Traffic Noise Field Measurements & Model Validation

Speakers: Ray Umscheid & Meredith Worthen (TxDOT)

This session will cover requirements and best practices for traffic noise field measurements and validation of existing condition noise models.

As time permits, we will also discuss other hot topics for noise, such as future noise policy updates, TNM, and noise barrier constructability assessments.
Traffic Noise Field Measurements and Existing Model Validation

2021 Environmental Conference
Introduction

Determine Need for a Traffic Noise Analysis (Type I project)

Collect Data

Measure/Model Noise Levels

Existing Levels (Field Measurement, Model, Model Validation)

Predicted Levels (Model)

Determine Impact

Absolute impact

Predicted levels approach, equal, or exceed the NAC

OR

Predicted levels exceed existing by more than 10 dB(A)

Relative impact

Consider/Evaluate Abatement Measures

Traffic Noise Workshop(s)

Video of sound level meter taking noise measurement during vehicle pass-bys
Traffic Noise Field Measurements

Introduction and Requirements
Traffic Noise Field Measurements

- Existing noise levels **must** be collected on new location roadways.
- The Traffic Noise Model cannot determine noise levels without a roadway!
- These measurements will be used to determine whether there are project noise impacts.
Equipment needed for noise measurements

- **Integrating** Sound Level Meter
- ANSI Type I or II
- dB(A) $L_{eq}$

![Sound level meter](image)

![Calibrator](image)

![Tripod](image)

![Windscreen](image)

Equipment needed for noise measurements includes:

- **Integrating** Sound Level Meter
- ANSI Type I or II
- dB(A) $L_{eq}$
Other Equipment that may be needed for noise measurements

- For weather and location information:
  - anemometer (wind speed & direction)
  - thermometer
  - GPS unit
Field Procedures – Choosing locations

- Choose potential measurement locations associate with human activity at noise sensitive locations.

- **Tip:** Avoid choosing locations with permanent, localized, noise sources (pump houses, generators, HVAC or ventilation fans) that do not represent the general noise environment for project area.

- **Tip:** Consider difficulty in access to the site while choosing locations.
  - Obtain Right-of-entry if going on private property.
Field Procedures – When to Go?

- During peak hour traffic or when the highest noise levels are expected.
  - MAY NOT BE PEAK HOUR
- Day of the week (weekend vs. work day)
- Week of the year (tourist season vs. non-tourist season)
- When the roadway pavement is dry
- When the wind speed is less than 15 mph
Field Procedures – Before you go...

- Check weather forecast
- Construction or unusual traffic patterns
- Equipment and data sheets
- Pre-field checklist
- Safety is important
Field Measurement.. Before you go

- If you take summertime afternoon measurements, might encounter this:

- What to do?
  - Relocate site away from trees and brush
  - Come back in the morning (males usually call in afternoon and evening)

*Annual Cicada, Neotibicen sp.*

(sound file of a calling cicada)
Field Procedures – Set up

- Make sure that site is still appropriate “in person”

- Calibrate sound level meter (SLM) – beginning and end of day

- Attach windscreen over microphone

- Set up noise meter on tripod at a 70 degree angle to the roadway

- Measurements must be made with meter set using dB(A) LEQ
Field Procedures – Details

- Length of time for measurement
  - Minimum 15 minutes

- Take enough 15 minute measurements to see an increase in sound level and then a decrease

- Discontinue a measurement or find an alternate site?
  - Excessive or unusual noises not associated with traffic
  - Barking dogs
  - Horns or sirens
  - Rumble strips
  - Traffic is no longer free-flowing

- Wear PPE
- Safe distance from roadway
Field notes are important to

- Describe the site and the context of the measurements
- The Noise Levels
- The weather
- Capture all unusual sounds or traffic activity
Documentation and Ultimate Usage for Impact determination

- Existing level is disclosed in traffic noise studies
- Often the predicted level will be greater than 10 decibels difference; a relative impact
- An impact, triggers abatement analysis.

