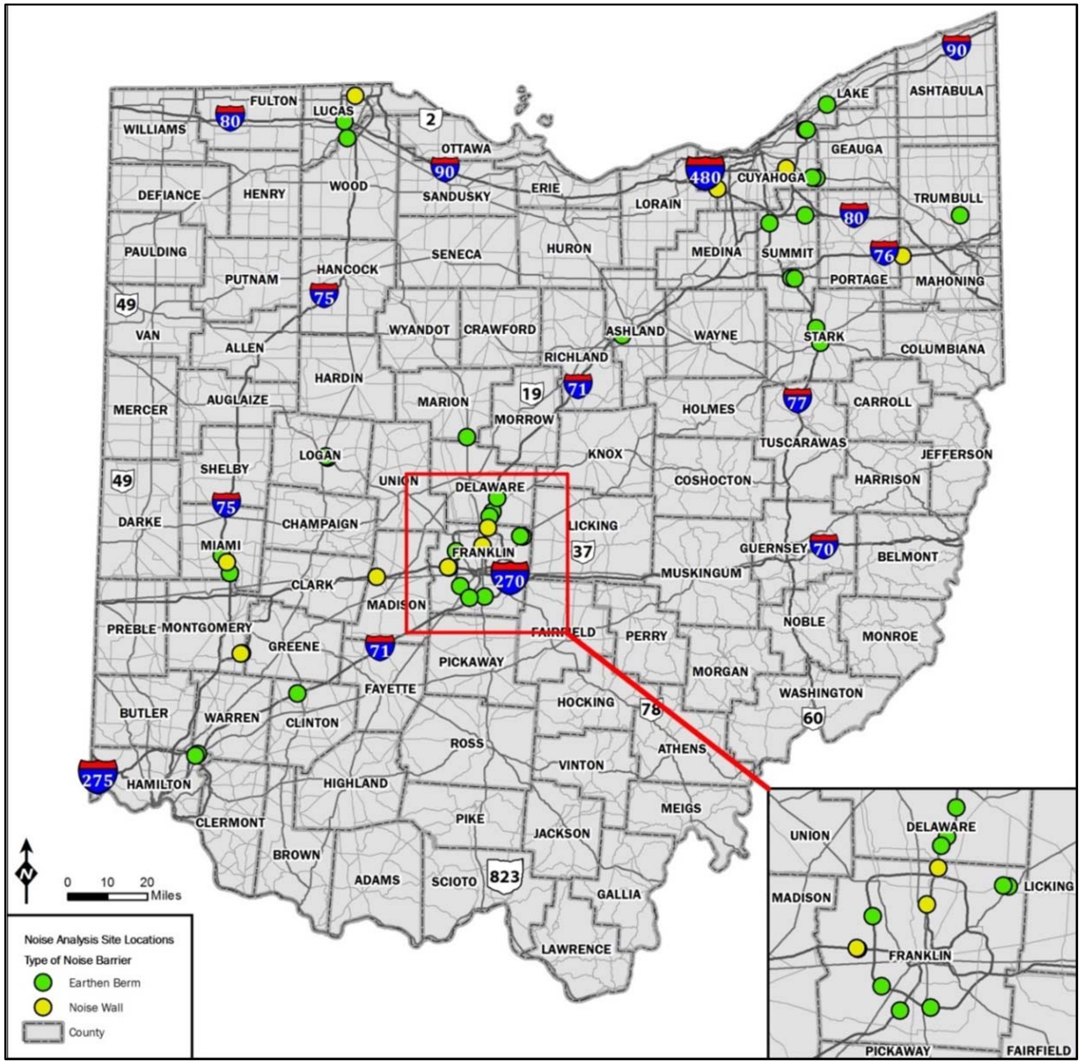
Literature Review Results

- Research on the effectiveness of earthen berms compared to structural walls is scarcely available.
- Sources indicated that earthen berms have some advantages:
  - Providing a natural appearance
  - Providing a more open, less confined feeling
  - Typically not requiring additional safety fences
  - Costing less if materials are readily available and no ROW is needed
  - Costing less to maintain
  - Having an unlimited life span

