Appendix C. Traffic Noise Impact Analysis

Traffic Noise Impact Assessment for Northshore Drive Realignment

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SDDOT Project # EM 8064 (32)
FHU Project No. 122309-01

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1.0 INTRODUCTION

The National Environmental Policy Act (NEPA) of 1969 established a mandate for federal agencies to consider the potential environmental consequences of their proposed actions, to document the analysis, and to make information available to the public for comment prior to implementation. The purpose of this project is to evaluate the construction of a new roadway north of Northshore Drive to separate agricultural, school, and commuter traffic from local traffic along McCook Lake, accommodate future growth, improve vehicle and pedestrian safety, and create a direct connection from Interstate 29 (I-29) to County Road 23 (CR 23). In accordance with NEPA and related regulations, the South Dakota Department of Transportation (SDDOT) as the Lead Agency, in cooperation with the Federal Highway Administration (FHWA) as a Joint Lead Agency, are preparing a NEPA environmental decision document for this project.

The purpose of the analyses presented in this report was to conclude whether noise levels at properties near the proposed road improvements (i.e., receptors) may exceed applicable thresholds, according to SDDOT and FHWA guidelines. This report presents the evaluation of existing and future traffic noise levels in the project area for Alternative 1 and Alternative 2 to assess potential traffic noise impacts to properties near proposed road improvements.

1.1 Project Description

The existing section of Northshore Drive from the intersection with Street Drive/I-29 on the east to the intersection with Westshore Drive on the west is approximately one mile in length. This section of roadway is classified as an Urban Minor Arterial. The street has a two-lane cross-section. The posted speed limit on Northshore Drive is 35 miles per hour (MPH) west of Westshore Drive and 25 MPH east of Westshore Drive. A ten-foot trail runs along the north side of Northshore Drive from 484th Avenue. There are currently 39 access points along the south side of the roadway and 15 access points on the north side from 484th Avenue/Westshore Drive to just west of Streeter Drive. West of 484th Avenue/Westshore Drive, Northshore Drive becomes CR 23.

This project proposes to improve existing traffic operations and accommodate planned future growth in the vicinity of Northshore Drive, including the potential for new transportation infrastructure. The project may also involve modification to existing roads, intersections, and driveways to improve overall traffic operations in the vicinity of the project and is anticipated to involve modification or construction of a new storm drainage system. The project would also look for opportunities to improve pedestrian and bicyclist continuity with the use of the Americans with Disabilities Act (ADA) compliant sidewalks, crosswalks, ramps, trails, and/or shared use paths that connect to existing trail infrastructure (**Figure 1**).

Property rights for improvements (such as temporary/permanent easements and right of way acquisition) may be necessary to construct the project and are expected. Acquisition of property rights will be completed in compliance with the Uniform Act.

Based on the proposed improvements, temporary and permanent easements are expected, including right-of-way acquisition at the location of the new interchange and culvert pipe locations. No relocations of homes or businesses are anticipated.

The proposed project would also include the following activities:

- Survey and staking
- Pavement removal
- Grading within and outside the hinge point
- New culvert installation and replacement, extension, or repair of existing culverts
- Utility work (including overhead transmission line, fiber optic cables, and lighting)
- Paving
- Curb and gutter
- Earth shoulder construction
- Erosion and sediment control (including but not limited to barriers, post-construction erosion control, vegetation, and other best management practices)
- Retaining walls and barrier walls
- Sidewalk and Pedestrian/Bicycle Trail construction
- Signals, lighting, and signage with and without soil disturbance
- Pavement marking

Figure 1 Typical Cross-Section of Realignment

1.2 Logical Termini

Western Terminus:

Westshore Drive. This terminus is recommended because Westshore Drive connects to the existing Northshore Drive at the west end of the stretch of Northshore Drive for which the project seeks to improve traffic operations (i.e., between Westshore Drive and I-29/Streeter Drive) (**Figure 2**). Westshore Drive would be the logical connection point for any improvements to this stretch of Northshore Drive or any new roadways that would bypass Northshore Drive. Further west is limited by the presence of wetlands and the Adam's Homestead Nature Preserve.

Eastern Terminus:

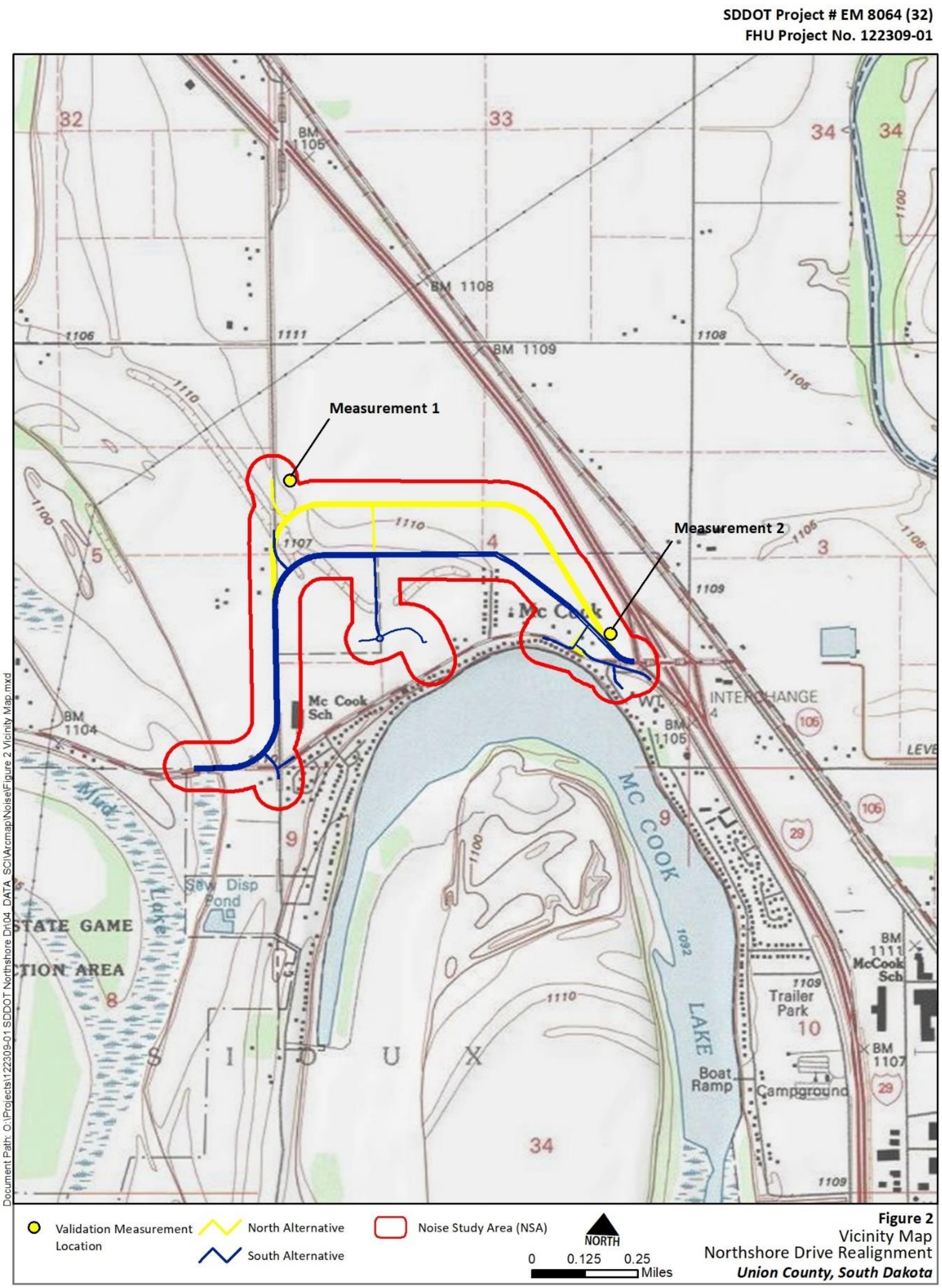
Interstate 29 (I-29)/Streeter Drive. This terminus is recommended because the intersection is a travel shed transition point at which drivers can turn to navigate onto I-29 or continue eastward toward Military Road and/or south along Street Drive which leads to River Drive, a main thoroughfare in North Sioux City.

Independent Utility:

The proposed project would improve traffic operations along Northshore Drive between Westshore Drive and I-29/Street Drive, a section of roadway with known congestion issues, many access points, and a history of rear-end collisions. Improvements to this stretch of Northshore Drive would provide a transportation benefit even if no additional transportation improvements are made in the area.

The project would not restrict consideration of alternatives for other reasonably foreseeable transportation improvements. The master plan for north of Northshore Drive calls for the farmland to be developed into residential and commercial infrastructure, but there are not yet any specific projects planned. This project would not restrict any future transportation development in this area. The adjacent I-29 corridor and adjacent interchange is being studied by SDDOT, but there are no programmed projects.