wall?
# Field Measurement For Existing Impact Wrap Up

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To determine existing noise levels for a project to be used for impact determination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>At representative receiver or an equivalent location</td>
</tr>
<tr>
<td>Traffic conditions</td>
<td>Peak or worst traffic hour</td>
</tr>
<tr>
<td></td>
<td>Free-flowing</td>
</tr>
<tr>
<td>Weather</td>
<td>Dry &amp; wind speed &lt; 15 mph</td>
</tr>
<tr>
<td>Required Data Collection</td>
<td>Noise measurement</td>
</tr>
<tr>
<td></td>
<td>Field conditions</td>
</tr>
<tr>
<td></td>
<td>Photos</td>
</tr>
<tr>
<td>Other considerations</td>
<td>Right of entry may be an issue, so measurements at existing roadway ROW is acceptable</td>
</tr>
</tbody>
</table>
Traffic Noise Existing Model Validation

Requirements and Best Practices
The validation measurements and procedures ensure that TNM modeling reasonably replicates actual field conditions.

What does validation tell you?
- Verifies model can reasonably predict real noise levels for the project
- Model structure is “good” – lane placement and terrain
- Confidence in your model(s), including future condition

What does validation NOT tell you?
- That the existing condition model for impact determination is “correct”
- That existing or future traffic is data is good
What makes a good site for validation?

- Choose locations within major noise-sensitive areas (NSA), common noise environments (CNE), or neighborhoods

- **Tip:** Avoid choosing locations with any permanent, localized, noise sources (pump houses, generators, HVAC or ventilation fans) that would interfere with measurement of the roadway noise source.
  - Obtain Right-of-entry if going on private property

- The number of validation sites and locations are project-specific and must be coordinated with the District or ENV Noise SME before field work
  - An email describing your project/sites + a KMZ showing project limits and potential sites (primary and backup) is sufficient.
  - A view of ALL lanes
Field Procedures – Before you go...

- Pre-field checklist found in FHWA’s Noise Measurement Field Guide
- Take measurements when traffic is free flowing.
- Same equipment as field measurement but with some additions
  - Video cameras for car counting and Speed estimation
**Validation Field Procedures**

- Length of time for measurement
  - Minimum 15 minutes

- Meter set up is the same as for Existing Field Measurements

- Must collect traffic counts
  - Simultaneous traffic counts during 15-minute measurement period
  - Count all roadways within line-of-sight, both directions
  - Differentiate between cars, medium trucks, and heavy trucks
Counting Traffic

- **Vehicle Classification**
  - Auto – all vehicles with two axles and four tires (passenger cars, vans, light trucks)
  - Medium Truck – all vehicles with two axles and six tires
  - Heavy Truck – all vehicles with three or more axles

- Buses and motorcycles may also be counted separately

- **For traffic counts:**
  - Field sheets, mechanical counters, or data logger
  - Video camera for high volume roadways
  - Hand count for low volume roadways
  - Line-of-sight to all lanes or coordinate with second spotter

- **For traffic speeds:**
  - Radar gun or Fixed-object estimation
Validation FAQs

- If traffic is flowing and wind and weather is normal with no external sounds, only one measurement/count per location is necessary. However, it is recommended to repeat to ensure that good data was retrieved as a back up.

- When should I discontinue a measurement or find an alternate site?
  - Excessive or unusual noises not associated with traffic
  - Barking dogs
  - Horns or sirens
  - Rumble strips
  - Traffic is no longer free-flowing
  - CICADAS
Post-Field Activities

- Validation Modeling
  - Validation measurement location as a receiver
  - Traffic inputs
  - Traffic speed

- Convert traffic counts to model inputs
  - Multiply 15-minute counts by four to get hourly traffic for model:

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>15-minute count</th>
<th>Hourly traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>162</td>
<td>648</td>
</tr>
<tr>
<td>Medium Truck</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Heavy Truck</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

![Image of traffic count conversion tool]
Existing Model Validation

Select Validation Site(s)

Coordinate with District Noise Specialist or ENV Subject Matter Expert

Minimum 15-minute measurement period

Collect Field Measurements

Sound Level Measurement dB(A) Leq(h)

Traffic Information
- Count number and types of vehicles
- Determine speed

Collect sound level measurements and traffic info simultaneously

Input Field-collected Traffic Data to Existing Condition Validation Model

Field-measured Sound Level

Model-calculated Sound Level

Is difference within (+/-) 3 dB(A)?

