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MDOT US-131/US-131 BR Interchange Improvements Kalamazoo, MI Draft Traffic Noise Technical Report

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List of Acronyms and Abbreviations

ANSI	American National Standards Institute
BR	Business Route
CNE	common noise environment
CPBU	cost per benefited receptor unit
dB	decibel (measure of sound pressure level on a logarithmic scale)
dBA	A-weighted decibel (sound pressure level)
DU	dwelling unit
DUE	dwelling unit equivalent
FHWA	Federal Highway Administration
Leq	equivalent sound level (energy averaged sound level)
Leq(1h)	A-weighted, energy average sound level during a 1-hour period
LOS	level of service
MDOT	Michigan Department of Transportation
mph	miles per hour
NAC	noise abatement criteria
NR	noise reduction
ROW	right of way
ST	short-term
LT	long-term
TNM	Traffic Noise Model

Executive Summary

This noise analysis was conducted to assess the noise impacts associated with the US-131 / US-131 Business Route (BR) Interchange improvement project in Kalamazoo, MI. The purpose of the proposed project improvements is to improve safety, maintain required capacity, provide operational consistency, and adhere to current MDOT design and environmental standards. The project includes the addition of the two missing interchange ramps and other improvements, some of which would be within 500 feet of existing noise-sensitive land uses. This includes several single-family homes and a church along West GH Avenue, the Kalamazoo River Valley Trail, and single-family homes along Boyce Dr.

FHWA defines Type I projects as Federal highway projects that result in a highway in a new location, a physical alteration of an existing highway that significantly changes either horizontal or vertical alignment, or an increase to the number of through lanes. This noise study is required for this project because the new interchange ramps are being added between US-131 and US-131 BR, satisfying the definition of a Type I project. Thus, the entire project area needs to be studied as a Type I project and assessed for potential noise impacts and mitigation options.

This noise study included on-site noise measurements in the project vicinity. Measurements were conducted in October 2022 to validate noise models. A total of one long-term (LT) and 5 short-term (ST) noise measurements were conducted at representative locations across the project area.

A predictive noise model was developed in the FHWA Traffic Noise Model (TNM) version 2.5 and validated against these field measurements. Noise-sensitive receptors were then identified and classified with existing and future traffic noise levels calculated in TNM 2.5. Predicted noise levels were then checked against FHWA and MDOT standards to determine traffic noise impacts in the study area. Noise abatement for these impacts were analyzed using TNM and assessed per MDOT feasibility and reasonableness criteria.

The analysis identified a total of five defined Common Noise Environments (CNEs). Of these five established CNEs, four were identified to contain at least one impacted receptor for the future build condition. Abatement in the form of noise walls were considered in each impacted CNE but none were determined to be reasonable and feasible in accordance with MDOT policy. A summary of these findings is presented in Table ES-1 and discussed in more detail in the body of the report.

Table ES-1 Summary of Project Impacts and Proposed Noise Abatement

CNE	Description/Location	Existing Impacts	Future Impacts	Noise Abatement Recommendation
CNE-1	Single-Family Homes East of NB US-131, North of US-131 BR, West of W G Ave	0	0	Not Recommended
CNE-2	Single-Family Homes East of NB US-131, North of US-131 BR, South of W G Ave	1	1	Not Recommended
CNE-3	Single-Family Homes, Multi-family Homes, Churches South of US-131 BR, East of NB US131, East of Ravine Road	11	11	Not Recommended
CNE-4	Single-Family Homes, Recreational Nature Path East of NB US-131, South of US-131 BR, West of Ravine Road, North of Kalamazoo River Valley Trail	0	1	Not Recommended
CNE-5	Single-Family Homes East of US-131, North of W H Ave., South of Kalamazoo River Valley Trail	0	1	Not Recommended

1. Introduction and Project Description

1.1 Project Description

This project is located on US-131 from W H Ave on the south to north of W G Ave, a distance of approximately 1.8 miles. The project area and limits are shown in Figure 1-1. The proposed US-131 / US131 BR modifications qualify the project as Type I and thus require a full noise analysis. FHWA and MDOT policy requires the noise analysis to assess the entire project area for noise impacts and potential noise abatement. All noise-sensitive properties with a defined outdoor use area within approximately 500 feet of the project roadways were evaluated for noise impacts and potential noise abatement in accordance with MDOT policy.

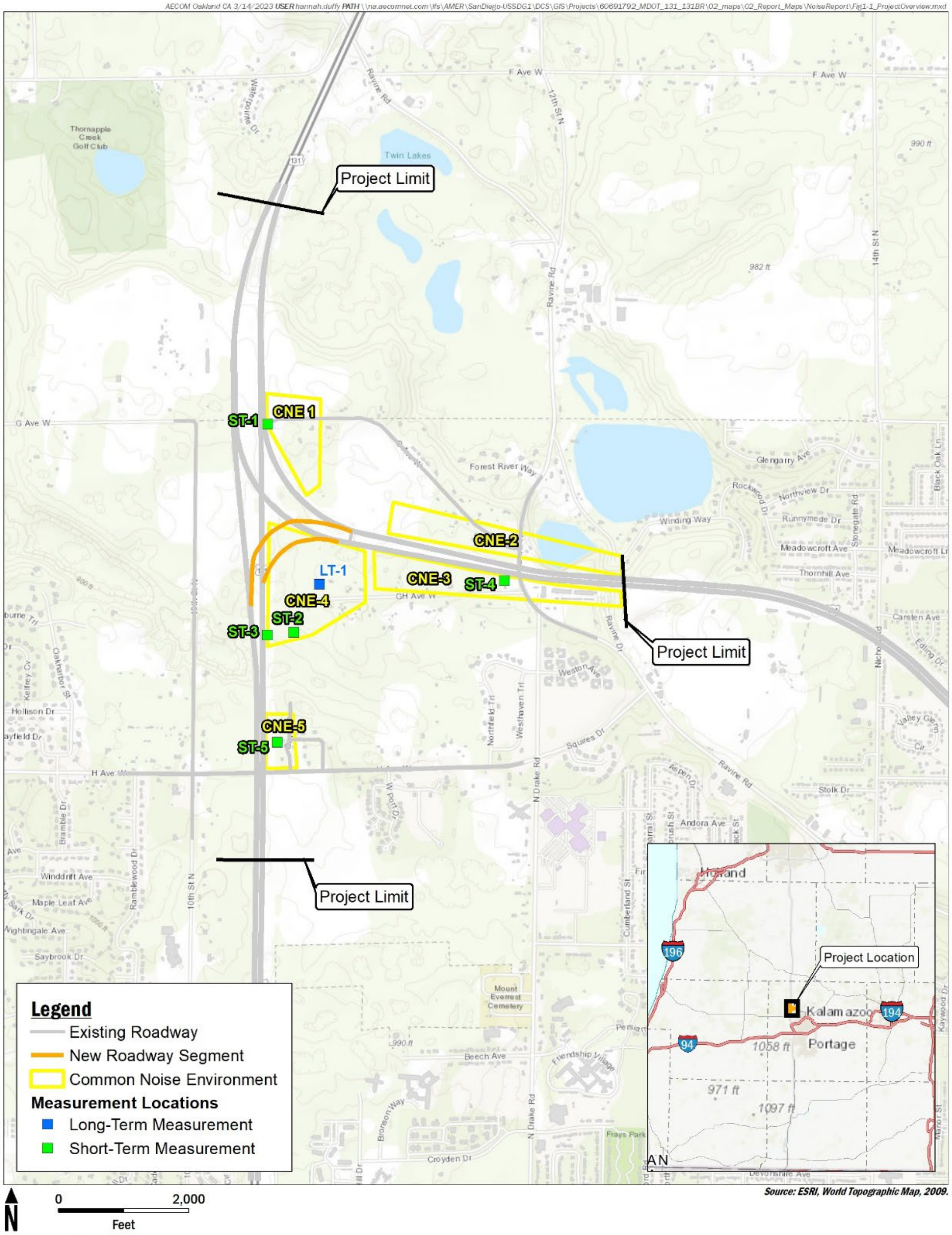
This project adds two missing ramps to the existing US-131/US-131 BS interchange in Kalamazoo, MI. The ramps are northbound US-131 to eastbound US-131 BS and westbound US-131 BS to southbound US-131. Currently, traffic uses alternate routes such as the US-131/M-43 interchange and the I-94 BS/I-94 BL interchange to make these movements. The addition of these ramps is expected to reduce industrial and commercial traffic travelling through nearby residential areas, and to improve traffic operations along M-43 and I-94 BL.

1.2 Description of Alternatives

This project includes one future build alternative to be evaluated:

- Future build (includes all proposed improvements and projected traffic volumes for Year 2050)

Figure 1-1 Project Overview



Source: ESRI, World Topographic Map, 2009.

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Michigan Department of Transportation (MDOT)

MDOT US-131/131BR Interchange Improvements".

KALAMAZOO COUNTY, MI

2. Traffic Noise Concepts

The following glossary of acoustical terms is intended to help frame the discussion of project-generated noises and their potential effects on neighboring communities in the project area.

2.1 Glossary of Acoustical Terms

Noise: Whether something is perceived as a noise event is influenced by the type of sound, the perceived importance of the sound, and its appropriateness in the setting, the time of day, and the type of activity during which the noise occurs, and the sensitivity of the listener. Local jurisdictions may have legal definitions of what constitutes “noise” and such environmental parameters to consider.

Sound: For this analysis, sound is a physical phenomenon generated by vibrations that result in waves that travel through a medium, such as air, and result in auditory perception by the human brain.

Frequency: Sound frequency or “pitch” is measured in hertz (Hz), which is a measure of how many times each second the crest of a sound pressure wave passes a fixed point. For example, when a drummer beats a drum, the skin of the drum vibrates a number of times per second. When the drum skin vibrates 100 times per second, it generates a sound pressure wave that is oscillating at 100 Hz, and this pressure oscillation is perceived by the brain as a tonal pitch of 100 Hz. Sound frequencies between 20 and 20,000 Hz are within the range of sensitivity of the best human ear.

Amplitude or Level: Sound levels are measured in decibels (dB) using a logarithmic scale. A sound level of zero dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB. Sound levels above approximately 110 dB begin to be felt inside the human ear as discomfort and eventually as pain at 120 dB and higher levels. The minimum change in the sound level of individual events that the average human ear can detect is about 1 to 2 dB. A 3 to 5 dB change is readily perceived. A change in sound level of about 10 dB usually is perceived by the average person as a doubling (or if decreasing by 10 dB, halving) of the sound’s loudness. Table 2-1 shows typical indoor and outdoor sounds and their corresponding dB levels, arranged on what often is referenced as an “acoustic thermometer” to show relative loudness.

Sound pressure: Sound level usually is expressed by reference to a known standard. This report refers to sound pressure level, which is expressed on a logarithmic scale with respect to a reference value of 20 micropascals. Sound pressure level depends not only on the power of the source, but also on the distance from the source and the acoustical characteristics of the space surrounding the source.

A-weighting: Sound from a tuning fork contains a single frequency (a pure tone), but most sounds heard in the environment do not consist of a single frequency; instead, they are composed of a broad band of frequencies, differing in sound levels. The method commonly used to quantify environmental sounds consists of evaluating all frequencies of a sound according to a weighting system that reflects the typical frequency-dependent sensitivity of average healthy human hearing. This is called “A-weighting,” and the measured decibel level is referred to as A-weighted decibels (dBA).

Equivalent sound level: Environmental noise levels vary continuously and include a mixture of noise from near and distant sources. A single descriptor, energy-average sound level during a measured time interval (L_{eq}), may be used to describe such sound that is changing in level from one moment to another. L_{eq} is the energy-average sound level during a measured time interval. This is the “equivalent” constant sound level that would have to be produced by a single, steady source to equal the acoustic energy contained in the fluctuating sound level measured.

Insertion loss (IL): The IL is the reduction in noise level at a location from noise abatement means, placed in the sound path between that location and a sound source.

2.2 Fundamentals of Traffic Noise Assessment and Control

Sound Propagation

Atmospheric conditions (e.g., wind, temperature gradients, humidity) can change how sound propagates over distance and can affect the level of sound received at a given location. The degree to which the ground surface absorbs acoustical energy also affects sound propagation. Sound traveling over an acoustically absorptive surface (e.g., grass) attenuates at a greater rate than sound traveling over a hard surface (e.g., pavement, expanses of open water). When located near either the sound source or the listener position, physical barriers (e.g., naturally occurring ridgelines or buildings, and other topography that block the line-of-sight between a source and receiver) also increase the attenuation of sound over distance.

Multiple Sound Sources

Because sound pressure levels in decibels are based on a logarithmic scale, they cannot be added or subtracted in an arithmetic fashion. Therefore, sound pressure level dB are logarithmically added on an energy summation basis. In other words, adding a new noise source to an existing noise source, both producing noise at the same level, does not double the noise level. Instead, if the difference between two noise sources is 10 dBA or more, the louder noise source dominates, and the resultant noise level is equal to the noise level of the louder source. In general, if the difference between two noise sources is 0 to 1 dBA, the resultant noise level is 3 dBA higher than the louder noise source, or both sources if they are equal. If the difference between two noise sources is 2 to 3 dBA, the resultant noise level is 2 dBA above the louder noise source. If the difference between two noise sources is 4 to 10 dBA, the resultant noise level is 1 dBA higher than the louder noise source.

How Noise is Measured

Sound can vary over an extremely large range of amplitudes. The decibel (dB) is a logarithmic unit that is the accepted standard unit for measuring the amplitude of sound because it accounts for these large variations in amplitude and reflects the way people perceive changes in sound amplitude. Different sounds may have different frequency content. Frequency content of a sound refers to its tonal quality or pitch. When describing sound and its effect on a human population, A-weighted (dBA) sound levels are typically used to account for the response of the human ear. The term "A-weighted" refers to a filtering of the noise signal to emphasize frequencies in the middle of the audible spectrum and to de-emphasize low and high frequencies in a manner corresponding to the way the human ear perceives sound. This filtering network has been established by the American National Standards Institute (ANSI). The A-weighted noise level has been found to correlate well with peoples' judgments of the noisiness of different sounds and has been used for many years as a measure of community noise. Table 2-1 illustrates sound pressure levels in dBA of various sound sources between 0 dBA (threshold of hearing) and 120 dBA (threshold of pain). An increase of 3 dBA in noise level can barely be perceived, while an increase of 5 dBA is readily noticeable and considered a significant noise increase. A 10 dBA increase corresponds to a subjective doubling of loudness. A relationship between changes in noise level and loudness is indicated in Table 2-2. Since noise fluctuates from moment to moment, it is common practice to condense the noise level over a specified period of time into a single number called the Equivalent Noise Level (Leq). Many surveys have shown that the Leq properly predicts annoyance, and thus this metric is commonly used for noise measurements, prediction, and impact assessment.

Table 2-1 Common Indoor and Outdoor Noise Levels

Common Outdoor Noise Levels Noise Level	Noise Level (A-weighted decibels)	Common Indoor Noise Levels
	110	Rock Band
Jet Flyover at 1000 feet	100	Inside Subway Train (NY)
Gas Lawn Mower at 3 feet		
Diesel Truck at 50 feet	90	Food Blender at 3 feet
Noisy Urban Daytime	80	Garbage Disposal at 3 feet
Gas Lawn Mower at 100 feet	70	Vacuum Cleaner at 10 feet
Commercial Area		Normal Speech at 3 feet
	60	
		Large Business Office
Quiet Urban Daytime	50	Dishwasher Next Room
Quiet Urban Nighttime	40	Small Theater
Quiet Suburban Nighttime		Library
	30	
Quiet Rural Nighttime		Bedroom at Night
	20	
		Broadcast & Recording Studio
	10	
	0	Threshold of Hearing

Source: Adapted from Guide on Evaluation and Attenuation of Traffic Noise, AASHTO-1974

Table 2-2 Relationship between Changes in Noise Level and Perceived Loudness

Increase (or Decrease) in Noise Level	Loudness Multiplied (or Divided) by
3 decibels	1.2
6 decibels	1.5
10 decibels	2
20 decibels	4

How Highway Noise is Generated

Highway noise is generated from three primary sources: tire/pavement noise, engine noise, and exhaust noise. Tire/pavement noise is the noise generated by the rubber tires rolling over the pavement surface and may vary in intensity and character depending on the type and condition of both the tires and the pavement. For automobiles and light trucks traveling at typical highway speeds (over about 50 miles per hour [mph]), tire/pavement noise is generally the dominant noise source. For medium and heavy trucks (like large commercial delivery vehicles and long-haul tractor-trailers) engine and exhaust noise also contribute to the noise that they produce. At typical highway speeds, one large truck can produce as much noise energy as ten automobiles. How highway noise is experienced at nearby homes is controlled by a number of factors, including: the total number of vehicles on the highway, the percentage of large trucks, the average speed of the vehicles, the distance to the highway, obstructions blocking the view of the highway, and meteorological conditions. Generally speaking, the more vehicles, the higher percentage of large trucks or the closer one is to the highway, the greater the noise will be. Intervening obstructions, either manmade (buildings, walls, berms) or natural (such as intervening terrain) will reduce noise levels. Foliage and vegetation can reduce noise levels, but it must be dense (completely obscuring the view of the highway) and thick (on the order of 50 to 100 feet) to make a noticeable difference.

How Highway Noise Can Be Reduced

Highway noise can be reduced in several ways. Here are some of the most recognized:

Traffic Controls

The faster vehicles travel, and the higher percentage of large trucks, the louder the noise. Reduced speed limits, or more rigorously enforced existing speed limits, and heavy truck restrictions will reduce noise levels. However, the implementation of such measures is often politically difficult for the sake of lower noise levels alone.

Land Use Controls:

Perhaps the most common sense and fiscally responsible solution to highway noise, and one favored by most highway agencies is to restrict the development of lands near highways. Restricting development of land near new highway corridors to non-noise sensitive land uses, such as commercial or industrial activities can eliminate most noise problems. However, this approach is not suitable for circumstances when land near existing or future highways has already been developed for residential land use.

Quieter Vehicle Noise Sources

Quieter vehicles mean less highway noise. For automobiles, this means quieter tires (since tire/pavement noise is the dominant noise source). For large trucks, the EPA has established standards for maximum noise levels for new and in-use trucks. The maximum noise levels for new trucks are lower than those for some older trucks, so as old trucks are phased out and replaced with newer ones the noise produced by the average truck may go down.

Noise Barrier Walls and Berms

Noise barriers, both structural walls and earthen berms, are often constructed specifically for the purpose of reducing highway noise levels. Noise barriers can be very effective for reducing noise levels at nearby homes, often reducing noise levels by as much as 10 decibels at the closest homes (a perceived halving of loudness). Noise barriers can be expensive to build, on the order of $2 million per mile. Because of their cost, the construction of noise barriers is often restricted to large highway improvement or construction projects. Some jurisdictions; however, are quite active in constructing “retrofit” noise barriers on existing highways.

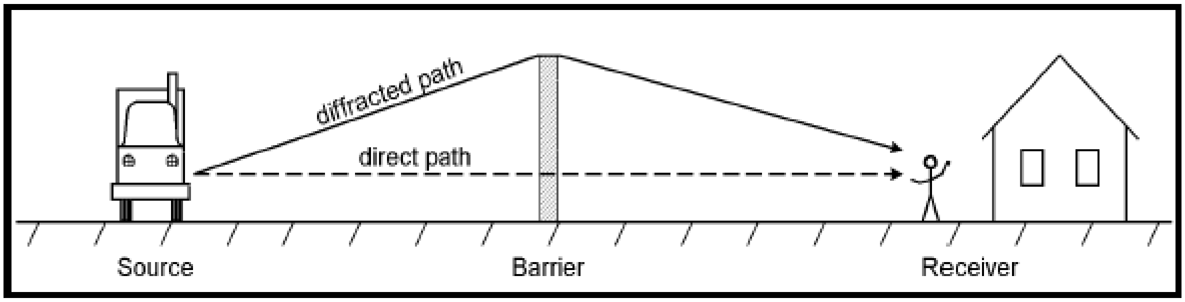
Quieter Pavements

It has long been recognized that some pavement types tend to be quieter than others. White concrete pavement, for example, is typically louder than asphalt blacktop. White concrete with tining (grooves cut into the pavement surface) is louder still. However, white concrete pavement (also known as Portland Concrete Cement, or PCC) is thought to be more durable, and perhaps safer than blacktop pavements (due to better skid resistance and drainage). There is also considerable concern that the low noise advantages of some blacktop pavements may diminish over time. As the tiny “nooks and crannies” in the blacktop pavement that give it acoustical absorption may fill up with silt and sand or become compressed over time, the acoustical benefits are reduced. The quest for quiet, safe, and durable highway pavements is currently the focus of a considerable amount of research.