Study Area Sites

- 45 noise measurement sites
  - 35 earthen berm sites
  - 10 structural wall sites

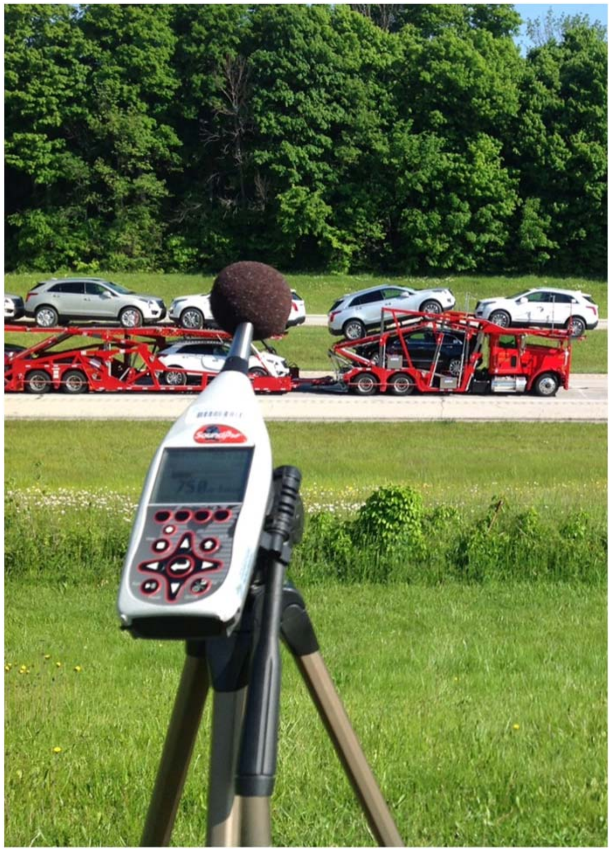
- Readings were taken at 4 locations at each site:
  - A - top of berm or wall
  - B - rear base of berm or wall
  - C - 100 feet behind B
  - D - 100 feet behind C



Analysis Results

Effects on Noise Levels

- Level of effect from different elements varied:
  - Major Effect
    - Traffic Volumes (especially trucks)
    - Distance Offset
    - Traffic Speed
    - Functional Class (related to traffic volumes)
  - Minor Effect
    - Berm Height (strong performance by Small-Height Berms)
    - Temperature
  - No Effect
    - Vegetation, Berm Length, Wind



Analysis Results

Equivalent Height Comparisons

- 2 methods of calculating the equivalent height ratio:
- Method 1 – Field Data
  - For 1.00 foot of berm height, a structural wall would need to be 1.19 feet in height for an equivalent noise reduction.
- Method 2 – Snapshot Scenario Analysis
  - For 1.0 foot of berm height, a structural wall would need to be 1.11 feet in height for an equivalent noise reduction.
- Final Calculation
  - Average of Methods 1 & 2
  - For 1.0 foot of berm height, a structural wall would need to be 1.15 feet in height for an equivalent noise reduction.

Analysis Results

Cost-Benefit Analysis Overview

- C-B analysis included 3 cost types: Construction, ROW & Maintenance
- To calculate these costs, a spreadsheet model was built in 5 parts:
  1. Cost Variables & Calculations – C/R/M costs
  2. Initial Cost Comparisons - C/R costs by land use type
  3. Life Cycle Cost Comparisons - C/R/M costs over time
  4. Equivalent Height Comparisons – wall vs. berm
  5. Noise Barrier Spreadsheet Calculator – wall vs. berm, height+length+time+location