NO
Take additional measurements, adjust model, and/or document why not validated

YES
Existing model is Validated

Use to predict existing noise (with TPP traffic) and update with future design and traffic to predict future noise
Validation Study

- **For the whole project**
- Real traffic counts taken as measurements were taken
- Input into model
- If within +/- 3 dB, then model is considered validated

### Table 1: Validation Noise Model Validation

<table>
<thead>
<tr>
<th>Representative Receiver</th>
<th>Field Measured Level dBA (Leq)</th>
<th>Modeled Level dBA (Leq)</th>
<th>Difference (+/-)</th>
<th>Validated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Validation Site 1 - West of the intersection of US 290 and SH 71</td>
<td>68.4</td>
<td>67.2</td>
<td>-1.2</td>
<td>Yes</td>
</tr>
<tr>
<td>Validation Site 2 - East of the intersection of US 290 and S View Road</td>
<td>72</td>
<td>73</td>
<td>+1</td>
<td>Yes</td>
</tr>
<tr>
<td>Validation Site 3 - East of the intersection of US 290 and Old Fredericksburg Road</td>
<td>71.4</td>
<td>68.8</td>
<td>-2.6</td>
<td>Yes</td>
</tr>
<tr>
<td>Validation Site 4 - Southeast of the intersection of SH 71 and Silvermine Drive</td>
<td>68.6</td>
<td>69.4</td>
<td>+0.8</td>
<td>Yes</td>
</tr>
</tbody>
</table>
What if it doesn’t validate?

- **Options**
  - Check lane coordinates and geometry
  - Do lanes overlap in the model?
  - Include shoulders, medians, ground zones
  - Did you observe non-traffic noise generators?

- “Calibration” is discouraged

- **Pavement**
  - Are allowed to change model pavement type in a validation model
  - However, still use “average” for noise impact determination models

- Re-take measurements?

- Consult with ENV

>3 dB!!!
Documentation

- Include copies of field data sheets (including traffic counts) with the noise analysis report submittal.

- Maps and photos are also appreciated!

- Documentation for Validation
  - Validation Study template: see Standard Language (Example B)
    - Attach to noise analysis report
  - Noise Analysis Report templates have suggested validation language
  - Include validation model(s) with TNM submittal
### Field Measurement Considerations for Validation Wrap Up

<table>
<thead>
<tr>
<th>Consideration</th>
<th>Measurement for Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose</strong></td>
<td>Determine whether the existing Traffic Noise Model (TNM) is reasonably accurate.</td>
</tr>
</tbody>
</table>
| **Locations**                          | Any location adjacent to roadway, but prefer  
  • At/near noise sensitive areas  
  • Near representative typical sections |
| **Traffic conditions**                 | Any time  
  Free-flowing traffic |
| **Weather**                            | Dry & wind speed < 15 mph |
| **Required Data Collection**           | Noise measurement  
  Simultaneous traffic counts  
  Average traffic speed(s)  
  Field conditions  
  Photos |
| **Other considerations**               | Line-of-sight to all existing travel lanes is important for traffic counts |
Comparison of Field Noise Measurements vs Validation

- Part of the Traffic Noise Analysis Process

  - Field noise measurements
  - Validation of existing condition model

**Flowchart: (Type I project)**

1. Determine Need for a Traffic Noise Analysis
2. Collect Data
3. Measure/Model Noise Levels

   - Existing Levels (Field Measurement, Model, Model Validation)
   - Predicted Levels (Model)

4. Determine Impact

   - IF Predicted levels exceed existing by more than 10 dB(A)
   - OR Predicted levels approach, equal, or exceed the NAC