How Noise Barriers Work

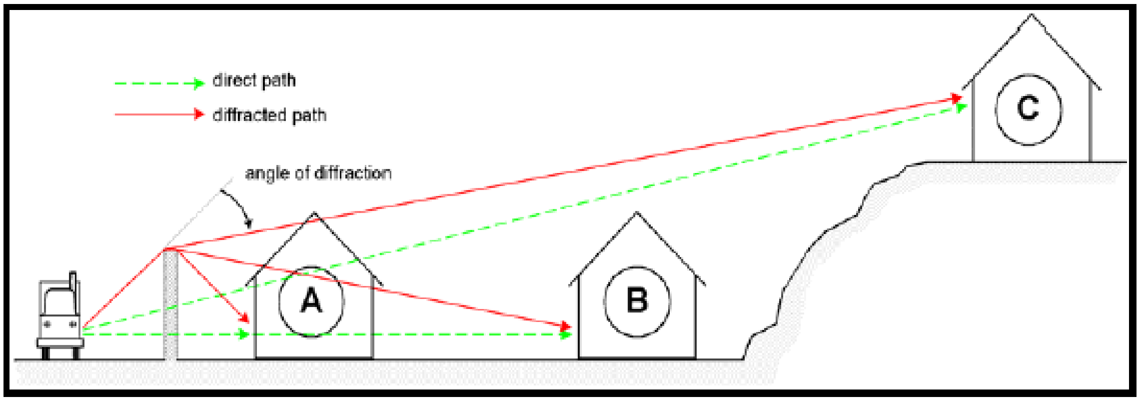
Noise barriers reduce noise levels by interrupting or lengthening the path that the noise takes between the source and the receiver. To be effective at reducing noise, noise barriers must be able to block the “line of sight” between the object producing the noise (like vehicles on the highway) and the person subjected to the noise (like residents living near the highway). The amount that the noise will be reduced is related to the path length difference between the “direct path” that the uninterrupted sound would take between the source and receiver (with no barrier) and the “diffracted path” that the sound must take going over or around the barrier, as illustrated in Figure 2-1

Figure 2-1 Simple Noise Barrier Geometry



Noise barriers may work better for some homes than for others. In Figure 2-2, below, home “A” is relatively close to the highway where the noise barrier can provide a large path length difference between the direct and diffracted paths, resulting in a substantial noise reduction (perhaps as much as 10 to 15 decibels). Home “B” is further from the barrier and the path length difference is not as great, resulting in less noise reduction (perhaps 7 to 10 decibels). Home “C” is even further from the highway and also elevated above the highway grade, providing an even smaller path length difference (resulting in a noise reduction of perhaps 3 to 5 decibels). In general, for a given barrier height and location, the further the receiver is from the barrier or the higher the receiver is elevated, the smaller the path length difference (or angle of diffraction) and the smaller the resulting noise reduction.

Figure 2-2 Path Length Difference for Varying Receiver Geometry



2.3 Regulatory Overview

2.3.1 Federal Regulations

The FHWA noise policy is contained within The Code of Federal Regulations, Title 23, Part 772 (23 CFR 772) which provides procedures for preparing operational and construction noise studies and evaluating noise abatement considered for federal and federal-aid highway projects. The code was recently updated in July of 2010. Under the current version of 23 CFR 772.5, projects are categorized as Type I, Type II, or Type III projects. The FHWA defines a Type I project as a proposed federal or federal-aid highway project for the construction of a highway on a new location, the physical alteration of an existing highway which significantly changes either the horizontal or vertical alignment or increases the number of through-traffic lanes. The proposed project is a Type I project as defined by the FHWA.

Type I projects include those that create a completely new noise source, as well as those that increase the volume or speed of traffic or move the traffic closer to a receptor. Type I projects include the addition of an interchange, ramp, auxiliary lane, or truck-climbing lane to an existing highway, or the widening of an existing ramp by a full lane width for its entire length. Projects unrelated to increased noise levels, such as lighting, signing, and landscaping, are not normally considered Type I projects.

Under 23 CFR 772.13, noise abatement must be considered for Type I projects if the project is predicted to result in a traffic noise impact. In such cases, 23 CFR 772 requires that the project sponsor "consider" noise abatement before adoption of the final NEPA document. This process involves identification of noise abatement measures that are reasonable, feasible, and likely to be incorporated into the project, and of noise impacts for which no apparent solution is available.

Traffic noise impacts, as defined in 23 CFR 772.5, occur when the design year condition noise levels approach or exceed the noise abatement criteria (NAC) specified in 23 CFR 772, or design year condition noise levels create a substantial noise increase over existing noise levels. 23 CFR 772 does not specifically define the terms "substantial increase" or "approach"; these criteria are defined in the MDOT Noise Analysis and Abatement Handbook (July 13, 2011), as described in the following section.

Table 2-3 summarizes the FHWA NAC corresponding to various defined land use activity categories. Activity categories and related traffic noise impacts are determined based on the actual land use in each area.

In identifying noise impacts, primary consideration is given to exterior areas of frequent human use. Interior noise impacts will only be addressed for land uses listed with Activity Category D.

Table 2-3 FHWA Noise Abatement Criteria

Activity Category	Activity Criteria		Evaluation Location	Activity description
	Leq(h)	L10(h)		
A	57	60	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67	70	Exterior	Residential
C	67	70	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52	55	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio stations recording studios, schools, and television studios.
E	72	75	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	--	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	--	--	--	Undeveloped lands that are not permitted.

1 Either Leq(h) or L10(h) (but not both) may be used on a project.

2 The Leq(h) and L10(h) Activity Criteria values are for impact determination only, and are not design standards for noise

3 Includes undeveloped lands permitted for this activity

2.3.2 State Regulations and Policies

MDOT has published the noise policy which provides guidelines in the analysis of highway traffic noise and the evaluation of noise abatement measures. Effective July 13, 2011, the MDOT *Highway Noise Analysis and Abatement Handbook* (hereafter referred to as "the MDOT handbook") also includes current policies, procedures, and practices to be used by agencies that sponsor new construction or reconstruction of federal or federal-aid highway projects. The MDOT noise handbook defines that a noise impact occurs when the sound level approaches or exceeds the assigned NAC level for a specific category, which is defined as an Leq(h) sound level 1 dBA less than the NAC identified in 23 CFR 772. This means that for an Activity Category B land use (residential), a peak hour noise level of 66 dBA is considered to approach the NAC of 67 dBA and is identified as an impact. The MDOT noise handbook defines a noise increase as substantial when the predicted traffic noise levels with project implementation exceed existing noise levels by 10 dBA. The MDOT noise handbook provides detailed technical guidance for the evaluation of highway traffic noise. This includes field measurement methods, noise modeling methods, and report preparation guidelines. In addition to the NAC criteria above, the MDOT noise handbook also specifies the following definitions and policies:

- **Benefited Receptor** is the recipient of an abatement measure that receives a noise reduction at or above the minimum threshold of 5 dBA.
- **Feasible Noise Abatement Measure** is an abatement measure that is acoustically feasible and meets engineering requirements for constructability. A noise abatement measure is considered feasible when it can provide at least a 5 dBA reduction to at least 75% of impacted noise receptors and meets constructability, safety, access, utility, and drainage requirements.
- **Reasonable Noise Abatement Measure** is an abatement measure that has been determined to be cost-effective if it costs at or below the allowable cost per benefited receptor unit (CPBU) of $49,907 and is considered acceptable to the majority of residents and property owners who benefit from the noise abatement. The MDOT design year attenuation requirement requires that a minimum of one benefited receptor achieve at least a 10 dBA noise reduction and that at least 50% of benefited receptors achieve a 7 dBA reduction.

3. Methods of Noise Analysis

3.1 Defining Area or Potential Impact

The extent of the noise study analysis area should include all receptors potentially impacted by the project. The FHWA does not establish a fixed distance to define the noise impact analysis area. Historically, absolute noise impacts (those areas with noise levels approaching or exceeding the NAC – 66 dBA for residential land uses) rarely exist beyond about 500 feet from the roadway. The MDOT noise handbook defines the study zone to be a minimum of 500 feet, including all noise-sensitive receptors on all sides of the highway. If an impact is identified at 500 feet, the next closest receptor would need to be analyzed until a distance where impacts are no longer identified is reached. If no receptors are located within the 500-foot zone, then the closest receptor(s) should be analyzed.

3.2 Field Measurement Procedures

Several field noise measurements were conducted for this project. In general, the noise measurement procedures in the field follow recommended standard procedures, including those outlined in the FHWA's Measurement of Highway Related Noise, May 1996, and the MDOT noise handbook. Specifically, the following practices and procedures were used.

The short-term noise measurements (typically 15-25 minutes) were conducted at actual or representative receptor locations and were used primarily to validate the noise prediction model (at locations where traffic noise was dominant). Short-term noise measurements were generally conducted at exterior areas of frequent human use and were only conducted during periods of free-flowing traffic, dry roadways, and low to moderate wind speeds (less than 12 mph to avoid extraneous wind noise).

One long-term measurement (24-hour period) was conducted at an actual or representative receptor location and was used to show a typical noise pattern throughout the day.

ANSI (American National Standards Institute) Class I sound level meters were used for both ST and LT measurements. The meters were subjected to a field calibration check before and after the measurement regime.

Concurrent traffic counts (classified in auto, medium and heavy trucks, buses, and motorcycles) for the acoustically dominant road were conducted for each short-term measurement. Traffic was videotaped during the measurements to be subsequently counted. The traffic counts can be found in Table 3-3.

All field data were recorded on field data sheets, which included the time, name and location of the measurement, instrument information, observed meteorological data, field calibration results, a measurement site diagram, GPS coordinates, and notes regarding the dominant noise sources and any other observed acoustically relevant events (such as aircraft over-flights, emergency vehicle pass-bys, etc.). Field sheets and photographs of measurement sites can be found in Appendix A.

3.3 Analysis Objectives

The purpose of this noise analysis report is to identify, and document potential noise impacts associated with the proposed future Project and to identify feasible and reasonable abatement. The general analysis procedure for the Project noise study includes the following steps:

1. **Review Project Description:** Review the project description and project data to be analyzed and collect additional required data (including roadway design files, existing and future traffic data, land use data, etc.). Consider all alternatives, design options, and construction phasing scenarios. This information is presented in Section 1 of this report.

2. **Identify Regulatory Framework:** Investigate and establish the regulatory framework to be followed for the noise analysis, including federal, state, and local regulations and ordinances applicable to the Project. This information is presented in Section 2 of this report.

3. **Noise Analysis Methodology and Establish Existing Land Use and Noise Environment:** Investigate and document the existing noise environment for the Project area, including existing noise-sensitive land uses and existing noise levels in the Project area. These were accomplished with a careful review of local zoning information, review of aerial photography, and a site visit to the Project area. This information is presented in Section 3 of this report.

4. **Predict Future Noise Levels and Assess Noise Impacts:** Future noise levels at noise-sensitive land uses for the future build alternative are predicted using the FHWA TNM Version 2.5. For each alternative, future noise levels (as well as increases in future noise levels over existing noise levels) are assessed for compliance with the identified noise impact criteria and quantify resulting noise impacts. This information is presented in Section 4 of this report.

5. **Evaluate Noise Abatement:** Where noise impacts are identified, evaluate potential noise abatement measures. Abatement measures are evaluated for feasibility and reasonableness according to FHWA and MDOT standards. This information is presented in Section 5 of this report.

6. **Construction Noise Considerations:** Analyze potential construction noise impacts and discuss available abatement options. This information is presented in Section 6 of this report.

7. **Information for Public Officials:** Provide or identify appropriate information for local public officials to help avoid future noise impacts. This information is presented in Section 7 of this report.

A more detailed accounting of the specific procedures involved in each of the above analysis steps is provided in the indicated report section.

3.4 Selection of Noise-Sensitive Receptors

In general, modeled noise-sensitive receptors are identified to represent potentially impacted land uses within the Project area. A common noise environment, or CNE, is generally defined as a group of receptors within the same Activity Category in Table 2-3 that are exposed to similar noise sources and levels; traffic volumes, traffic mix, and speed; and topographic features. Generally, common noise environments occur between two secondary noise sources, such as interchanges, intersections, and/or cross-roads. The delineated CNEs for this Project are described in Section 3.9.2 of this report. Within each CNE, representative noise measurements and noise prediction locations are identified. Typically, each CNE would have one short-term measurement location and multiple noise prediction locations. The number and locations of the receptors (measurement and modeling locations) within each CNE are selected to adequately represent all of the noise-sensitive property units (dwellings) within that CNE, and these properties may include Activity Categories A through E and G in Table 2-3 (including residential, noise-sensitive commercial, parks, schools, hotels, and undeveloped lands.). Activity Category F (agriculture, retail, industrial, transportation, and utilities), may still be located within a CNE, but would be considered a noise-compatible land use and would not require noise analysis. For residential properties, more-isolated residences would generally be modeled as individual receptors, while residences in multi-family buildings and dense neighborhoods may be modeled with one modeled receptor location representing multiple dwelling units or homes (receptors).

All noise prediction locations are placed to represent an exterior area of frequent human use of the receptor. For residential properties, this would normally be an exterior activity area between the structure and the proposed project roadway, such as a pool, patio, or play area. For CNE 3 in this analysis, noise-sensitive receptors Ravine Apartments were placed at the pool, picnic area, pet park, basketball hoop, and playground. Each of these receptors had their own calculated DUEs. Calculations can be seen in Appendix E.

3.5 Loudest Hour Noise Conditions

When determining noise impacts, traffic noise predictions must be made for the loudest noise hour (generally during level of service [LOS] C or D with high heavy truck volumes and speeds close to the posted speed limit or design speed). The loudest hour noise is typically either the peak vehicular truck hour or the peak vehicular volume hour (with LOS A through D conditions).

3.6 Noise Abatement Requirements

According to FHWA policy and the MDOT noise handbook, once a noise impact has been identified, feasible and reasonable noise abatement measures must be considered. For noise abatement, primary consideration is given to the exterior areas of frequent human use.

When traffic noise impacts are identified, noise barrier walls, at a minimum, are required to be considered. In addition to noise walls, other abatement elements may also be considered, if appropriate and applicable, including the following:

- Traffic management measures.
- Alteration of horizontal and vertical alignments.
- Acquisition of property to serve as a buffer to preempt development that would be adversely impacted by traffic noise; and
- Noise insulation (NAC D Only).

When noise barriers are considered, a noise barrier design analysis must show that the barrier is feasible. This typically requires that the barrier provides a minimum required level of noise reduction. According to the MDOT noise handbook, feasible noise barriers must provide at least 5 dBA of noise reduction to at least 75% of impacted receptors. In addition to meeting minimum noise reduction requirements, noise barriers must also meet engineering and constructability feasibility requirements in terms of safety, property and emergency access, drainage control, overhead and underground utility clearance, and other issues.

Noise barrier reasonableness is generally related to cost-effectiveness and benefited receptors. The MDOT noise handbook expresses barrier cost-effectiveness by a quotient formula called the Cost Per Benefited Receptor Unit (CPBU), which divides the total square-foot-cost of the barrier (at a rate of \$45.00/ft^2) by the number of benefitted dwelling units. To maintain reasonableness, the total CPBU cannot exceed \$49,907, (the total allowable cost established by MDOT for FY 2022). Barriers must also achieve the MDOT noise reduction design goal of 10 dBA reduction for at least one benefited receptor, and 7dBA reduction for at least 50% of benefitted receptors.

If noise barriers are determined to be reasonable and feasible as defined above, then the viewpoints of property owners and residences should be taken into consideration. Approval by a simple majority (greater than 50%) of all responding benefited owners and residences is needed to implement noise abatement. Public votes should occur during final design and could happen during the Context Sensitive Design aesthetic public input phase.

3.7 Noise Modeling Methodology

Future build noise levels, along with existing noise levels, were predicted using FHWA TNM Version 2.5, the most recent version available at the time of the analysis. All conventional modeling techniques and recommendations for TNM by both FHWA and MDOT were implemented. These included the following modeling procedures and conventions:

- TNM roadways were generally modeled as bundled roadways with no more than three lanes represented by a single modeled roadway.
- All roadway pavement types were modeled as “Average”.
- Traffic speeds and volumes for peak traffic hour as provided in the traffic data were modeled to predict worst-case noise levels. Traffic speeds and volumes used in this analysis were based on the predicted traffic data included in Table 3-1.
- Existing terrain lines (topography) and buildings were modeled where appropriate.
- All TNM inputs and models runs were reviewed for accuracy by an independent noise analyst.
- Sample TNM input/output files for this project provided in Appendix B
- All TNM model runs are available upon request

3.8 Project Traffic Data

Predicted traffic data for the existing and Future Build were provided by MDOT. Existing traffic data from 2020, the most recent available, and Future Build data for year 2050 were used in the study. AM and PM peak values were evaluated; however, it was determined that combined AM peak values were greater and therefore were used in the loudest hour noise analysis. A summary of the traffic data used for this analysis can be found in Table 3-1.

Table 3-1 Existing and Future Peak Hour Traffic Volumes

	Existing Traffic (AM Peak)							
	Project Roadways							
	US-131 (South of US-131 BR)		**US-131 (North of US-131 BR)**		**US-131 BR**		**US-131 NB to US-131BR SB (New ramp)**	**US-131BR NB to US-131 SB (New ramp)**
	NB	**SB**	**NB**	**SB**	**EB**	**WB**	**-**	**-**
Speed (mph)[1]	70	70	70	70	70	70	-	-
Total	1129	1507	1399	1896	370	171	-	-
Auto and Light Trucks	1016	1356	1259	1706	333	154	-	-
Medium Duty Trucks	79	105	98	133	26	12	-	-
Heavy Duty Tucks	34	45	42	57	11	5	-	-
	Future Traffic (AM Peak)							
	Project Roadways							
	US-131 (South of US-131 BR)		**US-131 (North of US-131 BR)**		**US-131 BR**		**US-131 NB to US-131BR SB (New ramp)**	**US-131BR NB to US-131 SB (New ramp)**
	NB	**SB**	**NB**	**SB**	**EB**	**WB**	**-**	**-**
Speed (mph)[1]	70	70	70	70	70	70	70	70
Total	1269	1697	1501	2032	502	232	111	108
Auto and Light Trucks	1142	1527	1351	1829	452	209	98	97
Medium Duty Trucks	89	119	105	142	35	16	11	10
Heavy Duty Tucks	38	51	45	61	15	7	2	1

Notes

1. posted speeds for Autos/Medium Trucks/ Heavy Trucks

Source: MDOT TAR 3526, JN 212745PE

3.9 Existing Condition and Common Noise Environments

3.9.1 Existing Land Use and Zoning

Land uses within the Project study area are a mix of residential (single- and multi-family), commercial, industrial, and undeveloped land. Undeveloped areas are assumed to be available for future residential or commercial development.

3.9.2 Common Noise Environments

To better categorize the potential noise impacts and evaluate noise abatement for the various project alternatives, all the potentially impacted noise-sensitive receptors have been organized into Common Noise Environments (CNEs). A CNE is defined as an area containing land uses that share a common highway traffic noise influence. Descriptions of delineated CNEs, including location, primary land use, and type of noise-sensitive receptors are listed in Table 5-2. Figure 5-2 shows an overview of the Project area illustrating the defined CNEs.

Table 3-2 Common Noise Environments

CNE	Location	Land Use	Measurement ID
CNE-1	East of NB US-131, North of US-131 BR, West of W G Ave	Single-Family Homes	ST-1
CNE-2	East of NB US-131, North of US-131 BR, South of W G Ave	Single-Family Homes	None
CNE-3	South of US-131 BR, East of NB US131, East of Ravine Road	Single-Family Homes, Playground, Pool, Picnic Area, Church	ST-4
CNE-4	East of NB US-131, South of US-131 BR, West of Ravine Road, North of Kalamazoo River Valley Trail	Single-Family Homes	LT-1, ST-2, ST-3
CNE-5	East of US-131, North of W H Ave., South of Kalamazoo River Valley Trail	Single-Family Homes	ST-5

3.9.3 Existing Noise Environment

3.9.3.1 Field Noise Measurements

Noise measurements were conducted for this project between October 10 and October 11, 2022. Noise measurements were conducted to provide information for noise model validation (short-term measurements with accompanying classified traffic counts). Noise measurements were conducted as described in Section 3.2. Appendix A includes measurement-related materials.

A total of five ST noise measurements were conducted as summarized in Table 3-3. Figure 3-2 contains an aerial figure of the Project area showing each measurement location.

3.9.3.2 Noise Model Validation and Results

The FHWA TNM Version 2.5 was used to predict noise levels for both the existing condition and future build alternative at receptor locations where noise levels are dominated by traffic noise on project roadways. To demonstrate that the noise model is predicting traffic noise levels within a reasonable margin of error, the noise model runs were validated by comparing predicted noise levels to measured noise levels for similar traffic conditions. However, since the TNM only predicts noise levels associated with traffic noise, the model runs can only be validated at measurement locations where noise levels were dominated by project roadways. For this project, noise model validation was possible for all five ST noise measurement locations. Noise models are considered to be validated if the difference between measured and modeled noise levels for comparable conditions is 3 dBA or less. The successful results of the noise validation effort are presented in Table 3-3.

Table 3-3 TNM Validation Summary

Measurement ID and Location	Observed Traffic Count					Measured Leq, dBA	Modeled Leq, dBA	Difference
ST-1	**Type**	**US 131 NB**	**US 131 SB**	**US 131BR EB**	**US 131BR WB**	65.0	67.9	+2.9
	Autos	678	708	102	95			
	Medium Trucks	103	110	54	45			
	Heavy Trucks	10	23	7	8			
	Busses	0	0	0	0			
	Motorcycles	1	2	0	0			
ST-2	**Type**	**US 131 NB**	**US 131 SB**	**US 131BR EB**	**US 131BR WB**	65.8	62.8	-3.0
	Autos	602	612	92	85			
	Medium Trucks	92	94	56	47			
	Heavy Trucks	9	9	4	9			
	Busses	0	0	0	0			
	Motorcycles	3	1	0	0			
ST-3	**Type**	**US 131 NB**	**US 131 SB**	**US 131BR EB**	**US 131BR WB**	75.1	72.9	-2.2
	Autos	642	671	109	88			
	Medium Trucks	153	156	54	49			
	Heavy Trucks	12	9	5	5			
	Busses	0	0	0	0			
	Motorcycles	1	2	0	0			
ST-4	**Type**	**US 131 NB**	**US 131 SB**	**US 131BR EB**	**US 131BR WB**	62.0	64.2	2.2
	Autos	603	632	110	98			
	Medium Trucks	143	135	41	39			
	Heavy Trucks	12	13	9	9			
	Busses	0	0	0	0			
	Motorcycles	0	2	0	0			
ST-5	**Type**	**US 131 NB**	**US 131 SB**	**US 131BR EB**	**US 131BR WB**	63.7	60.8	-2.9
	Autos	648	590	102	78			
	Medium Trucks	123	102	56	41			
	Heavy Trucks	8	13	6	8			
	Busses	0	0	0	0			
	Motorcycles	0	3	0	0			

As shown in Table 3-3, all calculated differences between modeled and measured noise levels are 3.0 dBA or less, therefore, the noise model predictions are considered to be valid.

