Michigan Department of Transportation

US-23 Improvements
Noise Analysis Report

US-23/M-14 West Interchange to Silver Lake Road

CS 81075 and 47013
JN 122678

MDOT University Region,
Ann Arbor Charter and Northfield Townships,
Washtenaw County, MI and
Green Oak Township, Livingston County, MI

February 2015

Bergmann associates
architects // engineers // planners

1427 W. Saginaw Street, Suite 200
East Lansing, MI 48823
517.272.9835 (phone)
517.272.9836 (fax)

Noise Analysis Report

Table of Contents

Tables

Figures

Appendices

Noise Analysis Technical Report

1. EXECUTIVE SUMMARY

This report evaluated the potential noise impacts of the proposed improvements to US-23 and the interchanges between west US-23/M-14 interchange and Silver Lake Rd in Washtenaw and Livingston Counties. This report was completed in conformance with corresponding Federal regulations and guidance and the National Environmental Policy Act (NEPA). The goal of this project is to address the infrastructure deficiencies and the directional peak hour congestion.

The project is being studied as a Type I project because the construction of two enhanced median (inside) shoulders for traffic flow (called dynamic shoulder use) are proposed during directional peak congestion periods, southbound in the morning and northbound in the evening. The Federal Highways Administration (FHWA) determined that the Preferred Alternative requires a noise abatement analysis because the shoulders will be used at regularly scheduled times as travel lanes during peak hours and are considered new travel lanes. The addition of new travel lanes fits under the definition of a Type I project under 23 CFR 772.5 and such projects are required to undergo a noise analysis. Moreover, under the Type I definition: "(8) If a project is determined to be a Type I project under this definition then the entire project area as defined in the environmental document is a Type I project" which means the noise analysis will also cover the capital improvement section (CPM) north of the Active Traffic Management (ATM) to the Silver Lake Rd interchange.

The noise analysis presents the existing and future acoustical environment at various receptors located along US-23. The determination of noise abatement measures and locations is in compliance with the FHWA's *Procedures for Abatement of Highway Traffic Noise and Construction Noise* as presented in the Code of Federal Regulations, Title 23 Part 772 (23 CFR 722), and the Michigan Department of Transportation (MDOT): *Highway Noise Analysis and Abatement Handbook, July 2011*. The MDOT: *Highway Noise Analysis and Abatement Handbook* is in compliance with the MDOT *State Transportation Commission Policy 10136 Noise Abatement,* dated July 31, 2003.

Field measurements with concurrent traffic counts were taken to compare with modeled noise levels to validate the Traffic Noise Model® (TNM) for use on this project to predict existing and design year noise levels. Existing noise level measurements were conducted on July 22, 2014 and July 23, 2014 at eleven (11) representative sites in the project vicinity. A minimum 15 minute measurement were taken at each site during peak and off-peak traffic time periods. Peak traffic periods are generally defined as between 7:00 am and 9:00 am and between 4:00 pm and 6:00 pm. Traffic counts were taken at each site, concurrent with the noise measurements.

The traffic noise prediction program, TNM®2.5, was used to model existing (2015) and Build (2040) traffic noise levels within the study area. Table 1 lists the number of locations within a Common Noise Environment (CNE) that approach or exceed the FHWA Noise Abatement Criteria (NAC). The limits of the CNEs are depicted in Figure 1. The Future 2040 Build traffic noise levels, within the overall project area, would increase by up to 2 dB(A), L_{eq} over the existing conditions. In some areas, the concrete median barrier that is proposed as a part of the Future 2040 Build condition will result in a reduction in traffic noise levels.

Table 1: Number of Locations Within CNEs that Approach or Exceed the NAC

Activity Description			2015	2040
CNE Area A	–	Residential	0	0
CNE Area B	–	Residential	0	0
CNE Area C	–	Mixed Use	1	1
CNE Area D	–	Residential	0	0
CNE Area E	–	Residential	1	1
CNE Area F	–	Mixed Use	0	0
CNE Area G	–	Residential	16	15
CNE Area H	–	Residential	13	13
CNE Area I	–	Residential	8	6
CNE Area J	–	Residential	10	10
CNE Area K	–	Mixed Use	1	0
CNE Area L	–	Residential	33[1]	33[1]
CNE Area M	–	Residential	3	3
CNE Area N	–	Residential	13	20
CNE Area O	–	Commercial	0	0
CNE Area P	–	Commercial	0	0
CNE Area Q	–	Residential	0	0
CNE Area R	–	Residential	8	9
CNE Area S	–	Residential	23[2]	24[2]
CNE Area T	–	Mixed Use	1	1
CNE Area U	–	Residential	5	6

1) Includes twenty-eight (28) Dwelling Unit Equivalent receivers
2) Includes seven (7) Dwelling Unit Equivalent receivers

CNE areas A, B, D, F, K, O, P, and Q have no impacted receptors with the future (2040) Build condition, and do not require abatement analysis. Noise barriers were modeled within each CNE along areas with impacted receivers to determine if the barrier meets feasibility and reasonableness requirements. The noise barriers that were evaluated for CNEs C, H, and T failed to meet MDOT's feasibility and reasonableness criteria. The noise barriers that were evaluated for CNEs E, G, I, J, L, M, N, and U were found to satisfy MDOT's feasibility criteria, but failed to meet MDOT's reasonableness criteria. The noise barrier that was evaluated for CNE R (including an impacted section of CNE S) was found to satisfy MDOT's feasibility and reasonableness criteria. *Based on the study completed, noise abatement will be required at CNE R and an impacted portion of CNE S*

FHWA encourages local agencies to practice noise compatible land use planning to prevent highway traffic noise impacts on future developments on currently vacant lands. The study estimated 71 dB(A) and 66 dB(A) contours along the US-23 project corridor to identify potential impact areas. The decibel levels reflect the impact levels on the land use activity categories in FHWA Noise Abatement Criteria (Table 3). The 71 dB(A) and 66 dB(A) noise contours were located approximately 205 ft and 315 ft, respectfully, from the center of the existing median on average, but vary based on the existing topography. These contours are depicted in Appendix C.

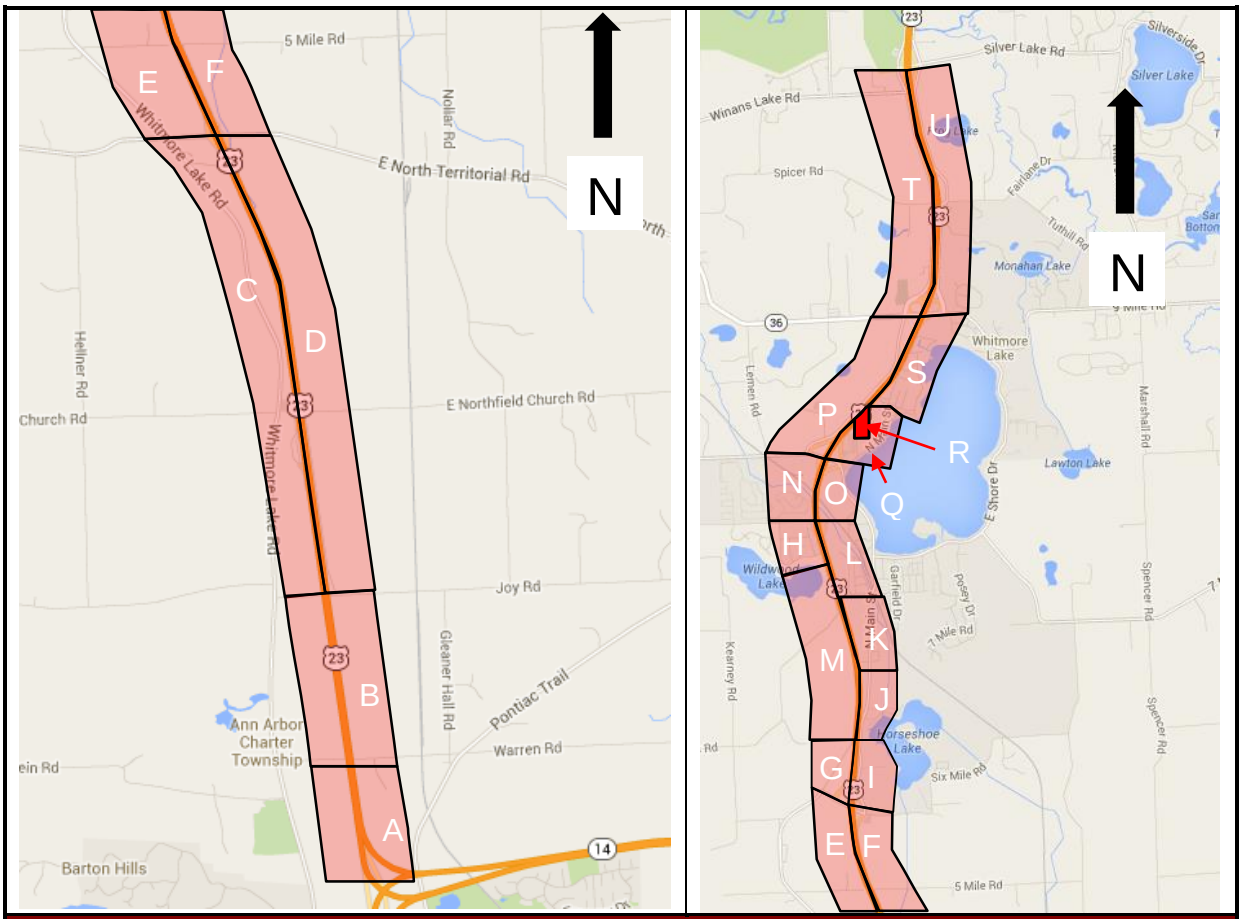


Figure 1: Common Noise Environment Locations along US-23

2. PURPOSE OF THE REPORT

This report evaluates the potential noise impacts within the US-23 corridor in conformance with Federal regulations and guidance, and NEPA. The project is being studied as Type I project because the construction of two enhanced median (inside) shoulders for traffic flow (called dynamic shoulder use) are proposed during directional peak congestion periods, southbound in the morning and northbound in the evening. The FHWA determined that the Preferred Alternative requires a noise abatement analysis because the shoulders will be used at regularly scheduled times as travel lanes during peak hours and are considered new travel lanes. The addition of new travel lanes fits under the definition of a Type I project under 23 CFR 772.5 and such projects are required to undergo a noise analysis. Moreover, under the Type I definition: "(8) If a project is determined to be a Type I project under this definition then the entire project area as defined in the environmental document is a Type I project" which means the noise analysis will also cover the capital improvement section (CPM) north of the ATM to the Silver Lake Rd interchange.

The determination of noise abatement measures and locations is in compliance with the FHWA's *Procedures for Abatement of Highway Traffic Noise and Construction Noise* as presented in the Code of Federal Regulations, Title 23 Part 772 (23 CFR 722), and the Michigan Department of Transportation (MDOT): *Highway Noise Analysis and Abatement Handbook, July 2011*. The MDOT: *Highway Noise Analysis and Abatement Handbook* is in compliance with the *State Transportation Commission Policy 10136 Noise Abatement*, dated July 31, 2003.

3. PROJECT DESCRIPTION

The US-23 freeway is a major north-south arterial that begins in Michigan at the Ohio State Line near Toledo, traverses through the cities of Ann Arbor and Flint, runs adjacent to the Lake Huron shoreline and terminates at Mackinaw City. The project corridor is a 10 mile, four-lane section of US-23 within Livingston and Washtenaw Counties (Figure 2) and extends from the west US-23/M-14 (tri-level) interchange (Exit 45) north to the Silver Lake Rd interchange (Exit 55).

The goal of this project is to address the infrastructure deficiencies and the directional peak hour congestion.