5. Consider/Evaluate Abatement Measures

6. Traffic Noise Workshop(s)
Noise Field Measurement Applications

Basic Field Measurement Practices

Existing Noise Levels
- New location projects
- Noise studies

Model Validation
- Existing models

Measurement directly used in the noise analysis

Measurement supports the noise analysis process
Hot Topics for Traffic Noise

2021 Environmental Conference
<table>
<thead>
<tr>
<th></th>
<th>Table of contents – Hot Topics for Traffic Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Updates to 23 CFR 772 and TNM</td>
</tr>
<tr>
<td>2</td>
<td>Noise Wall Removal Policy</td>
</tr>
<tr>
<td>3</td>
<td>Constructability Assessment for Proposed Noise Barriers</td>
</tr>
<tr>
<td>4</td>
<td>Reminders – Noise Activities in ECOS and the Traffic Noise Toolkit</td>
</tr>
<tr>
<td>5</td>
<td>FYI - NHI Online Traffic Noise Courses</td>
</tr>
</tbody>
</table>
Updates to 23 CFR 772 and TNM?

- FHWA Notice of Proposed Rulemaking (NPRM) for changes to 23 CFR 772
  - NPRM package was ready at beginning of 2021
  - But new administration, so back in review at FHWA

- TNM 3.0 was released by FHWA in February 2020
  - TNM 3.1 release could happen in next couple of months?

- For now, continue to use **TNM 2.5** for all traffic noise analysis work!
  - ENV will send out an update when this changes

**STAY TUNED !!!**
Noise Wall Removal Policy

- Effective September 13, 2021 – see policy document in noise toolkit
  - Applies to noise walls already built or under construction
- Requirements:
  - Written request for removal sent to TxDOT district engineer
  - Agreement from 100% of CURRENT adjacent property owners
- TxDOT will not pay for removal
- Requestor must reimburse original wall construction costs (adjusted for inflation), unless TxDOT chooses to waive
- If there’s a future Type I project with impacts, TxDOT could propose a new wall
Constructability Assessment

- What is a constructability assessment?
  - Confirmation that proposed noise abatement is feasible (constructable)

- “Statement of Likelihood” in environmental documentation:
  “Any subsequent project design changes may require a reevaluation of this preliminary noise barrier proposal. The final decision to construct the proposed noise barrier will not be made until completion of the project design, utility evaluation, and polling of all benefited and adjacent property owners and residents.”

- Noise analysis may be based on schematic-level design
  - SUE and detailed survey may not happen until PS&E
  - other site constraints
Constructability Assessment

- **When** to do a constructability assessment?
  - Before environmental clearance
    - IF have design information, can be documented in the noise report
  - After environmental clearance but **BEFORE** the noise workshop
    - Detailed design information (PS&E)
    - Utility information
    - Confirm location, layout, and barrier height

- **Why** is a constructability analysis important?
  - Avoid an “oops” moment if workshop held too early
    - Don’t want folks to vote on a wall and then find out later that it’s not feasible or needs to be changed
  - Preliminary barrier design information = better noise workshop
    - Help property owners and residents make an informed decision
Constructability Assessment

- Confirm that proposed noise barrier location and layout is \textbf{FEASIBLE}
  - Sight lines? Access or maintenance issues?
  - Utility conflicts? Construction concerns?
  - Terrain and drainage okay?
- Have designers identify potential issues and explore options...
Constructability Assessment

- What if we need to change the barrier location or layout?
  - May need to update and re-run the noise modeling
    - Confirm noise barrier height and that it’s still feasible and reasonable

- What if a barrier might be “too expensive” due to site constraints?
  - Too expensive = more than 2x the standard barrier cost
  - Alternate Barrier Cost Assessment spreadsheet in toolkit
    - Factor in the “extra costs” – utility relocates, crash base, new ROW, etc

- Constructability Assessment Outcomes
  - Noise barrier (with or without adjustments) is still feasible and reasonable
    - Proceed to noise workshop
  - Noise barrier is not feasible and reasonable
    - Provide documentation and do not hold a noise workshop
Constructability Assessment

- What might a constructability assessment look like?