4. Noise Impact Analysis

4.1 Future Noise Levels and Impacts

This section presents predicted noise levels and noise impacts (or noise impact distances for identified CNE areas and general undeveloped areas).

4.1.1 Predicted Noise Levels and Noise Impacts

Traffic noise impacts, as defined in 23 CFR 772.5, occur when the design year condition noise levels approach or exceed the noise abatement criteria (NAC) specified in 23 CFR 772, or design year condition noise levels create a substantial noise increase over existing noise levels. 23 CFR 772 does not specifically define the terms “substantial increase” or “approach”; these criteria are defined in the MDOT Noise Analysis and Abatement Guidelines (July 13, 2011), as described in the following section. Table 2-3 summarizes the FHWA NAC corresponding to various defined land use activity categories.

MDOT noise handbook defines that a noise impact occurs when the sound level approaches or exceeds the NAC level, which is defined as an Leq(h) sound level 1 dBA less than the NAC identified in 23 CFR 772. This means that a loudest-hour noise level of 66 dBA is considered to approach the NAC for Category B of 67 dBA and is identified as an impact. The MDOT noise handbook defines a noise increase as substantial when the predicted traffic noise levels with project implementation exceed existing noise levels by 10 dBA. All conventional modeling techniques and recommendations for TNM by both FHWA and MDOT were implemented, as described in Section 3.7.

Table 6-1 below contains a summary of the predicted noise levels and noise impacts at all modeled CNE locations in the Project. Figures 5-1**,** 5-2, 5-3, 5-4 contain detailed aerial imagery of the Project area showing all modeled receptor locations and predicted future build impacts. Due to the large number of modeled receptors and CNEs within the Project area, prediction information for individual receptors is presented in detail in Appendix C.

Table 4-1 Summary of Predicted Noise Levels by CNE

CNE	**No. of Modeled Receptors**	**Total Dwelling Units**	**Predicted Noise Level (Range), Leq (1h)**		**Total Number of Future Noise Impacted Units**		
			Existing	Future Build	Approach or Exceed NAC	Significant Increase	Total Impacted DU
CNE-1	2	2	59.8-61.9	60.0-62.3	0	0	0
CNE-2	6	6	57.7-65.9	57.9-66.1	1	0	1
CNE-3	12	17	58.0-70.4	61.9-72.3	11	0	11
CNE-4	6	6	53.4-59.7	54.0-65.5	1	0	1
CNE-5	4	4	59.7- 65.3	60.7-66.3	1	0	1

Note: Dwelling units for CNE-3 include Dwelling Unit Equivalents (DUE) for several common exterior use areas associated with an apartment building, including a basketball hoop, picnic area, swimming pool, playground, and pet exercise area. DUE calculations are provided in Table E-1` in Appendix E.

Figures showing all receiver locations along with evaluated noise abatement elements are included in Section 5.

5. Noise Abatement Evaluation

5.1 Noise Abatement Measures

According to FHWA and MDOT policies, when noise impacts are identified, noise barriers (at a minimum) must be considered as noise abatement. Other potential noise abatement measures might include heavy truck or speed restrictions, alignment changes, and depressed roadways. Of these alternatives, the Project alignment was evaluated and compared for noise impacts (as presented in Section 4), but truck restrictions and speed restrictions below proposed speed limits would significantly reduce the value of the roadway. Noise barriers were evaluated for each CNE with noise impacts for feasibility and reasonableness. The following section describes the results of the barrier assessments for each evaluated CNE.

5.2 Feasible and Reasonable Criteria and Requirements

For abatement to be recommended, the barrier must meet certain feasibility and reasonableness requirements established by MDOT in the Noise Analysis and Abatement Guidelines.

When noise barriers are considered, a preliminary noise barrier design analysis must show that the barrier is feasible. According to the MDOT noise handbook, feasible noise barriers must provide at least 5 dBA of noise reduction to 75% of the impacted receptors. In addition to meeting minimum noise reduction requirements, noise barriers must also meet engineering and constructability feasibility requirements in terms of safety, property and emergency access, drainage control, overhead and underground utility clearance, and other issues.

Noise barrier reasonableness is generally related to cost-effectiveness and benefited receptors, where a benefited receptor receives at least 5 dBA of noise reduction (NR), and cost-effectiveness is driven by a Cost per Benefited Receptor Unit (CPBU) value. The handbook identifies a CPBU of $49,907, which is a final quotient resulting from dividing the total cost of abatement (at a rate of $45.00 ft^2) by the total number of benefited receptors. Additionally, The MDOT design year attenuation requirement requires that a minimum of one benefited receptor achieve at least a 10 dBA noise reduction and that at least 50% of benefited receptors achieve a 7dBA reduction for noise abatement to be reasonable.

To summarize, for a barrier to be considered feasible and reasonable, it must have:

- A noise reduction of at least 5 dBA must be achieved at 75% of impacted receptors
- A noise reduction of 10 dBA must be achieved for at least one receptor
- A noise reduction of 7 dBA must be achieved at 50% of benefitted receptors

For a noise barrier to be considered reasonable in addition to the requirements listed above, the viewpoints of benefited property owners and residents must be taken into consideration. Greater than 50% in favor of all responding benefited owners and residents is needed to construct noise abatement. Public viewpoints and votes of benefited receptors are not part of this noise analysis but are collected during the Preliminary Engineering Phase and are recorded in the environmental documentation.

5.3 Findings and Recommendations for Noise Abatement

Noise abatement was considered for each CNE with identified noise impacts. Initially, noise abatement was checked for feasibility (5 dBA reduction for at least 75% of impacted receptors and access restrictions). If abatement was determined to be feasible, the abatement was analyzed for cost-effectiveness and other reasonableness factors. For all impacted receptors meeting feasibility requirements, preliminary barrier designs were evaluated using TNM. If the abatement was found to be both reasonable and feasible, it would be recommended for inclusion in the project pending a polling of viewpoints from benefited receptors. A summary of the barrier locations and resulting sound levels are provided in Table 5-1. The details of the barrier analysis including determinations of feasibility and reasonableness are included in Table 5-2. The narrative results of abatement evaluations for each impacted CNE are summarized in subsequent sub-sections.

Table D-1 in Appendix D lists the predicted existing, future build, and future build with barrier noise levels per modeled receptor location. The table also includes the information regarding benefited receptors and barrier design goal achievement.

Table 5-1 Evaluated Barrier Descriptions

Barrier ID	Location	Existing Leq (dBA)	Future Leq Range (dBA)		Barrier Noise Reduction (dBA)	Barrier Geometries (feet)	
			No Barrier	With Barrier		Length	Avg. Height
Wall-3	CNE 3, along US-131 BR EB ROW, East of Ravine Rd	66-70	67-72	59-60	0-10	633	19

Table 5-2 Barrier Analysis Results

Barrier ID	Number of Attenuated Locations[1]					Cost[2]	Cost Per Benefitted Unit	Feasible?	Reasonable?	Recommended?
	≥ 10 dBA	≥ 7 dBA		≥ 5 dBA (Benefitted Receptors)						
		#	% of Benefit	#	% of Impacts					
Wall-3	1	5	71%	7	70%	$541,215	$77,316	No	No	No

Note:
1) MDOT policy requires that reasonable and feasible noise walls must be constructable, provide at least 10 dBA noise reduction at one impacted receptor, at least 7 dBA noise reduction for at-least 50% of benefited receptors, at least 5 dBA noise reduction for at least 75% of impacted receptors, and be constructed at an estimated cost of no more than $49,907 per benefited receptor.
2) Wall costs reported here are based on wall area in square feet as calculated by TNM times MDOT unit cost of $45.00/square foot.

Three of the analyzed CNEs (CNE-2, -4, and -5) each have a single impacted dwelling unit. In these cases, an FHWA recommended “rule-of-thumb” was used to estimate required noise barrier length. Barrier cost was then estimated by multiplying the estimated length by a typical 12-foot height and MDOT estimated cost of $45/square-foot. The guidance from the FHWA Noise Barrier Design Handbook recommends that a barrier should be long enough such that the distance between a receiver and a barrier end is at least four times the perpendicular distance from the receiver to the barrier. More detail regarding this method is provided in Appendix D.

5.3.1 CNE-1 Noise Abatement Analysis

CNE-1, East US 131 NB, contains 2 receiver locations representing a total of 2 dwelling units, none of which were impacted. No abatement was analyzed. CNE-1 is shown in Figure 5-1.

5.3.2 CNE-2 Noise Abatement Analysis

CNE-2 contains 6 modeled receiver locations representing a total of 6 individual dwelling units, 1 of which was impacted. A noise wall at this location that would provide adequate noise reduction for the single impacted receptor would be approximately 1520 feet long and cost at least $820,000 (based on FHWA noise wall design guidance). This is well over the maximum Cost/benefitted Unit allowance of $49,907. Therefore, no abatement was proposed. CNE-2 is shown in Figure 5-2.

5.3.3 CNE-3 Noise Abatement Analysis

CNE-3 contains 12 modeled receiver locations consisting of single family homes, a church and an apartment complex representing a total of 17 individual dwelling units. Of these receivers six are single family homes, one is a place of worship, and five are common use areas associated with the apartment complex (since none of the actual apartment units included its own exterior use area such as a balcony or patio). The common use areas, including a basketball hoop, picnic area, pool, playground, and pet exercise area were assigned Dwelling Unit Equivalent values (DUEs) of one to three units each in accordance with MDOT policy. A total of 11 dwelling units were determined to be impacted under the future build condition. Three noise walls were analyzed with one wall, Wall 3, being the most beneficial. Wall 3 is located along US-131 BR EB ROW, East of Ravine Road. When analyzing this wall only receivers 03-08, 03-09, 03-10, 03-11, and 03-12 were included in the noise wall analysis as impacted receiver 03-07 was too far removed from the rest of the impacted receivers. Wall 3 would cost approximately $77,316 per benefitted dwelling unit, which is over the allowable CPBU. Additionally, only 70% of impacted units receive a 5 dBA or greater noise reduction, which falls short of the 75% requirement for feasibility. Thus, abatement is not recommended for this CNE. CNE-3 and Wall 3 are shown in Figure 5-2.

5.3.4 CNE-4 Noise Abatement Analysis

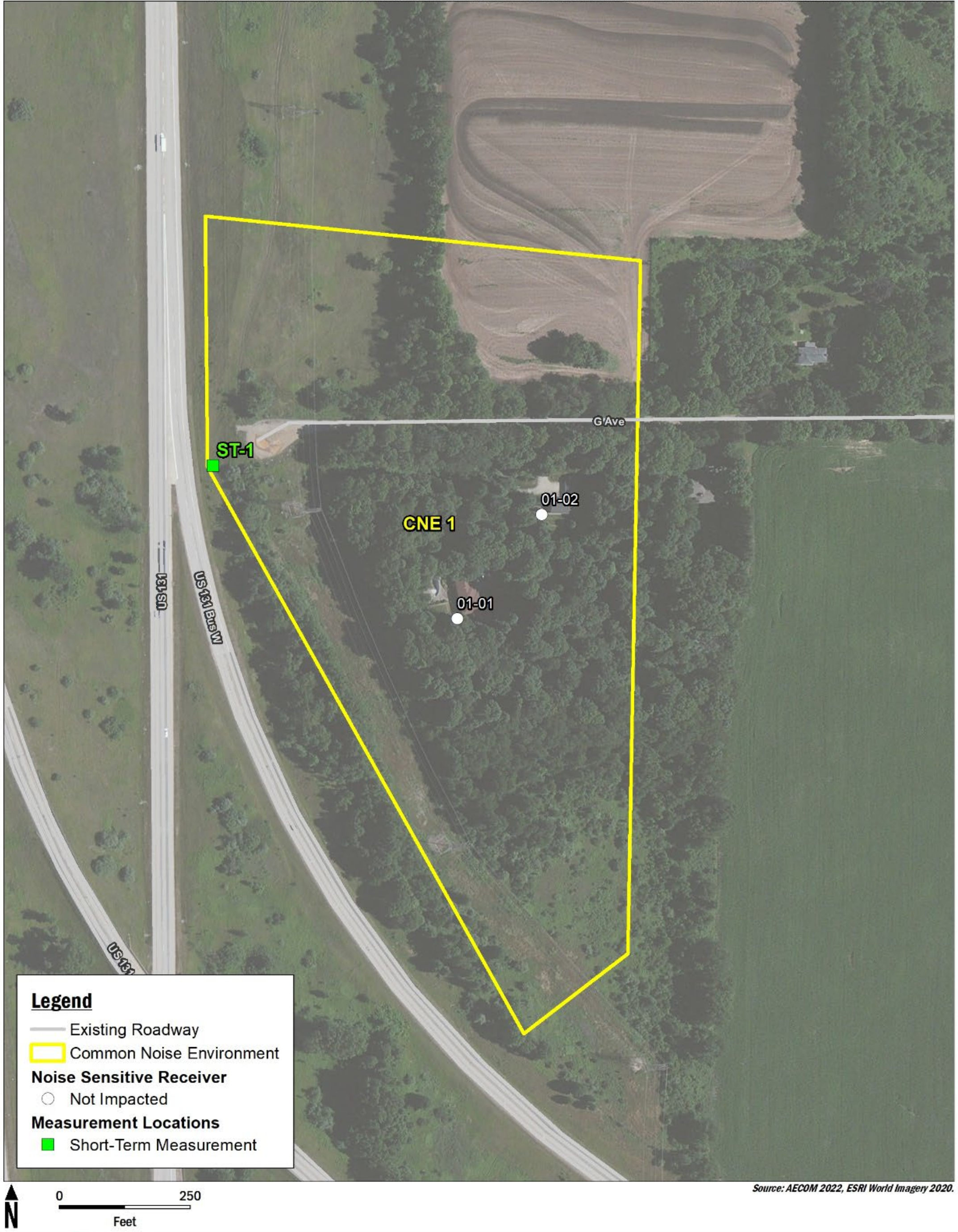
CNE-4 contains 6 modeled receiver locations representing a total of 6 individual dwelling units, 1 of which was impacted. A noise wall at this location that would provide adequate noise reduction for the single impacted receptor would be approximately 3360 feet long and cost at least $1,815,000 (based on FHWA noise wall design guidance). This is well over the maximum Cost/benefitted Unit allowance of $49,907. Therefore, no abatement was proposed. CNE-4 is shown in Figure 5-3.

5.3.5 CNE-5 Noise Abatement Analysis

CNE-5 contains 4 modeled receiver locations representing a total of 6 individual dwelling units, 1 of which was impacted. A noise wall at this location that would provide adequate noise reduction for the single impacted receptor would be approximately 1400 feet long and cost at least $756,000 (based on FHWA noise wall design guidance). This is well over the maximum Cost/benefitted Unit allowance of $49,907. Therefore, no abatement was proposed. CNE-5 is shown in Figure 5-4.

Figure 5-1. Acoustical Analysis for CNE-1

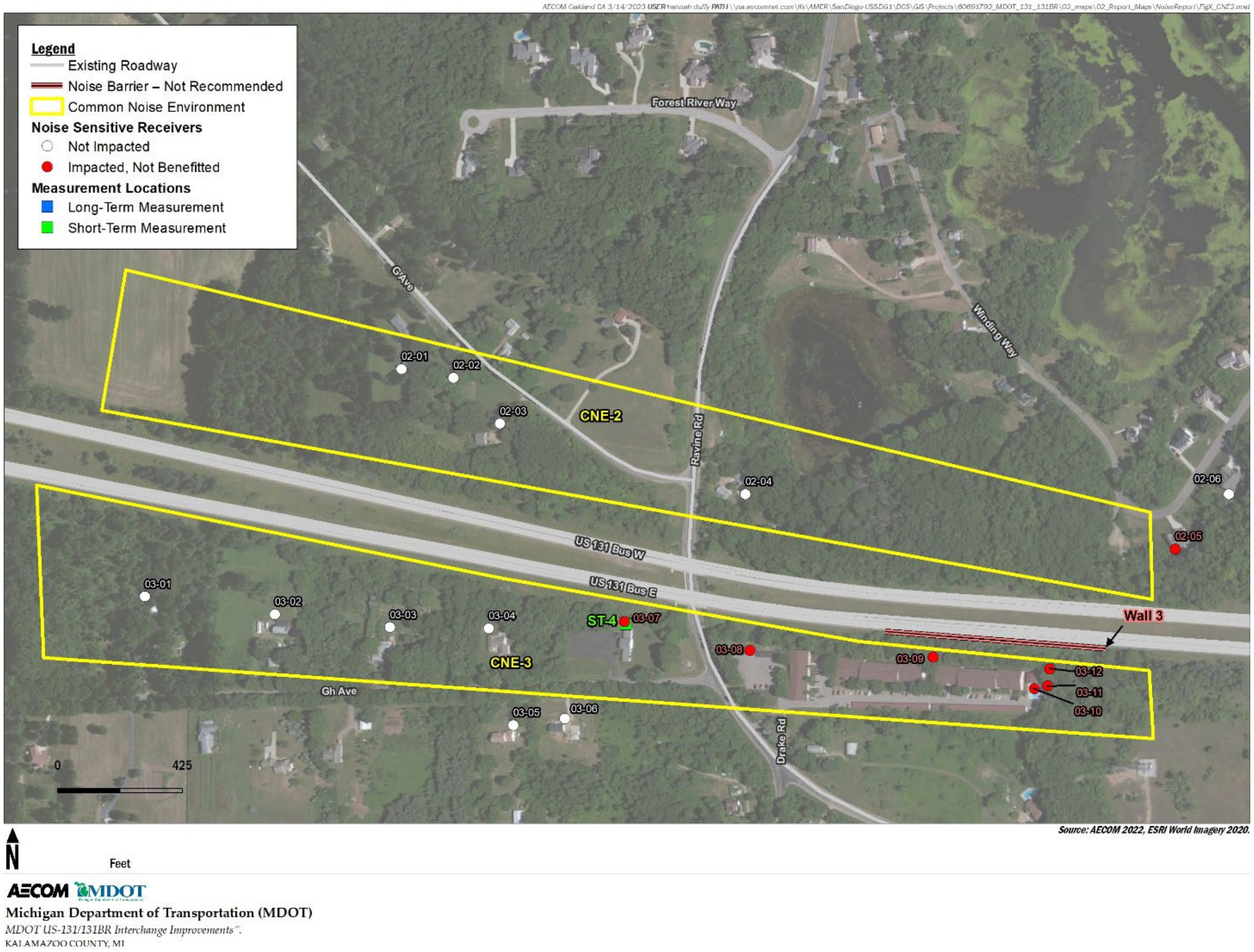
AECOM Oakland CA 3/14/2023 **USER** hannah.duffy **PATH** \\na.aecomnet.com\lfs\AMER\SanDiego-USSDG1\DCS\GIS\Projects\60691792_MDOT_131_131BR\02_maps\02_Report_Maps\NoiseReport\FigX_CNE1.mxd



Source: AECOM 2022, ESRI World Imagery 2020.

Michigan Department of Transportation (MDOT)
MDOT US-131/131BR Interchange Improvements".
KALAMAZOO COUNTY, MI

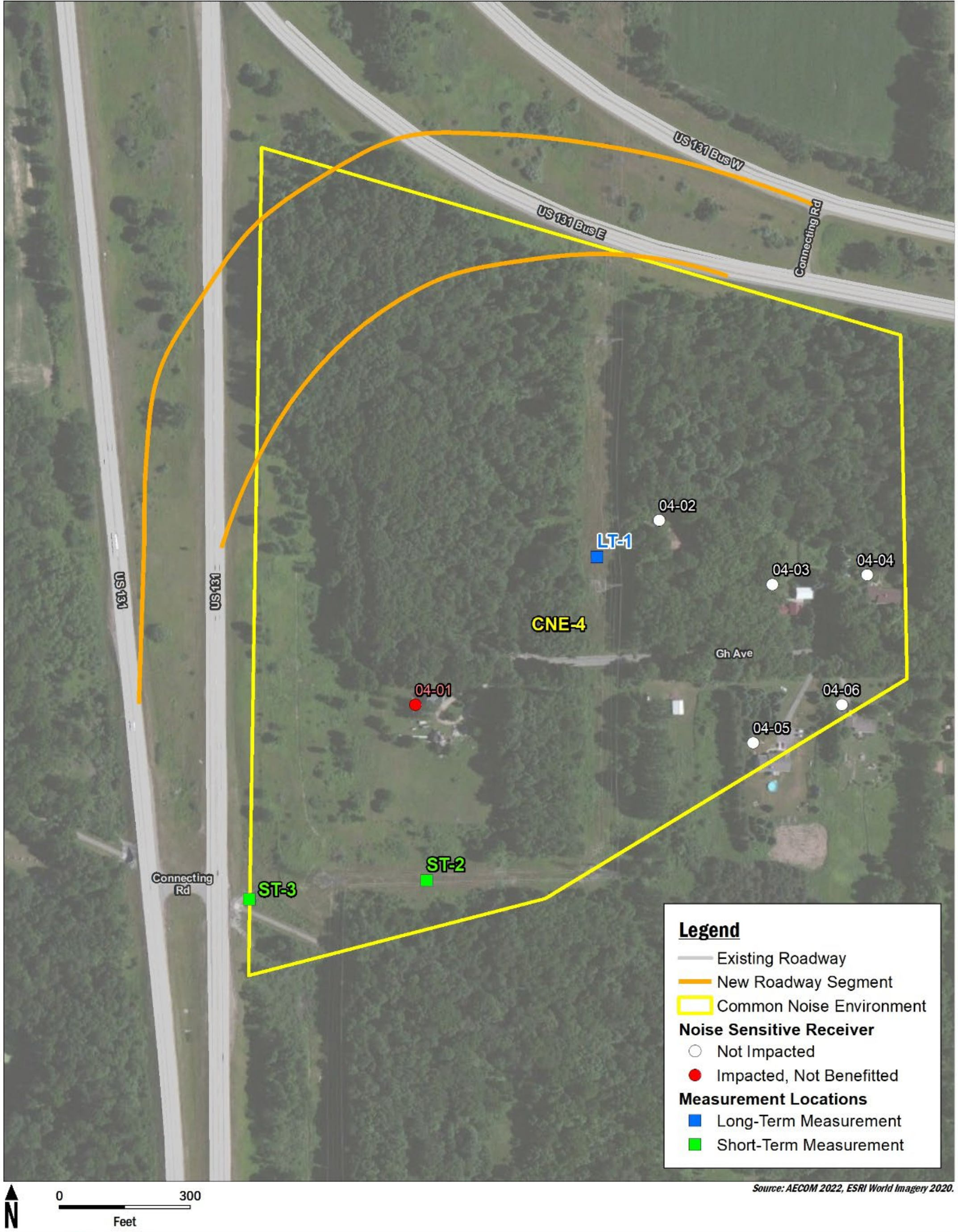
Figure 5-2. Acoustical Analysis for CNE-2, CNE-3



Source: AECOM 2022, ESRI World Imagery 2020.