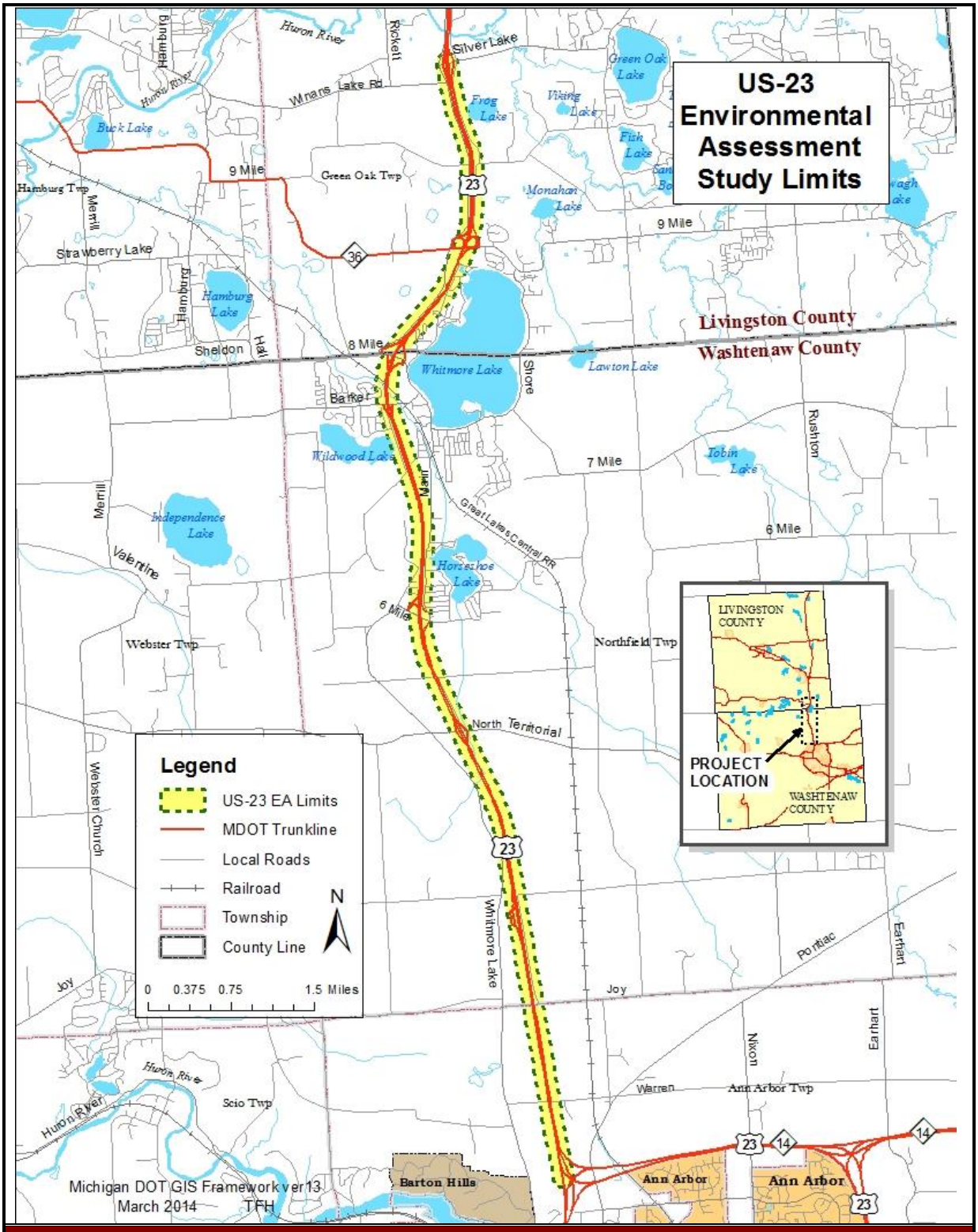


Figure 2: Project Location Map

4. TRAFFIC NOISE CONCEPTS, POLICY AND GUIDELINES

4.1. Basic Acoustic Concepts

Noise can be described as unwanted sound that may interfere with communication, or may disturb the community. Three characteristics of noise that have been identified as being important to analyzing the subjective community response to noise include: intensity, frequency, and the time-varying characteristics of the noise.

Intensity is a measure of the magnitude or energy of the sound, and is directly related to pressure level. The human ear is capable of sensing a wide range of pressure levels. Pressure levels are expressed in terms of a logarithmic scale with units called decibels (dB). As the intensity of a noise increases, it is judged to be more annoying.

The decibel scale is a logarithmic representation of the actual sound pressure variations. The manner in which the logarithmic nature of sound is perceived as loudness, and the accompanying change in traffic volumes is depicted in Table 2: Logarithmic Nature of Sound.

Table 2: Logarithmic Nature of Sound

Change in L_{eq}(1h) Sound Level	Relative Loudness in the Natural Environment
+/- 3 dB(A)	Barely Perceptible Change
+/- 5 dB(A)	Readily Perceptible Change
+/- 10 dB(A)	Considered Twice or Half as Loud

Frequency is a measure of the tonal qualities of sound. The spectrum of frequencies provides the identity of a sound. People are most sensitive to sounds in the middle to high frequencies; therefore, higher frequencies tend to cause more annoyance. This sensitivity led to the use of the A-weighted sound level, which provides a single number measure that weighs different frequencies of the frequency spectrum in a manner similar to the sensitivity of the human ear. Thus, the A-weighted sound level in decibels (dB(A)) provides a simple measure of intensity and frequency that correlates well with the human response to environmental noise. Figure 3 depicts how logarithmic decibel scale relates to frequently encountered environments and noise sources.

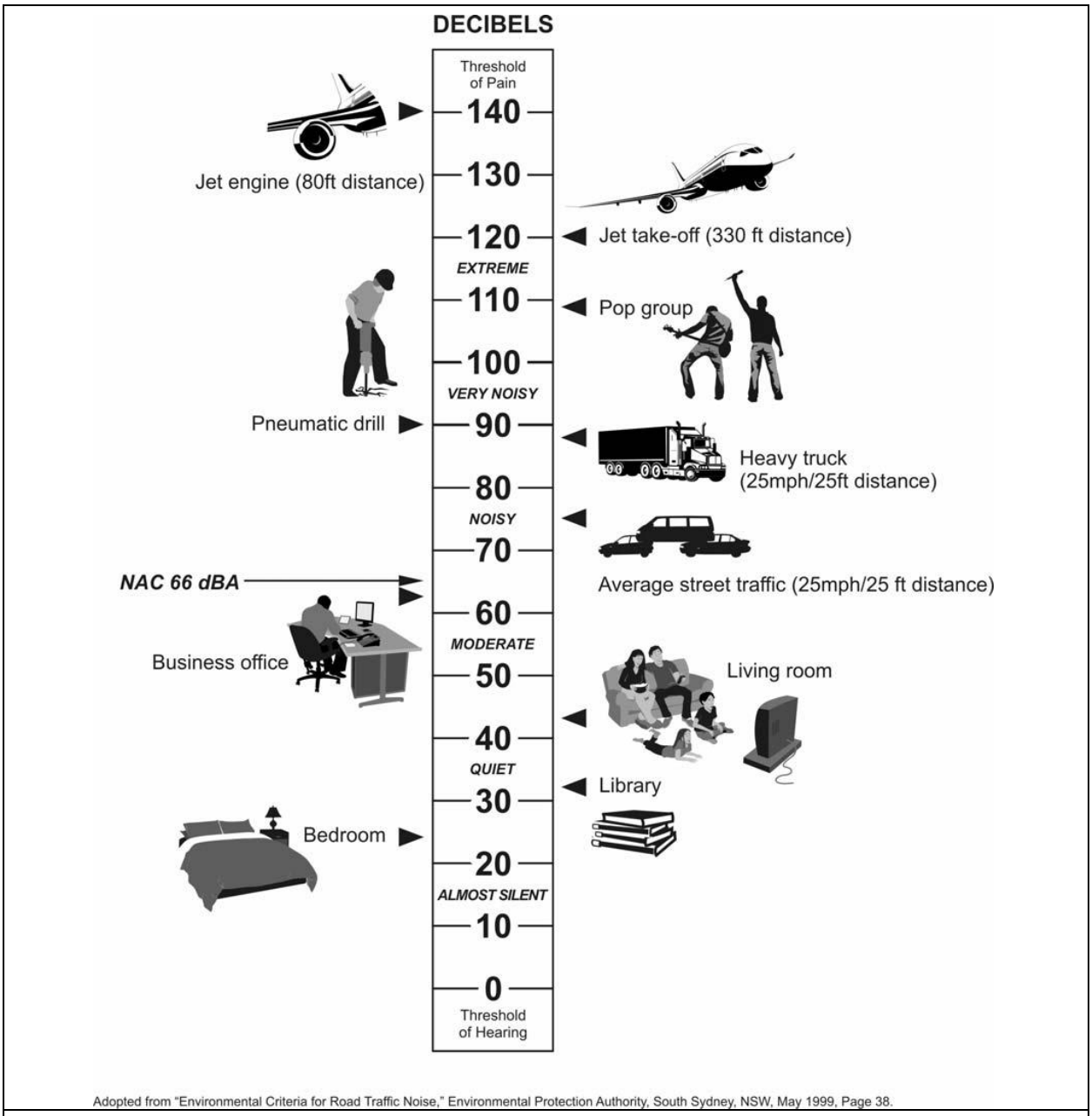


Figure 3: Sound Levels of Typical Noise Sources

It is necessary to use a method of measure that will account for the time-varying nature of sound when studying environmental noise. The equivalent sound pressure level (L_{eq}) is defined as the continuous steady sound level that would have the same total A-weighted sound energy as the real fluctuating sound measured over a given period of time. As a result, the three characteristics of noise combine to form a single descriptor (L_{eq} in dB(A)) that helps to evaluate human response to noise, and has been chosen for use in this study. The time period used to determine noise levels is typically one hour and uses the descriptor L_{eq}(1h).

Traffic noise at a receiver is influenced by the following major factors: distance from the traffic to the receiver, volume of traffic, speed of traffic, vehicle mix, and acoustical shielding.

Tire sound levels increase with vehicle speed, but also depend upon road surface, vehicle weight, tread design and wear. Change in any of these can vary noise levels, however, average tire and pavement conditions are assumed in the noise prediction model. At lower speeds, especially in trucks and buses, the dominant noise source is the engine and exhaust.

4.2. Federal Regulations and Guidance

FHWA's *Procedures for Abatement of Highway Traffic Noise and Construction Noise*, 23 CFR 772, requires the following during the planning and design of a highway project.

1) Identification of highway traffic noise impacts;
2) Examination of potential abatement measures;
3) Gather public input approval for reasonable and feasible abatement measures;
4) Incorporation of reasonable and feasible highway traffic noise abatement measures into the highway project;
5) Coordination with local officials to provide helpful information on compatible land use planning and control; and
6) Identification and incorporation of necessary measures to abate construction noise

The highway traffic noise impact identification process involves a review of the existing land use activity categories that parallel the roadway corridor and determining existing and future noise levels within those areas. Existing land use of developed lands is identified by inspecting aerial photography and performing site reconnaissance. Highway traffic noise analyses are also performed for undeveloped lands when they are considered permitted developments.

The existing noise levels are then determined based on a noise model validation process that compares modeled noise levels to actual measured noise levels. The existing noise environment is determined by gathering noise measurements and concurrent site and traffic information. The FHWA mandates the use of the most recent version of the Traffic Noise Model® (TNM) software be used to construct these models. Additional information concerning TNM software is provided in Section 5.1 of this report. The noise model must predict noise levels that are within 3 dB(A) of the actual levels in order to be considered valid. Future design year traffic is applied to a model that has been validated for the existing condition to estimate future 2040 noise levels.

A traffic noise impact is defined as a future noise level that approaches or exceeds the FHWA Noise Abatement Criteria (NAC); or a future noise level that creates a substantial noise increase over existing noise levels. An approaching noise level is defined as being at least 1 dB(A) less than the noise level value listed in the NAC for Activity Category A through E listed in Table 3. The FHWA allows States to define a substantial noise increase as an increase of anywhere between 5 and 15 dB(A).

The NAC, which is presented in 23 CFR 772, establishes the noise abatement criteria for various land uses, and is presented in Table 3.

Table 3: Noise Abatement Criteria [1]

Activity Category	Activity Criteria[2]		Evaluation Location	Description of Activity Category
	L_{eq} (1h)[3]	L_{10} (1h)[4]		
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[5]	67	70	Exterior	Residential
C[5]	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 studios, 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	-	-		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.

1) MDOT defines a noise impact as a 10 dB(A) increase between the existing noise level to the design year predicted noise level, OR a predicted design year noise level that is 1 dB(A) less than the levels shown in Table 3.
2) Either L_{eq}(h) or L_{10}(h) (but not both) may be used on a project. MDOT only uses L_{eq}(h). The L_{eq}(h) and L_{10}(h) Activity Criteria values are for impact determination only, and are not design standards for noise abatement measures.
3) L_{eq} is the equivalent steady-state sound level which in a stated period of time contains the same acoustic energy as the time-varying sound level during the same time period, with L_{eq}(h) being the hourly value of L_{eq}.
4) L_{10} is the sound level that is exceeded 10 percent of the time (90th percentile) for the period under consideration, with L_{10}(h) being the hourly value of L_{10}.
5) Includes undeveloped lands permitted for this activity category

The potential abatement alternative are examined after the traffic noise impacts are identified. The following abatement alternatives, which are listed in 23 CFR 772.15(c) are permitted and can be evaluated where applicable:

1) Construction of noise barriers including acquisition of property rights, either within or outside the highway right-of-way;
2) Traffic management measures;
3) Alteration of horizontal and vertical alignments;
4) Acquisition of real property or interests therein, to serve as a buffer zone to preempt development;
5) Noise insulation of Activity Category D land use facilities listed in Table 3.

At a minimum, State highway agencies are required to consider noise abatement in the form of noise barriers.

FHWA defines feasible highway traffic noise abatement as objective engineering considerations (e.g., can a barrier be built given the topography of the location; can a substantial noise reduction be achieved given certain access, drainage, safety, or maintenance requirements; are other noise sources present in the area, etc.). An abatement measure must achieve a noise reduction of at least 5 dB(A) to be considered feasible, according 23 CFR 772.13 (d)(1)(i). MDOT's feasibility criteria are provided in Section 4.3.

The FHWA lists three required reasonableness factors when considering noise barriers: cost effectiveness; viewpoints of benefitting receptors; and achievement of noise reduction design goals. For reasonableness, 23 CFR 772.13 (d)(2)(iii) requires State DOTs to define design year reduction goals somewhere between 7 and 10 dB(A). FHWA lists optional reasonableness factors that can be added to, but not overrule the required reasonableness factors. MDOT's reasonableness criteria are provided in Section 4.3.