- Looked at other options:
  - Avoid utilities
  - Different placement
  - Relocate utilities

Utility Conflicts
Utilities were found to be in conflict with the proposed location of the noise wall (Table 1). The District then evaluated two other options, 1) placing the wall as close to the ROW as possible while avoiding known utilities, and 2) placing the wall as close to the frontage road as possible while following safety and design standards for sight distance, etc. These two options evaluated the wall being installed (1) at a 20-ft offset from the ROW line, and (2) at a 63-ft offset from the ROW line, respectively (See Attachment A for Exhibit of 20-ft offset). Unfortunately, according to the traffic noise analysis of these options, the traffic noise reduction was not sufficient and a wall at these locations was not reasonable and feasible.

Table 1. List of Utilities Near Eastern ROW Boundary of US 181

<table>
<thead>
<tr>
<th>Utility Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP Overhead Electric</td>
</tr>
<tr>
<td>Charter Overhead CATV</td>
</tr>
<tr>
<td>San Patricio 18-inch water line</td>
</tr>
<tr>
<td>Frontier underground FOC</td>
</tr>
</tbody>
</table>
Constructability Assessment

- When site constraints are “too expensive” to overcome...

Alternate Barrier Cost Assessment Worksheet

Module 1: Standard Barrier Cost Assessment

- Total Length of Proposed Barrier (ft): 1325
- Average Height of Proposed Barrier (ft): 14
- Benefited Receivers: 16
- Standard Barrier Cost Total: $649,250
- Square Footage Per Beneficiary: 1158.375
- Cost Per Beneficiary: $40,578
- Current FHWA-approved cost: $35
- Current FHWA-approved square footage per benefited receiver: 1500
- Current FHWA-approved cost per benefited receiver: $52,500

**BARRIER IS COST REASONABLE. PROCEED WITH ALTERNATE COST ASSESSMENT.**

Module 2: Alternate Barrier Cost Assessment

Standard Barrier Cost Total [from Module 1]: $649,250

- Estimated costs of any additional ROW (including easements) needed to construct the THIS noise barrier: $0
- Estimated costs for ROW clearing for permanent placement and construction access to THIS noise barrier: $0
- Estimated costs of utility adjustments directly associated with construction of THIS noise barrier: $1,672,500
- Estimated costs of additional design elements necessary to accommodate unusual topographic features due to the construction of this barrier: $0
- Estimated costs of drainage features directly associated with construction of THIS noise barrier: $84,564
- Estimated costs of additional design elements directly associated with THIS noise barrier (describe below): $0

**Describe Issues**

- Estimated costs of Alternate Barrier Cost: $2,406,414
- Benefited Receivers: 16
- Project Total Per Beneficiary Receiver: $150,401
- Current FHWA-approved Alternate Barrier Cost Per Beneficiary Receiver Cannot Exceed: $10,600

**BARRIER IS NOT COST REASONABLE. PROJECT EXCEEDS FHWA-APPROVED ALTERNATE BARRIER COST.**
Constructability Assessment

- Flexible format – no template (yet?)
  - Memo from design engineering team
- Include as needed:
  - plan markups
  - construction cost estimates
  - alternate barrier cost spreadsheet
- Clearly summarize the issues, considerations, and the outcome

Summary

Based on traffic noise modeling and analysis of the proposed US 181 project, a noise barrier (wall) was found to be reasonable and feasible. The 14-ft, 1,325 foot long wall would be constructed adjacent to the Seco/Pecos Neighborhood located east of US 181 just north of Wildcat Drive. Multiple known utilities were found to be in conflict with the wall and based on an alternate barrier cost assessment the cost of drainage design modifications and utility relocations exceeded the FHWA-approved cost per benefitted receiver. Therefore, the noise wall was found not to be cost reasonable.
Reminders – Noise in ECOS