Figure 5-3. Acoustical Analysis for CNE-4

AECOM Oakland CA 3/14/2023 **USER** hannah.duffy **PATH** \\na.aecomnet.com\lfs\AMER\SanDiego-USSDG1\DCS\GIS\Projects\60691792_MDOT_131_131BR\02_maps\02_Report_Maps\NoiseReport\FigX_CNE4.mxd

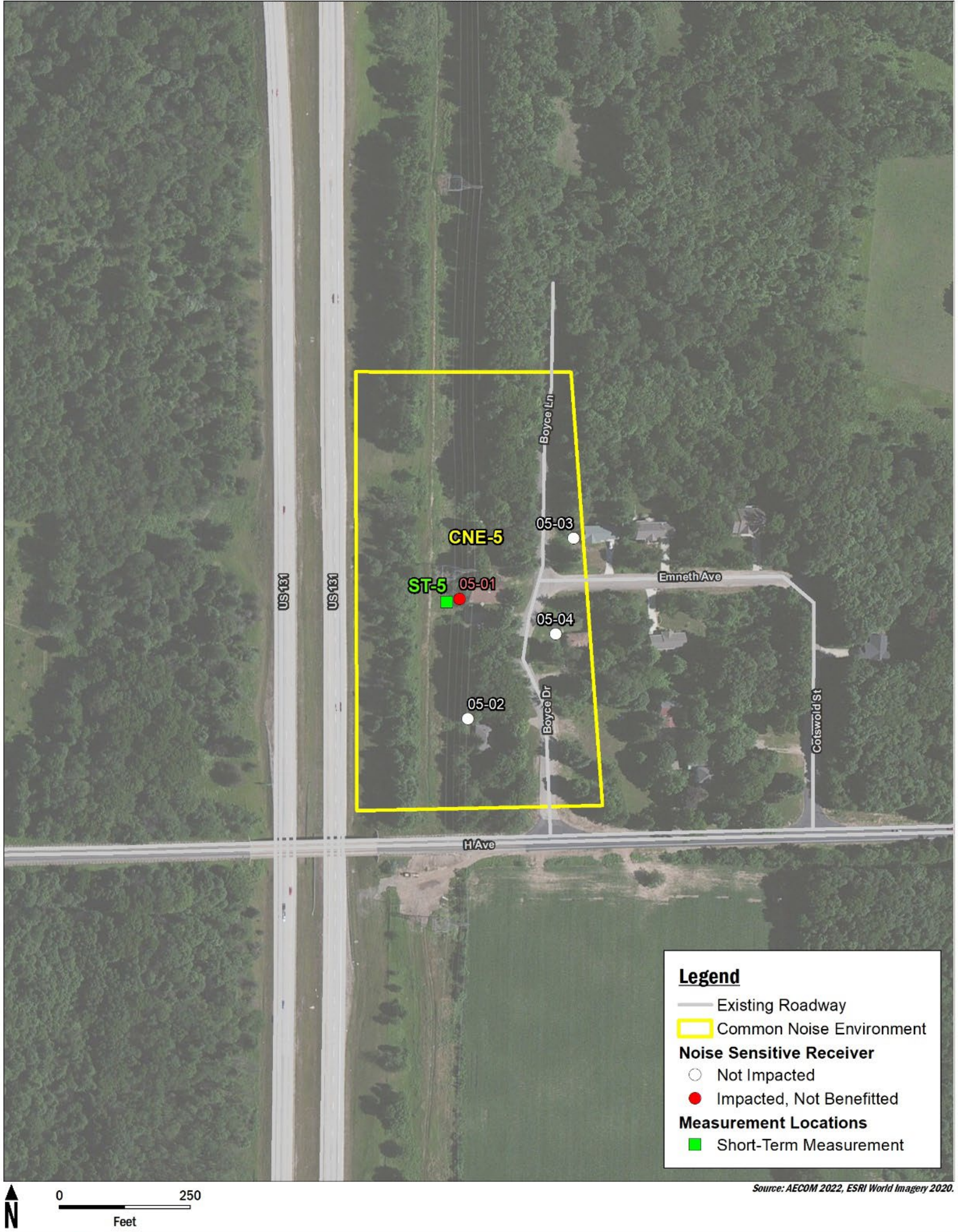


Source: AECOM 2022, ESRI World Imagery 2020.

Michigan Department of Transportation (MDOT)
MDOT US-131/131BR Interchange Improvements".
KALAMAZOO COUNTY, MI

Figure 5-4. Acoustical Analysis for CNE-5

AECOM Oakland CA 3/13/2023 **USER** hannah.duffy **PATH** \\na.aecomnet.com\lfs\AMER\SanDiego-USSDG1\DCS\GIS\Projects\60691792_MDOT_131_131BR\02_maps\02_Report_Maps\NoiseReport\FigX_CNE5.mxd



Source: AECOM 2022, ESRI World Imagery 2020.

Michigan Department of Transportation (MDOT)
MDOT US-131/131BR Interchange Improvements".
KALAMAZOO COUNTY, MI

6. Construction Noise Analysis

FHWA policy requires that construction noise be considered in a Type 1 highway noise analysis. This analysis would generally include the following:

1. Identification of land uses that may be affected by construction noise,
2. Determination of the measures needed in the plans and specifications to minimize or eliminate construction noise impacts; and,
3. Incorporate needed abatement into the plans and specifications.

Neither FHWA nor MDOT identify specific construction noise impact criteria. In addition, the detailed information necessary to predict actual construction noise levels (construction schedules, phasing, equipment lists, laydown areas, etc.) has not yet been determined. However, for this project, it is anticipated that pile driving and some nighttime construction work will be required.

It is recognized that areas adjacent to the highway right of way and other construction areas (such as staging areas and laydown sites) can temporarily be exposed to high levels of noise during peak construction periods. It is reasonable to assume that the same CNEs identified for potential traffic noise impacts could also be exposed to construction noise. The effect of the noise on the local area can be reduced if the hours and days of construction activity are limited to less sensitive time periods. The project construction standard noise specifications help minimize the effects of construction noise.

The following special provisions may be incorporated into the construction contract:

- Inform the local public in advance of construction activities that may generate particularly high noise levels (such as pile drivers) or periods of nighttime construction activity.
- Noise barriers approved for incorporation into the project should be constructed as close to the beginning of the project's construction timeline as practical.
- Noise created by truck movement shall not exceed 88 dBA at a distance of 50 feet.
- When working between 7:00 P.M. and 10:00 P.M., use “smart alarms” instead of standard reverse signal alarms or use spotters. When working between 10:00 P.M. and 7:00 A.M. use spotters instead of auditory alarms.
- Have portable noise meters on the job at all times for noise level spot checks on specific operations. Employ an individual trained in the use of noise meters, with working knowledge of sound measurements and their meaning and use as applied to these abatement/abatement measures.

7. Typical Construction Noise Levels

Table 7-1 contains a list of commonly used construction equipment and noise levels associated with using that equipment.

Table 7-1 Typical Construction Equipment Noise Levels

Equivalent Type	Lmax Ref dBA (50 feet)	AUF %
Auger Drill	84	20
Backhoe	78	40
Boring Jack Power Unit	83	50
Chain Saw	84	20
Compactor (ground)	83	20
Compressor (air)	78	40
Concrete Mixer Truck	79	40
Concrete Pump Truck	81	20
Concrete Saw	90	20
Crane	81	16
Dozer	82	40
Drill Rig Truck	79	20
Drum Mixer	80	50
Dump Truck	76	40
Excavator	81	40
Flat Bed Truck	74	40
Front End Loader	79	40
Generator (>25KVA)	81	50
Generator (<25KVA)	73	50
Gradall	83	40
Grader	85	40
Horizontal Boring Jack	82	25
Hoe Ram	90	20
Jackhammer	89	20
Man Lift	75	20
Pavement Scarafier	90	20
Paver	77	50
Pickup Truck	75	40
Pneumatic Tools	85	50
Pumps	81	50
Roller	80	20
Scraper	84	40
Shears (on backhoe)	96	40
Tractor	84	40
Vacuum Excavator	85	40
Vacuum Street Sweeper	82	10
Ventilating Fan	79	100
Vibrating Hopper	87	50
Vibratory Concrete Mixer	80	20
Warning Horn	83	5
Welder/Torch	74	40

Source: RCNM User Guide, Table 1 (actual measured Lmax)

8. Construction Noise Abatement Measures

Although MDOT does not identify any specific abatement measures related to construction noise, the following list could be considered best practices for the avoidance of any potential problems related to construction noise impacts:

- No construction shall be performed within 1,000 feet of an occupied dwelling unit on Sundays, legal holidays, or between the hours of 10 p.m. and 6 a.m. on other days without the approval of the MDOT construction project manager.
- All equipment used shall have sound-control devices no less effective than those provided on the original equipment. No equipment shall have unmuffled exhaust.
- All equipment shall comply with pertinent equipment noise standards of the U.S. Environmental Protection Agency.
- No pile driving or blasting operations shall be performed within 3,000 feet of an occupied dwelling unit on Sundays, legal holidays, or between the hours of 8 p.m. and 8 a.m. on other days without the approval of the MDOT construction project manager.
- The noise from rock crushing or screening operations performed within 3,000 feet of any occupied dwelling shall be mitigated by strategic placement of material stockpiles between the operation and the affected dwelling or by other means approved by the MDOT construction project manager.

If a specific noise impact complaint is received during construction of the project, the contractor may be required to implement one or more of the following noise abatement measures at the contractor’s expense, as directed by the construction project manager:

- Locate stationary construction equipment as far from nearby noise-sensitive properties as feasible.
- Shut off idling equipment.
- Reschedule construction operations to avoid periods of noise annoyance identified in the complaint.
- Notify nearby residents whenever extremely noisy work will be occurring.
- Install temporary or portable acoustic barriers around stationary construction noise sources.
- Operate electrically powered equipment using line voltage power or solar power.

9. Information for Local Government Officials

FHWA and MDOT policy specify that local officials should be provided appropriate information to assist with future compatible land use planning, especially regarding the planning and development of undeveloped lands near the proposed project right-of-way. Table 9-1 below provides potential noise impact distances for from the roadway pavement for future developments on undeveloped lands.

Table 9-1 Noise Impact Distances for Undeveloped Lands

Project Roadway	Distance from the Edge of Pavement (Feet)	
	71 dBA	**66 dBA**
US-131	110	185
US-131 BR	140	210

10. Conclusions and Recommendations

The noise analysis for the proposed project included a total of 6 short-term measurement locations and 233 predicted representative noise levels for 232 dwelling units in the project area. The project was split into five separate CNEs for noise impact analysis within the study area.

Four of the five of the CNEs contained receptors with predicted future noise levels approaching or exceeding the NAC. Noise abatement was not found to be feasible and reasonable as defined by MDOT policy. Therefore, no noise abatement is recommended for this project.

11. Statement of Likelihood

Based on the studies thus far accomplished, MDOT does not intend to install highway traffic noise abatement for this project. The preliminary noise abatement measures were based on preliminary roadway design, and design and costs for noise abatement as presented in Table 5-2 in this document. If roadway designs have substantially changed during the final design process, noise abatement measures may be re-evaluated.

12. References

Federal Highway Administration, 23 CFR 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 2010. https://www.fhwa.dot.gov/legsregs/directives/fapg/cfr0772.htm

Federal Highway Administration (FHWA). 2011. Highway Traffic Noise: Analysis and Abatement Guidance. U.S. Department of Transportation, Federal Highway Administration, Washington, DC. . https://www.fhwa.dot.gov/environment/noise/regulations_and_guidance/analysis_and_abatement_guidance/revguidance.pdf

Michigan Department of Transportation, Highway Noise Analysis and Abatement Handbook. July 13, 2011. https://www.michigan.gov/documents/mdot/MDOT_HighwayNoiseAnalysis_and_AbatementHandbook_358156_7.pdf

FHWA Noise Barrier Design Handbook, August 2017
https://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/design/design00.cfm

Appendix A Noise Measurement Data and Documentation

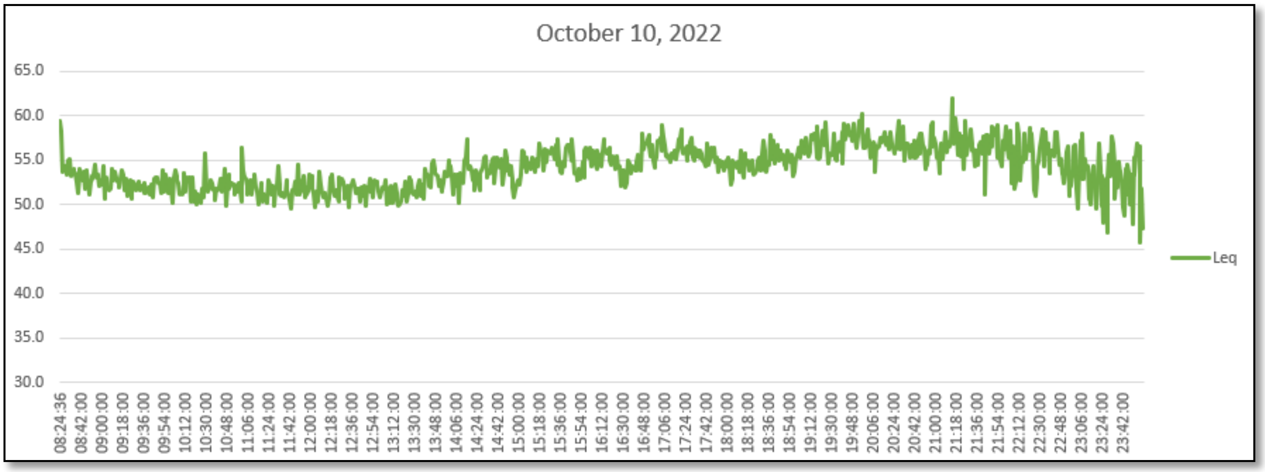
Appendix A contains the following noise measurement data and documentation:

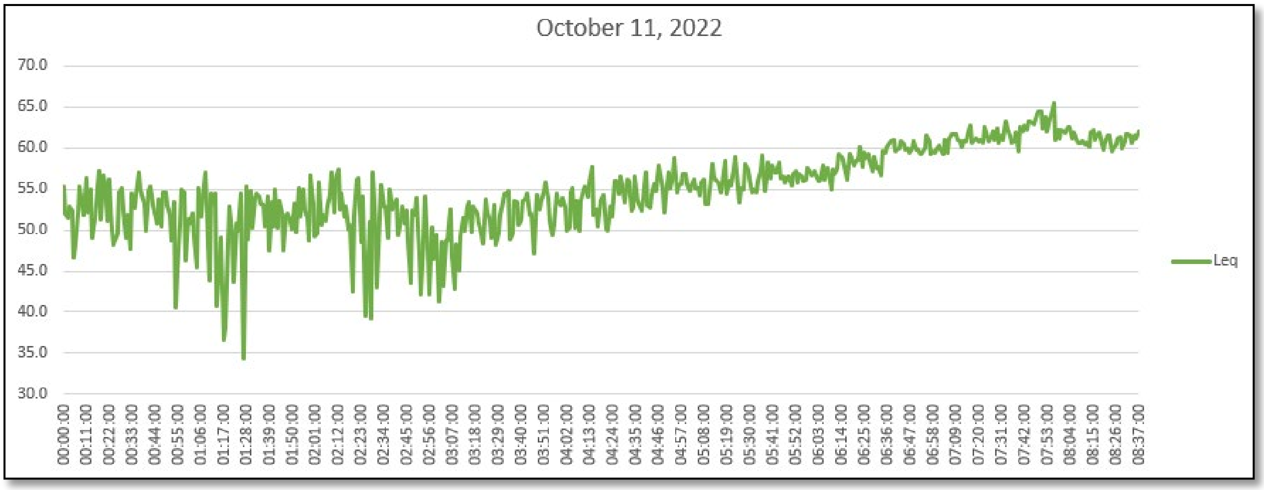
- Short-term Noise Measurement Summary Table
- Long-term Noise Measurement Summary Table
- Noise Measurement Photo Log
- Noise Measurement Field Data Sheets
- Noise Measurement Equipment Calibration Certificates

A.1 Short Term Measurement Summary

ID	*Location*	*Average Leq (dBA)*	*Leq Range (dBA)*	*Start (hh:mm)*	*Stop (hh:mm)*	*Duration (hh:mm)*
ST-1	5721 West GH Avenue	65.0	59.1-70.6	16:04	16:24	00:20
ST-2	Kalamazoo River Valley Trail	65.8	57.8-72.1	18:12	18:32	00:20
ST-3	Kalamazoo River Valley Trail	75.1	64.2-84.7	17:47	18:07	00:20
ST-4	4445 Ravine Rd	62.0	46.3-70.8	16:36	16:56	00:20
ST-5	3251 Boyce Dr	63.7	58.3-68.7	17:14	17:34	00:20

A.2 Long-Term Monitoring Summary





A.3 Noise Measurement Photo Log

Photo 1

Monitoring Site:

LT-1

Date Taken:

October 10, 2022

Camera Facing:

Northwest

Description:

View of the noise monitor set up towards the closest receptor.

Photo 2

Monitoring Site:

LT-1

Date Taken:

October 10, 2022

Camera Facing:

West

Description:

View of the noise monitor set up.

	**Photo 3** **Monitoring Site:** ST-1 **Date Taken:** October 10, 2022 **Camera Facing:** East **Description:** View toward project area.
	**Photo 4** **Monitoring Site:** ST-1 **Date Taken:** October 10, 2022 **Camera Facing:** North **Description:** View toward nearest noise-sensitive receptor.

<table>
<tr>
<td></td>
<td>Photo 5
Monitoring Site:
ST-2
Date Taken:
October 10, 2022
Camera Facing:
West
Description:
View toward nearest noise-sensitive receptor.</td>
</tr>
<tr>
<td></td>
<td>Photo 6
Monitoring Site:
ST-2
Date Taken:
October 10, 2022
Camera Facing:
East
Description:
View toward project area.</td>
</tr>
</table>

<table>
<tr>
<td></td>
<td>

Photo 7

Monitoring Site:
ST-3

Date Taken:
October 10, 2022

Camera Facing:
East

Description:
View toward project area.

</td>
</tr>
<tr>
<td></td>
<td>

Photo 8

Monitoring Site:
ST-3

Date Taken:
October 10, 2022

Camera Facing:
South

Description:
View toward nearest noise-sensitive receptor.

</td>
</tr>
</table>

Photo 9

Monitoring Site:
ST-4

Date Taken:
October 10, 2022

Camera Facing:
Northeast

Description:
View of noise meter

Photo 10

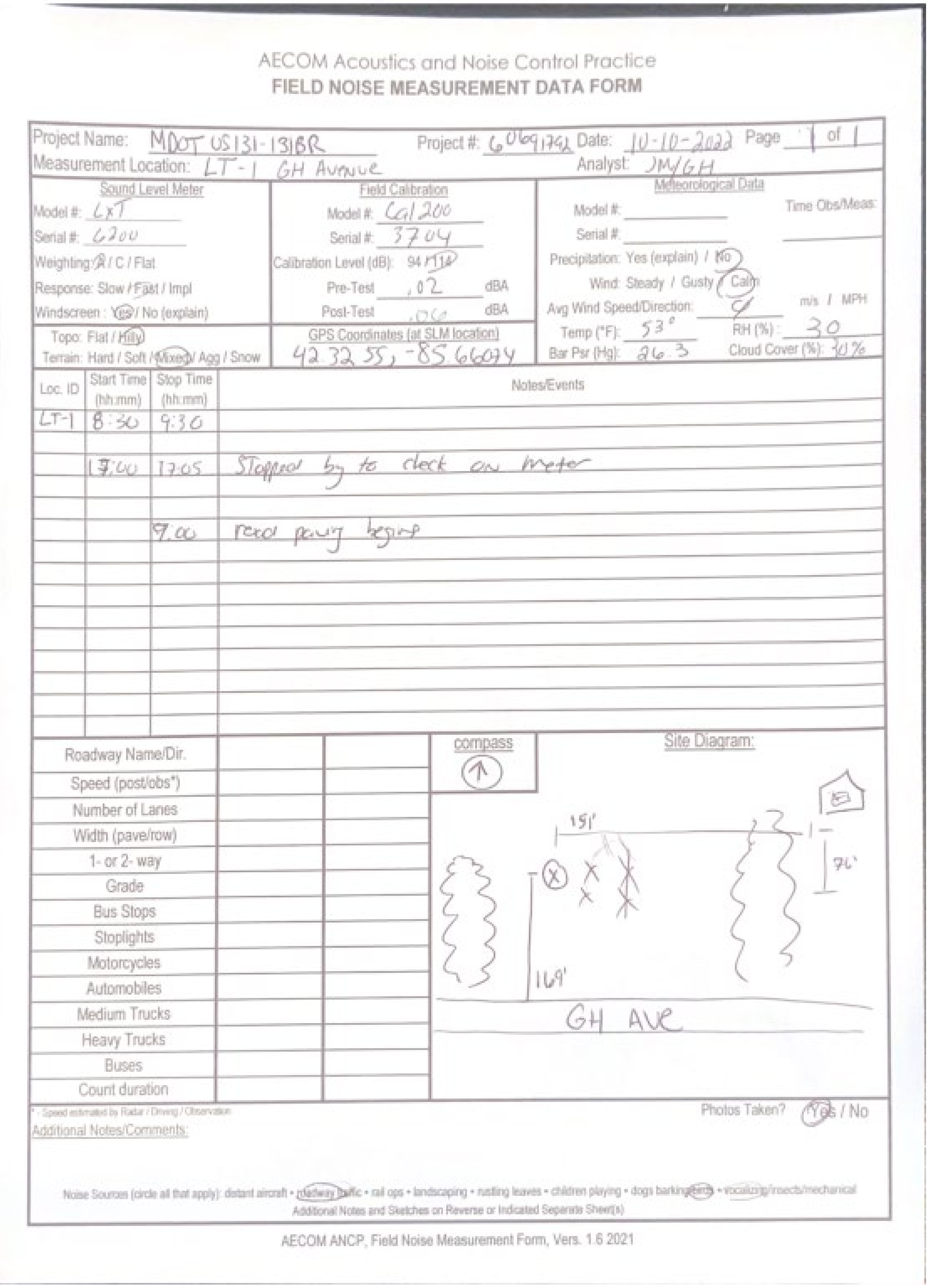
Monitoring Site:
ST-5

Date Taken:
October 10, 2022

Camera Facing:
East

Description:
View toward nearest noise-sensitive receptor.