4.3. State Rules and Procedures

MDOT's *Highway Noise Analysis and Abatement Handbook* is the State's tool for implementing 23 CFR 772, which was discussed in Section 4.2. The *Highway Noise Analysis and Abatement Handbook* expands on 23 CFR 772 by refining definitions and establishing milestones within the design phase for the completion of noise impact analysis and mitigation development.

The *Highway Noise Analysis and Abatement Handbook* includes the following definitions:

Common Noise Environment (CNE) A group of receptors within the same Activity Category (Table 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 cross roads

Noise Impact: A substantial noise increase or a predicted design year noise level that is 1 dB(A) less, equal to, or greater than the NAC level.

Substantial Noise Increase: A 10 dB(A) or greater increase between the existing noise level and the design year predicted noise level.

Feasible Noise Barrier: A barrier that has no construction impediments, meets safety requirements for the traveling public, and provides at least 5 dB(A) noise reduction at 75% of the impacted receptors.

Reasonable Noise Barrier: A barrier that is cost effective, favorable to benefitting receptors, and achieves noise reduction design goals by meeting or exceeding the reasonableness factor.

Cost Effective Noise Barrier: A noise barrier analyzed for environmental clearance with a preliminary construction cost that is not more than 3% above the allowable cost per benefited receptor unit (CPBU) of $44,187 (year 2014), assuming a $45.00 per square foot noise barrier construction cost.

Benefited Receptor: A receptor that receives a 5 dB(A) or greater insertion loss as a result of a proposed noise barrier.

Attenuation Requirement: Reduce design year traffic noise by 10 dB(A) for at least one benefited receptor and provide at least a 7 dB(A) reduction for 50% or more of the benefited receptor sites.

Permitted Development: Any presently undeveloped lands that have received a building permit from the local township or municipality.

Dwelling Unit Equivalent (DUE): The receptor count for public areas such as parks, schools, libraries, and churches, which is determined based on the number of employees or attendees and frequency of used. See the *Highway Noise Analysis and Abatement Handbook* for examples of how DUE are calculated.

5. NOISE ANALYSIS

5.1. FHWA Traffic Noise Model (TNM)

TNM is FHWA's computer program for highway traffic noise prediction and analysis. The use of the most resent TNM® software is a mandatory requirement for all traffic noise related projects, under State and Federal regulations. The following parameters are used in this model to calculate an hourly L_{eq} at a specific receiver location:

- Distance between roadway and receiver;
- Relative elevations of roadway and receiver;
- Hourly traffic volumes by classification;
- Vehicle speeds;
- Ground absorption;
- Weather conditions; and
- Topographic features, including retaining walls and berms.

Hourly traffic volumes have been divided into five vehicle classifications: automobiles (A); medium trucks (MT); heavy trucks (HT); Buses (B); and Motorcycles (M). Each vehicle class is defined by the *FHWA Traffic Noise Model, User's Guide, (February 1998); TNM v2.5 Update Sheet, Technical Manual: Part 1* as follows:

- Automobiles – all vehicles with two axles and four tires, includes passenger vehicles and light trucks, less than 9,900 pounds.
- Medium trucks – all vehicles having two axles and six tires, vehicle weight between 9,900 and 26,400 pounds.
- Heavy trucks – all vehicles having three or more axles, vehicle weight greater than 26,400 pounds.
- Buses – all vehicles designed to carry more than nine passengers.
- Motorcycles – all vehicles with two or three tires and an open-air driver/passenger compartment.

5.2. Analysis

5.2.1. Land Use and Field Measured Levels

Land use in the project area is a mixture of single family residential, commercial properties, parks, churches, school, agricultural lands, and undeveloped wooded lands. Sites within the US-23 corridor with similar land use and traffic, i.e. land use and traffic characteristics were grouped into Common Noise Environments (CNEs) for analysis. Descriptions of each CNE within the project limits are provided in Table 4.

Table 4: Project Area Common Noise Environments

CNE	Site Description
A	Low Density Residential
B	Low Density Residential
C	Residential and Commercial Mixed Use
D	Residential and Commercial Mixed Use
E	Low Density Residential
F	Residential and Commercial Mixed Use
G	Medium Density Residential
H	Medium Density Residential
I	Medium Density Residential
J	Medium Density Residential
K	Residential and Commercial Mixed Use
L	Medium Density Residential with Park Land
M	Low Density Residential
N	High Density Residential
O	Low Density Commercial
P	Low Density Commercial
Q	Residential and Commercial Mixed Use
R	High Density Residential
S	Medium Density Residential
T	Residential and Commercial Mixed Use
U	Medium Density Residential

Field measurements with concurrent traffic counts were taken to compare with modeled noise levels to validate the TNM for use on this project to predict existing and design year noise levels. Existing noise level measurements were conducted on July 22, 2014 and July 23, 2014 at eleven (11) representative sites in the project vicinity. Refer to Appendices A and C for maps which include the location of these sites

A minimum fifteen minute measurement were taken at each site, during peak and off-peak traffic time periods. The measurements were conducted in accordance with FHWA and MDOT guidelines using an integrating sound level analyzer. Traffic counts were taken at each site, concurrent with the noise measurements. Posted traffic speeds in the project area were verified using the “floating car method” during the site visits. Concurrent weather readings were obtained from the weather station in Whitmore Lake, for accurate modeling purposes. The data collected at the eleven (11) sites are presented in Table 5.

Table 5: Measured Existing Noise Levels during Peak Traffic

Field Site ID	Site Description (Distance From The Outside Edge of the Shoulder)	Date	Start Time	Duration (min)	Traffic[1]						Measured Noise Level, dB(A) L_{eq}
					Roadway, Direction[2, 3]	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles	
1	At the Spicer Rd / Whitmore Lake Rd intersection (50 ft)	7/22/14	7:00 AM	20	US-23, NB US-23, SB	395 1073	17 18	60 40	1 3	4 2	79
2	At the Jennings Rd / Wildwood Lake Dr intersection (63 ft)	7/22/14	7:35 AM	15	US-23, NB US-23, SB	378 715	15 18	49 32	0 1	4 2	72
3	Whitmore Lake Public School (68 ft)	7/22/14	8:00 AM	15	US-23, NB US-23, SB	367 592	20 20	42 29	0 1	0 2	73
4	At the Shady Beach / Main St intersection (43 ft)	7/22/14	8:25 AM	15	US-23, NB US-23, SB	343 531	26 7	34 28	1 0	3 4	77
5	At the Coyle Rd / Winter Ln intersection (66 ft)	7/22/14	8:50 AM	25	US-23, NB US-23, SB	525 854	30 18	81 69	1 3	6 5	71
6	Northern parking lot for Best Western hotel (55 ft)	7/22/14	5:35 PM	15	US-23, NB US-23, SB	762 564	13 13	37 39	2 1	7 7	77
7	Behind Tractor Supply Co. (56 ft)	7/22/14	5:00 PM	15	US-23, NB US-23, SB	654 357	11 9	24 26	0 2	4 1	74
8	SB US-23 Rest Area (220 ft)	7/22/14	4:20 PM	20	US-23, NB US-23, SB	1029 543	28 11	28 42	0 1	6 3	66
9	North of 9 Mile Rd on Fieldcrest Dr (30 ft)	7/23/14	7:00 AM	15	US-23, NB US-23, SB	306 793	8 13	56 23	0 0	1 4	78
10	Across from Site 6 (45 ft)	7/23/14	7:25 AM	20	US-23, NB US-23, SB	598 969	17 24	50 27	0 1	0 3	77
11	At the park entrance north of Joy Rd (62 ft)	7/23/14	8:10 AM	15	US-23, NB US-23, SB	331 777	19 15	40 39	1 0	1 2	77

1) Vehicle counts classifications are according to Section 5.1 of this report.
2) Vehicle speeds for US-23 are 70 mph.
3) Vehicle traffic on the roadways that are adjacent to the US-23 Right-of-Way was insignificant.

5.2.2. Field Measured vs. Modeled Noise Levels

TNM was used to compare the field measurements to the model using the traffic count information. Comparing the modeled noise levels to the measured noise levels validates the TNM model for use on the specific project. All of the modeled data when compared with the measured data was within 3 dB of each other as shown in Table 6. This satisfies the MDOT requirement for validating noise measurements. The site by site comparison is presented in Table 6.

Table 6: Comparison of Measured and Modeled Noise Levels for Peak Traffic

Field Site ID	Noise Level, dB(A) L_{eq} (1h)		Difference in Noise Level, dB(A) L_{eq} (1h) (Modeled Minus Measured)
	Measured	Modeled	
1	79	80	+1
2	72	74	+2
3	73	74	+1
4	76	77	+1
5	69	71	+2
6	76	77	+1
7	75	74	-1
8	66	66	0
9	77	78	+1
10	77	77	0
11	75	77	+2

5.2.3. Predicted Traffic Noise Levels and Noise Impact Analysis

The traffic noise prediction program, TNM, was used to model existing and future Build 2040 traffic noise levels within the project area. For analysis purposes, the "loudest noise hours" were used identify the impacted receivers along US-23. The "loudest noise hours" are usually occurs during peak traffic hours when truck volumes and vehicle speeds are the greatest and when traffic is at or near free-flow conditions. Due to the daily flow of traffic into and out of Ann Arbor, the "loudest noise hours" for the receivers located on the west side of US-23 occurs between 7 and 9 AM and between 4 and 6 PM for the receivers located on the east side of US-23. The existing (2015) and future (2040) traffic volumes (AM and PM peak) that were used in the modeling are shown in Table 7 through Table 10. The existing and future traffic volumes were developed by MDOT as a part of the Environmental Assessment (EA). Vehicle class distributions used in the noise impact analysis were based on information that MDOT provided. In accordance to Section 2.5.2 of the *Highway Noise Analysis and Abatement Handbook*, the existing and future traffic volumes were assumed to operate under free-flow conditions.

Eight-hundred-sixty-three (863) receiver locations were included in the noise model. These receivers represent frequently used outdoor areas at the residential properties, commercial properties, cemeteries, churches, and parks that are within 500 ft of the outside edge of pavement. All of the receivers that were included in the model represent existing sites. For additional information concerning the location of the receiver locations refer to Figures 1-20 in Appendix C.

Ann Arbor Charter Township, Northfield Township, and Green Oak Township were contacted during this study to determine if any presently undeveloped lands within 500 feet of the outside edge of pavement could be considered permitted developments under MDOT Policy. Based on information received from the Ann Arbor Charter Township, an area that is currently being used for agriculture purposes is zoned for a trailer park, but there are no plans to develop the area in the near future. Northfield Township and Green Oak Township did not respond to the request for information, so no building permits for developing undeveloped areas or redeveloping existing areas were anticipated.

The results of the noise impact analysis are provided in Appendix D. The addresses that are provide were obtained from the Washtenaw County GIS site and Livingston County tax information.

Table 7: Existing 2015 Traffic Volumes (AM Peak)

Roadway Segment[1]	Volumes by Vehicle Type[2]				
	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
NB - M-14 to Territorial Road	1337	41	163	3	4
SB - M-14 to Territorial Road	3416	43	127	2	7
NB - Territorial Road to 6 Mile Road	1422	44	173	3	4
SB - Territorial Road to 6 Mile Road	3357	43	125	2	6
NB - 6 Mile Road to Barker Road	1451	45	177	3	4
SB - 6 Mile Road to Barker Road	3152	40	117	2	6
NB - Barker Road to 8 Mile Road	1422	44	173	3	4
SB - Barker Road to 8 Mile Road	3026	38	112	2	6
NB - 8 Mile Road to 9 Mile Road	1529	47	186	3	4
SB - 8 Mile Road to 9 Mile Road	2542	32	94	2	5
NB - 9 Mile Road Silver Lake Road	1536	48	187	3	4
SB - 9 Mile Road Silver Lake Road	2211	28	82	1	4

1) Minor streets within the US-23 were assumed to have an insignificant effect on the number of noise related impacts.
2) Volume distribution based on a traffic study performed by MDOT.

Table 8: Existing 2015 Traffic Volumes (PM Peak)

Roadway Segment[1]	Volumes by Vehicle Type[2]				
	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
NB - M-14 to Territorial Road	3358	36	114	3	7
SB - M-14 to Territorial Road	1964	31	125	3	5
NB - Territorial Road to 6 Mile Road	3630	39	123	3	8
SB - Territorial Road to 6 Mile Road	2004	31	127	3	5
NB - 6 Mile Road to Barker Road	3630	39	123	3	8
SB - 6 Mile Road to Barker Road	2045	32	130	3	5
NB - Barker Road to 8 Mile Road	3485	37	118	3	8
SB - Barker Road to 8 Mile Road	1994	31	127	3	5
NB - 8 Mile Road to 9 Mile Road	3467	37	117	3	8
SB - 8 Mile Road to 9 Mile Road	2114	33	134	3	5
NB - 9 Mile Road Silver Lake Road	3450	37	117	3	8
SB - 9 Mile Road Silver Lake Road	2124	33	135	3	5

1) Minor streets within the US-23 were assumed to have an insignificant effect on the number of noise related impacts.
2) Volume distribution based on a traffic study performed by MDOT.