- “Perform Noise Analysis”
  - ENV reviews the noise analysis when:
    - project is an EIS
    - project has noise impacts
    - and/or at district request

- “Perform Notification of Noise Information to Local Officials”
  - Send letter after clearance, within 30 days

- “Perform Noise Constructability Assessment/ Workshop”
  - Noise barrier outcomes
  - Constructability assessment and noise workshop
  - ENV reviews this documentation

- “Perform Noise SME Consultation”
- “Perform Noise Mitigation”
Traffic Noise Toolkit

Traffic Noise Toolkit - Policy and Guidance

Streamlined - Requirements Only
Addresses requirements outlined in 23 CFR 772 that must be specified by the state DOT and approved by FHWA

User-friendly
Guidance, how-to instructions & examples
Can be updated without formal FHWA approval
Traffic Noise Toolkit - Report Templates & Example Language

- In Traffic Noise Toolkit
- Templates:
  - No Impact
  - Impact No Abatement
  - Impact With Abatement
- Standard Language for Documenting Traffic Noise Analyses
  - Validation Writeup
  - Abatement Paragraph Examples
  - Language for Environmental Assessment
  - Atypical Analysis Examples
NHI Traffic Noise Courses

- Developed by National Highway Institute and FHWA
- [https://www.nhi.fhwa.dot.gov/](https://www.nhi.fhwa.dot.gov/)
- Nine online courses
- Self-paced and can be taken in any order.
- Free
### NHI Traffic Noise Courses

<table>
<thead>
<tr>
<th>NHI #</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>142086</td>
<td>Acoustics of Highway Traffic and Construction Noise</td>
<td>2</td>
</tr>
<tr>
<td>142087</td>
<td>Highway Traffic and Construction Noise Regulations</td>
<td>2</td>
</tr>
<tr>
<td>142088</td>
<td>How to Measure Highway Traffic Noise</td>
<td>2</td>
</tr>
<tr>
<td>142089</td>
<td>Abatement and Design Considerations for Highway Traffic Noise</td>
<td>2</td>
</tr>
<tr>
<td>142090</td>
<td>An Introduction to the Traffic Noise Model (TNM) 3.0</td>
<td>3</td>
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<tr>
<td>142091</td>
<td>Public Involvement for Highway Traffic and Construction Noise Projects</td>
<td>1</td>
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<tr>
<td>142092</td>
<td>How to Mitigate Construction Noise</td>
<td>1</td>
</tr>
<tr>
<td>142093</td>
<td>How to Document Highway Traffic Noise Study Results</td>
<td>1</td>
</tr>
<tr>
<td>142094</td>
<td>Noise Compatible Planning (NCP) for Highway Traffic Noise</td>
<td>2</td>
</tr>
</tbody>
</table>

- Each course has:
  - Narrated slides (with transcripts), graphics, & lots of information
  - Resource links, job aids, and printable module notes to download
- However, written for a NATIONAL audience, so not TxDOT-specific guidance
**Example NHI Course Slides**

### Type I Projects

Construction of highway on new location or alteration of an existing highway

- If a portion of a project proposes Type I work, the entire project qualifies as a Type I project.

### But, is it feasible?

- **Integrating Sound Level Meters**
  - Analyzers: automated sampling
  - Integrating SLM: automatically measures
  - No integration: check-off method
  - ANSI SLM classes:
    - Type 0: laboratory reference
    - Type 1: precision field measurements and research
    - Type 2: general field use

### Types of Noise Walls

- **Post and Panel**
  - Consists of noise barrier panels mounted with foundation attachments between foundation-supported posts
  - Usually prefabricated and shipped to project site
  - Panel size and configuration vary
  - Steel and concrete posts can support panels made up of:
    - Wood
    - Steel
    - Concrete

- **Block and Brick**

- **Precast Concrete**

- **Stone Cribs**

- **Direct Burial**

- **Cast-In-Place Concrete**

Select each button to read about each type of noise wall.
Contact ENV Noise SMEs

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