Figure 2 Noise Study Area and Noise Measurement Locations

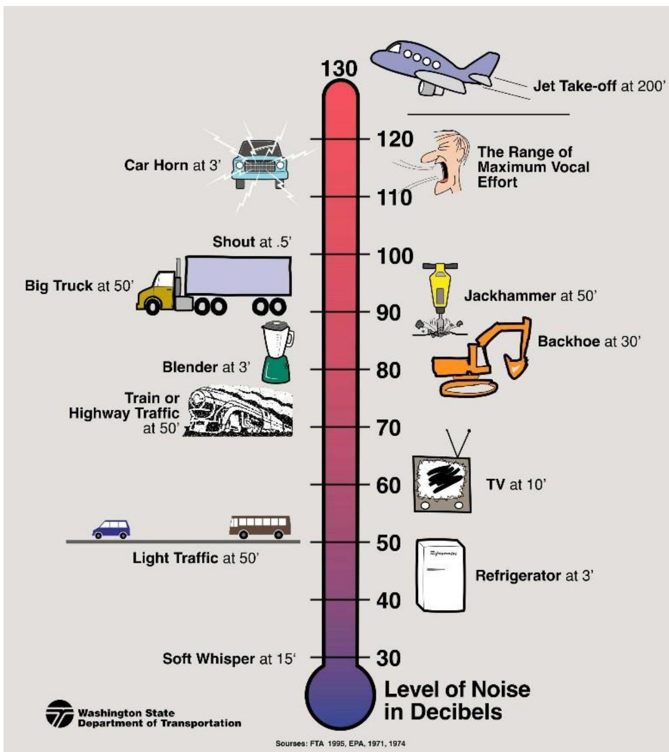


1.3 Basics of Sound

Sound is created when an object vibrates and radiates part of that energy as acoustic pressure changes or waves through a medium, such as air, water or a solid. Noise is commonly defined as unwanted sound. Sound and noise have many characteristics that are important to consider for impacts, including loudness (energy intensity), frequency, and fluctuations over time.

Sound and noise intensities are measured in units of decibels (dB). The dB scale is logarithmic. To illustrate this, consider that two identical noise sources, each producing 60 dB, would produce 63 dB when added together. A 10-dB increase in sound levels represents ten times more sound energy. The human ear can sense a wide range of sound energy levels, with the maximum levels having more than a million times the sound energy of the minimum levels. Examples of common sound levels are shown in **Figure 3**.

Figure 3 Typical Sound Levels



Source: Washington State Department of Transportation website, 2016

The human ear is not equally sensitive to all frequencies of sound-producing vibrations. To address these discrepancies accurately, mathematical adjustments to raw sound levels using the "A" weighting curve are often used to approximate how the human ear perceives sounds. This weighting consists of reducing the raw sound levels of low and very high sound frequency bands by specified amounts. Sound levels that have been weighted this way are reported in dBA. FHWA and SDDOT guidance specify sound units in dBA. Research has shown that most people do not notice a difference in loudness between sound levels of less than 3 dBA, which is a two-fold change in the sound energy. Likewise, most people relate a 10-dBA increase in sound levels to a doubling of sound loudness.

Noise often fluctuates over time because of the characteristics of the source. Traffic noise will fluctuate over short timeframes from changes in traffic volumes, vehicle types and vehicle speeds. This frequent fluctuation can make it difficult to describe the noise conditions fully through a single value, but FHWA and SDDOT use the one-hour equivalent sound level (L_{eq}) as the metric for assessing traffic noise impacts (SDDOT, 2023). In simple terms, the L_{eq} is the "average" of the fluctuating noise levels over the time period (usually one hour); more specifically, it is the constant sound level that would produce the same overall amount of sound energy as the fluctuating noise levels.

Sound levels decrease with distance from the source because of acoustic spreading, atmospheric absorption, interferences from objects and ground effects. "Hard" ground (such as asphalt) and "soft" ground (such as grass) affect sound transmission differently. "Hard" ground is more reflective and will result in louder sound levels farther from the source. Using traffic noise passing over "hard" ground as an example, a 3-dBA increase in noise levels could be caused by either doubling the traffic volume or cutting the distance from the listener to the roadway in half, and the change would be barely noticeable to most people.

On busy roads and highways, the loudest traffic noise generally occurs when the largest traffic volume can travel at the highest speed, which is not necessarily the peak of rush hour when the traffic volume can be so high that the roads become congested and vehicle speeds slow. This noisiest traffic condition generally corresponds to Level of Service (LOS) C or D for a highway (FHWA, 2011).

1.4 Noise Analysis Approach

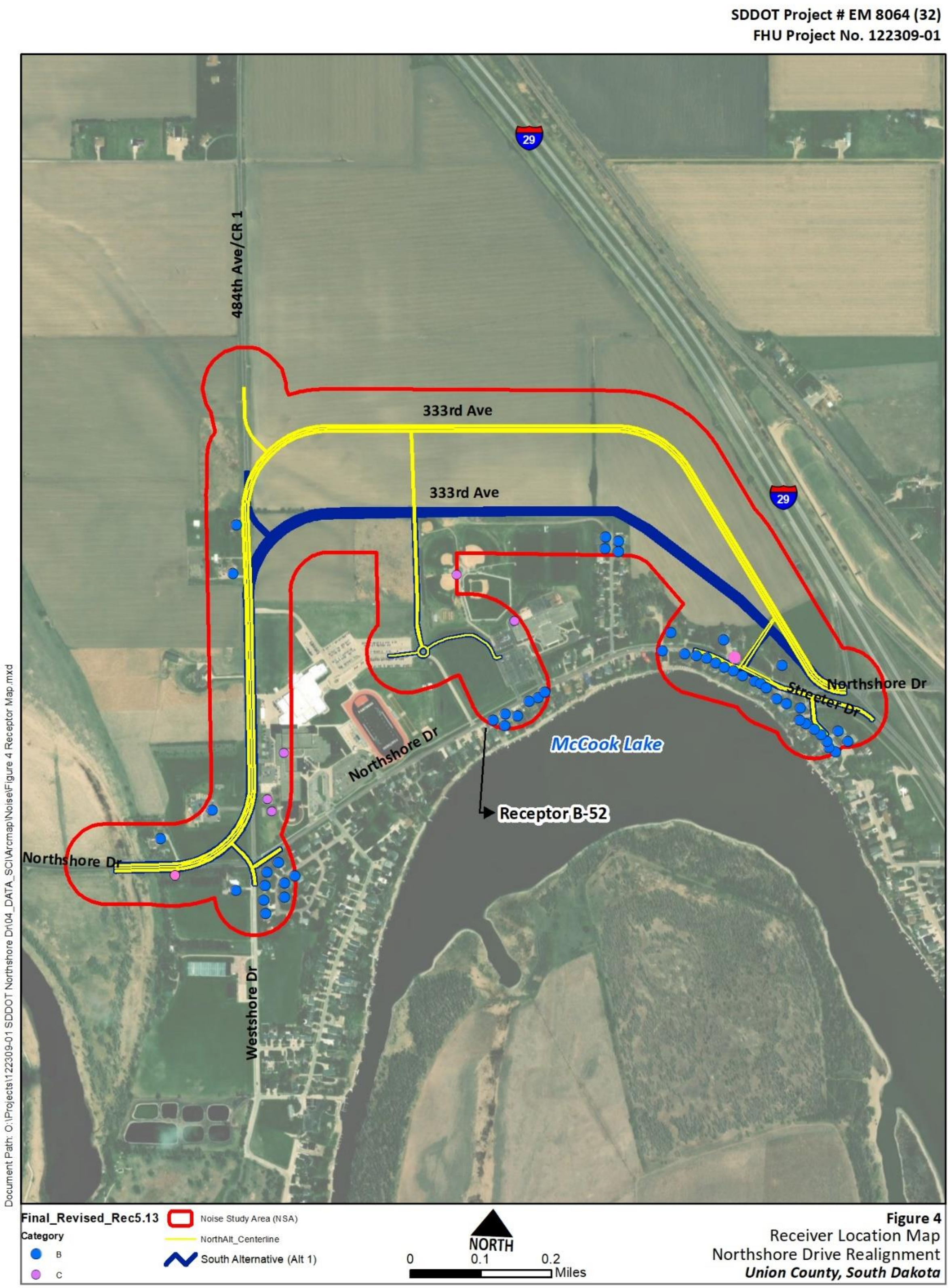
This analysis followed the SDDOT *Noise Analysis and Abatement Guidance* (SDDOT, 2023), which is referenced in SDDOT's *Environmental Procedures Manual* (2019). The overall purpose of the noise analysis was to conclude whether noise levels at any sensitive receptors within a minimum distance of 300 feet from potential project improvements (**Figure 4**) may exceed applicable impact thresholds because of the Preferred Alternative. If so, noise abatement actions for the impacted receptors would be considered for the project.