Table 9: Future 2040 Traffic Volumes (AM Peak)

Roadway Segment[1]	Volumes by Vehicle Type[2]				
	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
NB - M-14 to Territorial Road	1441	45	176	3	4
SB - M-14 to Territorial Road	3681	47	137	2	7
NB - Territorial Road to 6 Mile Road	1533	48	187	3	4
SB - Territorial Road to 6 Mile Road	3618	46	134	2	7
NB - 6 Mile Road to Barker Road	1564	48	191	3	4
SB - 6 Mile Road to Barker Road	3397	43	126	2	6
NB - Barker Road to 8 Mile Road	1533	48	187	3	4
SB - Barker Road to 8 Mile Road	3261	41	121	2	6
NB - 8 Mile Road to 9 Mile Road	1647	51	201	3	5
SB - 8 Mile Road to 9 Mile Road	2739	35	102	2	5
NB - 9 Mile Road Silver Lake Road	1656	51	202	3	5
SB - 9 Mile Road Silver Lake Road	2383	30	88	2	5

1) Minor streets within the US-23 were assumed to have an insignificant effect on the number of noise related impacts.
2) Volume distribution based on a traffic study performed by MDOT.

Table 10: Future 2040 Traffic Volumes (PM Peak)

Roadway Segment[1]	Volumes by Vehicle Type[2]				
	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
NB - M-14 to Territorial Road	3619	39	123	3	8
SB - M-14 to Territorial Road	2117	33	135	3	5
NB - Territorial Road to 6 Mile Road	3912	42	133	3	9
SB - Territorial Road to 6 Mile Road	2160	34	137	3	5
NB - 6 Mile Road to Barker Road	3912	42	133	3	9
SB - 6 Mile Road to Barker Road	2204	34	140	3	5
NB - Barker Road to 8 Mile Road	3756	40	127	3	8
SB - Barker Road to 8 Mile Road	2149	34	137	3	5
NB - 8 Mile Road to 9 Mile Road	3737	40	127	3	8
SB - 8 Mile Road to 9 Mile Road	2278	36	145	3	6
NB - 9 Mile Road Silver Lake Road	3718	40	126	3	8
SB - 9 Mile Road Silver Lake Road	2289	36	146	3	6

3) Minor streets within the US-23 were assumed to have an insignificant effect on the number of noise related impacts.
4) Volume distribution based on a traffic study performed by MDOT.

Noise impacts may occur when future Build (2040) noise levels either exceed existing noise levels by 10 dB(A) or more; or approach or exceed the NAC. For this project, the predicted future build loudest noise hour levels for year 2040 range from 49 dB(A) to 75 dB(A). These values vary from 4 dB(A) lower to 2 dB(A) higher than existing loudest hour noise levels. The incorporation of the median concrete barrier in the build condition is responsible for the reduction in noise levels. A summary of the noise impact assessment (or the number of receiver locations that approach or exceed the NAC) is provided in Table 11.

Table 11: Number of Locations within CNEs that Approach or Exceed the NAC

Activity Description			2015	2040
CNE Area A	–	Residential	0	0
CNE Area B	–	Residential	0	0
CNE Area C	–	Mixed Use	1	1
CNE Area D	–	Residential	0	0
CNE Area E	–	Residential	1	1
CNE Area F	–	Mixed Use	0	0
CNE Area G	–	Residential	16	15
CNE Area H	–	Residential	13	13
CNE Area I	–	Residential	8	6
CNE Area J	–	Residential	10	10
CNE Area K	–	Mixed Use	1	0
CNE Area L	–	Residential	33[1]	33[1]
CNE Area M	–	Residential	3	3
CNE Area N	–	Residential	13	20
CNE Area O	–	Commercial	0	0
CNE Area P	–	Commercial	0	0
CNE Area Q	–	Residential	0	0
CNE Area R	–	Residential	8	9
CNE Area S	–	Residential	23[2]	24[2]
CNE Area T	–	Mixed Use	1	1
CNE Area U	–	Residential	5	6

1) Includes twenty-eight (28) Dwelling Unit Equivalent receivers
2) Includes seven (7) Dwelling Unit Equivalent receivers

6. ABATEMENT MEASURES

6.1. Federal and State Abatement Guidance

MDOT's Noise Policy has established the criteria for determining where noise abatement must be provided. The policy is summarized as follows:

- Where adverse noise impacts are expected to occur, noise abatement will be considered and will be implemented if found feasible and reasonable for existing developments, and future developments that were approved before the date of public knowledge of the project. Approved means that a building permit has been received. After the date of public knowledge, MDOT is not responsible for providing noise abatement for new developments. The date of public knowledge is the date that the project's environmental analysis and documentation is approved (i.e. the date of approval of a CE, date of the issuance of the Finding of No Significant Impact for an EA, or the date of the Record Decision for an EIS). The date of the clearance of the Categorical Exclusion will be the date of public knowledge. The provision of noise abatement for new developments becomes the responsibility of local governments and private developers.

- Feasible - This refers to engineering considerations such as: constructability of a noise barrier on the existing topography; achievement of substantial noise reductions; the presence of other noise sources in the area; and the ability to maintain access, drainage, safety, utilities in the area. While every reasonable effort should be made to obtain a substantial noise reduction, a noise abatement measure is not feasible if it cannot achieve at least a 5 dB(A) noise reduction for 75% of impacted receivers during design year traffic noise.

- Reasonable - Noise mitigation will be considered reasonable if:
    - During the environmental clearance phase, the preliminary cost per benefiting unit is less than 3% above allowable per benefitting unit level ($44,187 in 2014 dollars, based on a $45/square foot unit cost);
    - The public viewpoint reasonableness factor for the environmental clearance phase receives generally positive comments from the benefiting units; and
    - The noise barrier provides a design year traffic noise reduction of 10 dB(A) for at least one benefitted unit and at least a 7 dB(A) for 50% or more of the benefitted units.

Highway traffic noise abatement alternatives, which are listed in 23 CFR 772.15(c) include:

1) Construction of noise barriers including acquisition of property rights, either within or outside the highway right-of-way;
2) Traffic management measures;
3) Alteration of horizontal and vertical alignments;
4) Acquisition of real property or interests therein, to serve as a buffer zone to preempt development;
5) Noise insulation of Activity Category D land use facilities listed in Table 3

Review of the listed abatement alternatives has determined that reductions of speed limits, although acoustically beneficial, are seldom practical unless the design speed of the proposed roadway is also reduced; restriction or prohibition of trucks is extremely undesirable because US-23 is a major north-south freeway in Michigan; design criteria, project limits, and the existing terrain preclude substantial horizontal and vertical alignment shifts that could potentially produce noticeable changes in the projected acoustical environment; cost restrictions typically prohibit the acquisition of property for any reason; and the construction of noise berms is neither feasible nor reasonable because of the amount of space that would be required. Therefore, the construction of noise barriers within the existing Right-of-Way was the only mitigation measure that received in-depth evaluation.

6.2 Noise Barrier Analysis

Twenty-one (21) CNE areas were identified within the project limits. CNE areas A, B, D, F, K, O, P, and Q have no impacted receptors with the future (2040) Build condition, and do not require abatement analysis. Impacted noise receptors were identified at the remaining CNE areas, so noise barriers were analyzed in accordance with the minimum requirement established by the MDOT: *Highway Noise Analysis and Abatement Handbook*. The alignment of the noise barriers that were analyzed are depicted in Appendix C. The results of the evaluated barriers, including barrier location, future L_{eq}(1h) noise levels without and with a barrier, barrier length and height, and the noise reduction provided by the barrier are presented in Table 12. The receivers that are being benefited by the barriers that were evaluated are summarized Appendix E. The receivers that are noted in Appendix D, but are not included in Appendix E, will not receive any measurable reductions in noise levels. The following information is presented for each of the barriers in Table 13:

- The number of substantial noise reduction locations.
- The number of locations with more than 7 dB(A) attenuation.
- The total estimated cost (based on $45.00 per square foot).
- The number of benefited receivers (i.e. residential, commercial, and equivalent).
- The cost per benefited receiver.
- The feasibility determination.
- The reasonableness determination.

Table 12: Evaluated Noise Barriers

Noise Barrier ID	Locations	Existing L_{eq} (1hr) Noise Levels, dB(A)	Range of Future L_{eq}(1hr) Noise Levels, dB(A)		Noise Reduction (dB(A))	Barrier Characteristics	
			w/o Barrier	With Barrier		Length (ft)	Avg. Ht. (ft)
NB-C	Along the western Right-of-Way line, between points 5000 ft south and 5600 ft south of North Territorial Rd	56-68	55-68	55-68	0-4	600	18.00
NB-E	Along the western Right-of-Way line, between points 300 ft north and 400 ft south of 5 Mile Rd	55-69	53-69	53-64	0-5	700	13.57
NB-G	Along the western Right-of-Way line, between points 1000 ft north and 2200 ft north of 6 Mile Road	58-75	55-75	54-64	0-12	1200	13.25
NB-H	Along the western Right-of-Way line, from the SB US-23 entrance ramp at Barker Rd (Jennings Rd) to a point 250 ft south of Wildwood Lake Dr.	50-70	49-70	48-69	0-10	1000	15.10
NB-I	Along the eastern Right-of-Way line in two locations: from the NB US-23 entrance ramp at 6 Mile Rd (Main St) northerly for 700 ft; and from a point 250 ft south of Shady Beach St northerly to a point 450 ft north of Shady Beach St	50-70	50-69	47-64	0-7	1400	13.71
NB-J	Along the eastern Right-of-Way line, from a point 500 ft south of Greenland Ave northerly to a point 650 ft north of Schrum Dr	56-72	54-71	52-65	1-10	1500	14.07

Table 12: Evaluated Noise Barriers (Continued)

Noise Barrier ID	Locations	Existing L_{eq} (1hr) Noise Levels, dB(A)	Range of Future L_{eq}(1hr) Noise Levels, dB(A)		Noise Reduction (dB(A))	Barrier Characteristics	
			w/o Barrier	With Barrier		Length (ft)	Avg. Ht. (ft)
NB-L	10 ft west of the eastern Right-of-Way line, from Barker Rd southerly to a point 500 ft south of the Jennings Athletic Complex and Park	53-76	52-76	51-64	0-15	3100	11.47
NB-M	Along the western Right-of-Way line, from a point 450 ft south of Wildwood Lake Dr southerly for 2200 ft	55-71	54-72	54-64	0-10	2200	14.36
NB-N	Along the western Right-of-Way line, from the Barker Rd bridge northerly to the railroad bridge	55-68	56-68	56-67	0-11	750	20.46
NB-R	Along the eastern Right-of-Way line, from the earth berm west of Heidelberg Rd northerly to a point 600 ft north of Cappy Ln	49-74	49-74	49-71	0-10	2000	11.1
NB-T	Along the western Right-of-Way line, from a point 2100 ft north of 9 Mile Rd to a point 2700 ft north of 9 Mile Rd.	53-68	53-68	53-65	0-4	600	16.00
NB-U	Along the eastern Right-of-Way line, from the NB entrance ramp at 9 Mile Rd (Fieldcrest Dr) northerly for 900 ft	56-71	55-71	55-67	0-10	900	24.44

Table 13: Noise Barrier Feasibility and Reasonableness

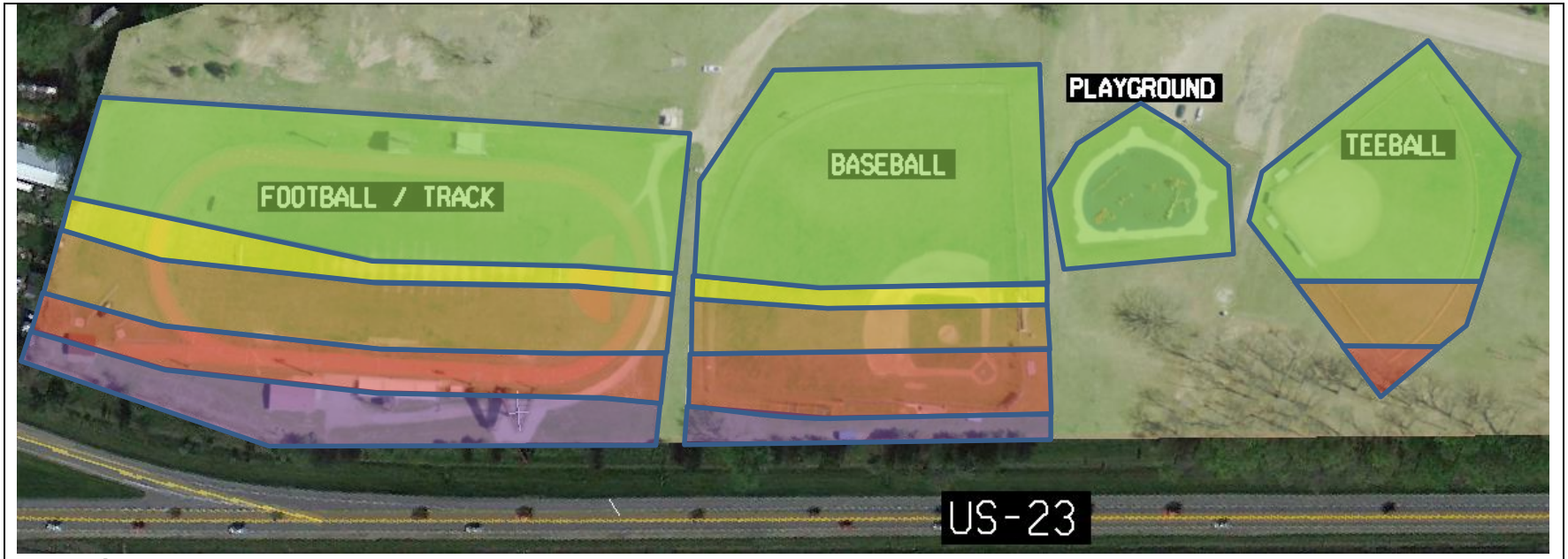
Noise Barrier ID	Number of Attenuated locations					Cost [1]	Cost / Benefited	Feasible	Reasonable
	≥ 10 dB(A)	≥ 7 dB(A)		≥ 5 dB(A) (Benefited Receivers)					
		#	% of Benefited	#	% of Impacted			(Y/N)	(Y/N)
NB-C	0	0	0%	0	0%	$486,000	-	N	N
NB-E	0	0	0%	1	100%	$427,500	$427,500	Y	N
NB-G	5	8	62%	13	80%	$715,500	$55,050	Y	N
NB-H	1	7	88%	8	61%	$679,500	$85,950	N	N
NB-I	0	1	17%	6	80%	$864,000	$144,00	Y	N
NB-J	1	6	67%	9	80%	$949,500	$105,500	Y	N
NB-L	8[3]	16[3]	61%	26[3]	76%[3]	$1,620,000	$62,600	Y	N
NB-M	1	3	75%	4	100%	$1,422,000	$355,500	Y	N
NB-N	1	4	40%	10	50%	$690,750	$69,075	N	N
NB-R[2]	6[3]	14[3]	58%	24[3]	80%[3]	$733,500	$41,625	Y	Y
NB-T	0	0	0%	0	0%	$432,000	-	N	N
NB-U	1	1	33%	3	100%	$990,000	$330,00	Y	N