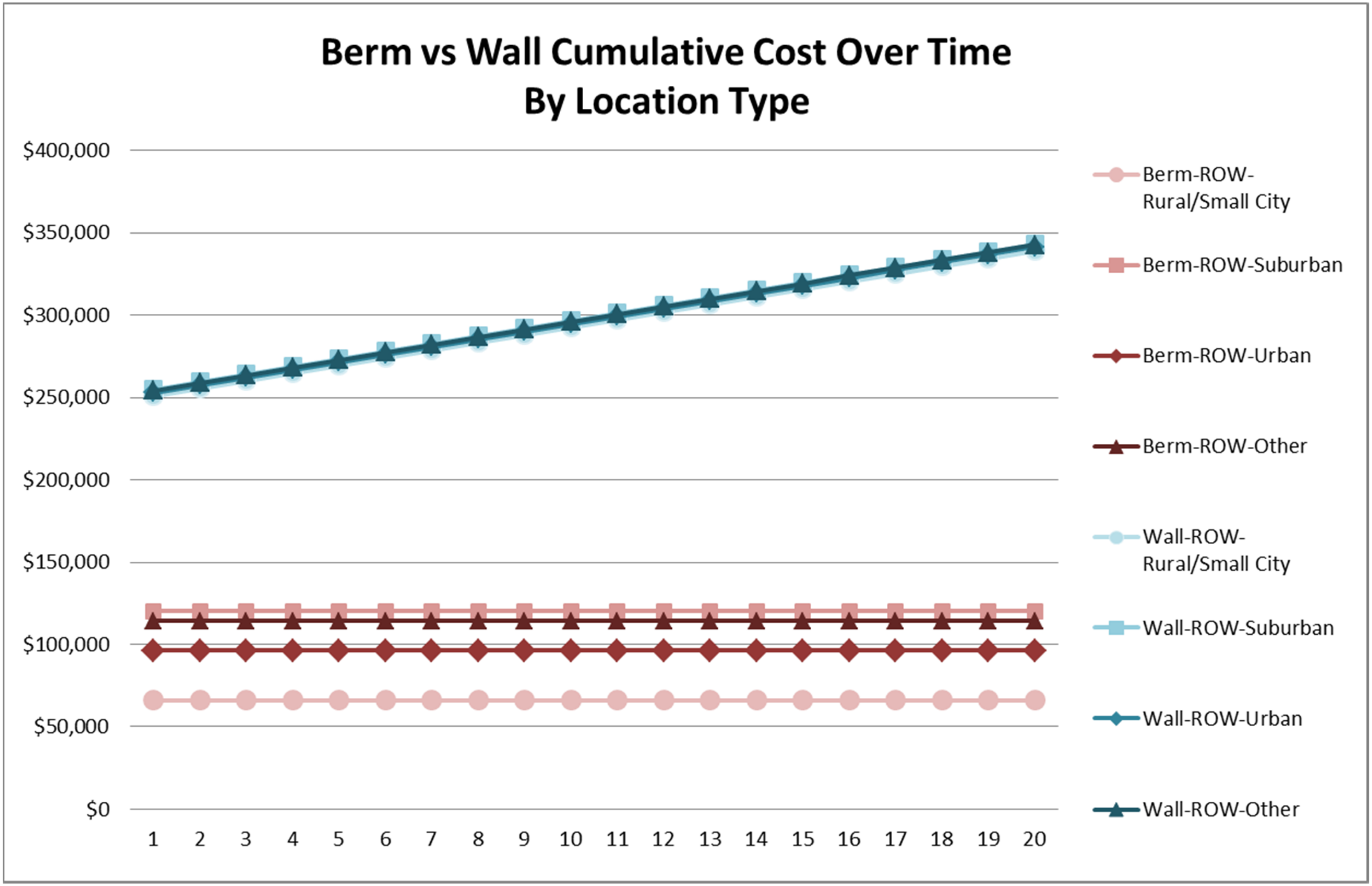
Analysis Results

Life Cycle Cost Comparisons

LIFE CYCLE COST COMPARISONS								
Per unit height/length			*Test Demo - Barrier Ht:*		*10 ft*	*Length:*	*1000 ft*	
	Berm Cost, Cumulative over time				Wall Cost, Cumulative over Time			
Year	Berm-ROW-Rural/Small City	Berm-ROW-Suburban	Berm-ROW-Urban	Berm-ROW-Other	Wall-ROW-Rural/Small City	Wall-ROW-Suburban	Wall-ROW-Urban	Wall-ROW-Other
1	$66,006	$120,093	$96,316	$114,033	$250,784	$254,840	$253,057	$254,386
2	$66,006	$120,093	$96,316	$114,033	$255,426	$259,482	$257,699	$259,028
3	$66,006	$120,093	$96,316	$114,033	$260,068	$264,124	$262,341	$263,670
4	$66,006	$120,093	$96,316	$114,033	$264,710	$268,766	$266,983	$268,312
5	$66,006	$120,093	$96,316	$114,033	$269,352	$273,408	$271,625	$272,954
6	$66,006	$120,093	$96,316	$114,033	$273,994	$278,050	$276,267	$277,596
7	$66,006	$120,093	$96,316	$114,033	$278,636	$282,692	$280,909	$282,238
8	$66,006	$120,093	$96,316	$114,033	$283,278	$287,334	$285,551	$286,880
9	$66,006	$120,093	$96,316	$114,033	$287,920	$291,976	$290,193	$291,522
10	**$66,006**	**$120,093**	**$96,316**	**$114,033**	**$292,562**	**$296,618**	**$294,835**	**$296,164**
11	$66,006	$120,093	$96,316	$114,033	$297,204	$301,260	$299,477	$300,806
12	$66,006	$120,093	$96,316	$114,033	$301,846	$305,902	$304,119	$305,448
13	$66,006	$120,093	$96,316	$114,033	$306,488	$310,544	$308,761	$310,090
14	$66,006	$120,093	$96,316	$114,033	$311,130	$315,186	$313,403	$314,732
15	$66,006	$120,093	$96,316	$114,033	$315,772	$319,828	$318,045	$319,374
16	$66,006	$120,093	$96,316	$114,033	$320,414	$324,470	$322,687	$324,016
17	$66,006	$120,093	$96,316	$114,033	$325,056	$329,112	$327,329	$328,658
18	$66,006	$120,093	$96,316	$114,033	$329,698	$333,754	$331,971	$333,300