Roads of concern for the analysis were those that would be changed by the project, would have substantially different traffic volumes because of an alternative, or are locally significant noise sources. For this project, those consist of Northshore Dr (west of Westshore Dr and approximately 500 feet west of the Northshore Dr and Streeter Dr intersection), Westshore Dr, 484th Ave/ CR 1, 333rd Ave, and Streeter Dr in **Figure 4**.

The overall analysis was based on field measurements and on modeling of both existing (2022) conditions and future design year (2045) conditions (**Section 2.0**). Currently, the land uses in the project area consist of residences, schools, athletic fields, and undeveloped land. Current conditions and two Alternatives were examined for noise levels. Noise analysis efforts for this project occurred during 2024 and are based on best available data.

Two measurements of existing noise were performed in the project area in April 2024 for noise model validation (FHWA 2011) (**Figure 2** and **Section 3.0**). Computerized modeling was used to examine existing and expected future traffic noise conditions for numerous locations in the project area, focusing on potential impacts to the most sensitive and nearest receptors (**Sections 3.0** and **4.0**). The resulting noise levels were compared to applicable criteria to assess for and identify impacted areas (**Section 4.0**). When necessary, based on the outcome of the impacts evaluation, abatement measures for impacted areas are evaluated according to FHWA and SDDOT feasibility and reasonableness guidelines (**Section 5.0**).

Figure 4 Noise Study Area, Alignment Alternatives, and Receptor Locations



2.0 ANALYSIS METHODS

The reviewed Alternatives are considered Type 1 projects (SDDOT, 2023) because they involve the construction of new roadways and relocations of the associated road network closer to noise receptors. Under the reviewed Alternatives, the extent of roadway improvements that are considered Type 1 are encompassed by the Noise Study Area **(Figure 2).**

Sensitive receptors are located within 300 feet of the proposed improvements, so a noise analysis is necessary for both Alternatives. Noise impacts for the project from vehicle traffic were evaluated through a combination of measurements and computerized modeling. The specific methods used for each part of the analysis are described below.

Highways and streets are the focus of the project noise analysis. There are two ways receptors can be impacted by noise from a project: by traffic noise being too loud, or by traffic noise increasing "substantially" because of the project. FHWA has defined Noise Abatement Criteria (NAC) for seven land use categories (**Table 1**) that apply to its projects (FHWA, 2011). FHWA directed states to define their own thresholds where traffic noise levels "approach" the NAC and cause noise impacts. SDDOT has established an "approach level" for each FHWA NAC that is 1 dBA below the FHWA NAC (**Table 1**; SDDOT, 2023). Equaling or exceeding the approach level for a study area receptor is a noise impact. A "substantial" noise increase is defined by SDDOT as the future noise level increasing by 15 dBA or more over the existing level and is also a noise impact.

Land Use Categories B and C (**Table 1**) are the most frequent traffic noise concerns on road projects and are present in the Noise Study Area (**Figure 4**). The SDDOT approach level for residences (Category B) and other common noise-sensitive land uses (Category C) is an L_{eq} of 66 dBA. Note that these apply to exterior areas of frequent human use. Category G land uses are located north of the project but have no NAC approach level.

Table 1 SDDOT NAC Approach Levels

Land Use Category	NAC Approach Level (L_{eq})	Description of Land Use Category
A	56 dBA (Exterior)	Tracts of land in 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	66 dBA (Exterior)	Residential
C	66 dBA (Exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or non- profit institutional structures, radio studios, recording studios, schools, Section 4(f) sites, trails, trail crossings, and television studios
D	51 (Interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or non- profit institutional structures, radio studios, recording studios, schools and television studios
E	71 dBA (Exterior)	Hotels, motels, offices, restaurants, bars and other developed lands, properties or activities not included in A-D or F.
F	Not Applicable	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, ship yards, utilities (water resources, water treatment, electrical), and warehousing
G	Not Applicable	Undeveloped lands that are not permitted for development

Source: SDDOT, 2011

For the noise impact discussion, the "peak hour" refers to the highest traffic noise hour during a day, which may or may not correspond to the hour of largest traffic volume. Traffic noise can decrease during rush hour due to lower vehicle speeds from overloaded and congested roads (**Section 1.2**).

2.1 Traffic Noise Measurements

Traffic noise measurements were taken at two locations in triplicate in the project area (**Figure 2**) on April 24, 2024 using an NTI XL2 Type 1 sound level meter calibrated at the site with a Larson-Davis CAL200 calibrator. The measurement locations were chosen as representative locations for the exterior areas of frequent human use in this project area. This equipment conforms to American National Standards Institute Standard S1.4 for Type 1 sound level meters.

Calibrations traceable to the U.S. National Institute of Standards and Technology were performed in the field before and after each set of measurements using the acoustical calibrator. These meters undergo annual laboratory calibration and meters with current calibrations were used. Calibration records are available if requested.

Noise measurements were made during weather conditions that were acceptable according to FHWA guidance (FHWA, 1996) and SDDOT's *Noise Analysis and Abatement Guidance* (2023). A summary of meteorological data is listed in **Table 2**. The time, temperature, wind speed and direction, and relative humidity for validation measurements is included on data sheets in **Appendix A**. Weather conditions, including wind speed and direction, were monitored during the measurements. The measurement microphone was protected by a windscreen and located on a tripod approximately 5 feet above the ground. The microphone was positioned at each site to characterize the exposure to the dominant noise sources in the area. A continuous 15-minute traffic noise measurement was performed at each location (**Section 3.2**) to document existing ambient conditions in the study area.

Traffic counts, including the numbers of large trucks, were collected during the noise measurement periods for use in noise model validations. Vehicles were concluded to be traveling at the posted speed limits during the measurements—traffic was not congested. These measurement results were used to document ambient conditions and to evaluate the performance of the computerized traffic noise models.

Table 2 Summarized Meteorological Conditions During Data Collection

Temperature	72 degrees (F)
Humidity	25%
Wind (Avg. and Max.)	4 mph/9 mph
Wind Direction	Southeast
Conditions	Partly sunny

2.2 Traffic Noise Modeling Methods

The reviewed Alternatives are the future conditions being considered in the noise analysis, and it will include construction of 333rd Ave on a south alignment (Alternative 1) or a north alignment (Alternative 2). Alternative 3, widening the existing Northshore Dr was removed from consideration and not included in the analysis. Some local streets (e.g., Streeter Dr) would be realigned. Traffic will be the predominant noise source in the project area.

Computer modeling was performed for current conditions and the reviewed Alternatives for Year 2045. The traffic noise modeling software used was FHWA's Traffic Noise Model (TNM) Version 2.5. The main purposes of the models are to examine whether traffic noise levels from the project would cause noise impacts and subsequently whether noise abatement should be evaluated for any such impacts within the study area.

Modeling is used because day-to-day variations in traffic or weather conditions that affect noise levels cannot be captured or quantified by brief noise measurements alone, and because the future noise levels cannot be measured now. In addition, the modeling can evaluate many more locations than can reasonably be field measured. The modeling results represent predicted typical average traffic conditions during peak noise periods.

The existing traffic conditions model includes the 2022 road configurations and traffic volumes. The reviewed Alternatives were modeled for 2045 conditions (**Section 1.1**). The peak hourly traffic volumes are based on data from the traffic study for the project (Felsburg Holt & Ullevig [FHU], 2023). The morning peak hour traffic volumes were used in the TNM models because those had the highest traffic volumes on Northshore Dr and 333rd Ave. The preliminary reviewed Alternative roadway designs were developed by Stockwell Engineering.

TNM 2.5 was used to calculate noise levels at 56 model points representing 51 individual receptors within the study zone that extended at least 300 feet from roadway changes proposed with the reviewed Alternatives. Five Category C and fifty Category B model points were examined (**Appendix B**). No upper building floors with exterior spaces (i.e., balconies) were modeled. No currently undeveloped properties (Category G) with imminent development plans were identified, which would have required consideration as existing receptors. The study distance follows SDDOT guidance (SDDOT, 2023) and was identified as being sufficient to identify the receptors that could be impacted by traffic noise from the alternatives, based on the extent of impacts. In other words, no impacts were identified beyond the 300-foot study zone.

The modeled points typically represented the front or side yard activity areas of the single-family homes. Outdoor areas were modeled for athletic areas.

The same model points were used in each model for consistency (**Appendix B**). The modeled roadways were the roads that would be built or changed by the Preferred Alternative or were important local noise sources.