1) Based on $45.00 per square feet.
2) Includes a portion of receivers in CNE S.
3) Includes Dwelling Unit Equivalent (DUE) receivers. See Table 14 for DUE calculations

Table 14: DUE Calculations

Calculated Item	Affected Area (sqft)	Average Adjacent Lot Size (sqft)	Number of DUE Receivers [1]
NB-L: ≥ 10 dB(A) [2]	60,840	8,895 [4]	7
NB-L: ≥ 7 dB(A) [2]	127,375	8,895 [4]	14
NB-L: ≥ 5 dB(A) [2]	203,430	8,895 [4]	23
NB-L: Impacted Receivers [2]	249,950	8,895 [4]	28
NB-R: ≥ 10 dB(A) [3]	2,805	2,805 [5]	1
NB-R: ≥ 7 dB(A) [3]	8,355	2,805 [5]	3
NB-R: ≥ 5 dB(A) [3]	17,780	2,805 [5]	6
NB-R: Impacted Receivers [3]	19,210	2,805 [5]	7

1) Affected Area ÷ Average Adjacent Lot Size = Number of DUE Receivers.
2) Affected areas are depicted in Figure 4
3) Affected areas are depicted in Figure 5
4) 11 residential properties along Hillcrest Dr have a total area of 97,840 sqft (97,840 ÷ 11 = 8,895)
5) 15 residential properties within the southern trailer park have a total area of 42,075 sqft (42,075 ÷ 15 = 2,805)



Legend

= Non-impacted areas that are frequently used

= Impacted areas that are not benefited (0 – 5 dB(A) noise reduction) by the proposed noise barrier and are frequently used

= Impacted areas that will receive a 5 to 7 dB(A) noise reduction and are frequently used

= Impacted areas that will receive a 7 to 10 dB(A) noise reduction and are frequently used

= Impacted areas that will receive a noise reduction greater than 10 dB(A) and are frequently used

Figure 4: Park Areas Used to Calculate the Number DUE Receivers

Legend

= Non-impacted areas that are frequently used

= Impacted areas that are not benefited (0 – 5 dB(A) noise reduction) by the proposed noise barrier and are frequently used

= Impacted areas that will receive a 5 to 7 dB(A) noise reduction and are frequently used

= Impacted areas that will receive a 7 to 10 dB(A) noise reduction and are frequently used

= Impacted areas that will receive a noise reduction greater than 10 dB(A) and are frequently used

Figure 5: Affected Area within CNE R

The above table presents the modeled barrier analysis results to determine their feasibility and reasonableness. Modeled noise barriers NB-C, NB-H, NB-N, and NB-T has less than the required 75% of impacted receptors receiving a 5 dB(A) noise reduction and so did not meet the feasibility requirements. Barriers NB-C, NB-E, NB-G, NB-H, NB-I, NB-J, NB-L, NB-M, NB-N, NB-T, and NB-U did not meet the reasonableness criteria. NB-C, NB-E, NB-I, and NB-T did not receive the required 10 dB(A) future noise reduction for at least one receiver. NB-C, NB-E, NB-I, NB-N, NB-T, and NB-U has less than the required 50% of benefitting units receiving at least a 7 dB(A) noise reduction. Barriers NB-C, NB-E, NB-G, NB-H, NB-I, NB-J, NB-L, NB-M, NB-N, NB-T, and NB-U exceed the $44,187 plus 3% ($45,313) allowable cost per benefitting unit.

The results show that one barrier, NB-R, satisfies the MDOT feasible and reasonableness criteria, and is the recommended noise abatement.

6.3 Noise Compatible Land Use Planning

Noise compatible land use planning along this corridor should be considered by local officials to avoid future highway noise impacts. To aid in this planning the future (2040), a 66 dB(A) noise contour (the noise level corresponding with MDOTs definition of “approaching” the NAC for Activity Categories B and C) has been evaluated as a part of this study. The 66 dB(A) noise contour is offset approximately 315 ft from the center of the median. The construction of noise sensitive properties within these limits should be avoided to prevent future impacts. The 66 dB(A) contour line is depicted in Figures 1 through Figure 20 of Appendix C.

7. CONCLUSIONS AND RECOMMENDATIONS

MDOT's policy is to install noise abatement measures found to be feasible and reasonable that are associated with transportation improvements. Abatement of noise impacts for the proposed US-23 project appears to be feasible and reasonable for Noise Barrier R (see Table 16). Noise Barrier R is located along the east side of US-23, from the existing earth berm west of Heidelberg Rd northerly to a point 600 ft north of Cappy Ln.

An engineering level noise abatement analysis will be completed on the warranted abatement measure to ensure it meets final design phase feasibility and reasonableness criteria. Final design phase feasibility criteria are the same as in the environmental clearance phase and includes:

1) The approval of the abatement measure by a majority of the benefitting property owners and residents;

2) The cost benefit of the noise barrier is equal to or below the allowable per benefitting unit cost for the year of the final design; and

3) Noise attenuation level criteria that is the same as in the environmental clearance phase.

8. STATEMENT OF LIKELIHOOD

Based on the studies thus far accomplished, the Michigan Department of Transportation intends to install highway traffic noise abatement in the form of a barrier presented in Table 12 in this document. The preliminary indications of likely abatement measures are based on preliminary design for barrier cost(s) and noise abatement as illustrated in Table 13 in this document. If it subsequently develops during final design that these conditions have substantially changed, the abatement measures might not be provided. A final decision of the installation and aesthetics of the abatement measures(s) will be made upon completion of the project's final design and the Context Sensitive Design process.

9. CONSTRUCTION NOISE

The noise produced on highway construction sites originates from a variety of sources, which can be described by identifying those phases of construction applicable to the recommended project. Specifically, each phase of construction has its own scope, objective, mix of equipment, and therefore, its own noise characteristics. For most projects these phases will overlap due to time constraints and interdependency of activities.

Considering the relatively short-term nature of construction noise, impacts are not expected to be substantial. The transmission loss characteristics of nearby structures are believed to be sufficient to moderate the effects of intrusive construction noise.

10. REFERENCES

Anderson, G. S., C.S.Y. Lee, G.G. Fleming and C. Menge, "FHWA Traffic Noise Model®, Version 1.0 User's Guide", Federal Highway Administration, January 1998, p. 60.

"Commission Policy", (Guidance Document 10136), Michigan Transportation Commission, Michigan Department of Transportation, July 31, 2003.

Lau, Michael C., Cynthia S. Y. Lee, Gregg G. Judith L. Rochat, Eric R. Boeker, and Gregg C. Fleming. FHWA Traffic Noise Model® Users Guide (Version 2.5 Addendum). Federal Highway Administration, April 2004.

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

"Highway Traffic Noise: Analysis and Abatement Guidance", Federal Highway Administration, January 2011.
http://www.fhwa.dot.gov/Environment/noise/regulations_and_guidance/analysis_and_abatement_guidance/revguidance.pdf

Reherman, Clay N., Rochat, Judith L., Thalheimer, Erich S., Lau, Michael C., Fleming, Gregg G., Ferroni, Mark, and Corbisier, Christopher, FHWA Roadway Construction Noise Model, Version 1.0 User's Guide. Federal Highway Administration, January 2006.

"Report to the President and Congress on Noise", National Service Center for Environmental Publications, February 1972.

Title 23 CFR Part 772, "Procedure for abatement of Highway Traffic Noise and Construction Noise", Code of Federal Regulations
http://www.fhwa.dot.gov/hep/23cfr772.htm

Appendix A
Measurement Site Information:

Noise Measurements

SITE / LOCATION: **Site 1: Spicer Rd/Whitmore Lake Road** DATE: **7/22/14**

Peak Measurement — Period

Time Begin: 7:00 AM — 20 minutes — Leq 79

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1185	51	180	3	12
SB US-23	4292	72	160	12	8

Off-Peak Measurement — Period

Time Begin: 9:30 AM — 15 minutes — Leq 78

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1292	88	160	0	12
SB US-23	1780	80	144	4	12

LOCATION AERIAL:

Comments:

SITE PHOTOGRAPHS:

Looking SE

Lokking NE

Looking E

Noise Measurements

SITE / LOCATION: **Site 2: Jennings Rd/ Wildwood Lake Dr** DATE: **7/22/14**

Peak Measurement Period
Time Begin: 7:35 AM 15 minutes Leq 72

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1512	60	196	0	16
SB US-23	1160	96	148	0	16

Off-Peak Measurement Period
Time Begin: 10:00 AM 15 minutes Leq 74

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	2860	72	128	4	8
SB US-23	1672	52	136	0	4

LOCATION AERIAL:

Comments:

SITE PHOTOGRAPHS:

Looking NE

Looking E

Looking SE

Noise Measurements

SITE / LOCATION: **Site 3: Whitmore Lake Public School** DATE: **7/22/14**

Peak Measurement		Period			
Time Begin:	8:00 AM	15 minutes	Leq 73		
Traffic Counts (Veh/Hr):					
	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1468	80	168	0	0
SB US-23	2368	80	116	4	8

Off-Peak Measurement		Period			
Time Begin:	10:30 AM	20 minutes	Leq 73		
Traffic Counts (Veh/Hr):					
	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1227	72	141	3	3
SB US-23	1671	75	150	9	6

LOCATION AERIAL:

Comments:

SITE PHOTOGRAPHS:

Looking E

Looking NW

Looking W

Noise Measurements

SITE / LOCATION: **Site 4: Shady Beach/ Main St** DATE: **7/22/14**

Peak Measurement		Period			
Time Begin:	8:25 AM	15 minutes	Leq 76		
Traffic Counts (Veh/Hr):					
	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1372	104	136	4	12
SB US-23	2124	28	112	0	16

Off-Peak Measurement		Period			
Time Begin:	10:55 AM	15 minutes	Leq 76		
Traffic Counts (Veh/Hr):					
	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1396	108	140	4	8
SB US-23	1520	100	168	12	12

LOCATION AERIAL:

Comments: _____

SITE PHOTOGRAPHS:

Looking SW

Looking NW

Looking W

Noise Measurements

SITE / LOCATION: **Site 5: Coyle Rd/ Winters Ln** DATE: **7/22/14**

Peak Measurement Period
Time Begin: 8:50 AM 25 minutes Leq 69

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1260	72	194	2	14
SB US-23	2050	43	166	7	12

Off-Peak Measurement Period
Time Begin: 11:20 AM 15 minutes Leq 73

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1492	76	140	0	12
SB US-23	1648	48	188	8	4

LOCATION AERIAL:

Comments: _____

SITE PHOTOGRAPHS:

Looking SE

Looking NE

Looking E

Noise Measurements

SITE / LOCATION: **Site 6: Best Western** DATE: **7/22/14**

Peak Measurement — Period

Time Begin: 5:35 PM — 15 minutes — Leq 76

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	3048	52	148	8	28
SB US-23	2256	52	156	4	28

Off-Peak Measurement — Period

Time Begin: 2:50 PM — 15 minutes — Leq 75

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	2136	88	148	0	24
SB US-23	1480	72	184	4	16

LOCATION AERIAL:

Comments:

SITE PHOTOGRAPHS:

Noise Measurements

SITE / LOCATION: **Site 7: Tractor Supply Co.** DATE: **7/22/14**

Peak Measurement — Period

Time Begin: 5:00 PM — 15 minutes — Leq 75

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	2616	44	96	0	16
SB US-23	1428	36	104	8	4