19	$66,006	$120,093	$96,316	$114,033	$334,340	$338,396	$336,613	$337,942
20	**$66,006**	**$120,093**	**$96,316**	**$114,033**	**$338,982**	**$343,038**	**$341,255**	**$342,584**

- Construction, maintenance & ROW costs
- Rural/Small City, Suburban & Urban Locations
- 20-year projections
- Default: 10-foot high barrier, 1,000 feet long

- Year 1: wall costs 2 - 4 times more the berm
- Year 20: wall costs 3 - 5 times more than the berm


Berm vs Wall Cumulative Cost Over Time
By Location Type
$400,000
$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Berm-ROW-Rural/Small City
Berm-ROW-Suburban
Berm-ROW-Urban
Berm-ROW-Other
Wall-ROW-Rural/Small City
Wall-ROW-Suburban
Wall-ROW-Urban
Wall-ROW-Other

Analysis Results

Noise Barrier Spreadsheet Calculator

- 3 interactive tables for quick estimation of berm & wall life cycle costs.
- Calculates costs, equivalent effective heights, and equivalent costs.
- Developed for easy updates over time to remain useful into the future.

NOISE BARRIER SPREADSHEET CALCULATOR

Includes initial and ongoing costs

Look-Up Table 1: Berm/Wall Cost Comparison, Same Height/Length/Years

	Enter Berm or Wall Info				
	Height (ft)	Length (ft)	Years	Berm Total Cost	Wall Total Cost
ROW-Rural/Small City				$0	$0
ROW-Suburban				$0	$0
ROW-Urban				$0	$0
ROW-Other				$0	$0

Look-Up Table 2: Berm to Wall Conversion Cost Comparison, Equivalent Height for Same Mitigation Results

	Enter Berm Info					
	Height (ft)	Length (ft)	Years	Equivalent Wall Height	Berm Total Cost	Wall Equivalent Height Total Cost
ROW-Rural/Small City				0.00	$0	$0
ROW-Suburban				0.00	$0	$0
ROW-Urban				0.00	$0	$0
ROW-Other				0.00	$0	$0

Look-Up Table 3: Wall to Berm Conversion Cost Comparison, Equivalent Height for Same Mitigation Results