The TNM models require a considerable amount of input data regarding the geometry of the roadways as well as traffic volumes, vehicle mix and vehicle speeds. The current positions of roads and streets were mapped and used in the existing conditions model. The reviewed Alternative (**Section 1.1**) was modeled to assess the possible noise impacts from the prospective roadway changes. In general, the following data were used in the models:

- Units—feet and MPH (converted from meters and kilometers per hour (KPH))
- Current Roadway Alignments—XYZ coordinates from CAD files and aerial photographs
- Future Roadway Alignments—XYZ coordinates from Stockwell CAD files
- Vehicle Speeds—Northshore Dr-west of Westshore Dr-35 MPH, east of Westshore Dr-25 MPH, Streeter Dr-40 MPH; 484th Ave-25 MPH and 40 MPH; I-29- 65 MPH; I-29 ramps-30 MPH; and 333rd Ave-45 MPH. (**Appendix B**)
- Traffic Volumes— from the traffic study (FHU, 2023; **Appendix B**)
- Vehicle Mix—4 percent heavy trucks; 96 percent cars (FHU, 2023)
- Elevations—from ground surface contours of the study area and preliminary road designs; measurements and model points were 5 feet above ground surface.
- Ground zones and terrain lines were used as needed to emulate the existing area.

3.0 AFFECTED ENVIRONMENT

The current traffic noise conditions in the study area were assessed through a combination of measurements and modeling. The existing conditions for traffic noise for these areas are presented below.

3.1 Traffic Noise Measurements

The short-term noise measurement results presented below were intended to be representative of ambient conditions. Short-term traffic noise measurements were performed in the afternoon in the project area on April 24, 2024 (**Table 3**). The locations (**Figure 2**) targeted representative areas in the project vicinity. Each location was also representative of other nearby properties with similar features that may have the same or different land uses.

Table 3 Existing Traffic Noise Measurement Results

Location Number	Location Description (Parcel ID)	Category B NAC Approach (dBA)*	Measured L_{eq} (dBA)*	Approx. Distance to Future Pavement (ft)
1	11.00.04.1100 - 975 ft north of B111	66	47.6	300
2	05.15.04.1015 – 200 ft east of B95	66	58.1	70

* See Table 1.
Source: FHU field data, 2024.

None of the measurement results equaled or exceeded the SDDOT Category B NAC approach levels.

3.2 Traffic Noise Model Validation

As a check on the TNM noise model parameters, the traffic conditions observed during the noise measurements were used to construct a validation model in TNM. The intent was to check the accuracy of the noise levels calculated through a model that mimics the road alignment, traffic volumes and model receptors at the time of field measurement. A close match between model results and field measurements ensures that the models are providing accurate noise results (SDDOT, 2023).

The validation model covers the areas where noise level measurements were made (**Figure 4**). The model was constructed in TNM using the same approach as the reviewed Alternative models (**Section 2.2**).

The validation results are presented in **Table 4**. The measured and modeled results were found to be within 3 dBA of each other and acceptable (FHWA, 2011).

Table 4 Validation Noise Model Results

Location Number	PID and Approximate Location	Measurement L_{eq} (dBA)	Validation Model Result (dBA)	Difference (dBA)
1	11.00.04.1100- 975 ft north of B111	47.6	46.1	+1.5
2	05.15.04.1015 – 200 ft east of B95	58.1	59.0	-0.9

Source: FHU modeling results, 2025

3.3 Existing Conditions Model Results

A noise model was developed (**Section 2.2**) to evaluate existing conditions on a broader basis than available from field measurements alone. The existing conditions model includes the major existing roads that may be affected by the project, with existing (2022) traffic volumes and road layouts. A total of 53 locations were modeled for traffic noise levels (**Figure 4**).

The calculated results for each model point are presented in **Appendix B**. Overall, the calculated noise level range for the modeled points was about 48-66 dBA. No sound levels for Category C receptors were observed to be above the NAC approach level during the peak noise hour and only a single Category B receptor was impacted (B52).

4.0 ENVIRONMENTAL CONSEQUENCES

The reviewed Alternatives were described in **Section 1.1**. The traffic noise modeling effort was conducted as described in **Section 2.0** to assess whether future noise levels would equal or exceed the relevant SDDOT NAC approach levels and whether noise levels would increase substantially. If so, abatement measures to alleviate the predicted impacts would be considered and evaluated for the reviewed Alternatives following SDDOT guidelines.

The traffic noise model was developed as described in **Section 2.1**. The model included the major project roads using predicted future (2045) traffic volumes and road layouts. The modeled points are illustrated in **Figure 4**. The model noise results are tabulated in **Appendix B**.

4.1 Reviewed Alternatives 2045 Model Results

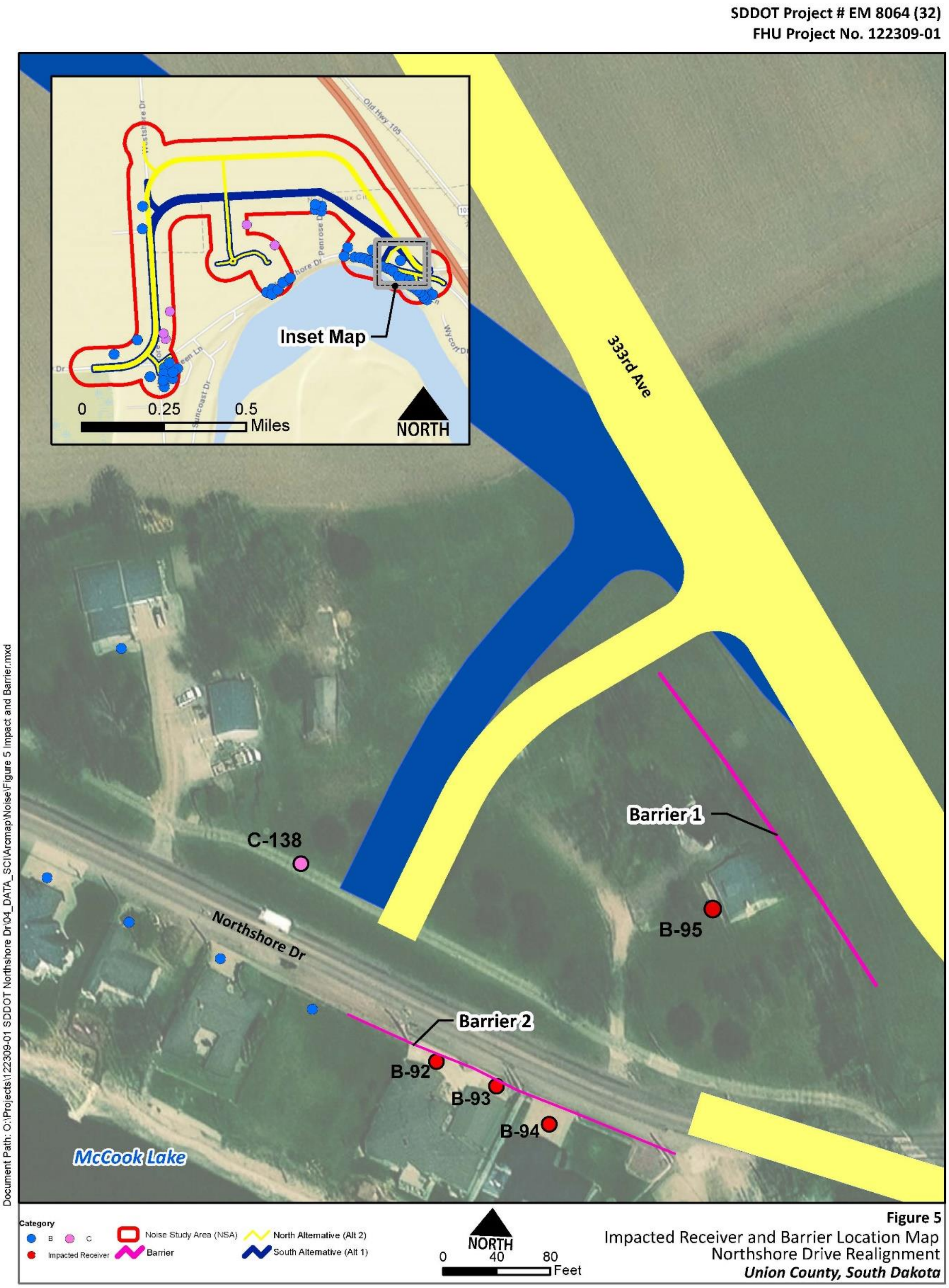
Results for both of the reviewed alternatives indicate that the same receptors would be impacted by future (2045) noise conditions (**Figure 5**; **Table 4**). The majority of future traffic would be automobiles and not medium/heavy trucks relocated from Northshore Dr to 333rd Ave, an area surrounded by undeveloped agricultural fields and few nearby receptors. This redirection of traffic would not cause impacts to most receptors along Northshore Dr. Traffic noise levels for both alternatives ranged from 51-68 dBA. Results indicate that B-92, B-93, B-94, and B-95 would approach or be above the NAC for Category B land uses. Under the Reviewed Alternatives B-95 will be surrounded by new or existing alignments and receptors B-92-B-94 will remain adjacent to the roadway.