Off-Peak Measurement — Period

Time Begin: 3:15 PM — 15 minutes — Leq 76

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	3016	116	112	16	16
SB US-23	1704	52	152	16	12

LOCATION AERIAL:

Comments:

SITE PHOTOGRAPHS:

Looking NE

Looking E

Noise Measurements

SITE / LOCATION: **Site 8: SB US-23 Rest Area** DATE: **7/22/14**

Peak Measurement — Period

Time Begin: 4:20 PM — 20 minutes — Leq 66

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	3087	84	84	0	18
SB US-23	1629	33	126	3	9

Off-Peak Measurement — Period

Time Begin: 3:50 PM — 20 minutes — Leq 67

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	3381	102	84	6	21
SB US-23	1737	30	102	3	0

LOCATION AERIAL:

Comments:

SITE PHOTOGRAPHS:

Looking SE

Looking NE

Looking E

Noise Measurements

SITE / LOCATION: **Site 9: Fieldcrest Dr** DATE: **7/23/14**

Peak Measurement — Period

Time Begin: 7:00 AM — 15 minutes — Leq 77

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1224	32	224	0	4
SB US-23	3172	52	92	0	16

Off-Peak Measurement — Period

Time Begin: 9:30 AM — 15 minutes — Leq 77

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1420	52	120	0	4
SB US-23	1924	44	200	12	12

LOCATION AERIAL:

Comments:

SITE PHOTOGRAPHS:

Looking SW

Looking NW

Looking W

Noise Measurements

SITE / LOCATION: **Site 10: Across from Best Western** DATE: **7/23/14**

Peak Measurement		Period			
Time Begin:	7:25 AM	20 minutes	Leq		
			77		
Traffic Counts (Veh/Hr):					
	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1794	51	150	0	0
SB US-23	2907	72	81	3	9

Off-Peak Measurement		Period			
Time Begin:	9:50 AM	15 minutes	Leq		
			77		
Traffic Counts (Veh/Hr):					
	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1324	88	204	0	8
SB US-23	1656	36	160	40	0

LOCATION AERIAL:

Comments:

SITE PHOTOGRAPHS:

Looking SE

Looking E

Looking NE

Noise Measurements

SITE / LOCATION: **Site 11: Forest Park Entrance** DATE: **7/23/14**

Peak Measurement Period

Time Begin: 8:10 AM 15 minutes Leq 75

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1324	76	160	4	4
SB US-23	3108	60	156	0	8

Off-Peak Measurement Period

Time Begin: 8:55 AM 15 minutes Leq 75

Traffic Counts (Veh/Hr):

	Auto	Med. Truck	Hvy Truck	Bus	Moto.
NB US-23	1292	112	176	0	0
SB US-23	2292	56	164	0	4

LOCATION AERIAL:

Comments:

SITE PHOTOGRAPHS:

Looking SW

Looking NW

Looking W

Appendix B
Traffic Data

MDOT Michigan Department of Transportation

OFFICE MEMORANDUM

DATE: July 17, 2014

TO: Tom Hanf, Environmental Section

FROM: Amy Lipset, Asset Management

SUBJECT: US-23 EA Noise Analysis

Traffic Information

The following tables contain the requested traffic information for US-23 in Livingston and Washtenaw Counties. Traffic volumes were calculated from counts taken in October 2013 at PTR 8239, south of Barker Road. A growth rate of 0.3% was used to calculate future traffic volume. This number is the growth rate agreed upon by MDOT and the MPO stakeholders for this project.

	West Tri-Level to Territorial Road							
	Northbound US-23				**Southbound US-23**			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	2015	2040	2015	2040	2015	2040	2015	2040
Automobiles	1337	1441	3358	3619	3416	3681	1964	2117
Medium Trucks	41	45	36	39	43	47	31	33
Heavy Trucks	163	176	114	123	127	137	125	135
Buses	3	3	3	3	2	2	3	3
Motorcycles	4	4	7	8	7	7	5	5

	Territorial Road to 6 Mile Road							
	Northbound US-23				**Southbound US-23**			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	2015	2040	2015	2040	2015	2040	2015	2040
Automobiles	1422	1533	3630	3912	3357	3618	2004	2160
Medium Trucks	44	48	39	42	43	46	31	34
Heavy Trucks	173	187	123	133	125	134	127	137
Buses	3	3	3	3	2	2	3	3
Motorcycles	4	4	8	9	6	7	5	5

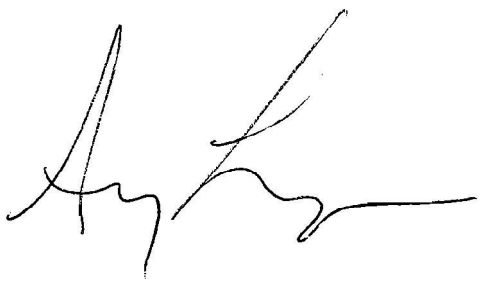
	6 Mile Road to Barker Road							
	Northbound US-23				Southbound US-23			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	2015	2040	2015	2040	2015	2040	2015	2040
Automobiles	1451	1564	3630	3912	3152	3397	2045	2204
Medium Trucks	45	48	39	42	40	43	32	34
Heavy Trucks	177	191	123	133	117	126	130	140
Buses	3	3	3	3	2	2	3	3
Motorcycles	4	4	8	9	6	6	5	5

	Barker Road to 8 Mile Road							
	Northbound US-23				Southbound US-23			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	2015	2040	2015	2040	2015	2040	2015	2040
Automobiles	1422	1533	3485	3756	3026	3261	1994	2149
Medium Trucks	44	48	37	40	38	41	31	34
Heavy Trucks	173	187	118	127	112	121	127	137
Buses	3	3	3	3	2	2	3	3
Motorcycles	4	4	8	8	6	6	5	5

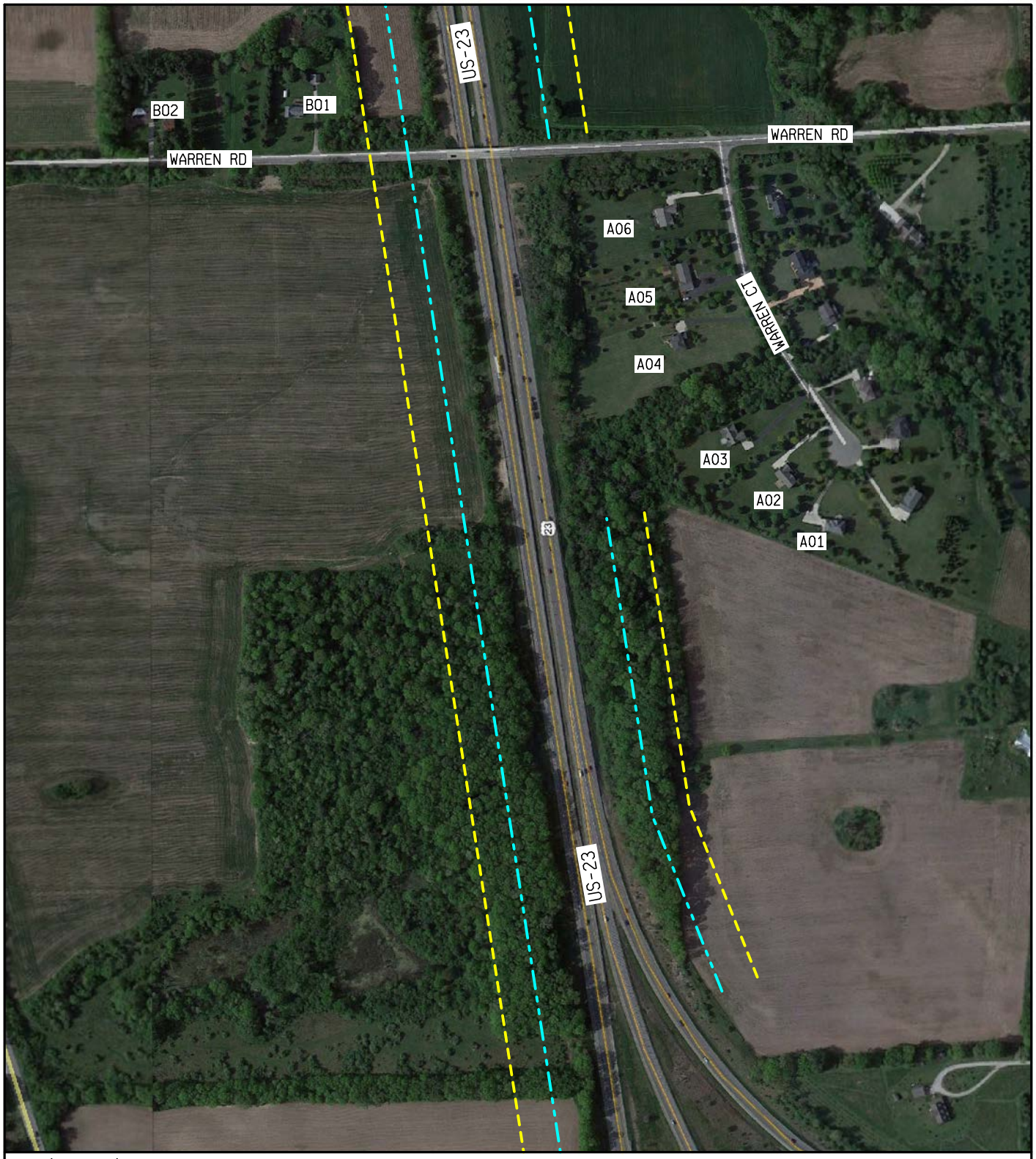
	8 Mile Road to 9 Mile Road							
	Northbound US-23				Southbound US-23			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	2015	2040	2015	2040	2015	2040	2015	2040
Automobiles	1529	1647	3467	3737	2542	2739	2114	2278
Medium Trucks	47	51	37	40	32	35	33	36
Heavy Trucks	186	201	117	127	94	102	134	145
Buses	3	3	3	3	2	2	3	3
Motorcycles	4	5	8	8	5	5	5	6

	9 Mile Road to Silver Lake Road							
	Northbound US-23				Southbound US-23			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	2015	2040	2015	2040	2015	2040	2015	2040
Automobiles	1536	1656	3450	3718	2211	2383	2124	2289
Medium Trucks	48	51	37	40	28	30	33	36
Heavy Trucks	187	202	117	126	82	88	135	146
Buses	3	3	3	3	1	2	3	3
Motorcycles	4	5	8	8	4	5	5	6

If you have any questions regarding this traffic analysis, please contact me at 517.373.2909.



Appendix C
Project Figures



Legend

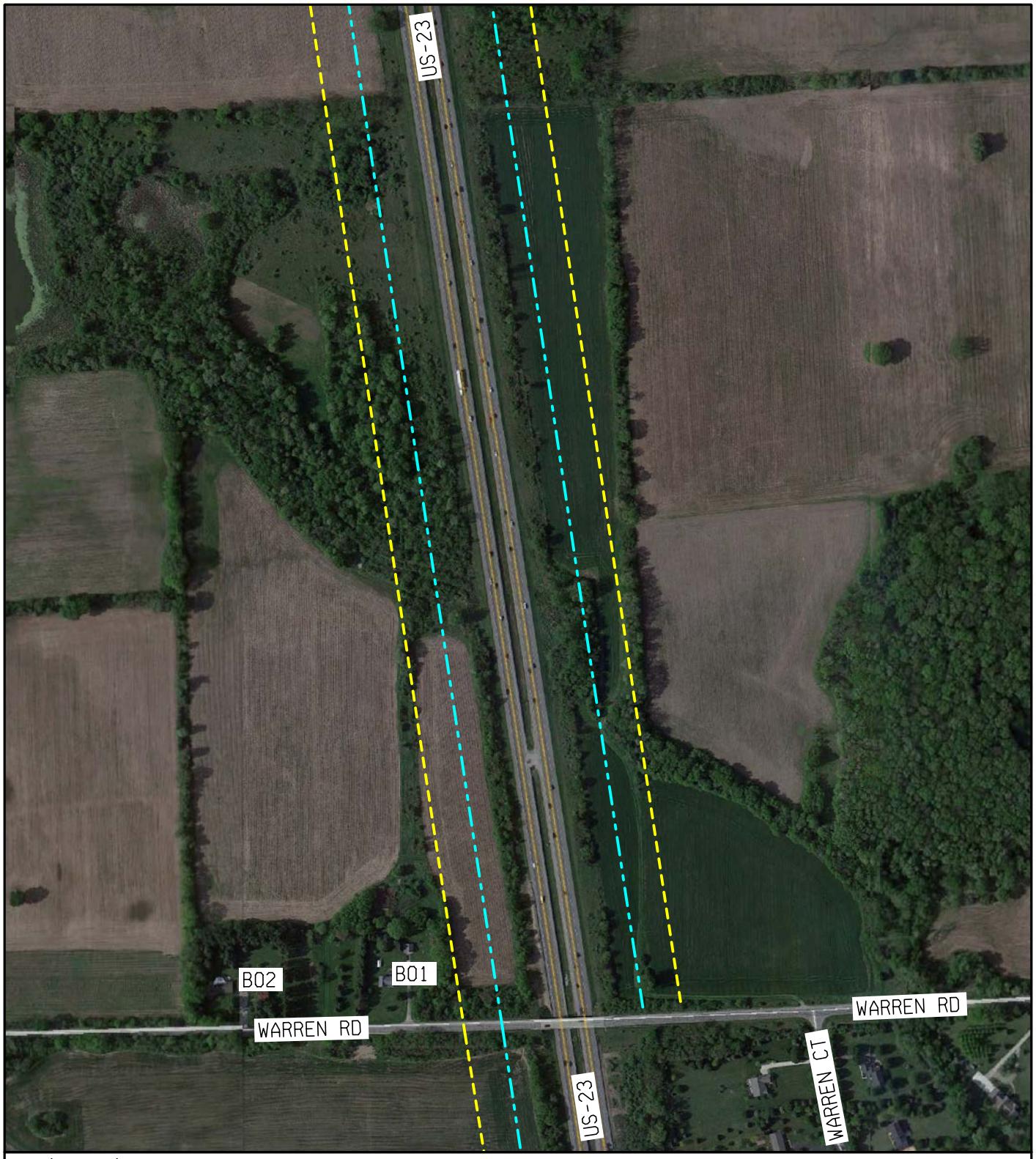
A00	Modeled site, not benefited and not impacted
A00	Modeled site, not benefited and impacted
A00	Modeled site, benefited and not impacted
A00	Modeled site, benefited and impacted
SITE 1	Field Measurement Site
	66 dB(A) Leq Setback
	71 dB(A) Leq Setback
	Feasible and Reasonable Noise Barrier
	Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 1