	Enter Wall Info					
	Height (ft)	Length (ft)	Years	Equivalent Berm Height	Berm Equivalent Height Total Cost	Wall Total Cost
ROW-Rural/Small City				0.00	$0	$0
ROW-Suburban				0.00	$0	$0
ROW-Urban				0.00	$0	$0
ROW-Other				0.00	$0	$0

Noise Barrier Spreadsheet Calculator

- Table 1: Berm/Wall Cost Comparison
- Table 2: Berm to Wall - Height & Cost Conversion
- Table 3: Wall to Berm - Height & Cost Conversion

Analysis Results

Noise Barrier Spreadsheet Calculator

- Example:
- Rural Berm/Wall
- 10-Year Cost Estimates

NOISE BARRIER SPREADSHEET CALCULATOR

Includes initial and ongoing costs

Look-Up Table 1: Berm/Wall Cost Comparison, Same Height/Length/Years

	Enter Berm or Wall Info				
	Height (ft)	Length (ft)	Years	Berm Total Cost	Wall Total Cost
ROW-Rural/Small City				$0	$0
ROW-Suburban				$0	$0
ROW-Urban				$0	$0
ROW-Other				$0	$0

Analysis Results

Noise Barrier Spreadsheet Calculator

- Example:
- Rural Berm/Wall
- 10-Year Cost Estimates

NOISE BARRIER SPREADSHEET CALCULATOR					
Includes initial and ongoing costs					
Look-Up Table 1: Berm/Wall Cost Comparison, Same Height/Length/Years					
	Enter Berm or Wall Info				
	Height (ft)	Length (ft)	Years	Berm Total Cost	Wall Total Cost
ROW-Rural/Small City	10	1,000	10	$66,006	$292,562
ROW-Suburban				$0	$0
ROW-Urban				$0	$0
ROW-Other				$0	$0

Analysis Results

Noise Barrier Spreadsheet Calculator

- Example:
- Rural Berm/Wall
- **20**-Year Cost Estimates

NOISE BARRIER SPREADSHEET CALCULATOR					
Includes initial and ongoing costs					
Look-Up Table 1: Berm/Wall Cost Comparison, Same Height/Length/Years					
	Enter Berm or Wall Info				
	Height (ft)	Length (ft)	Years	Berm Total Cost	Wall Total Cost
ROW-Rural/Small City	10	1,000	20	$66,006	$338,982
ROW-Suburban				$0	$0
ROW-Urban				$0	$0
ROW-Other				$0	$0

Analysis Results

Noise Barrier Spreadsheet Calculator

- Example:
- Rural **& Suburban** Berm/Wall
- 20-Year Cost Estimates

NOISE BARRIER SPREADSHEET CALCULATOR					
Includes initial and ongoing costs					
Look-Up Table 1: Berm/Wall Cost Comparison, Same Height/Length/Years					
	Enter Berm or Wall Info				
	Height (ft)	Length (ft)	Years	Berm Total Cost	Wall Total Cost
ROW-Rural/Small City	10	1,000	20	$66,006	$338,982
ROW-Suburban	10	1,000	20	$120,093	$343,038
ROW-Urban				$0	$0
ROW-Other				$0	$0

Analysis Results

Qualitative Evaluation

- Earthen Berm Positive Factors:
  - Aesthetics/visual effects
  - Environmental effects
  - Reduced construction impacts
- Earthen Berm Challenges:
  - **Ground space**
  - Conflicts with utilities & lighting
  - Drainage effects
  - “Ecological” issues
  - Clear zone impedance
  - Vegetation selection & mowing

Conclusions

- Earthen berms are more **cost effective** and more **effective at noise reduction** than structural noise walls.
- Small-height earthen berms (5'-6') were found to be very effective at reducing noise on both low & high-volume roadways.
- ODOT should consider prioritizing earthen mounds over structural walls for new barrier construction & old barrier replacement but opportunities will be very limited.
- Successful implementation should result in a significant annual costs savings - for construction and maintenance, compounding over time.
- Qualitative benefits should be emphasized too - better quality of life for residents, motorists, and wildlife.