Table 5 Summary of Receptor Impacted by Traffic Noise

Land Use Category	Existing Conditions—at or above NAC (2024)	Alternative 1 (South Alignment) Impacts (2045)	Alternative 2 (North Alignment) Impacts (2045)
Category B	1	4	4
Category C	0	0	0
Total	**1**	**4**	**4**

Source: FHU modeling results, 2025

Figure 5. Impacted Receptor and Barrier Location



4.2 Construction Noise

Adjoining properties in the project area could be exposed to noise from construction activities from the reviewed Alternatives. Construction noise differs from traffic noise in several ways:

- Construction noise lasts only for the duration of the construction event, with most construction activities in noise-sensitive areas being conducted during hours that are least disturbing to adjacent and nearby residents.
- Construction activities generally are short term and, depending on the nature of the construction operations, could last from seconds (e.g., a truck passing a receptor) to months (e.g., constructing a bridge).
- Construction noise is intermittent and depends on the type of operation, location, and function of the equipment, and the equipment usage cycle.

Construction noise is not assessed like operational traffic noise; there are no FHWA or SDDOT NACs for construction noise. Construction noise would be subject to relevant local regulations and ordinances, and any construction activities would be expected to comply with them. No construction or detour noise abatement actions are being proposed at this time; however, typical best management practices should be employed where possible. The project area includes residences. To address the temporary elevated noise levels that may be experienced during construction, standard best practices should be incorporated where it is feasible to do so. These measures may include:

- Notify neighbors in advance when construction noise may occur and its expected duration so that they may plan appropriately.
- Manage construction activities to keep noisy activities as far from sensitive receptors as possible.
- Exhaust systems on equipment would be in good working order. Equipment would be maintained on a regular basis, and equipment may be subject to inspection by the construction project manager to ensure maintenance.
- Properly designed engine enclosures and intake silencers would be used where appropriate.
- Use temporary noise barriers where appropriate and possible.
- New equipment would be subject to new product noise emission standards.
- Stationary equipment would be located as far from sensitive receptors as possible.
- Perform construction activities in noise sensitive areas during hours that are least disturbing to adjacent and nearby residents.

5.0 Traffic Noise Abatement Evaluation

The results from the traffic noise analysis indicated that the same receptors would be impacted by noise from the Reviewed Alternatives (**Section 4.1**). Therefore, potential abatement actions for the impacted receptor were investigated in accordance with relevant guidelines (SDDOT, 2023). Impacted areas are not guaranteed abatement measures under these guidelines, but abatement measures for the areas must be evaluated for feasibility and reasonableness. Reasonableness includes assessment of abatement benefits and costs.

Barriers are a common abatement action and were evaluated for receptors that were impacted by the 2045 future conditions. The overall feasibility and reasonableness of noise abatement actions that provide a substantive benefit for the impacted receptors were evaluated. Abatement actions found to be feasible and reasonable would be recommended for inclusion in the project.

Noise barriers can be earth berms or constructed walls and many materials can be effective barriers. Berms can be very effective but occupy considerably more space than comparable walls and would be impractical or impossible choices for the noise barriers for the proposed project.

5.1 Traffic Noise Barrier Evaluations

To evaluate the noise barrier, TNM models with a barrier protecting the impacted receptors were developed (**Appendix B**). Each barrier was placed near the limits of construction to make most use of the unaltered topography (**Figure 5**). The barriers were assessed for feasibility. If the minimum parameters for an effective barrier were met and the barrier was feasible, then the barrier was checked for reasonableness according to SDDOT guidance (SDDOT, 2023). The feasibility and reasonableness of each barrier determined whether the barrier was recommended for the Reviewed Alternatives.

Briefly, for an abatement action to be feasible it must:

- Not cause undue safety or related problems, including excessive restriction of sight distance, shadow causing icing, and severe drainage problems (FHWA, 2011)
- Not exceed 20 feet in height while still providing the requisite noise reductions
- Be located in an area with compatible topography
- Not cause undue drainage or utility problems
- Abatement measure must be maintainable, including access for maintenance tasks
- Provide at least 5 dBA of noise reduction to at least 60 percent of the front row receptors; and the barrier must extend completely across the affected property line(s)

For an abatement action to be reasonable it must:

- Provide at least 7 dBA of noise reduction to at least 40 percent of the benefitting receptors
- Cost no more than $25,000 per benefitted receptor
- Be supported by at least 50 percent of the voting points available from returned ballots under the public participation program for benefitting receptors (owners and/or tenants). Consideration of the noise abatement measure will continue unless more than 50 percent of all distributed ballots are returned that indicate the balloted voters do not want the abatement measure.

Two barriers (**Figure 5**) were modeled to determine the most efficient barrier size that provided the noise reductions required (SDDOT, 2023) for each impacted receptor (**Table 6**). The initial barrier cost-effectiveness (**Table 7**) was based on assumed costs of $52/square foot. The result was compared to the SDDOT upper threshold of $25,000/benefitted receptor. Barriers were evaluated for cost-effectiveness (**Table 7**), based on assumed costs described by SDDOT (2023).

Barrier 1

Barrier 1 was analyzed for receptor B-95 for both Build Alternatives (**Figure 5**) and was modeled to a maximum height of 20 feet and a length of 450 feet (**Table 6**). Noise levels at B-95 were reduced by 5-dBA but could not be reduced by 7-dBA. The cost of Barrier 1 would be approximately 18 times the allowable cost of a barrier per benefited receptor. Consequently, the evaluation criteria were not met (**Table 6**) and Barrier 1 was not feasible and reasonable.

Barrier 2

Barrier 2 was analyzed for receptors B-92, B-93, and B-94 for both Build Alternatives (**Figure 5**) and was modeled as an 11-foot by 190-foot noise wall (**Table 6**). Noise levels at 66 percent of receptors were reduced by 5-dBA and 7-dBA. The cost of Barrier 2 would be approximately 2 times the allowable cost of a barrier per benefited receptor. Consequently, the evaluation criteria were not met (**Table 6**) and Barrier 2 was not feasible and reasonable.

Table 6 Summary of Preliminary Prospective Noise Wall Size and Cost

Barrier Name	Approximate Wall Segment Dimensions	Approximate Wall Size (sq. ft)	Approximate Wall Cost	Number of Benefitting Receptors
Barrier 1	20 x450	9,000	$468,000	1
Barrier 2	11x190	1,938	100,776	2

Source: FHU modeling results, 2025

Table 7 Summary of Preliminary Noise Wall Feasibility and Reasonableness

Barrier Name	Feasible				Reasonable			
	Percent of front row with at least a 5 dBA benefit	Barrier fits topography and is maintainable	Barrier height is less than 20 feet	Barrier outside of clear zone with other walls	Percent of benefited front row receptors with 7 dBA reduction	Cost effectiveness ($/benefitted receptor)	Support of 50% of benefitting receptors	Barrier is feasible and reasonable?
Barrier 1	100	Yes	No	Yes	0	$468,000	NA	No
Barrier 2	66	Yes	Yes	No	66	$100,776	NA	No

Source: FHU modeling results, 2025

Conclusions

Several receptors were identified as being impacted with future traffic causing noise levels to exceed the NAC for Category B land uses. As such, two barriers were evaluated using feasible and reasonable tests from SDDOT (2023) guidelines. Barrier 1 was evaluated and described above and was unable to reach a decrease of 7-dBA at a barrier height of 20 feet or less and the cost per benefited receptor was well above the $25,000 limit when the cost of noise barriers was assumed to be $52/square foot (**Table 7**). Barrier 2 was evaluated and described above. Barrier 2 met the noise reduction criteria, but the cost per benefited receptor was above the $25,000 limit when the cost of noise barriers was assumed to be $52/square foot. Additionally, it does not appear that barrier would be outside of the clear zone given the proximity of the driveways and residences to the roadway (**Table 7**). Therefore, no noise abatement barriers are recommended for either of the Reviewed Alternatives.

6.0 SUMMARY

A traffic noise analysis was performed for a road improvement project that would construct a new alignment between 484th Ave and Northshore Dr. The results from the traffic noise analysis indicated that the same receptors for both Alternatives in the Noise Study Area would be impacted by noise in 2045. Because noise impacts are expected from either Alternative, traffic noise abatement measures were evaluated for the project, but deemed to be not practical based on SDDOT standards (2023).

6.1 Information for Local Officials

For informational purposes and planning by local governments, the distance from the outside travel lanes of either Alternative to the contour line for the peak-hour L_{eq} of 66 dBA (Categories B and C) in 2045 was estimated to be 9 feet. A 71-dBA contour could not be estimated as it does not appear traffic noise will increase to this level. Any future noise-sensitive development in the Noise Study Area that is within the applicable setback distances may experience traffic noise impacts.

6.2 Statement of Likelihood

The analysis described above concluded that there would be noise impacts within the study area but that prospective noise abatement barriers would not be considered feasible or reasonable. Therefore, no noise abatement barriers are recommended for either Alternative.