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan



Legend

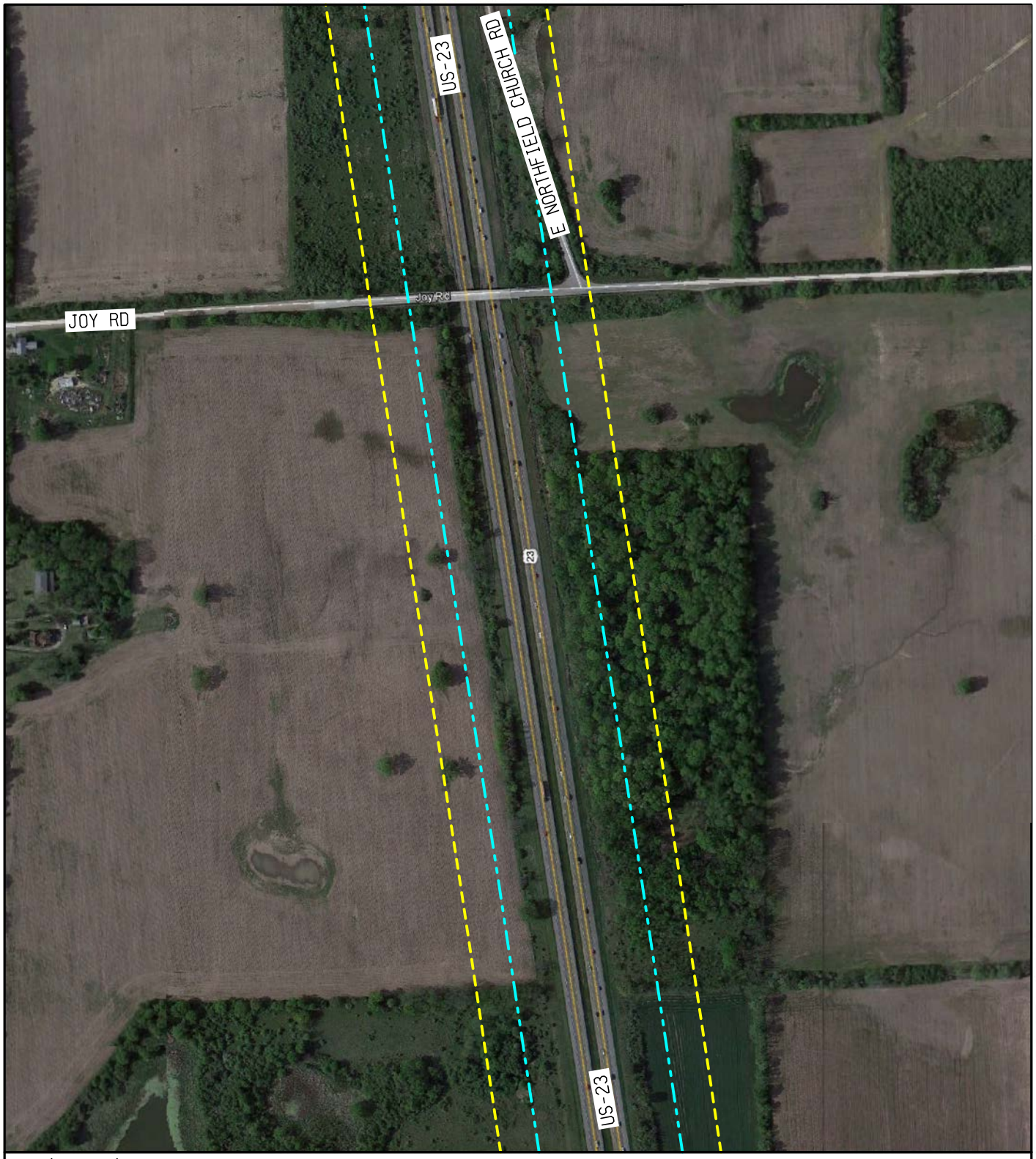
A00	Modeled site, not benefited and not impacted
A00	Modeled site, not benefited and impacted
A00	Modeled site, benefited and not impacted
A00	Modeled site, benefited and impacted
SITE 1	Field Measurement Site
	66 dB(A) Leq Setback
	71 dB(A) Leq Setback
	Feasible and Reasonable Noise Barrier
	Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 2

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan



Legend

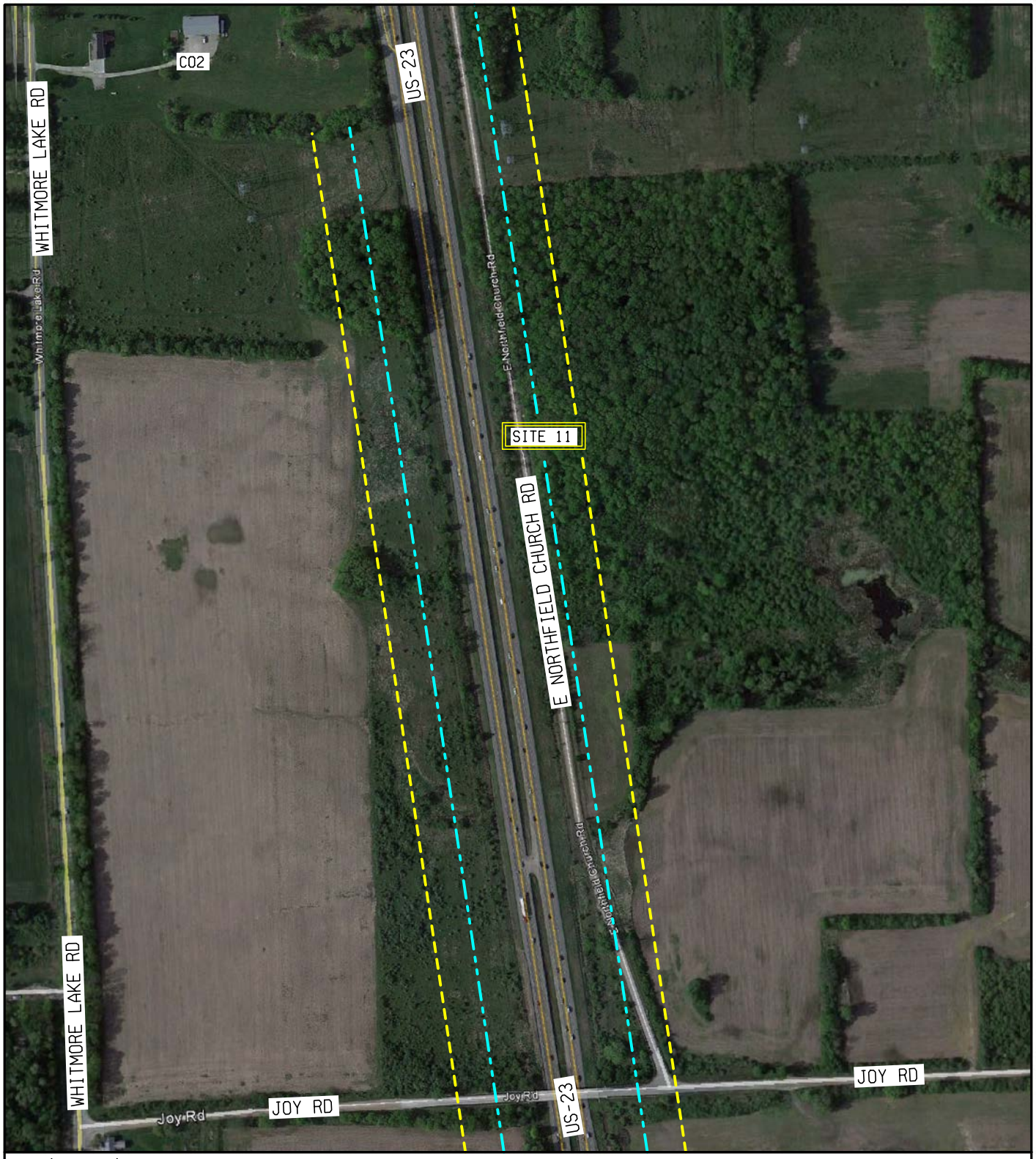
A00	Modeled site, not benefited and not impacted
A00	Modeled site, not benefited and impacted
A00	Modeled site, benefited and not impacted
A00	Modeled site, benefited and impacted
SITE 1	Field Measurement Site
	66 dB(A) Leq Setback
	71 dB(A) Leq Setback
	Feasible and Reasonable Noise Barrier
	Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 3

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan



Legend

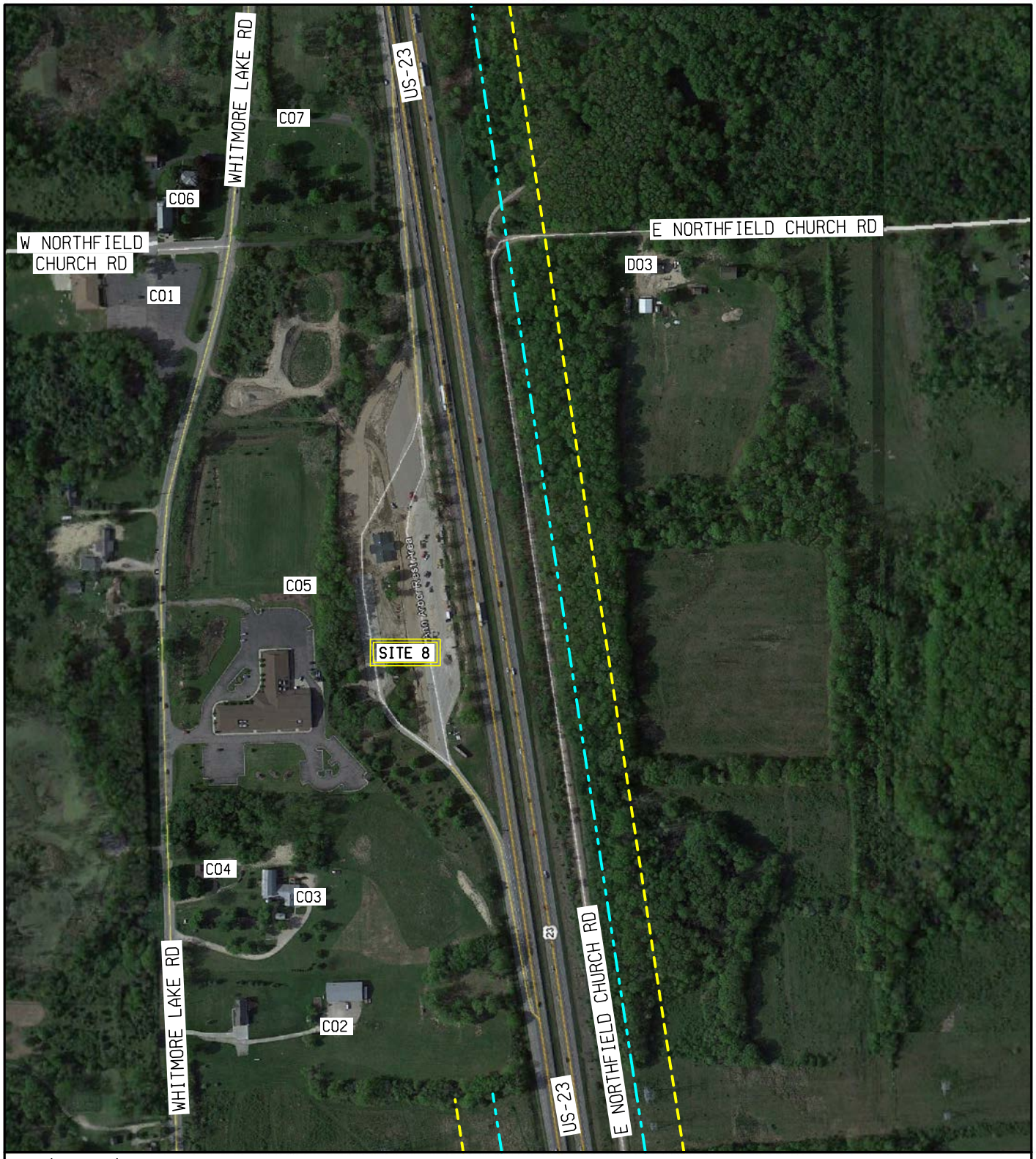
A00	Modeled site, not benefited and not impacted
A00	Modeled site, not benefited and impacted
A00	Modeled site, benefited and not impacted
A00	Modeled site, benefited and impacted
SITE 1	Field Measurement Site
	66 dB(A) Leq Setback
	71 dB(A) Leq Setback
	Feasible and Reasonable Noise Barrier
	Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 4