A.4 Field Sheets



AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US131-131BR Project #: 60691792 Date: 10-10-2022 Page 1 of 1

Measurement Location: LT-1 GH Avenue Analyst: JM/GH

Sound Level Meter

Model #: LxT

Serial #: 6200

Weighting: [✓ A] / C / Flat

Response: Slow / [✓ Fast] / Impl

Windscreen : [✓ Yes] / No (explain)

Topo: Flat / [✓ Hilly]

Terrain: Hard / Soft / [✓ Mixed] / Agg / Snow

Field Calibration

Model #: Cal200

Serial #: 3704

Calibration Level (dB): 94 / [✓ 114]

Pre-Test .02 dBA

Post-Test .06 dBA

GPS Coordinates (at SLM location)

42.3255, -85.66074

Meteorological Data

Model #: ____

Serial #: ____

Time Obs/Meas: ____

Precipitation: Yes (explain) / [✓ No]

Wind: Steady / Gusty / [✓ Calm]

Avg Wind Speed/Direction: 0 m/s / MPH

Temp (°F): 53°

RH (%): 30

Bar Psr (Hg): 26.3

Cloud Cover (%): 10%

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
LT-1	8:30	9:30	
	17:00	17:05	Stopped by to check on meter
		9:00	road paving begins

Roadway Name/Dir.		
Speed (post/obs*)		
Number of Lanes		
Width (pave/row)		
1- or 2- way		
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:

* - Speed estimated by Radar / Driving / Observation

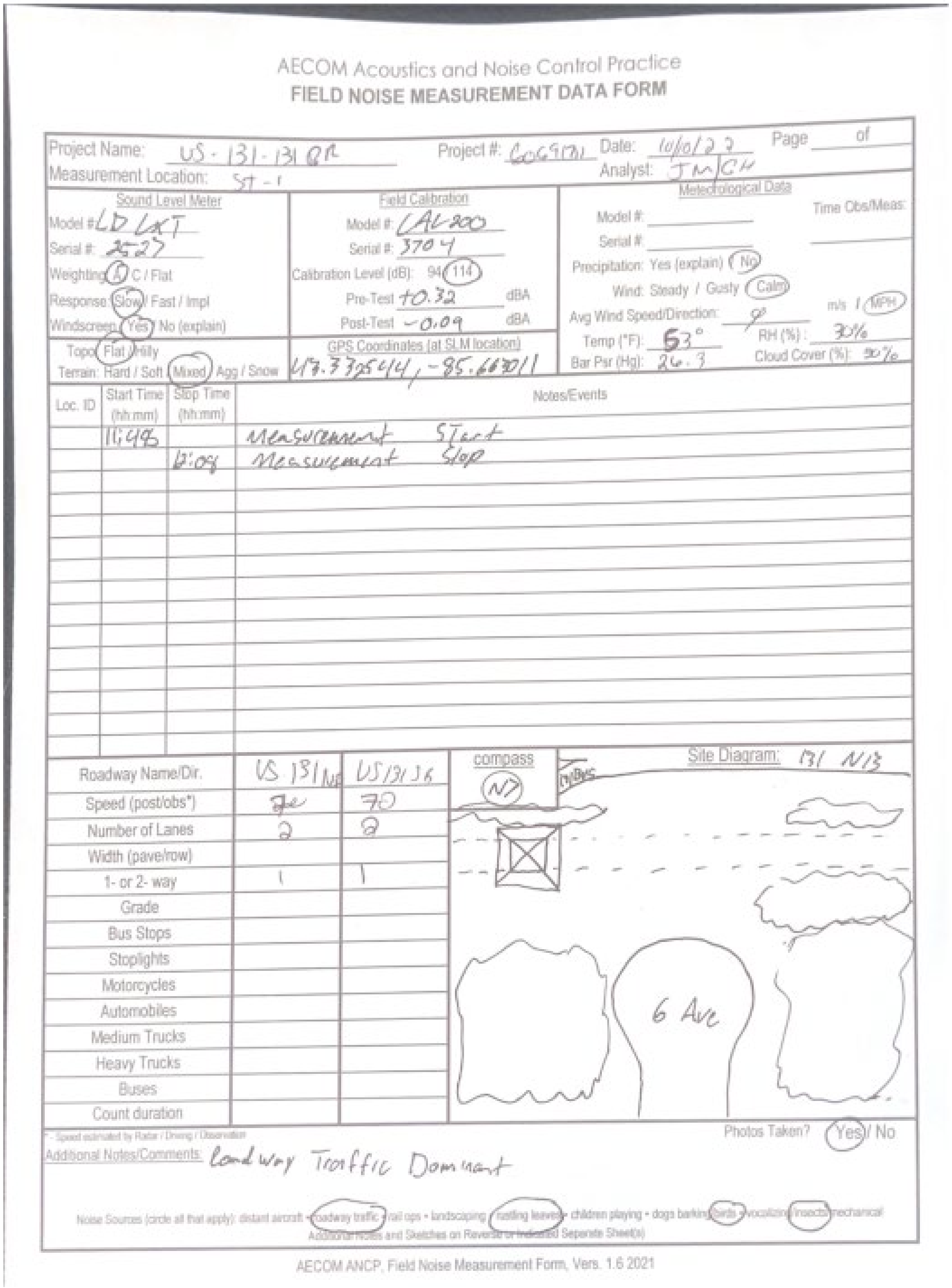
Photos Taken? [✓ Yes] / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • rustling leaves • children playing • dogs barking • [✓ birds] • vocalizing/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.6 2021



AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: US-131-131 BR
Project #: 6069171
Date: 10/10/22
Page ___ of ___
Measurement Location: ST-1
Analyst: JM/CH

Sound Level Meter

Model #: LD LxT
Serial #: 2527
Weighting: [✓ A] / C / Flat
Response: [✓ Slow] / Fast / Impl
Windscreen: [✓ Yes] / No (explain)

Field Calibration

Model #: CAL200
Serial #: 3704
Calibration Level (dB): 94 / [✓ 114]
Pre-Test +0.32 dBA
Post-Test -0.09 dBA

Meteorological Data

Model #:
Serial #:
Time Obs/Meas:
Precipitation: Yes (explain) / [✓ No]
Wind: Steady / Gusty / [✓ Calm]
Avg Wind Speed/Direction: 9 m/s / [✓ MPH]
Temp (°F): 53°
RH (%): 30%
Bar Psr (Hg): 26.3
Cloud Cover (%): 90%

Topo: [✓ Flat] / Hilly
Terrain: Hard / Soft / [✓ Mixed] / Agg / Snow

GPS Coordinates (at SLM location): 43.335444, -85.667011

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	11:48		Measurement Start
		12:08	Measurement Stop

Roadway Name/Dir.	US 131 NB	US 131 SB
Speed (post/obs*)	70	70
Number of Lanes	2	2
Width (pave/row)		
1- or 2- way	1	1
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram: 131 N/B

* - Speed estimated by Radar / Driving / Observation

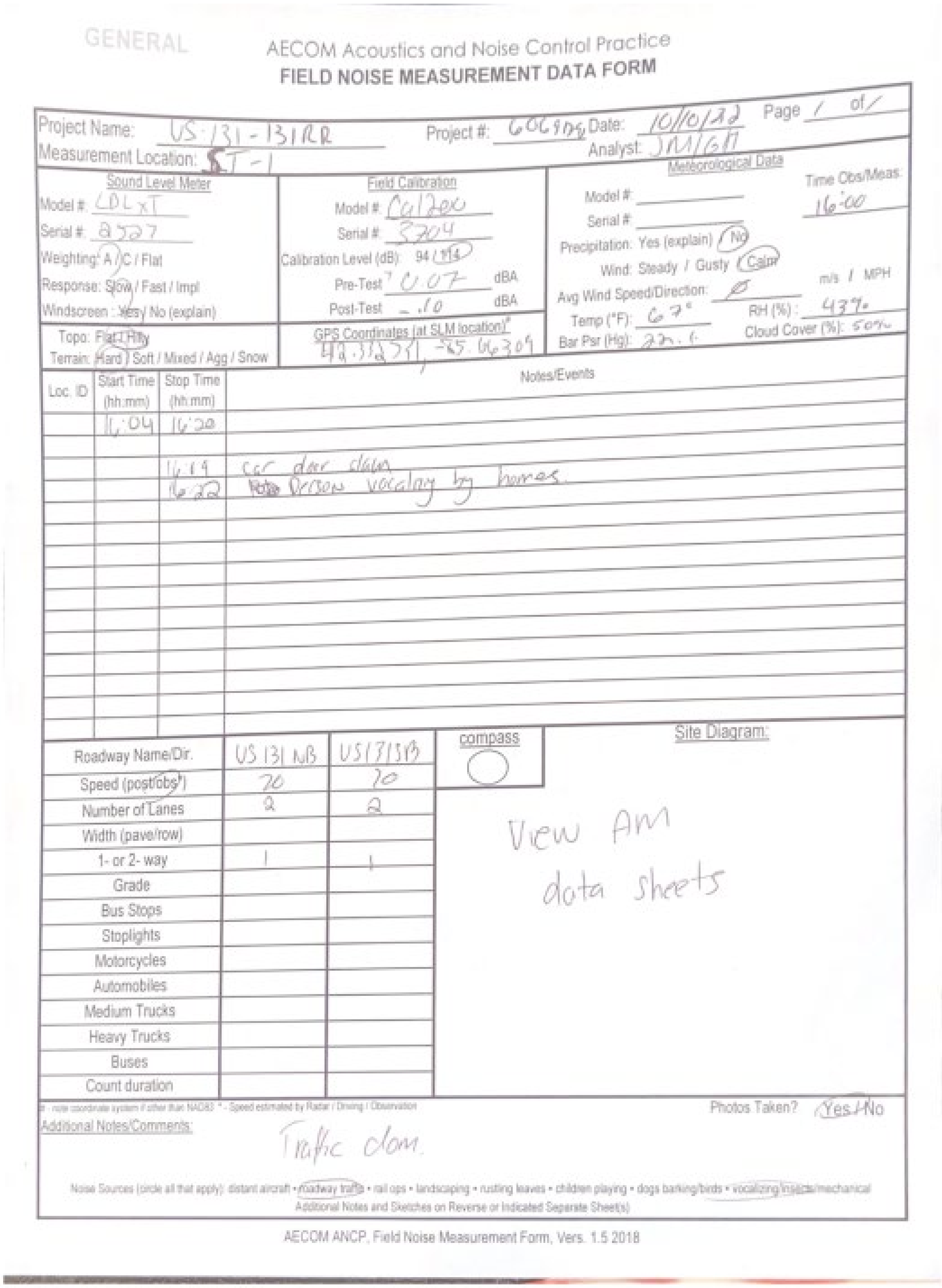
Photos Taken? [✓ Yes] / No

Additional Notes/Comments: Roadway Traffic Dominant

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • [✓ rustling leaves] • children playing • dogs barking • [✓ birds] • vocalizing • [✓ insects] • mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.6 2021



GENERAL

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: US-131-131BR Project #: 606905 Date: 10/10/22 Page 1 of 1
Measurement Location: ST-1 Analyst: JM/GH

Sound Level Meter
Model #: LDL xT
Serial #: 2527
Weighting: [✓ A] / C / Flat
Response: [✓ Slow] / Fast / Impl
Windscreen: [✓ Yes] / No (explain)

Field Calibration
Model #: Cal200
Serial #: 3704
Calibration Level (dB): 94 / [✓ 114]
Pre-Test 0.07 dBA
Post-Test -.10 dBA

Meteorological Data
Model #:
Serial #:
Time Obs/Meas: 16:00
Precipitation: Yes (explain) [✓ No]
Wind: Steady / Gusty [✓ Calm]
Avg Wind Speed/Direction: 0 m/s / MPH
Temp (°F): 67°
RH (%): 43%
Bar Psr (Hg): 29.1
Cloud Cover (%): 50%

Topo: Flat / Hilly
Terrain: [✓ Hard] / Soft / Mixed / Agg / Snow

GPS Coordinates (at SLM location)#: 42.31231, -85.66309

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	16:04	16:20	
		16:19	car door slam
		16:22	person vocalizing by homes.

Roadway Name/Dir.	US 131 NB	US 131 SB
Speed (post/[✓ obs]*)	70	70
Number of Lanes	2	2
Width (pave/row)		
1- or 2- way	1	1
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:

View AM data sheets

- note coordinate system if other than NAD83 * - Speed estimated by Radar / Driving / Observation

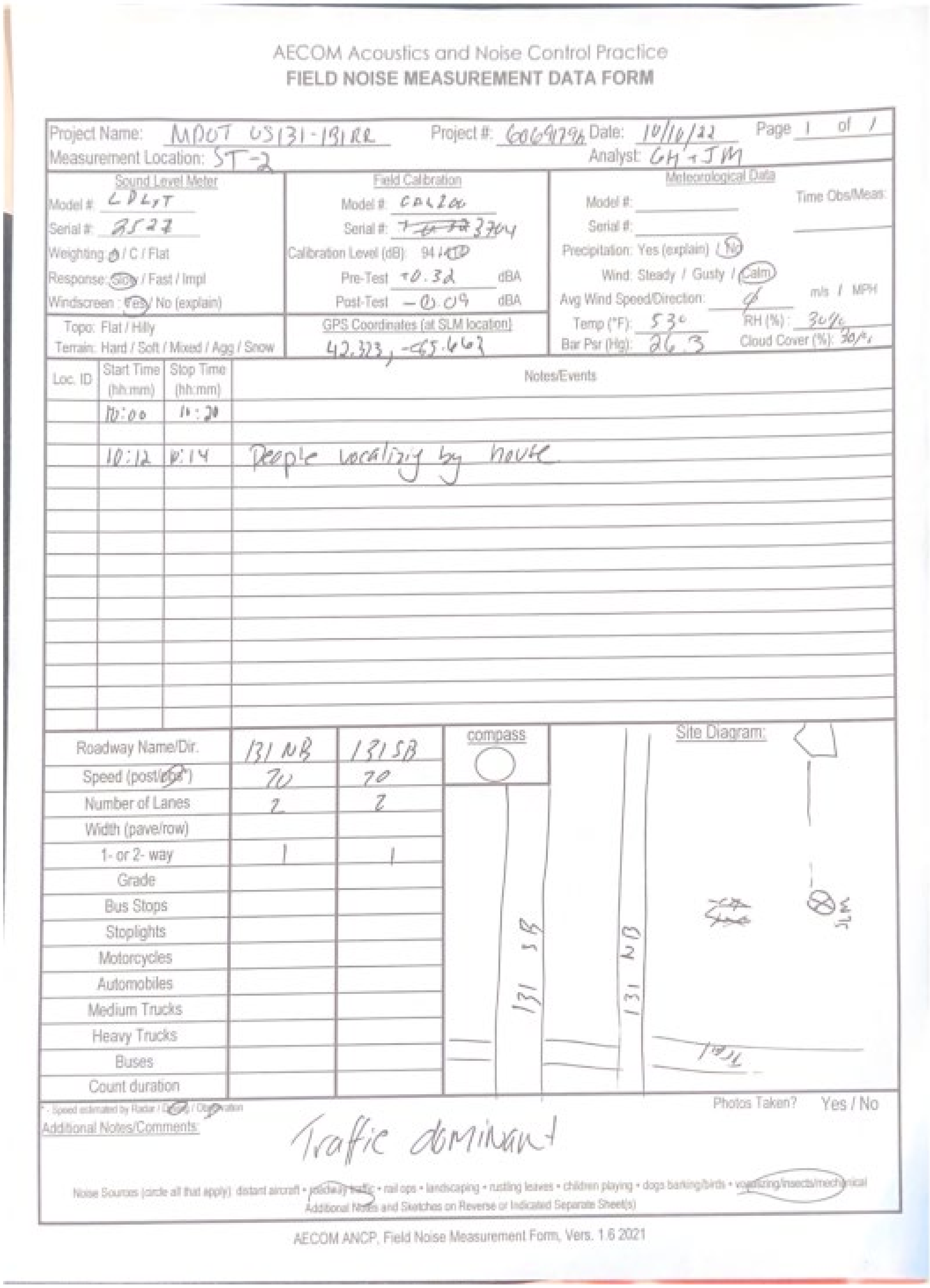
Photos Taken? [✓ Yes] / No

Additional Notes/Comments:

Traffic dom.

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • rustling leaves • children playing • dogs barking/birds • [✓ vocalizing/insects]/mechanical
Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.5 2018



AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US131-131BR Project #: 60691792 Date: 10/10/22 Page 1 of 1

Measurement Location: ST-2 Analyst: GH + JM

Sound Level Meter

Model #: LDLxT

Serial #: 2527

Weighting: [✓ A] / C / Flat

Response: [✓ Slow] / Fast / Impl

Windscreen: [✓ Yes] / No (explain)

Field Calibration

Model #: CAL200

Serial #: ~~7-6-73~~ 3704

Calibration Level (dB): 94 / 114

Pre-Test +0.32 dBA

Post-Test −0.09 dBA

Meteorological Data

Model #:

Serial #:

Time Obs/Meas:

Precipitation: Yes (explain) [✓ No]

Wind: Steady / Gusty / [✓ Calm]

Avg Wind Speed/Direction: 0 m/s / MPH

Temp (°F): 53°

RH (%): 30%

Bar Psr (Hg): 26.3

Cloud Cover (%): 30%

Topo: Flat / Hilly

Terrain: Hard / Soft / Mixed / Agg / Snow

GPS Coordinates (at SLM location)

42.323, -85.663

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	10:00	10:20	
	10:12	10:14	People vocalizing by house

Roadway Name/Dir.	131 NB	131 SB
Speed (post/[✓ est*])	70	70
Number of Lanes	2	2
Width (pave/row)		
1- or 2- way	1	1
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:

* - Speed estimated by Radar / [✓ Driving] / [✓ Observation]

Photos Taken? Yes / No

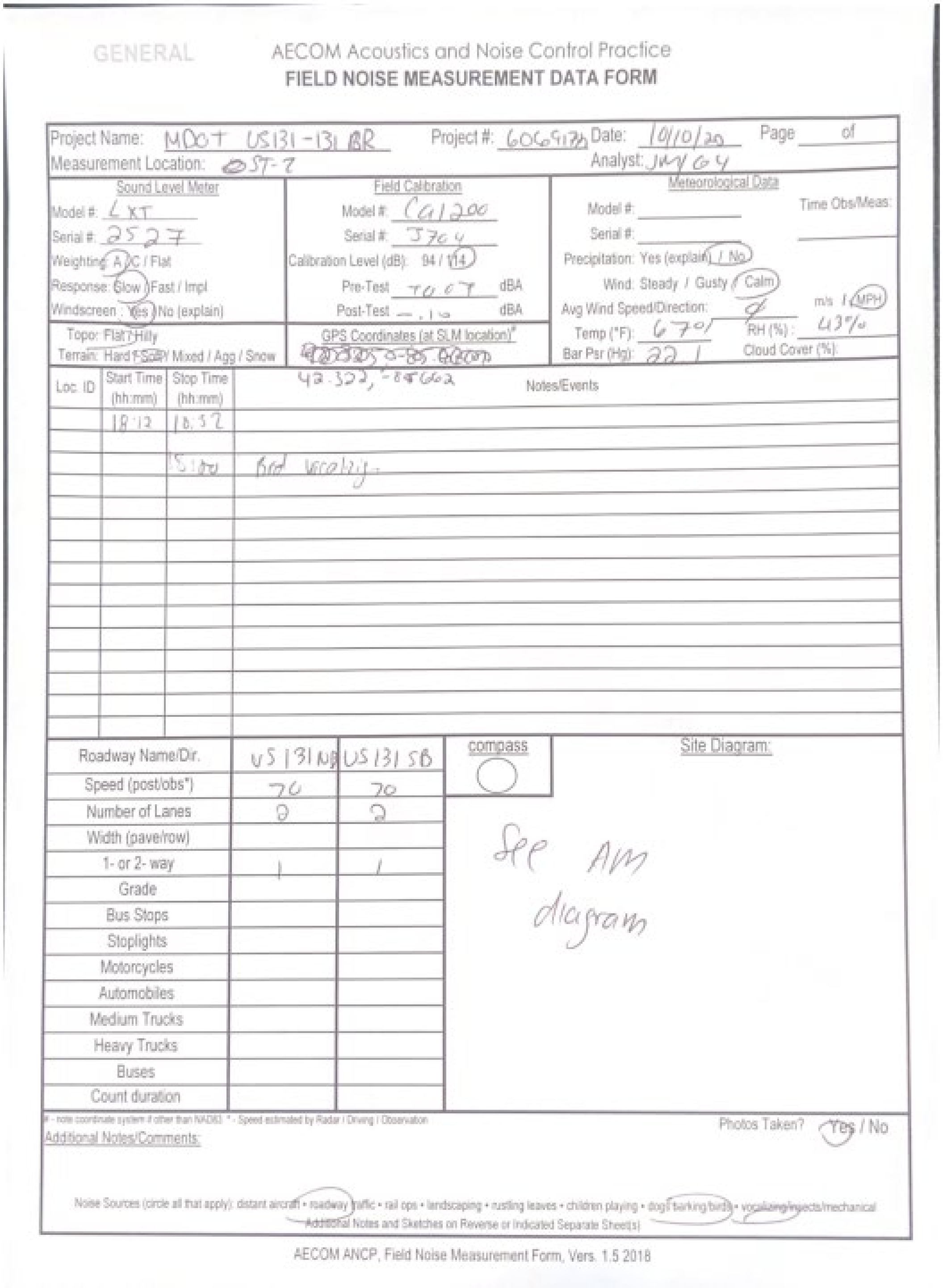
Additional Notes/Comments:

Traffic dominant

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • rustling leaves • children playing • dogs barking/birds • [✓ vocalizing/insects/mechanical]

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.6 2021



GENERAL

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US131-131 BR Project #: 6069179 Date: 10/10/20 Page ___ of ___

Measurement Location: ST-7 Analyst: JMY GY

Sound Level Meter

Model #: LXT

Serial #: 2527

Weighting: [✓ A] / C / Flat

Response: [✓ Slow] / Fast / Impl

Windscreen: [✓ Yes] / No (explain)

Topo: [✓ Flat] / Hilly

Terrain: Hard / [✓ Soft] / Mixed / Agg / Snow

Field Calibration

Model #: Cal200

Serial #: J704

Calibration Level (dB): 94 / [✓ 114]

Pre-Test 7007 dBA

Post-Test -.10 dBA

GPS Coordinates (at SLM location)#

42.322, -85662

Meteorological Data

Model #: ___

Serial #: ___

Time Obs/Meas: ___

Precipitation: Yes (explain) / [✓ No]

Wind: Steady / Gusty / [✓ Calm]

Avg Wind Speed/Direction: 0 m/s / [✓ MPH]

Temp (°F): 67°F

RH (%): 43%

Bar Psr (Hg): 22.1

Cloud Cover (%):

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	18:12	18:32	
		15:00	Bird vocalizing

Roadway Name/Dir.	US 131 NB	US 131 SB	compass
Speed (post/obs*)	70	70	
Number of Lanes	2	2	
Width (pave/row)			
1- or 2- way	1	1	
Grade			
Bus Stops			
Stoplights			
Motorcycles			
Automobiles			
Medium Trucks			
Heavy Trucks			
Buses			
Count duration			

Site Diagram:

See AM diagram

- note coordinate system if other than NAD83 * - Speed estimated by Radar / Driving / Observation

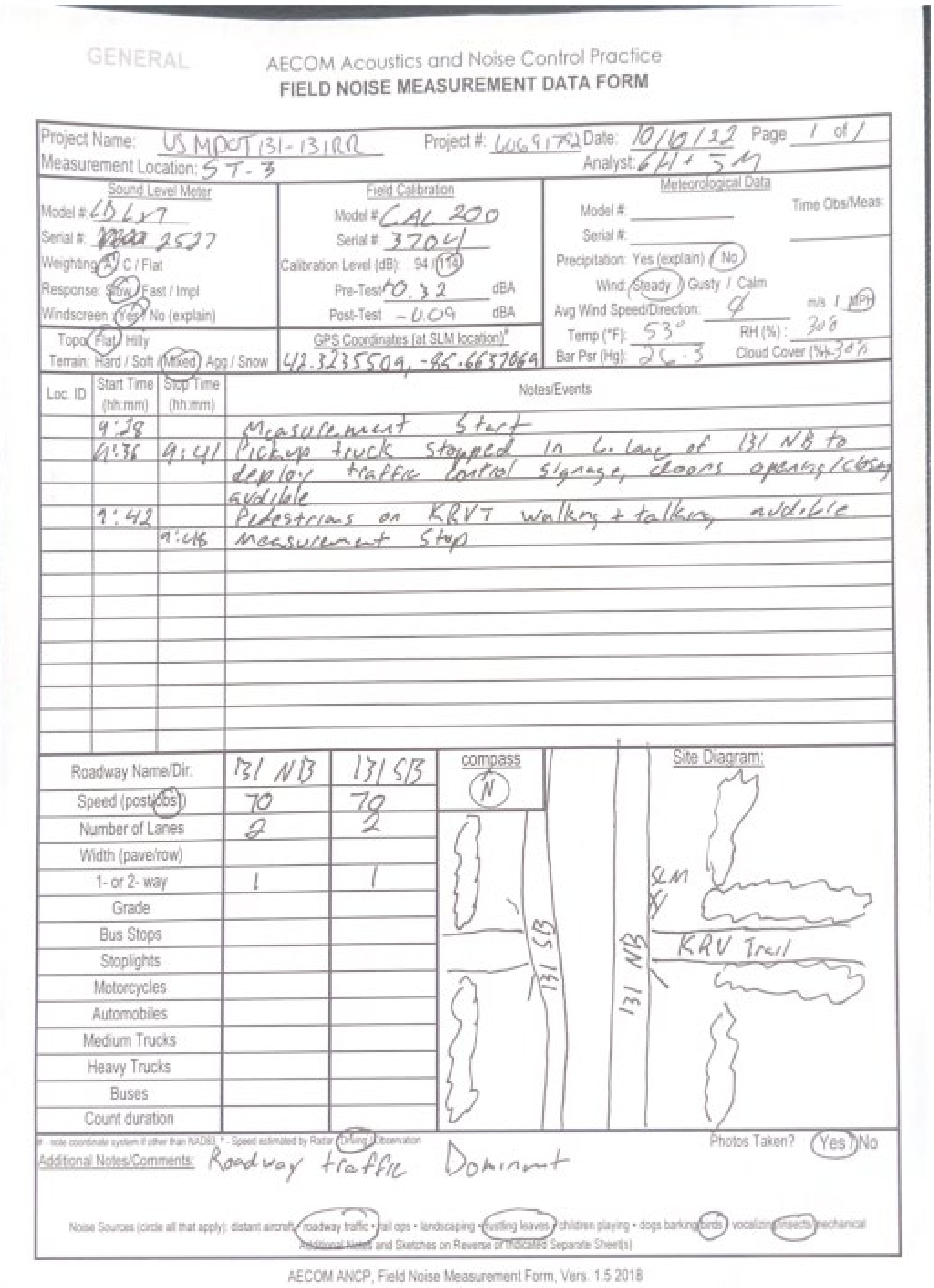
Photos Taken? [✓ Yes] / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • rustling leaves • children playing • dogs barking/[✓ birds] • [✓ vocalizing]/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.5 2018



GENERAL

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: US MDOT 131-131BR Project #: 60691792 Date: 10/10/22 Page 1 of 1

Measurement Location: ST-3 Analyst: GH + SM

Sound Level Meter

Model #: LD LxT

Serial #: 2527

Weighting: [✓ A] / C / Flat

Response: [✓ Slow] / Fast / Impl

Windscreen: [✓ Yes] / No (explain)

Topo: [✓ Flat] / Hilly

Terrain: Hard / Soft / [✓ Mixed] / Agg / Snow

Field Calibration

Model #: CAL 200

Serial #: 3704

Calibration Level (dB): 94 / [✓ 114]

Pre-Test: +0.32 dBA

Post-Test: -0.09 dBA

GPS Coordinates (at SLM location)#: 42.3235509, -85.6637064

Meteorological Data

Model #:

Serial #:

Time Obs/Meas:

Precipitation: Yes (explain) / [✓ No]

Wind: [✓ Steady] / Gusty / Calm

Avg Wind Speed/Direction: 9 m/s / [✓ MPH]

Temp (°F): 53°

RH (%): 30%

Bar Psr (Hg): 26.3

Cloud Cover (%): 30%

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	9:28		Measurement Start
	9:36	9:41	Pickup truck stopped in L. lane of 131 NB to deploy traffic control signage, doors opening/closing audible
	9:42		Pedestrians on KRVT walking + talking, audible
		9:46	Measurement Stop

Roadway Name/Dir.	131 NB	131 SB
Speed (post/[✓ obs]*)	70	70
Number of Lanes	2	2
Width (pave/row)		
1- or 2- way	1	1
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:

- note coordinate system if other than NAD83, * - Speed estimated by Radar / [✓ Driving] / Observation

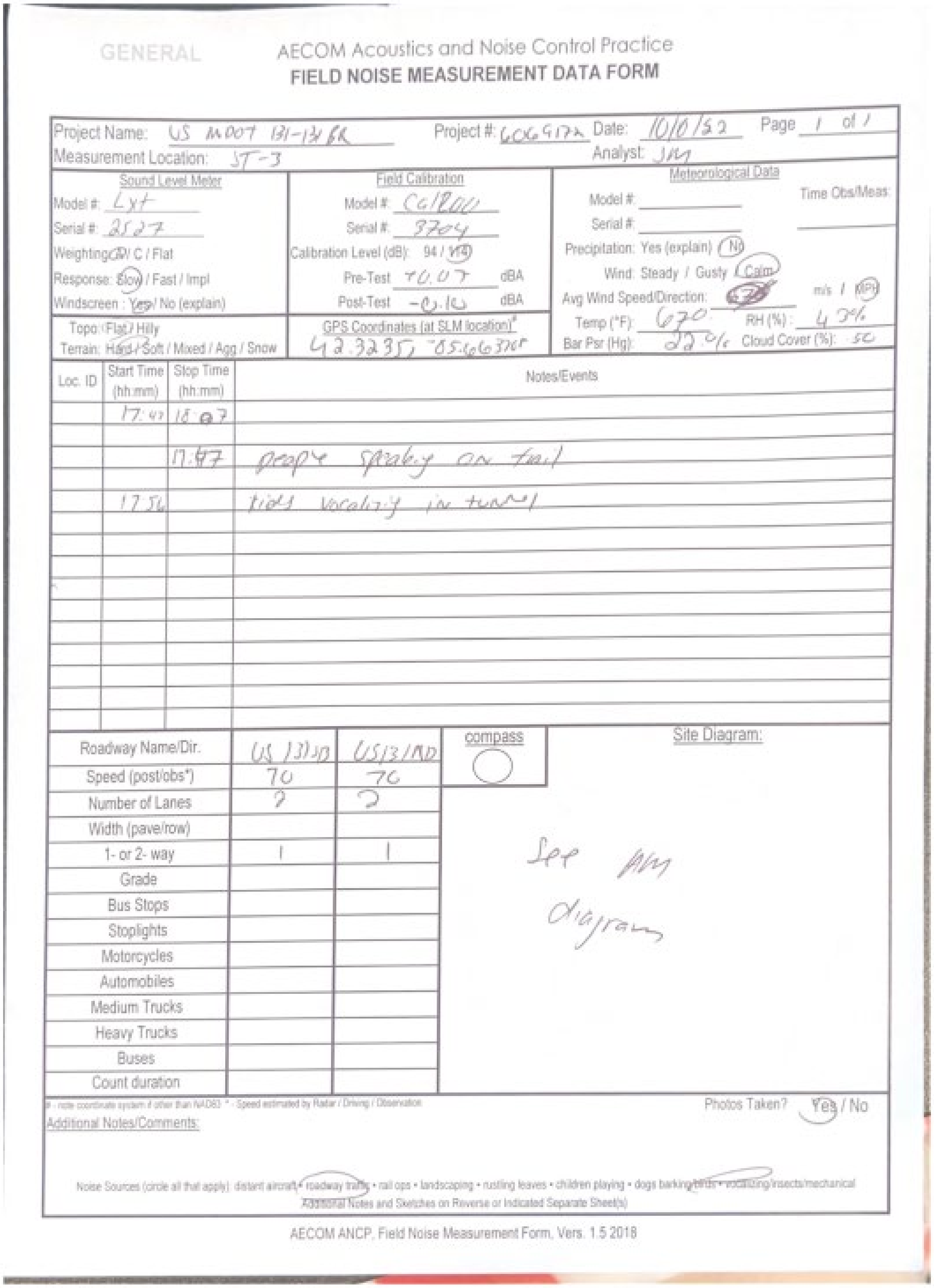
Photos Taken? [✓ Yes] / No

Additional Notes/Comments: Roadway traffic Dominant

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • [✓ rustling leaves] • children playing • dogs barking • [✓ birds] • vocalizing • [✓ insects] • mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.5 2018



GENERAL

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: US MDOT 131-131 BR Project #: 6069172 Date: 10/10/22 Page 1 of 1

Measurement Location: ST-3 Analyst: JM

Sound Level Meter

Model #: Lxt

Serial #: 2527

Weighting: [✓ A] / C / Flat

Response: [✓ Slow] / Fast / Impl

Windscreen : [✓ Yes] / No (explain)

Topo: [✓ Flat] / Hilly

Terrain: [✓ Hard] / Soft / Mixed / Agg / Snow

Field Calibration

Model #: CAL200

Serial #: 3704

Calibration Level (dB): 94 / [✓ 114]

Pre-Test +0.07 dBA

Post-Test -0.10 dBA

GPS Coordinates (at SLM location)#

42.3235, -85.663768

Meteorological Data

Model #:

Serial #:

Time Obs/Meas:

Precipitation: Yes (explain) [✓ No]

Wind: Steady / Gusty / [✓ Calm]

Avg Wind Speed/Direction: m/s / [✓ MPH]

Temp (°F): 67°

RH (%): 49%

Bar Psr (Hg): 29.96

Cloud Cover (%): 50

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	17:47	18:07	
		17:47	people speaking on trail
	17:56		birds vocalizing in tunnel

Roadway Name/Dir.	US 131 SB	US131 NB
Speed (post/obs*)	70	70
Number of Lanes	2	2
Width (pave/row)		
1- or 2- way	1	1
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:

See AM diagram

- note coordinate system if other than NAD83 * - Speed estimated by Radar / Driving / Observation

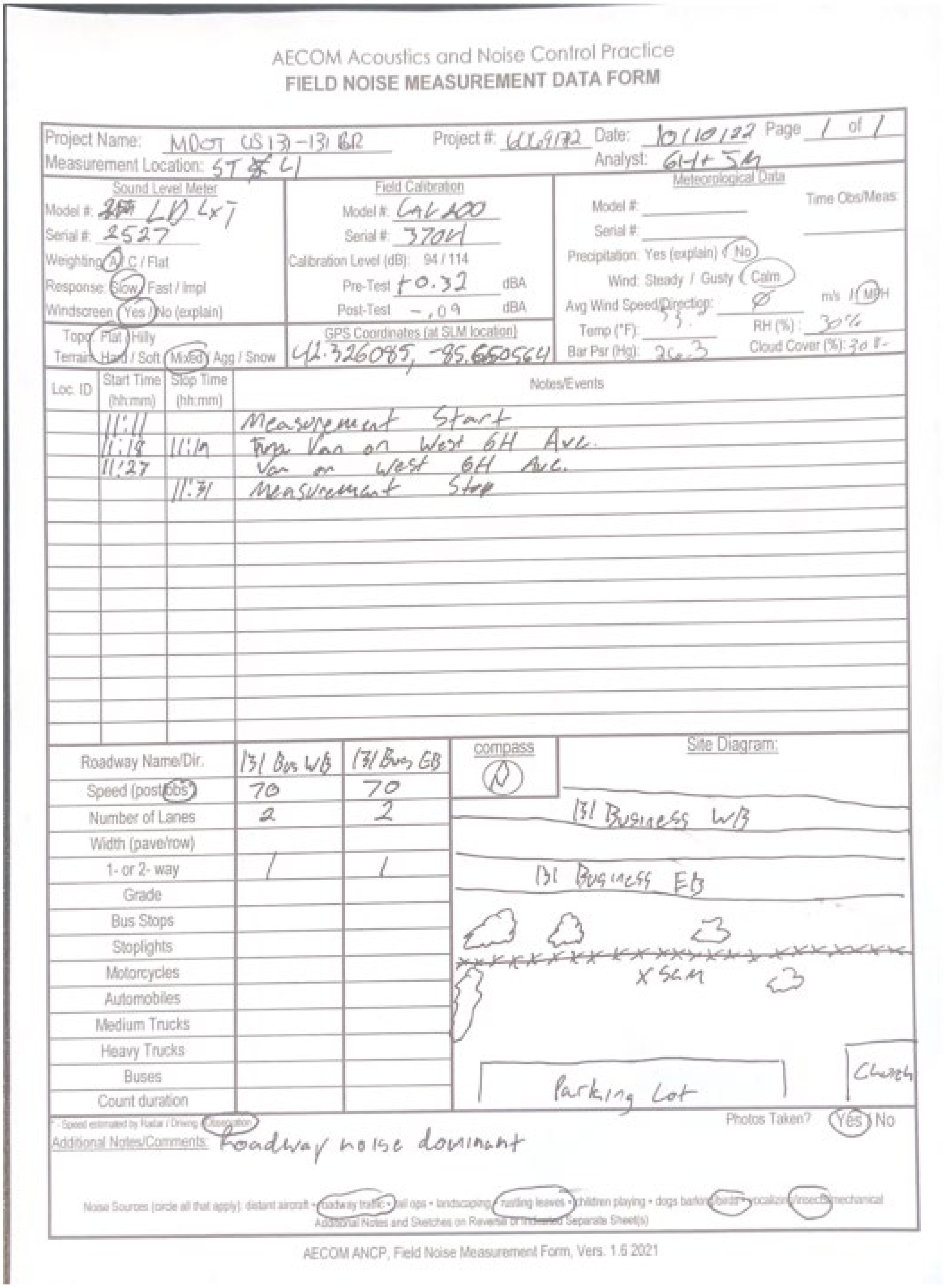
Photos Taken? [✓ Yes] / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • rustling leaves • children playing • dogs barking/[✓ birds • vocalizing]/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.5 2018



AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US131-131 BR
Project #: 60691792
Date: 10/10/22
Page 1 of 1
Measurement Location: ST ~~#~~ 41
Analyst: GH + SM

Sound Level Meter

Model #: ~~2[illegible]~~ LD LxT
Serial #: 2527
Weighting: [✓ A] / C / Flat
Response: [✓ Slow] / Fast / Impl
Windscreen: [✓ Yes] / No (explain)
Topo: [✓ Flat] / Hilly
Terrain: Hard / Soft / [✓ Mixed] / Agg / Snow

Field Calibration

Model #: CAL200
Serial #: 3704
Calibration Level (dB): 94 / 114
Pre-Test +0.32 dBA
Post-Test -.09 dBA

GPS Coordinates (at SLM location): 42.326095, -85.650564

Meteorological Data

Model #:
Serial #:
Time Obs/Meas:
Precipitation: Yes (explain) / [✓ No]
Wind: Steady / Gusty / [✓ Calm]
Avg Wind Speed/Direction: 0 m/s / [✓ MPH]
Temp (°F): 55.
RH (%): 30%
Bar Psr (Hg): 26.3
Cloud Cover (%): 20 %

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	11:11		Measurement Start
	11:18	11:19	Tuya Van on West 6H Ave.
	11:27		Van on West 6H Ave.
		11:31	Measurement Stop

Roadway Name/Dir.	131 Bus WB	131 Bus EB
Speed (post/[✓ obs]*)	70	70
Number of Lanes	2	2
Width (pave/row)		
1- or 2- way	1	1
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:

* - Speed estimated by Radar / Driving / [✓ Observation]