Property Valuation Comparison on Noise-Mitigated Residences

Problem Statement

- Structural noise walls are more costly to construct and maintain than earthen mounds, but earthen mounds require more space (land).
- The objective is to determine if property values are higher for residences located behind earthen berms or behind structural noise barriers – or if there is no measurable difference.
- Results could help state DOTs and communities prioritize the type of noise mitigation that is better for property values.

Hypotheses

1. Property values should be higher for noise-mitigated residences than non-mitigated residences.
   - Why? - Due to the benefit of reducing noise levels.

2. Property values should be slightly higher for residences behind earthen mounds than for residences behind structural walls.
   - Why? - Due to the higher aesthetic value of the natural landscaped elements of earthen berms over structural walls.

Process

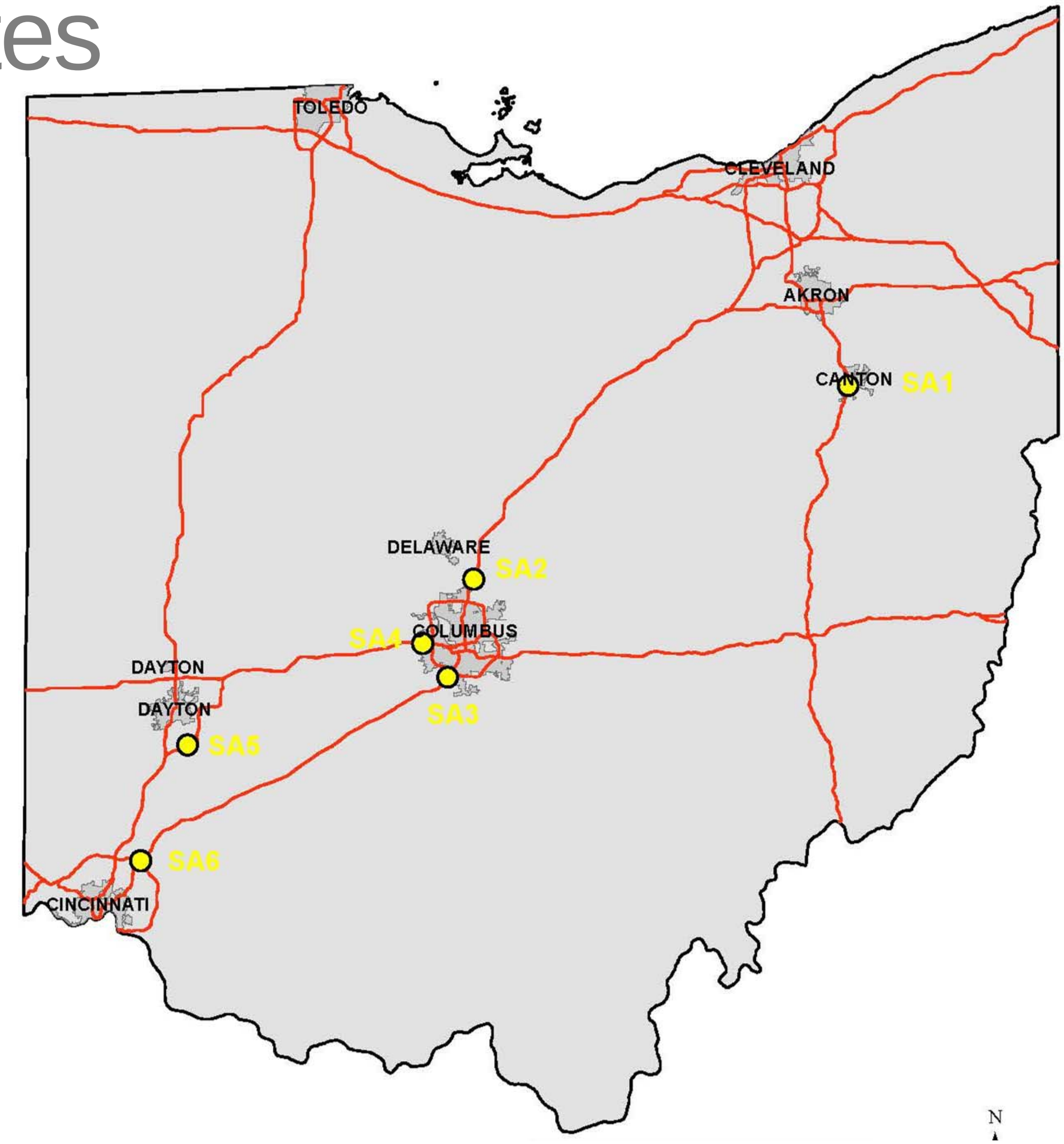
- Step 1: Project Kickoff, Identify Stakeholders
- Step 2: Data Collection, Literature Search
- Step 3: Model Variables & Structure
- Step 4: Stakeholder Meeting #1
- Step 5: Populate Spreadsheet Model & Run Model
- Step 6: Analyze Model Results
- Step 7: Stakeholder Meeting #2
- Step 8: Prepare Report
- Step 9: ODC & Community Meetings/Presentations
- Step 10: Finalize Report