6.3 Indirect and Cumulative Impacts

Indirect and cumulative effects from construction of either Alternative is not anticipated, as no permitted developments are known. However, conceptual plans for residential development are known, but as of the date of this report are not permitted. Based on the suggested 9-foot setback, it is unlikely that future developments will be impacted from traffic noise. Commercial, office, retail or industrial uses next to highways and interstates experience improved accessibility and easy access to transportation arteries. These land uses are not negatively affected by the noise, and they can serve to buffer residential or other sensitive uses from roadway generated sound. Land uses north of the study area is predominately row crop agriculture (Land use Category G) and do not have NAC approach levels.

7.0 REFERENCES

Felsburg Holt & Ullevig. 2023. Northshore Drive Realignment: Project No: EM 8064 (32) Alternatives Analysis. Traffic Report. December 2023

Federal Highway Administration. 1996. Measurement of Highway-Related Noise. May.

Federal Highway Administration. 2011. Highway Traffic Noise: Analysis and Abatement Guidance. December.

South Dakota Department of Transportation. 2023. Noise Analysis and Abatement Guidance. December 5.

South Dakota Department of Transportation. 2024. Traffic Data. https://experience.arcgis.com/experience/cb089bc673df486a8708f2d22b1e740b

South Dakota Department of Transportation. 2019. Environmental Procedures Manual.

APPENDIX A
TNM Model Input and Results

Summary of Modeled Traffic Data-Existing 2022

US-81 Segment	Year	Average daily traffic (ADT)	Direction	No. Cars	No Med. Trucks	No. Heavy Truck
Northshore Dr						
Noise Study Area (NSA) to Westshore Dr	2022	-	WB	46	0	2
			EB	204	0	8
Westshore Dr to Streeter Dr	2022	-	WB	110	0	5
			EB	471	0	19
Streeter Dr to I-29 SB Ramp	2022	-	WB	454	0	19
			EB	440	0	18
I-29 SB Ramp to I-29 NB Ramp	2022	-	WB	448	0	19
			EB	125	0	5
I-29 NB Ramp to NSA	2022	-	WB	97	0	4
			EB	154	0	6
Westshore Dr/484th Av						
NSA to Northshore Dr	2022	-	NB	30	0	1
			SB	11	0	0
Northshore Dr to NSA	2022	-	NB	115	0	5
			SB	41	0	1
Streeter Dr						
NSA to Northshore Dr	2022	-	NB	113	0	5
			SB	84	0	0
SB I-29 Ramp						
NSA to Northshore	2022	-	SB	47	0	2
NSA to Northshore	2022	-	SB	356	0	15
NB I-29 Ramp						
NSA to Northshore	2022	-	NB	407	0	117
NSA to Northshore	2022	-	NB	27	0	1
I-29						
NSA to Northshore Dr	2022	-	NB	374	0	112
			SB	294	0	88
Northshore Dr to NSA	2022	-	NB	294	0	88
			SB	374	0	112

Summary of Modeled Traffic Data-Alternative 1 (South Alignment) 2045

US-81 Segment	Year	Average daily traffic (ADT)	Direction	No. Cars	No Med. Trucks	No. Heavy Truck
Northshore Dr						
Noise Study Area (NSA) to Westshore Dr	2045	-	WB	149	0	6
			EB	336	0	14
Westshore Dr to Streeter Dr	2045	-	WB	29	0	1
			EB	216	0	9
Streeter Dr to 333rd	2045	-	WB	125	0	5
			EB	202	0	8
333rd to I-29 SB Ramp	2045	-	WB	701	0	29
			EB	638	0	27
I-29 SB Ramp to I-29 NB Ramp	2045	-	WB	677	0	28
			EB	163	0	7
I-29 NB Ramp to NSA	2045	-	WB	115	0	5
			EB	178	0	7
Westshore Dr/484th Av						
NSA to Northshore Dr	2045	-	NB	43	0	2
			SB	19	0	1
Northshore Dr to 333rd	2045	-	NB	302	0	13
			SB	144	0	6
333rd to NSA	2045	-	NB	197	0	8
			SB	91	0	4
Streeter Dr						
NSA to Northshore Dr	2045	-	NB	130	0	5
			SB	72	0	3
333rd						
448th to Northshore	2045	-	WB	125	0	5
			EB	446	0	19
SB I-29 Ramp						
NSA to Northshore	2045	-	SB	82	0	3
NSA to Northshore	2045	-	SB	528	0	22
NB I-29 Ramp						
NSA to Northshore	2045	-	NB	629	0	26
NSA to Northshore	2045	-	NB	27	0	1
I-29						
NSA to NSA	2045	-	NB	6022	0	1799
			SB	6022	0	1799

Summary of Modeled Traffic Data-Alternative 2 (North Alignment) 2045

US-81 Segment	Year	Average daily traffic (ADT)	Direction	No. Cars	No Med. Trucks	No. Heavy Truck
Northshore Dr						
Noise Study Area (NSA) to 333rd	2045	-	WB	149	0	6
			EB	336	0	14
333rd to Westshore Dr	2045	-	WB	58	0	2
			EB	91	0	4
Westshore Dr to Streeter Dr	2045	-	WB	29	0	1
			EB	216	0	9
Streeter Dr to 333rd	2045	-	WB	125	0	5
			EB	202	0	8
333rd to I-29 SB Ramp	2045	-	WB	701	0	29
			EB	638	0	27
SB I-29 Ramp to I-29 NB Ramp	2045	-	WB	677	0	28
			EB	163	0	7
NB I-29 Ramp to NSA	2045	-	WB	115	0	5
			EB	178	0	7
Westshore Dr/484th Av						
NSA to Northshore Dr	2045	-	NB	43	0	2
			SB	19	0	1
Northshore Dr to 333rd	2045	-	NB	302	0	13
			SB	144	0	6
333rd to NSA	2045	-	NB	197	0	8
			SB	91	0	4
Streeter Dr						
NSA to Northshore Dr	2045	-	NB	130	0	5
			SB	72	0	3
333rd						
448th to Northshore	2045	-	WB	125	0	5
			EB	446	0	19
SB I-29 Ramp						
NSA to Northshore	2045	-	SB	82	0	3
NSA to Northshore	2045	-	SB	528	0	22
NB I-29 Ramp						
NSA to Northshore	2045	-	NB	629	0	26
NSA to Northshore	2045	-	NB	53	0	2

I-29						
NSA to NSA	2045	-	NB	6022	0	1799
			SB	6022	0	1799

Noise Modeling Results-2045

Receiver (Category and Number)	NAC Approach Level Leq (dBA)	Existing Leq (dBA)	Alternative 1 (South Alignment) Leq (dBA) (2045)	Alternative 2 (North Alignment) Leq (dBA) (2045)	Δ[1 2]	Impact (Yes or No)
B3	66	50	54	53	3.1/4.2	No
B4	66	49	55	52	3.8/5.9	No
B5	66	47	53	53	6/6.6	No
B7	66	55	56	55	0.3/1.3	No
B8	66	57	56	56	-1.6/-0.8	No
B13	66	51	55	55	3.8/3.8	No
B14	66	50	53	52	2.3/2.8	No
B22	66	48	55	55	6.2/6.4	No
B23	66	50	56	56	5.7/5.7	No
B24	66	48	52	52	4.3/4.7	No
B25	66	49	53	52	2.8/3.4	No
B52	66	66	63	63	-2.8/-2.9	No
B53	66	65	63	63	-2.7/-2.7	No
B54	66	56	58	58	1.7/1.5	No
B55	66	57	58	58	0.8/0.5	No
B56	66	64	61	61	-2.2/-2.3	No
B57	66	65	62	62	-2.6/-2.6	No
B58	66	65	62	62	-2.6/-2.6	No
B81	66	65	63	63	-1.7/-1.8	No
B83	66	56	61	61	5/5	No
B84	66	56	65	64	7.8/8.1	No
B85	66	62	62	63	0.2/-0.1	No
B86	66	63	63	64	1.2/0.5	No
B87	66	63	64	64	1/1	No
B88	66	62	64	64	1.8/1.9	No
B89	66	62	64	64	2.1/2.2	No
B90	66	63	65	65	1.9/1.9	No
B91	66	62	65	65	2.6/2.4	No

B92	66	63	66	66	2.4/2.6	**Yes**
B93	66	64	66	66	2.4/2.5	**Yes**
B94	66	62	66	66	3.3/3.3	**Yes**
B95	66	59	68	68	9.1/9.1	**Yes**
B96	66	58	65	65	6.6/6.4	No
B97	66	58	65	65	6.7/6.6	No
B98	66	58	65	65	6.8/7.1	No
B99	66	57	64	65	7.5/7	No
B100	66	58	65	65	7.5/6.8	No
B103	66	56	65	65	8.9/8.8	No
B104	66	56	65	65	8.9/8.9	No
B105	66	56	64	64	8.7/8.3	No
B106	66	56	64	64	8.7/8.6	No
B107	66	56	64	64	8.2/8.2	No
B108	66	56	64	64	8/7.8	No
B109	66	56	64	64	7.9/7.9	No
B110	66	52	56	57	4.5/3.3	No
B111	66	55	56	60	5.8/1.3	No
C126	66	44	53	52	7.9/9	No
C128	66	44	54	52	8.2/9.6	No
C135	66	51	56	55	3.4/4.7	No
C136	66	51	57	56	5/5.8	No
C137	66	47	53	53	6/6.1	No
C-138	66	61	64	65	3.2/3.7	No
C-139	66	60	62	62	2.1/2.1	No