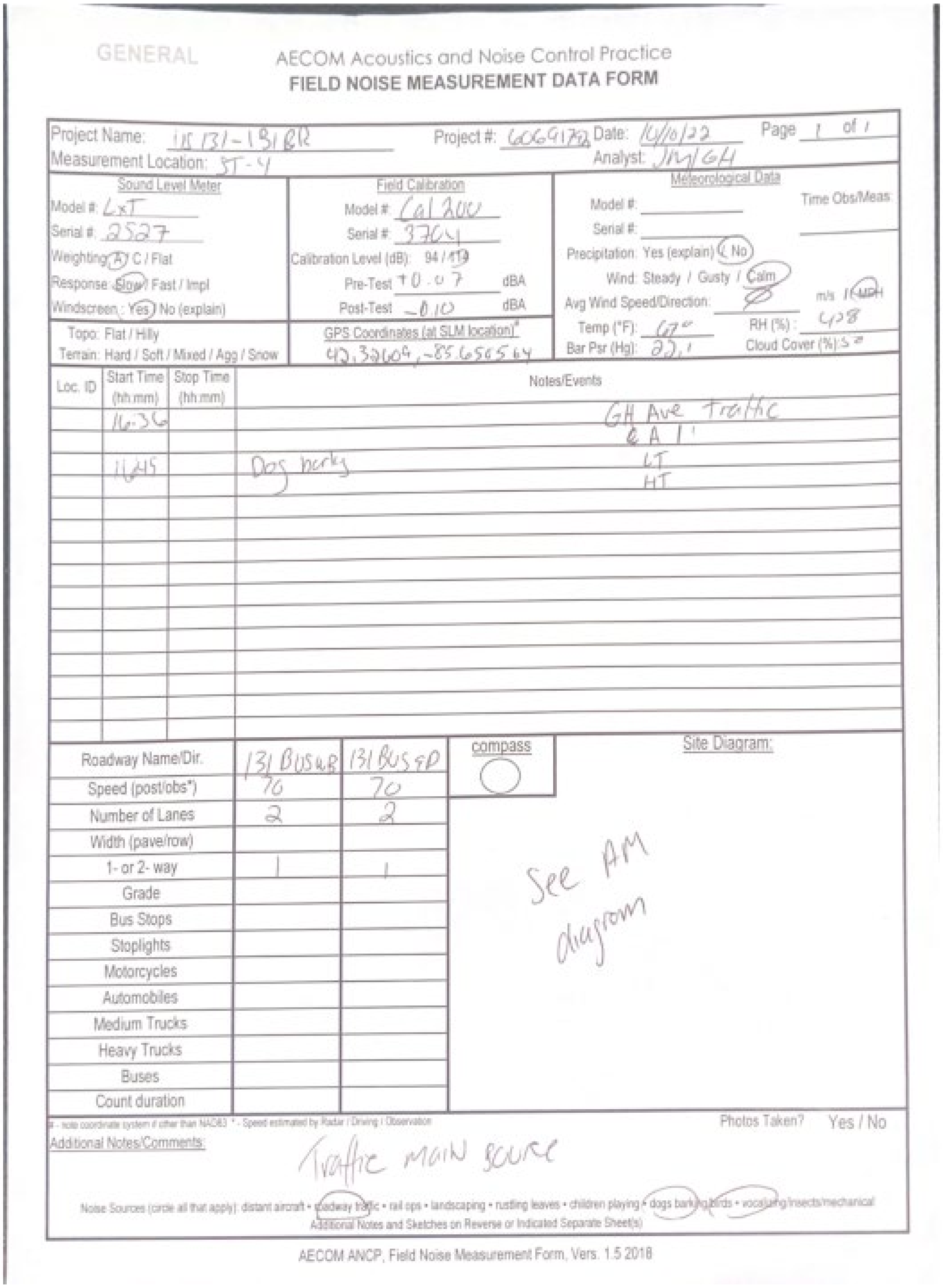
Photos Taken? [✓ Yes] No

Additional Notes/Comments: Roadway noise dominant

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • [✓ rustling leaves] • children playing • dogs barking • [✓ birds] • vocalizing • [✓ insects] • mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.6 2021



GENERAL

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: US 131-131 BR
Project #: 6069179Z
Date: 11/10/22
Page 1 of 1
Measurement Location: ST-4
Analyst: JM/GH

Sound Level Meter

Model #: LxT
Serial #: 2527
Weighting: [✓ A] / C / Flat
Response: [✓ Slow] / Fast / Impl
Windscreen: [✓ Yes] / No (explain)

Topo: Flat / Hilly
Terrain: Hard / Soft / Mixed / Agg / Snow

Field Calibration

Model #: Cal 200
Serial #: 3704
Calibration Level (dB): 94 / [✓ 114]
Pre-Test +0.07 dBA
Post-Test -0.10 dBA

GPS Coordinates (at SLM location)#
42.32604, -85.656564

Meteorological Data

Model #:
Serial #:
Time Obs/Meas
Precipitation: Yes (explain) / [✓ No]
Wind: Steady / Gusty / [✓ Calm]
Avg Wind Speed/Direction: 0 m/s / [✓ MPH]
Temp (°F): 67°
RH (%): 48
Bar Psr (Hg): 22.1
Cloud Cover (%): 50

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	16:36		GH Ave Traffic
			& A 1'
	11:45		Dog barks LT
			HT

Roadway Name/Dir.	131 Bus NB	131 Bus SB
Speed (post/obs*)	70	70
Number of Lanes	2	2
Width (pave/row)		
1- or 2- way	1	1
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:

See AM diagram

- note coordinate system if other than NAD83 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

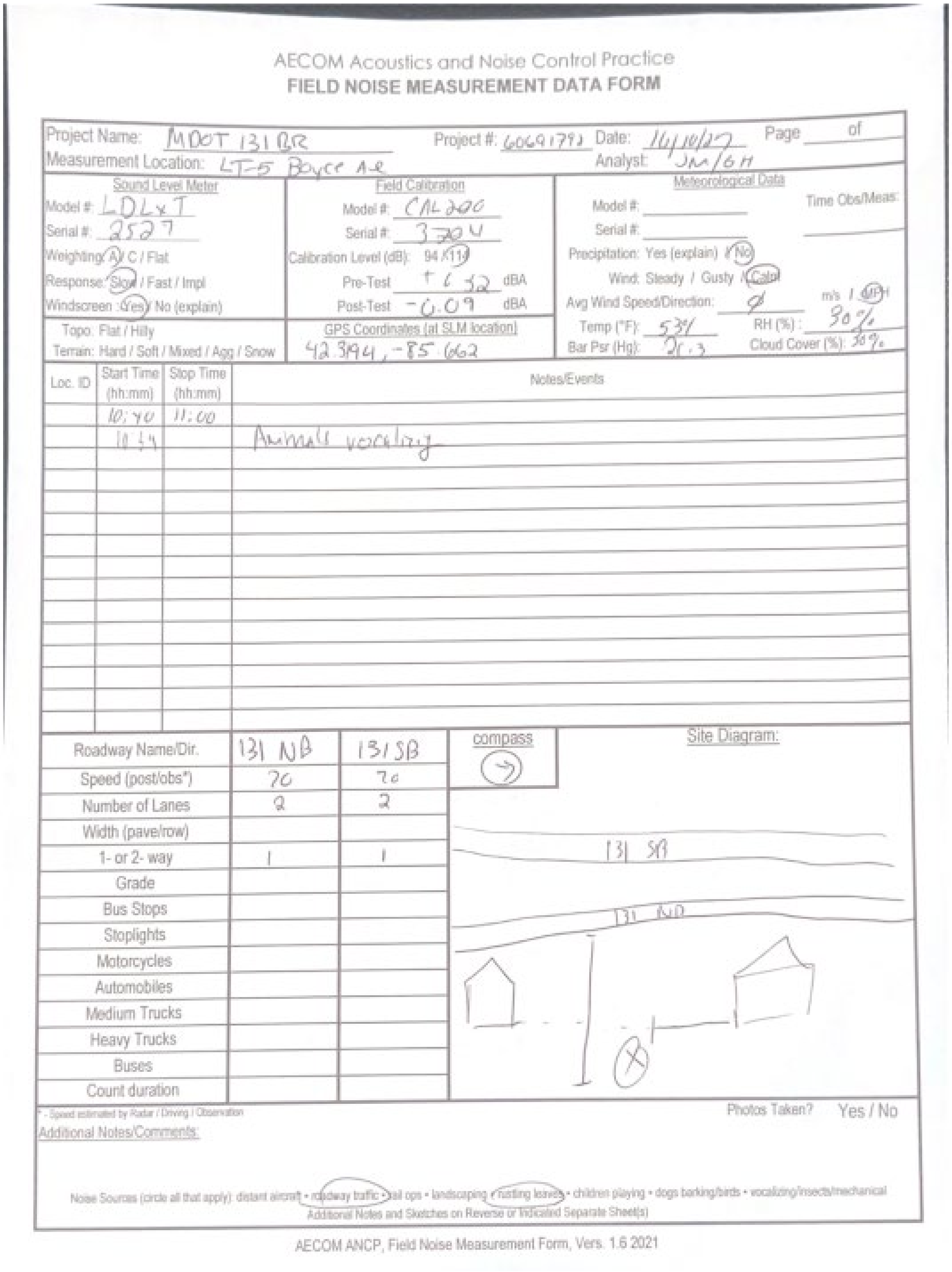
Additional Notes/Comments:

Traffic main source

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • rustling leaves • children playing • [✓ dogs barking] [✓ birds] • vocalizing/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.5 2018



AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT 131 BR Project #: 60691792 Date: 10/10/22 Page ___ of ___

Measurement Location: LT-5 Boyce Ave Analyst: JM/GH

Sound Level Meter

Model #: LDLxT

Serial #: 2527

Weighting: [✓ A] / C / Flat

Response: [✓ Slow] / Fast / Impl

Windscreen: [✓ Yes] / No (explain)

Field Calibration

Model #: CAL200

Serial #: 3704

Calibration Level (dB): 94 / [✓ 114]

Pre-Test +0.32 dBA

Post-Test -0.09 dBA

Meteorological Data

Model #: ___

Serial #: ___

Time Obs/Meas: ___

Precipitation: Yes (explain) / [✓ No]

Wind: Steady / Gusty / [✓ Calm]

Avg Wind Speed/Direction: 0 m/s / [✓ MPH]

Temp (°F): 53/ RH (%): 90%

Bar Psr (Hg): 29.3 Cloud Cover (%): 30%

Topo: Flat / Hilly

Terrain: Hard / Soft / Mixed / Agg / Snow

GPS Coordinates (at SLM location)

42.394, -85.662

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	10:40	11:00	
	10:44		Animals vocalizing

Roadway Name/Dir.	131 NB	131 SB
Speed (post/obs*)	70	70
Number of Lanes	2	2
Width (pave/row)		
1- or 2- way	1	1
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:

* - Speed estimated by Radar / Driving / Observation

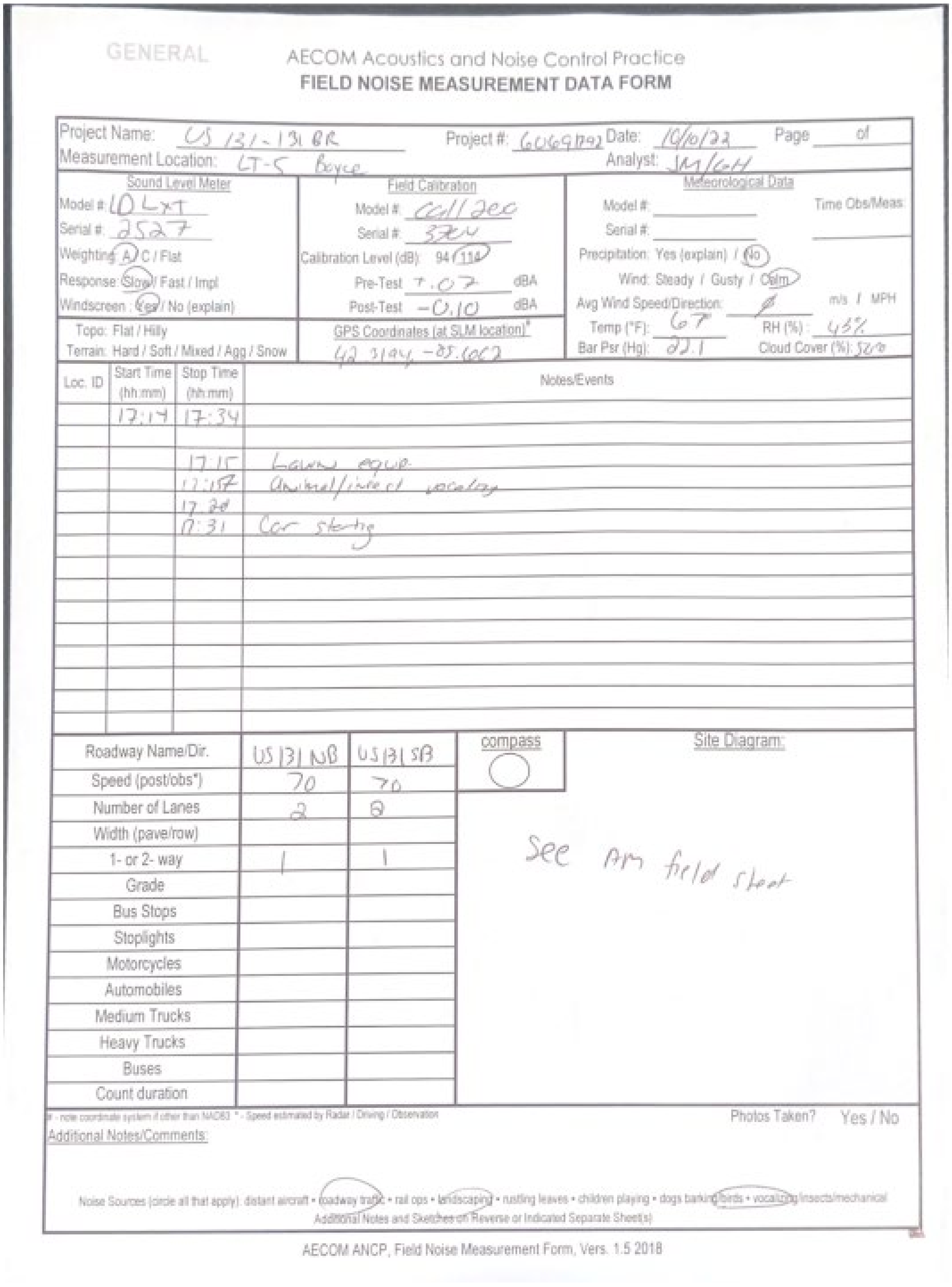
Photos Taken? Yes / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • landscaping • [✓ rustling leaves] • children playing • dogs barking/birds • vocalizing/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.6 2021



GENERAL

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: US 131-131 BR
Project #: 60691792
Date: 10/10/22
Page ___ of ___
Measurement Location: LT-5 Boyce
Analyst: JM/GH

Sound Level Meter
Model #: LD LxT
Serial #: 2527
Weighting: [✓ A] / C / Flat
Response: [✓ Slow] / Fast / Impl
Windscreen: [✓ Yes] / No (explain)

Field Calibration
Model #: Cal 200
Serial #: 3724
Calibration Level (dB): 94 / [✓ 114]
Pre-Test: 7.07 dBA
Post-Test: -0.10 dBA

Meteorological Data
Model #: ___
Serial #: ___
Time Obs/Meas: ___
Precipitation: Yes (explain) / [✓ No]
Wind: Steady / Gusty / [✓ Calm]
Avg Wind Speed/Direction: 0 m/s / MPH
Temp (°F): 67
RH (%): 45%
Bar Psr (Hg): 22.1
Cloud Cover (%): 50%

Topo: Flat / Hilly
Terrain: Hard / Soft / Mixed / Agg / Snow

GPS Coordinates (at SLM location)#
42 3194, -85.1062

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	Notes/Events
	17:14	17:34	
		17:15	Lawn equip
		17:17	animal/insect vocaliz
		17:20	
		17:31	Car starting

Roadway Name/Dir.	US 131 NB	US 131 SB
Speed (post/obs*)	70	70
Number of Lanes	2	2
Width (pave/row)		
1- or 2- way	1	1
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:

See Am field sheet

- note coordinate system if other than NAD83 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

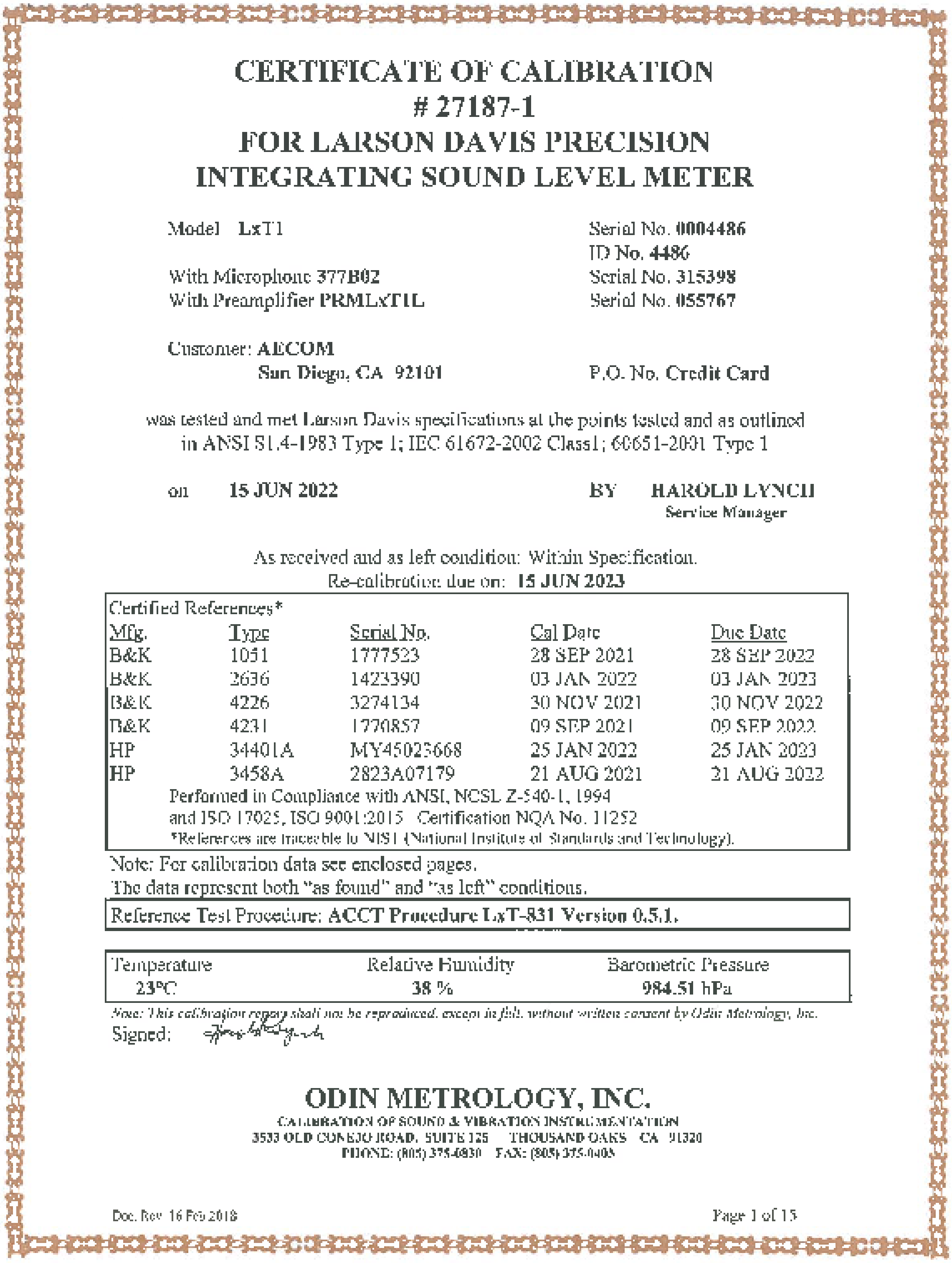
Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft • [✓ roadway traffic] • rail ops • [✓ landscaping] • rustling leaves • children playing • dogs barking/[✓ birds • vocalizing]/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.5 2018

A.5 Equipment Calibration Certificates



CERTIFICATE OF CALIBRATION
27187-1
FOR LARSON DAVIS PRECISION INTEGRATING SOUND LEVEL METER

Model LxT1 — Serial No. **0004486**
ID No. **4486**
With Microphone **377B02** — Serial No. **315398**
With Preamplifier **PRMLxT1L** — Serial No. **055767**

Customer: **AECOM**
San Diego, CA 92101 — P.O. No. **Credit Card**

was tested and met Larson Davis specifications at the points tested and as outlined in ANSI S1.4-1983 Type 1; IEC 61672-2002 Class1; 60651-2001 Type 1

on **15 JUN 2022** BY **HAROLD LYNCH**
Service Manager

As received and as left condition: Within Specification.
Re-calibration due on: **15 JUN 2023**

Certified References*

Mfg.	Type	Serial No.	Cal Date	Due Date
B&K	1051	1777523	28 SEP 2021	28 SEP 2022
B&K	2636	1423390	03 JAN 2022	03 JAN 2023
B&K	4226	3274134	30 NOV 2021	30 NOV 2022
B&K	4231	1770857	09 SEP 2021	09 SEP 2022
HP	34401A	MY45023668	25 JAN 2022	25 JAN 2023
HP	3458A	2823A07179	21 AUG 2021	21 AUG 2022

Performed in Compliance with ANSI, NCSL Z-540-1, 1994
and ISO 17025, ISO 9001:2015 Certification NQA No. 11252
*References are traceable to NIST (National Institute of Standards and Technology).

Note: For calibration data see enclosed pages.
The data represent both "as found" and "as left" conditions.