Literature Review Results

- The literature review identified previous research related to traffic noise impacts on property values:
  - Traffic noise has typically had negative impacts to single-family homes property values.
  - Hedonic pricing method is the common method used to conduct property value analyses.
  - Previous research has focused on the effect of different noise levels and locations on property values.
  - No studies were identified that compared the effect of different mitigation techniques on property values.

Study Area Sites

- 1 – Canton/I-77
- 2 – Orange Twp/I-71
- 3 – Grove City/I-71
- 4 – Hilliard/I-70
- 5 – Centerville/I-675
- 6 – Cincinnati/I-71



Selected Variables

- Dependent Variables
  - Building Value + Land Value = Total Value ($)
- Physical Variables
  - Lot Size (Acres)
  - Building Size (Sq Ft)
  - Total Rooms, Bedrooms (#s)
  - Half Baths/2 + Full Baths = Total Baths (#)
  - Building Stories (#)
  - Basement, Garage (Presence/Absence = 1/0)
  - Current Year (2016) - Year Built = Age of Home (Years)
- Location Variables
  - School District (Rating)
  - Neighborhood Median Income, Percent Vacant, Unemployment Rate, Percent Minority ($, %)
- Environmental Variables
  - Constructed Noise Wall (Presence/Absence = 1/0)
  - Noise Berm (Presence/Absence = 1/0)