[1] Δ=Is the difference from the Modeled Build 2045 Condition and the Existing Conditions (dBA)
[2] Alternative 1/Alternative 2

APPENDIX C
Noise Measurement Field Data Sheets

FELSBURG HOLT & ULLEVIG
connecting & enhancing communities
6400 Fiddlers Green Circle, Suite 1500
Greenwood Village, CO 80111
Ph. 303.721.1440

Date: 4-24-24

Project #: 122309-01

Noise Measurement Worksheet

Meter: (check box)

- [x] NTI XL2 (S/N A2A-04345-D1; gray)
- [ ] NTI XL2 (S/N A2A-06663-EO; white)
- [ ] L-D CAL200
- [x] Norsonic 1251

Project Name: Northshore

Measurement by: Adam Behmer

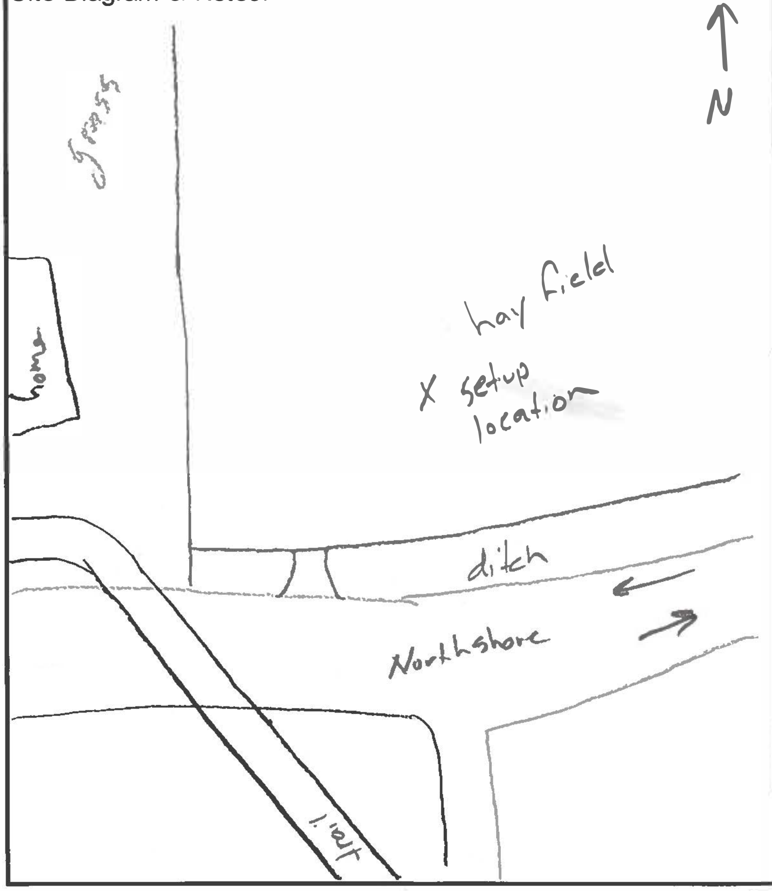
Pre-Check: 114 dBA

Post-Check: 114 dBA

Start Time	Duration	Leq	Maximum	Minimum
259	15m	58.1 dBA	dBA	dBA
Avg/Max Wind: 3.8 / 19.5 mph	Wind Direction: SE	Temperature: 71.2		
Data File: 2024-04-24-SLM-002		R. Humidity: 27.6 %		

UTM Coordinates:
Zone____ 42.5504383; -96.6113997

Site Diagram & Notes:



Traffic Counts

Direction	Cars	Med. Truck	Hvy. Truck	Bus	MC
WB	99	2	∅	11	∅
EB	50	3	∅	1	1

lawn mowers in background until 310

FELSBURG HOLT & ULLEVIG
connecting & enhancing communities
6400 Fiddlers Green Circle, Suite 1500
Greenwood Village, CO 80111
Ph. 303.721.1440

Date: 4-24-24

Project #: 122309-01

Noise Measurement Worksheet

Meter: (check box)

- ☑ NTI XL2 (S/N A2A-04345-D1; gray)
- ☐ NTI XL2 (S/N A2A-06663-EO; white)
- ☐ L-D CAL200
- ☑ Norsonic 1251

Project Name: North shore

Measurement by: Adam Behmer

Pre-Check: 114 dBA

Post-Check: 114 dBA

Start Time	Duration	Leq	Maximum	Minimum
315	15 min	61.3 dBA	dBA	dBA

Avg/Max Wind	Wind Direction	Temperature
3.8 / 19.5 mph	SE	71.2

Data File:	R. Humidity
2024-04-24-SLM-002	27.6 %

UTM Coordinates:
Zone_____ 42.5504383, -96.5113997

Site Diagram & Notes:

Sec #1

Traffic Counts

	Cars	Med. Truck	Hvy. Truck	Bus	MC
WB	76	Ø	Ø	Ø	Ø
EB	245	2	Ø	10	Ø

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Ph. 303.721.1440

Date: 4-24-24

Project #: 122309-01

Noise Measurement Worksheet

Meter: (check box)
- ☑ NTI XL2 (S/N A2A-04345-D1; gray)
- ☐ NTI XL2 (S/N A2A-06663-EO; white)
- ☐ L-D CAL200
- ☑ Norsonic 1251

Project Name: Northshore
Measurement by: Adam Behmer

Pre-Check: 114 dBA
Post-Check: 114 dBA

Start Time	Duration	Leq	Maximum	Minimum
332	15 Min	58.1 dBA	69.4 dBA	50.3 dBA

Avg/Max Wind	Wind Direction	Temperature
/ mph	SE	71.2

Data File:	R. Humidity
2024-04-24 - SLM 003	%

UTM Coordinates:
Zone____ 42.5504383; -96.5113997

Site Diagram & Notes:

Sec #1

Traffic Counts

	Cars	Med. Truck	Hvy. Truck	Bus	MC
WB	54	∅	∅	1	∅
EB	83	∅	∅	1	∅

00d

FELSBURG HOLT & ULLEVIG
connecting & enhancing communities
6400 Fiddlers Green Circle, Suite 1500
Greenwood Village, CO 80111
Ph. 303.721.1440

Date: 4-24-24

Project #: 122309-01

Noise Measurement Worksheet

Meter: (check box)

- [x] NTI XL2 (S/N A2A-04345-D1; gray)
- [ ] NTI XL2 (S/N A2A-06663-EO; white)
- [ ] L-D CAL200
- [x] Norsonic 1251

Project Name: Northshore

Measurement by: Adam Behmer

Pre-Check: 114 dBA

Post-Check: 114 dBA

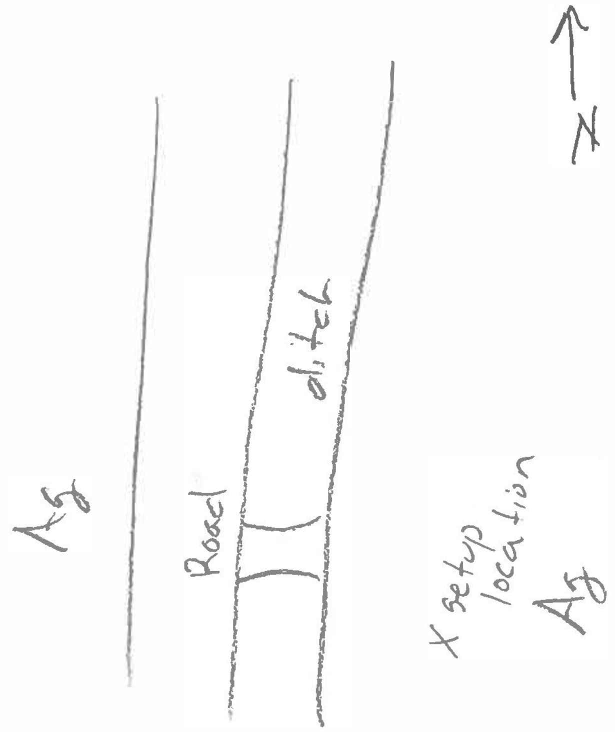
Start Time	Duration	Leq	Maximum	Minimum
203	15min	47.6 dBA	69.4 dBA	37.0 dBA

Avg/Max Wind	Wind Direction	Temperature
2.9 19.3 mph	SE	72.3

Data File:	R. Humidity
2024-04-24-SLM-000	224 %

UTM Coordinates:
Zone ____ 42556911 6; -96. 52657116

Site Diagram & Notes:



Traffic Counts

Direction	Cars	Med. Truck	Hvy. Truck	Bus	MC
NB	1	∅	∅	∅	∅
SB	3	1		∅	∅

FELSBURG HOLT & ULLEVIG
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Ph. 303.721.1440

Date: 4-24-24

Project #: 122309-01

Noise Measurement Worksheet

Meter: (check box)
- [ ] NTI XL2 (S/N A2A-04345-D1; gray)
- [x] NTI XL2 (S/N A2A-06663-EO; white)
- [ ] L-D CAL200
- [x] Norsonic 1251

Project Name: Northshore

Measurement by: Adam Behmer

Pre-Check: 114 dBA

Post-Check: 114 dBA

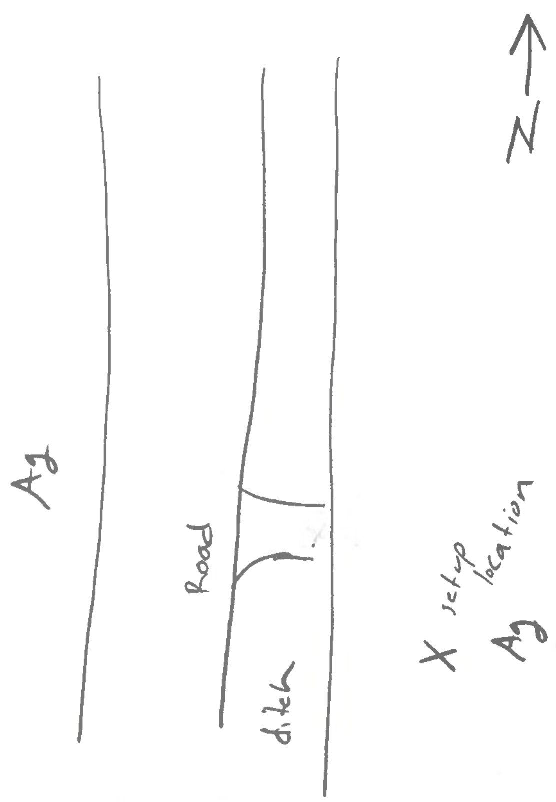
Start Time	Duration	Leq	Maximum	Minimum
218	15 min	47.6 dBA	69.4 dBA	37.0 dBA

Avg/Max Wind	Wind Direction	Temperature	R. Humidity
2.9 / 19.3 mph	SE	72.3	22.4 %

Data File: 2024-04-24-SLM-000

UTM Coordinates:
Zone_____ 42.5569116 ; -96.5265716

Site Diagram & Notes:



Traffic Counts

	Cars	Med. Truck	Hvy. Truck	Bus	MC
NB	1	Ø	Ø	Ø	Ø
SB	1	1		Ø	Ø

rev. 11_2020

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Greenwood Village, CO 80111
Ph. 303.721.1440

Date: 4-24-24

Project #: 122309-01

Noise Measurement Worksheet

Meter: (check box)
- [x] NTI XL2 (S/N A2A-04345-D1; gray)
- [ ] NTI XL2 (S/N A2A-06663-EO; white)
- [x] L-D CAL200
- [ ] Norsonic 1251

Project Name: Northshore

Measurement by: Adam Behmer

Pre-Check: 114 dBA

Post-Check: 114 dBA

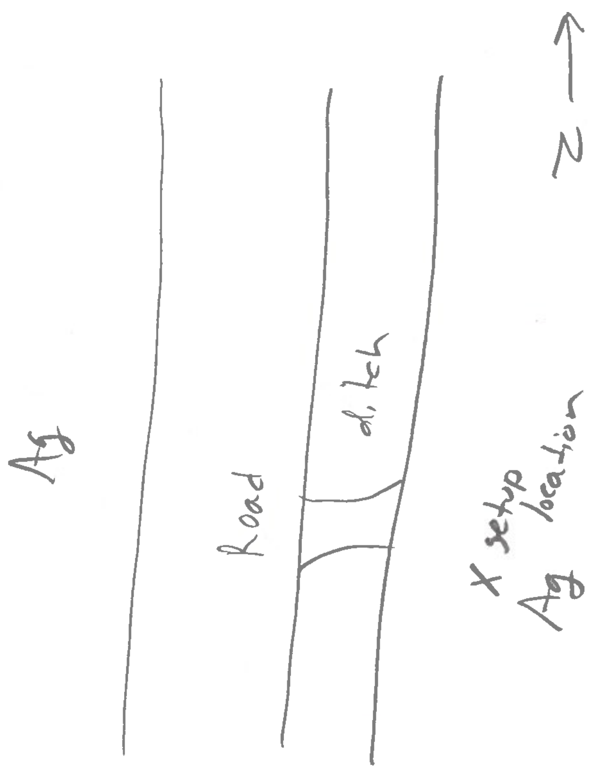
Start Time	Duration	Leq	Maximum	Minimum
354	15Min	49.5 dBA	67.4 dBA	37.9 dBA

Avg/Max Wind	Wind Direction	Temperature
4.3 / 8.9 mph	SE	69.2

Data File	R. Humidity
2024-04-24-SLM-004	22.5 %

UTM Coordinates:
Zone_____ 42.6569116; -96.5265 7116

Site Diagram & Notes:



Traffic Counts

	Cars	Med. Truck	Hvy. Truck	Bus	MC
NB	2	1	Ø	Ø	Ø
SB	Ø	Ø	Ø	Ø	Ø

rev. 11_2020

FELSBURG HOLT & ULLEVIG
connecting & enhancing communities
6400 Fiddlers Green Circle, Suite 1500
Greenwood Village, CO 80111
Ph. 303.721.1440

Date: 4-24-24

Project #: 122309-01

Noise Measurement Worksheet

Meter: (check box)

- [x] NTI XL2 (S/N A2A-04345-D1; gray)
- [ ] NTI XL2 (S/N A2A-06663-EO; white)
- [ ] L-D CAL200
- [x] Norsonic 1251

Project Name: North shore

Measurement by: Adam Behmer

Pre-Check: 114 dBA

Post-Check: 114 dBA

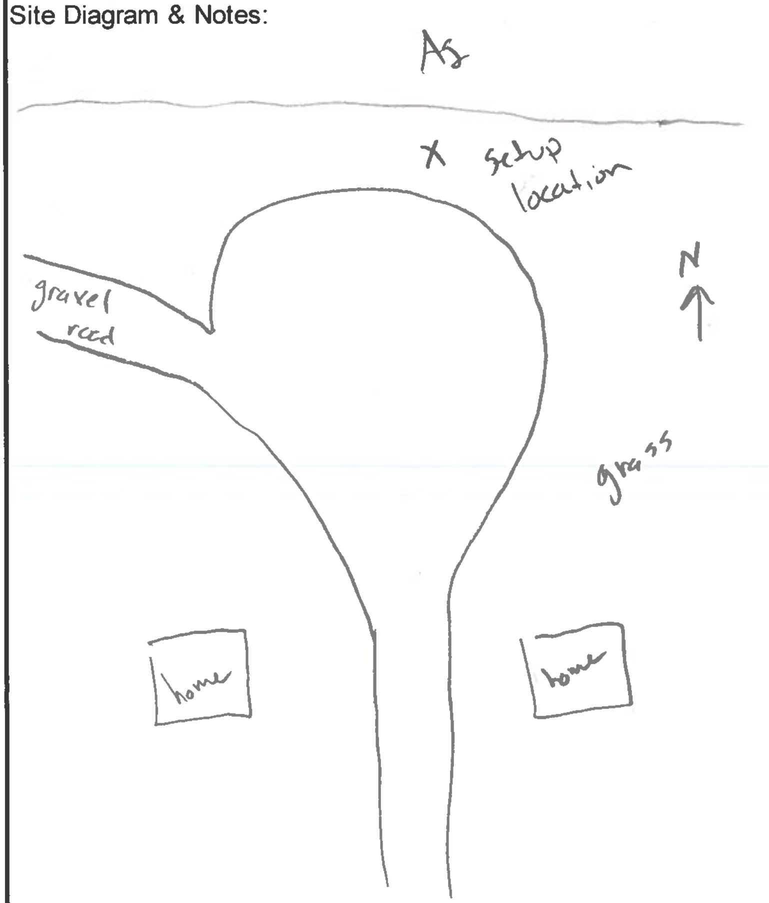
Start Time	Duration	Leq	Maximum	Minimum
240-249	15min (9min)	49.4 dBA	56.1 dBA	45.9 dBA

Avg/Max Wind	Wind Direction	Temperature
3.3 / 18.7 mph	E	74.9

Data File:	R. Humidity
2024-04-24-SLM001	31.1 %

UTM Coordinates:
Zone______ 42.5537652; -96.5168754

Site Diagram & Notes:



Traffic Counts

Cars	Med. Truck	Hvy. Truck	Bus	MC
Ø	Ø	Ø		
Ø	Ø	Ø	Ø	Ø

site skipped after 9 min b/c lawn mowing crew (1/0) started in area