Reference Test Procedure: **ACCT Procedure LxT-831 Version 0.5.1.**

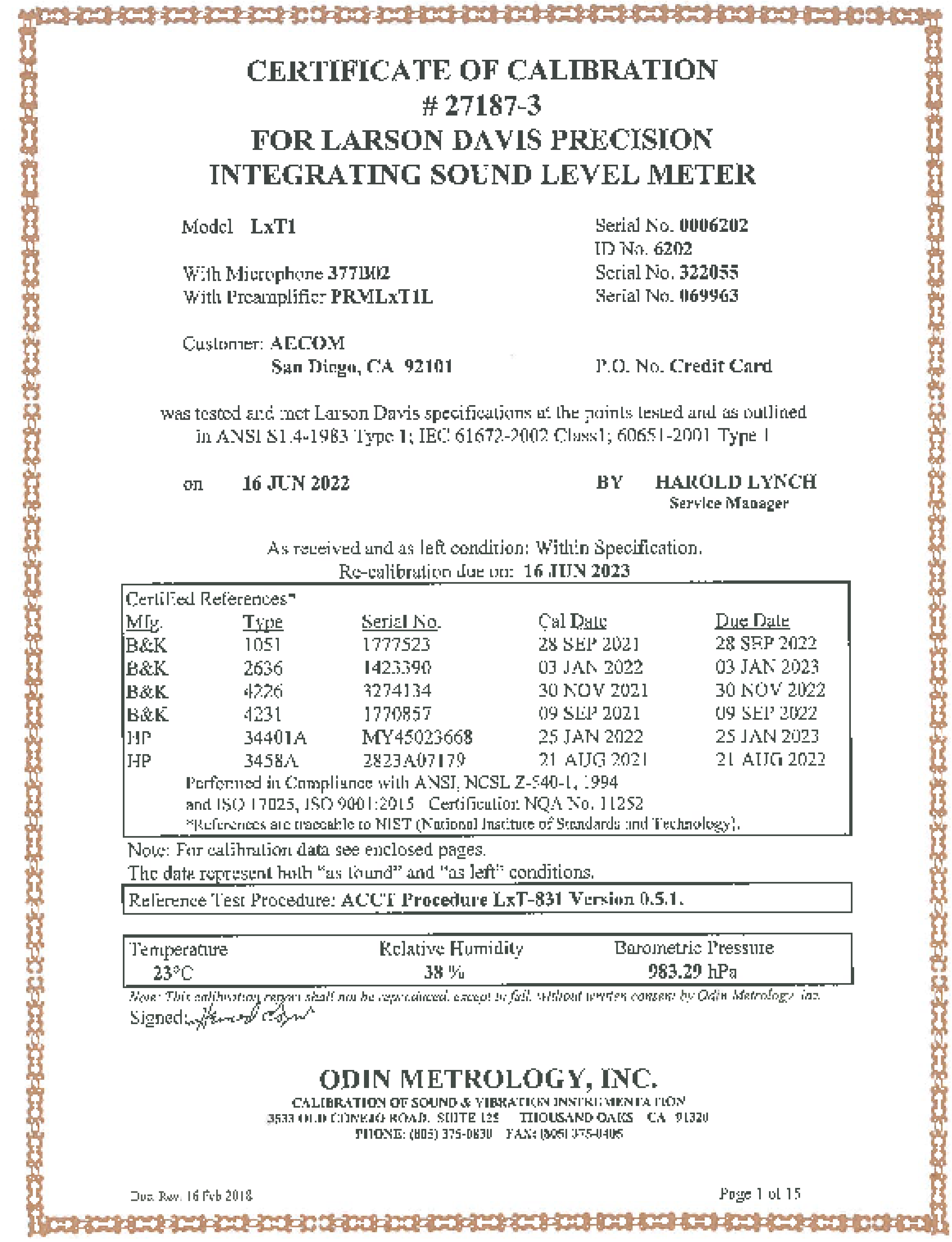
Temperature	Relative Humidity	Barometric Pressure
23°C	**38 %**	**984.51 hPa**

Note: This calibration report shall not be reproduced, except in full, without written consent by Odin Metrology, Inc.

Signed:

ODIN METROLOGY, INC.
CALIBRATION OF SOUND & VIBRATION INSTRUMENTATION
3533 OLD CONEJO ROAD, SUITE 125 THOUSAND OAKS CA 91320
PHONE: (805) 375-0830 FAX: (805) 375-0405

Doc. Rev 16 Feb 2018 — Page 1 of 15



CERTIFICATE OF CALIBRATION
27187-3
FOR LARSON DAVIS PRECISION INTEGRATING SOUND LEVEL METER

Model **LxT1**

Serial No. **0006202**
ID No. **6202**

With Microphone **377B02** Serial No. **322055**
With Preamplifier **PRMLxT1L** Serial No. **069963**

Customer: **AECOM**
San Diego, CA 92101

P.O. No. **Credit Card**

was tested and met Larson Davis specifications at the points tested and as outlined in ANSI S1.4-1983 Type 1; IEC 61672-2002 Class1; 60651-2001 Type 1

on **16 JUN 2022** BY **HAROLD LYNCH**
Service Manager

As received and as left condition: Within Specification.
Re-calibration due on: **16 JUN 2023**

Certified References*

Mfg.	Type	Serial No.	Cal Date	Due Date
B&K	1051	1777523	28 SEP 2021	28 SEP 2022
B&K	2636	1423390	03 JAN 2022	03 JAN 2023
B&K	4226	3274134	30 NOV 2021	30 NOV 2022
B&K	4231	1770857	09 SEP 2021	09 SEP 2022
HP	34401A	MY45023668	25 JAN 2022	25 JAN 2023
HP	3458A	2823A07179	21 AUG 2021	21 AUG 2022

Performed in Compliance with ANSI, NCSL Z-540-1, 1994
and ISO 17025, ISO 9001:2015 Certification NQA No. 11252
*References are traceable to NIST (National Institute of Standards and Technology).

Note: For calibration data see enclosed pages.
The data represent both "as found" and "as left" conditions.

Reference Test Procedure: **ACCT Procedure LxT-831 Version 0.5.1.**

Temperature	Relative Humidity	Barometric Pressure
23°C	**38 %**	**983.29 hPa**

Note: This calibration report shall not be reproduced, except in full, without written consent by Odin Metrology, Inc.

Signed:

ODIN METROLOGY, INC.
CALIBRATION OF SOUND & VIBRATION INSTRUMENTATION
3533 OLD CONEJO ROAD, SUITE 125 THOUSAND OAKS CA 91320
PHONE: (805) 375-0830 FAX: (805) 375-0405

Doc. Rev. 16 Feb 2018

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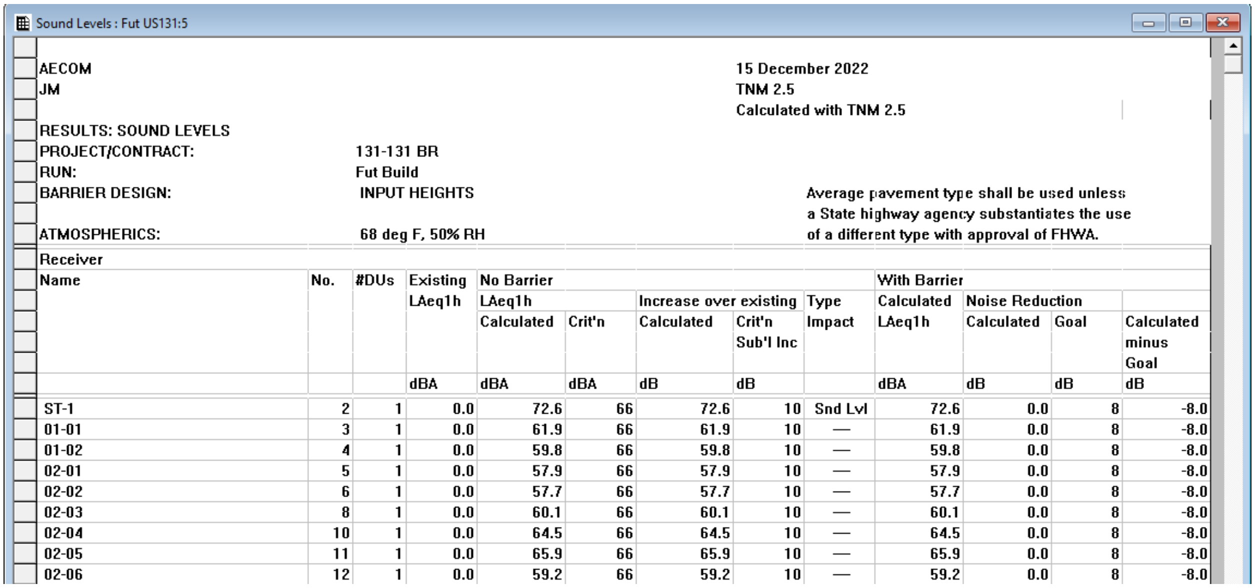
Appendix B Sample TNM Input/Output Files

Sample TNM output tables are provided for CNE 1 Abatement analysis. Additional input and output files are available upon request.

CNE 4 TNM Sound Level Prediction Output Table



AECOM
JM
RESULTS: SOUND LEVELS
PROJECT/CONTRACT: 131-131 BR
RUN: Fut Build
BARRIER DESIGN: INPUT HEIGHTS
ATMOSPHERICS: 68 deg F, 50% RH

15 December 2022
TNM 2.5
Calculated with TNM 2.5

Average pavement type shall be used unless
a State highway agency substantiates the use
of a different type with approval of FHWA.

Receiver Name	No.	#DUs	Existing LAeq1h	No Barrier LAeq1h Calculated	Crit'n	Increase over existing Calculated	Crit'n Sub'l Inc	Type Impact	With Barrier Calculated LAeq1h	Noise Reduction Calculated	Goal	Calculated minus Goal
			dBA	dBA	dBA	dB	dB		dBA	dB	dB	dB
ST-1	2	1	0.0	72.6	66	72.6	10	Snd Lvl	72.6	0.0	8	-8.0
01-01	3	1	0.0	61.9	66	61.9	10	—	61.9	0.0	8	-8.0
01-02	4	1	0.0	59.8	66	59.8	10	—	59.8	0.0	8	-8.0
02-01	5	1	0.0	57.9	66	57.9	10	—	57.9	0.0	8	-8.0
02-02	6	1	0.0	57.7	66	57.7	10	—	57.7	0.0	8	-8.0
02-03	8	1	0.0	60.1	66	60.1	10	—	60.1	0.0	8	-8.0
02-04	10	1	0.0	64.5	66	64.5	10	—	64.5	0.0	8	-8.0
02-05	11	1	0.0	65.9	66	65.9	10	—	65.9	0.0	8	-8.0
02-06	12	1	0.0	59.2	66	59.2	10	—	59.2	0.0	8	-8.0

Plan View

Appendix C Predicted Noise Levels and Impacts

Table C-1 Loudest Hour Noise Levels, Leq(1h), dBA

Receptor Number	Land Use	Activity Category	Units	FHWA/MDOT NAC	Existing	Build	Change
CNE 1							
01-01	Residential	B	1	66	62	62	0
01-02	Residential	B	1	66	60	60	0
CNE 2							
02-01	Residential	B	1	66	58	59	1
02-02	Residential	B	1	66	58	59	1
02-03	Residential	B	1	66	60	62	2
02-04	Residential	B	1	66	65	65	0
02-05	Residential	B	1	66	**66**	**67**	1
02-06	Residential	B	1	66	59	59	0
CNE 3							
03-01	Residential	B	1	66	61	62	1
03-02	Residential	B	1	66	61	62	1
03-03	Residential	B	1	66	61	61	0
03-04	Residential	B	1	66	63	64	1
03-05	Residential	B	1	66	58	59	1
03-06	Residential	B	1	66	60	62	2
03-07	Church	C	1	66	**68**	**69**	1
03-08	Basketball Hoop	B	1	66	**69**	**69**	0
03-09	Picnic Area	B	2	66	**70**	**72**	2
03-10	Pool	B	2	66	**66**	**67**	1
03-11	Playground	B	2	66	**66**	**68**	2
03-12	Pet Area	B	3	66	**67**	**69**	2
CNE 4							
04-01	Residential	B	1	66	60	**66**	6
04-02	Residential	B	1	66	58	59	1
04-03	Residential	B	1	66	57	58	1
04-04	Residential	B	1	66	57	58	1
04-05	Residential	B	1	66	54	55	1
04-06	Residential	B	1	66	53	54	1
CNE 5							
05-01	Residential	B	1	66	65	**66**	1
05-02	Residential	B	1	66	65	65	0
05-03	Residential	B	1	66	62	62	0
05-04	Residential	B	1	66	60	61	1

Appendix D Noise Barrier Analysis Detail

Noise Wall Analysis Detail, Comparison of Various Design Alternatives for Wall 3 (CNE-3)

To properly assess the reasonableness and feasibility of a noise wall for impacted receptors in CNE 3, three different noise wall design alternatives were evaluated. Wall 3A is a 300-foot-long wall designed to primarily benefit the picnic area (03-09), Wall 3B is a 333 foot long wall designed to primarily benefit the pool/playground/pet exercise area (03-10, 03-11, 03-12), and Wall 3C is a combination of both walls #a and 3B, as described in the following tables.

Table D-1 Noise Wall 3 Alternatives, Size and Costs

Wall ID	Length (feet)	Average Height (feet)	Area (Sq. feet.)	Cost
Wall-3A	300	15	4500	$ 202,500
Wall-3B	333	17	5661	$ 254,745
Wall-3C	633	19	12027	$ 541,215

Table D-2 Noise Wall 3 Alternatives, Acoustical Performance

Receptor Number	Land Use	Category	Equivalent Dwelling Units	FHWA/ MDOT NAC	Noise Level without Wall	Noise Level with Wall	Noise Reduction	Benefit?
Wall 3A (Picnic area)								
03-08	BB Hoop	B	1	66	69	69	0	
03-09	Picnic Area	B	2	66	72	64	8	2
03-10	Pool	B	2	66	67	67	0	
03-11	Playground	B	2	66	68	68	0	
03-12	Pet Area	B	3	66	69	69	0	
Wall 3B (pool/playground/ pet area)								
03-08	BB Hoop	B	1	66	69	69	0	
03-09	Picnic Area	B	2	66	72	72	0	
03-10	Pool	B	2	66	67	65	2	
03-11	Playground	B	2	66	68	60	8	2
03-12	Pet Area	B	3	66	69	59	10	3
Wall 3C (combined wall)								
03-08	BB Hoop	B	1	66	69	69	0	
03-09	Picnic Area	B	2	66	72	64	8	2
03-10	Pool	B	2	66	67	65	2	
03-11	Playground	B	2	66	68	60	8	2
03-12	Pet Area	B	3	66	69	59	10	3

Table D-3 Noise Wall 3 Alternatives, Reasonableness and Feasibility

Noise Wall 3 Design Comparison

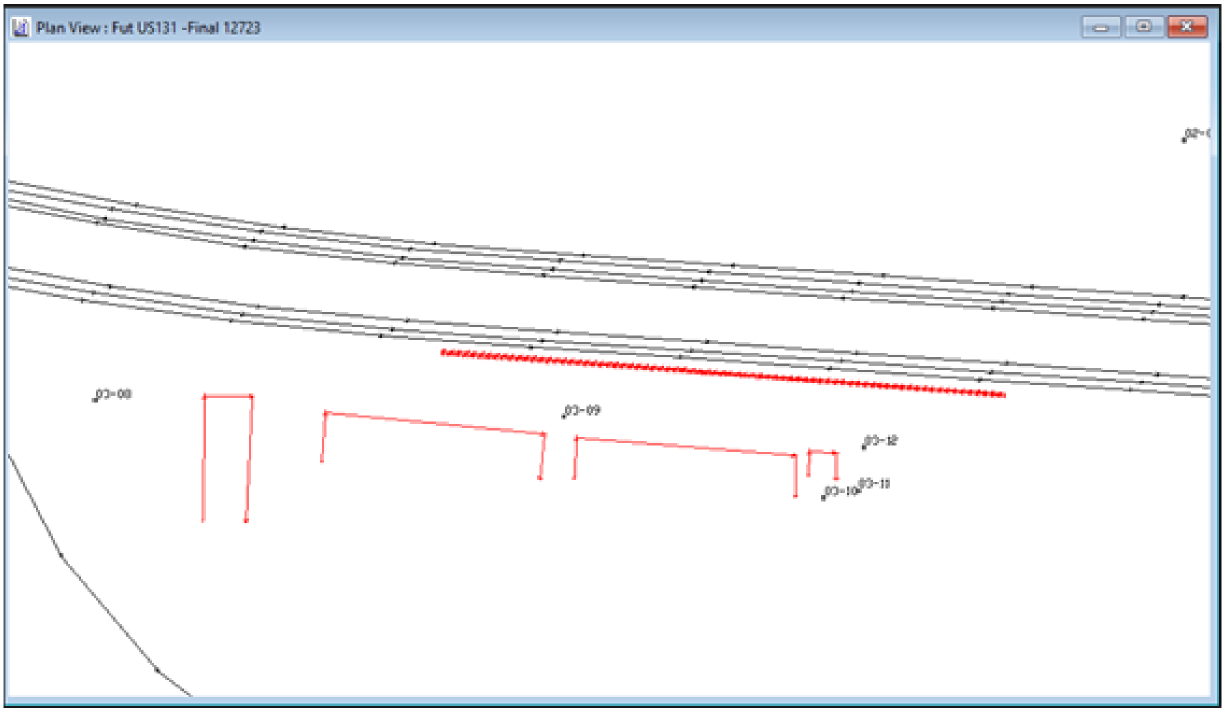
Wall ID	NR ≥ 10 dBA	NR ≥ 7 dBA		NR ≥ 5 dBA		Cost	CPBU	Feasible	Reasonable	Recommended
		#	% of Benefitted	#	% of Impacted					
3A	0	2	100%	2	20%	$202,500	$101,250	No	No	No
3B	1	3	60%	5	50%	$284,715	$56,943	No	No	No
3C	1	5	71%	7	70%	$541,215	$77,316	No	No	No

Based on the above results, noise wall alternative 3C was determined to be the most favorable design (closest to 75% benefitted receptors). However, with a CPBU of $77,316 was still well above the maximum allowable CPBU of $40,907, and therefore, not recommended.

Table D-4 Noise Wall 3C, Receiver Level Detail

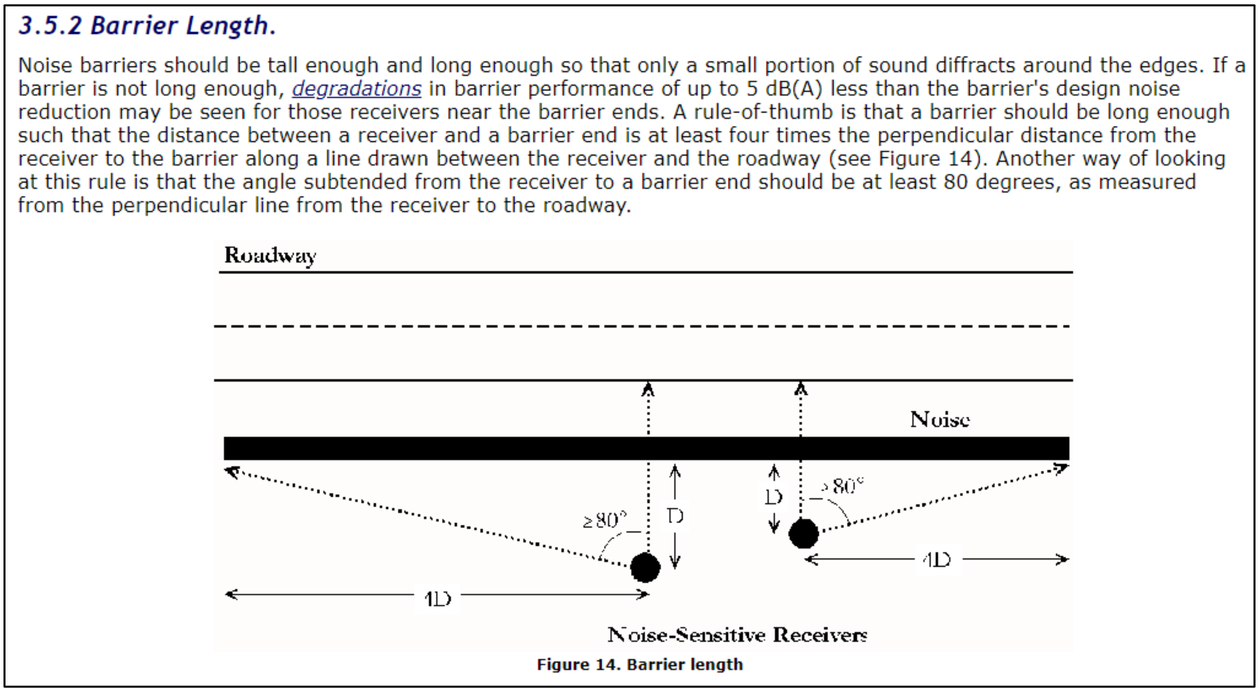
Receptor Number	Land Use	DUEs	FHWA/MDOT NAC	Noise Level wo/wall	Noise Level w/wall	Noise Reduction	Benefitted DUs (NR > 5 dBA)
03-08	Basketball Hoop	1	66	69	69	0	0
03-09	Picnic Area	2	66	72	64	8	2
03-10	Pool	2	66	67	65	2	0
03-11	Playground	2	66	68	60	8	2
03-12	Pet Area	3	66	69	59	10	3

Plan View Wall 3C



Three of the analyzed CNEs (CNE-2, -4, and -5) have a single impacted dwelling unit. In these cases, an FHWA approved “rule-of-thumb” was used to estimate required noise barrier length. Noise barrier cost was then estimated by multiplying the estimated barrier length by a typical height of 12 feet and the MDOT estimated cost of $45/square foot. The estimated barrier length, from the FHWA Noise Barrier Design Handbook, recommends that a barrier should be long enough such that the distance between a receiver and a barrier end is at least four times the perpendicular distance from the receiver to the barrier. The relevant excerpt from the FHWA Barrier Design Handbook (Section 3.5.2) demonstrating this method is provided below.

FHWA Guidance on Estimated Noise Barrier Length.



3.5.2 Barrier Length.

Noise barriers should be tall enough and long enough so that only a small portion of sound diffracts around the edges. If a barrier is not long enough, *degradations* in barrier performance of up to 5 dB(A) less than the barrier's design noise reduction may be seen for those receivers near the barrier ends. A rule-of-thumb is that a barrier should be long enough such that the distance between a receiver and a barrier end is at least four times the perpendicular distance from the receiver to the barrier along a line drawn between the receiver and the roadway (see Figure 14). Another way of looking at this rule is that the angle subtended from the receiver to a barrier end should be at least 80 degrees, as measured from the perpendicular line from the receiver to the roadway.

Figure 14. Barrier length

Source: FHWA Noise Barrier Design Handbook, 2017

Appendix E Dwelling Unit Equivalents Calculations

Table E-1 DUE Calculations for CNE-3

Receptor Location	Usage Assumption	Number of Occupants	People/ Household	Hours/ day	Days/ year	DUE (Calculated)	DUE (Rounded up)
Pool	Memorial to Labor Day	40	3	12	102	1.86	2
Playground	March to November	10	3	12	270	1.23	2
Pet Park	All year	10	3	18	365	2.50	3
Picnic Area	March to November	10	3	12	270	1.23	2
Basketball Hoop	March to November	6	3	12	270	0.74	1

Notes:

Pool maximum occupancy is posted as 40, Memorial to Labor day usage per apartment office.

Playground, picnic area basketball hoop assumed to be used during Spring, Summer, Fall months, up to 12 hours per day
Pet park assumed available year-round, up to 10 people max, 18 hours/day.

aecom.com