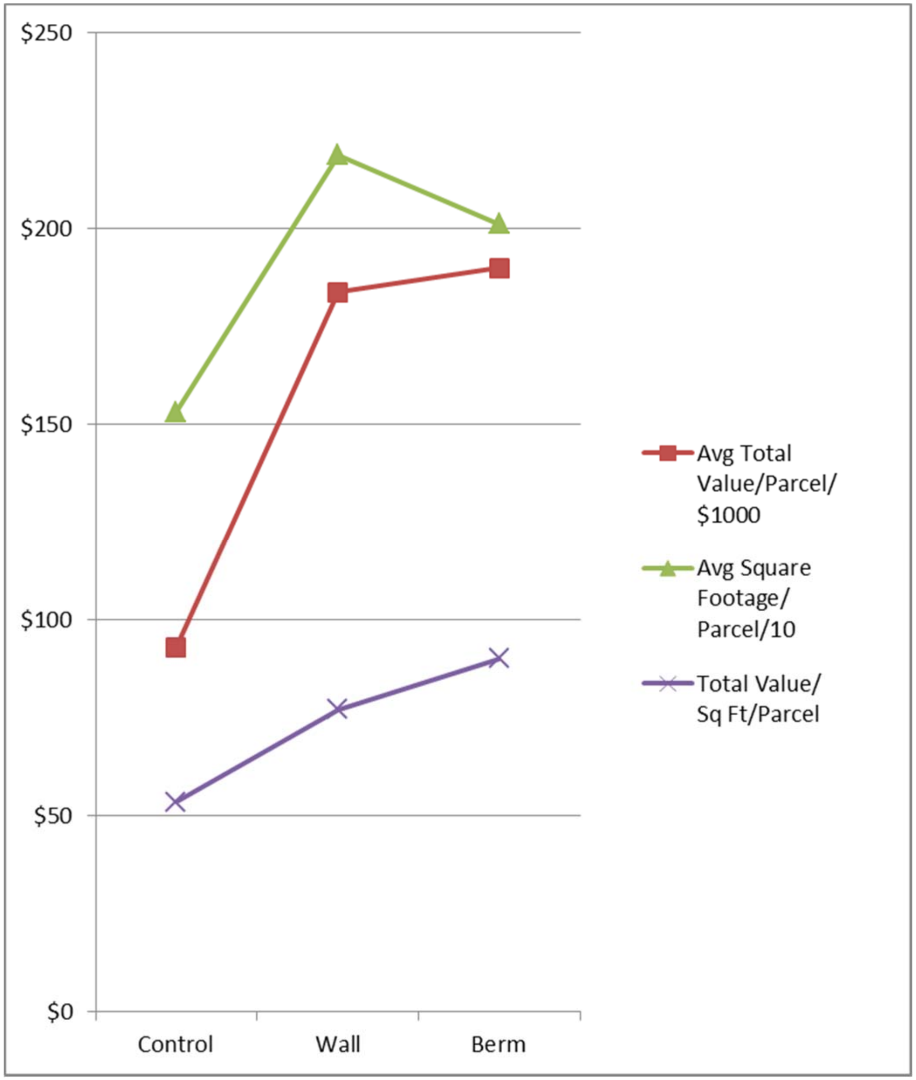
Analysis Results

1. Hedonic pricing method (multiple regression model) – **using all variables**
    - Neither hypothesis was true.
    - ✗ (1) Noise mitigation had a negative effect on property values.
    - ✗ (2) Property values were lower at earthen berms than noise walls.
  - Why? - selected neighborhoods were not “good” comparisons:
    - Appropriate sites were limited in availability - control, wall and berm sites in same school district on same road.
    - Most significant variables (age, size, school district rating) had largest standard deviations.
2. Hedonic pricing method – **only square footage & noise mitigation variables**
    - Both hypotheses were true.
    - ✓ Property values were higher for noise-mitigated residences than non-mitigated.
    - ✓ Property values were higher for residences behind earthen mounds than for structural walls.

Analysis Results

3. Additional simple analysis – compared average total value per square foot.
   - Both hypotheses were true with this method.
   - Results were still slightly skewed – walls/berms had higher & uneven slopes but all lines still showed upward slope.

	Control	Wall	Berm
Total Parcels	153	562	516
Avg Total Value/Parcel	$93,071	$183,647	$189,859
Avg Sq Ft/Parcel	1,531	2,186	2,011
Total Value/ Sq Ft/Parcel	$53.39	$77.18	$90.06



Conclusions

1. Common sense indicates that both hypotheses should be true.
2. The hedonic method models indicate that both hypotheses could be true – or not true.
3. The more variables that are included in the model and the more unique the neighborhood sites are from each other:
   - The less significant noise mitigation becomes.
   - The more skewed the noise mitigation effects become (from the hypotheses).
4. Additional variables that were not included in the model could also have significant influence, such as:
   - Quality of housing construction (newer homes), condition of housing (older homes), density, proximity to urban areas/jobs/amenities, noise levels, utilities, etc.

Wrap-Up

Wrap-Up

- These studies are aimed at providing accurate information on noise mitigation options to federal and state agencies and local municipalities.
- The results of these studies could result in priority and policy changes at the state level to save money and increase noise mitigation effectiveness
- In addition, communities could change their zoning codes at the local level in order to help improve residents' quality of life and property values.

Wrap-Up

Further Study Ideas

1. Perform TNM modeling for direct mitigation comparison of berm/wall.
2. Determine barrier type preferences from public opinion surveys.
3. Coordinate similar studies in other states.
4. Add additional detail to the barrier cost variables - structural materials, materials transportation, etc.

Wrap-Up

Further Study Ideas

5. Refine the property values used in ROW calculations.
6. Add present value factors to cost calculations,
7. Further acoustically assess small-height earthen berms via fieldwork and modeling (ODOT priority).
8. Add/substitute variables in the property value model:
   - Quality of housing construction (newer homes), condition of housing (older homes), density, proximity to urban areas/jobs/amenities, noise levels, utilities, etc.

QUESTIONS?

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