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan



Legend

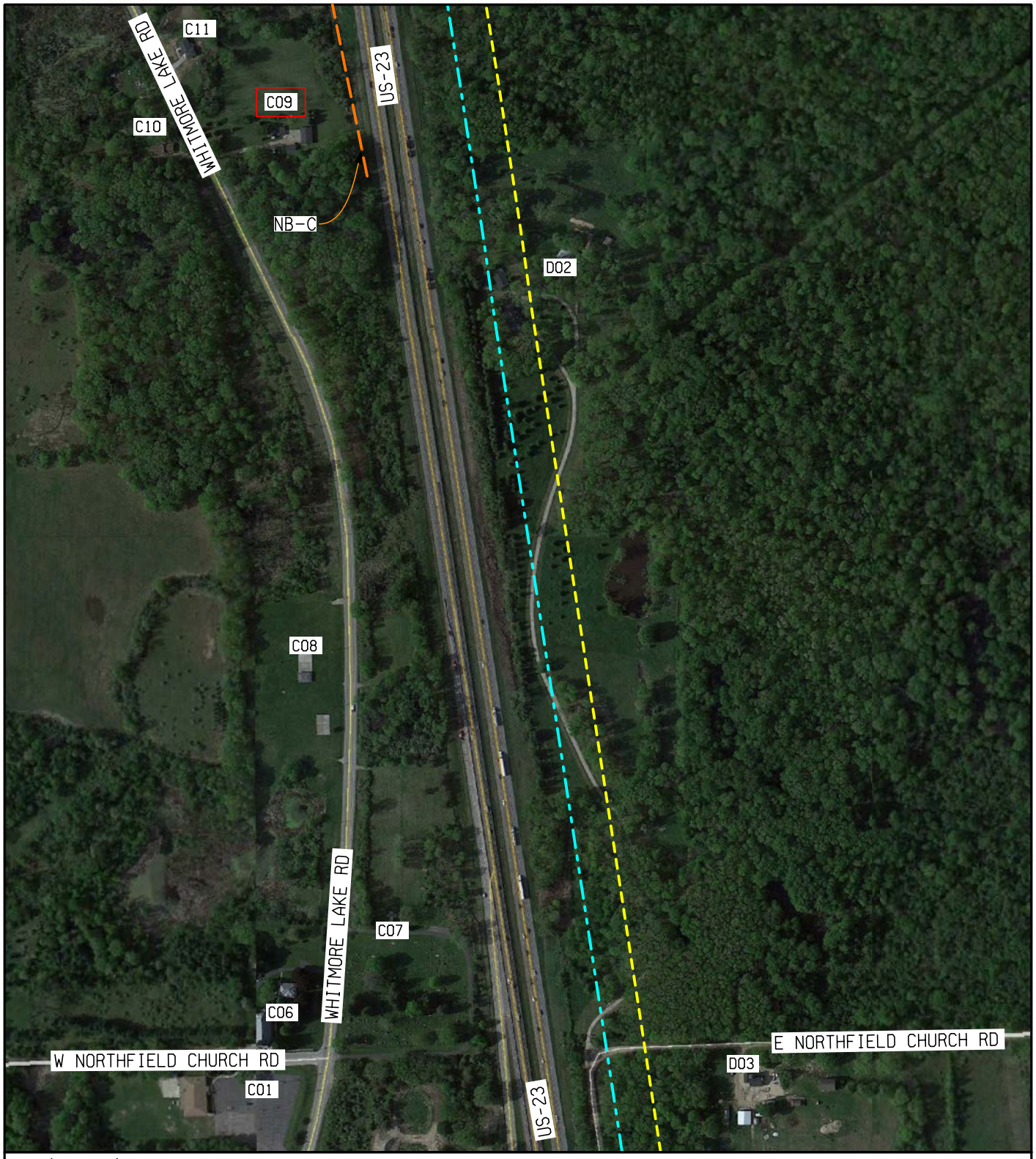
- A00 — Modeled site, not benefited and not impacted
- A00 — Modeled site, not benefited and impacted
- A00 — Modeled site, benefited and not impacted
- A00 — Modeled site, benefited and impacted
- SITE 1 — Field Measurement Site
- 66 dB(A) Leq Setback
- 71 dB(A) Leq Setback
- Feasible and Reasonable Noise Barrier
- Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 5

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan



Legend

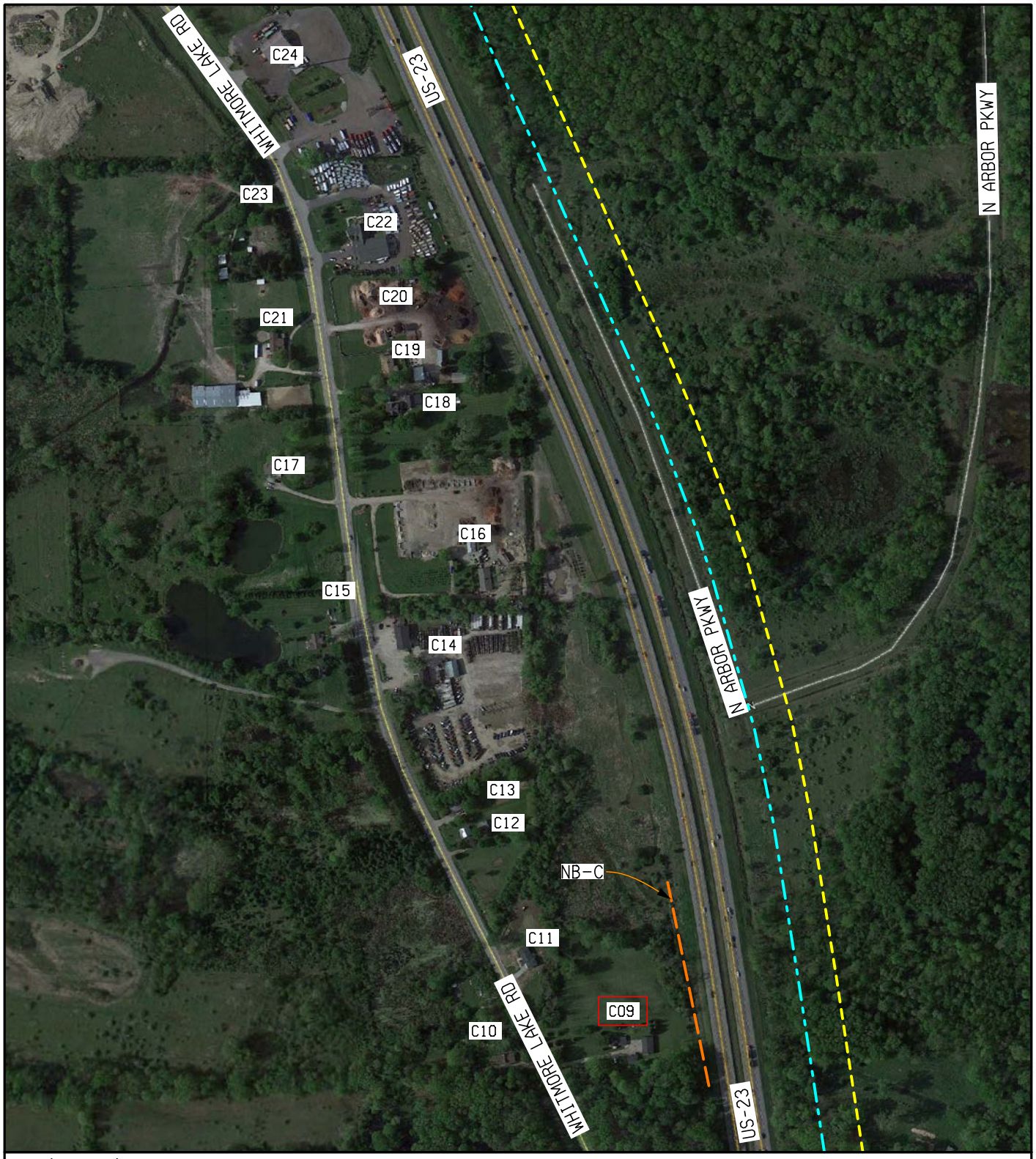
A00	Modeled site, not benefited and not impacted
A00	Modeled site, not benefited and impacted
A00	Modeled site, benefited and not impacted
A00	Modeled site, benefited and impacted
SITE 1	Field Measurement Site
	66 dB(A) Leq Setback
	71 dB(A) Leq Setback
	Feasible and Reasonable Noise Barrier
	Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 6

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan



Legend

A00	Modeled site, not benefited and not impacted
A00	Modeled site, not benefited and impacted
A00	Modeled site, benefited and not impacted
A00	Modeled site, benefited and impacted
SITE 1	Field Measurement Site
	66 dB(A) Leq Setback
	71 dB(A) Leq Setback
	Feasible and Reasonable Noise Barrier
	Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 7

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan

Legend

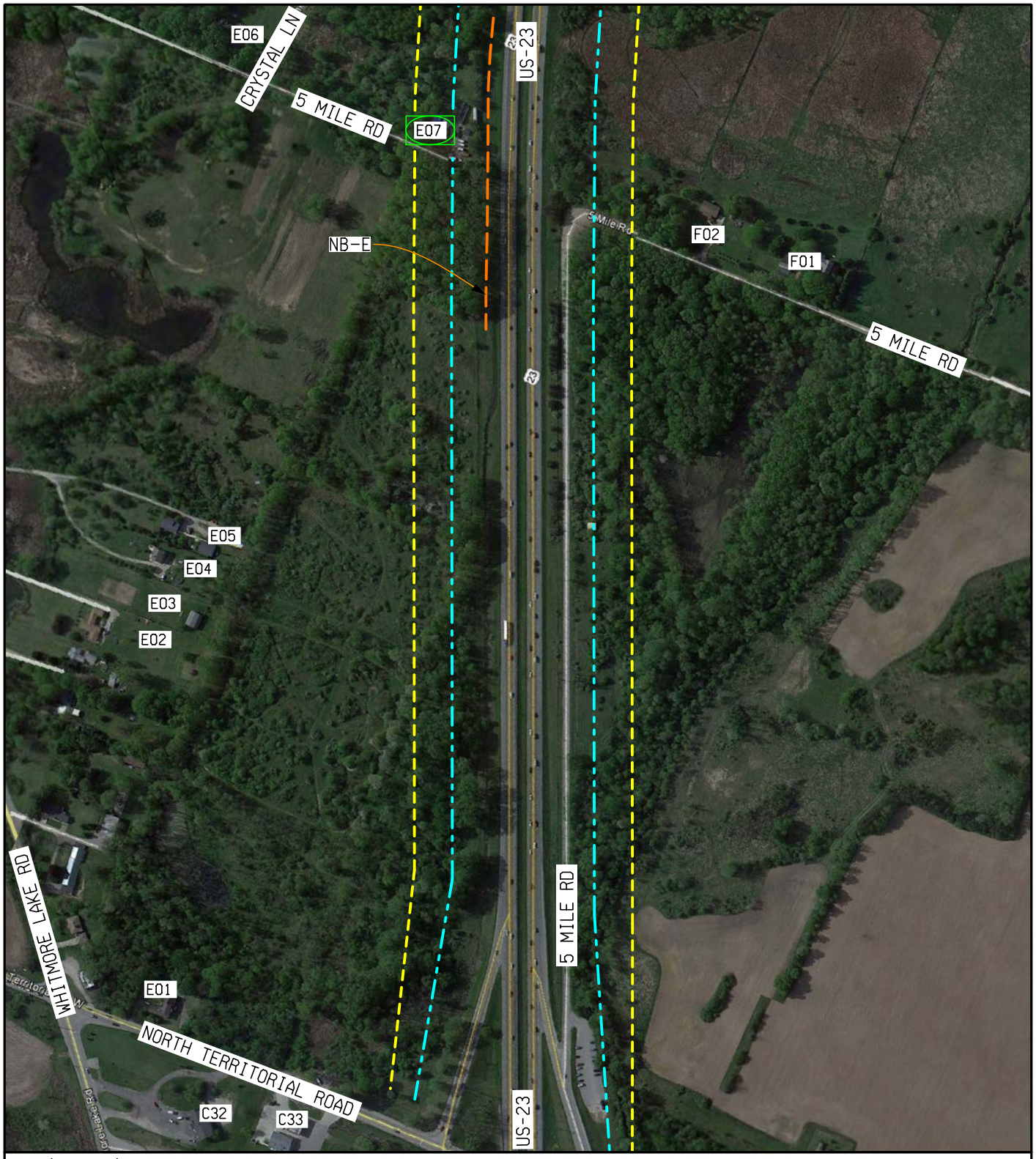
A00	Modeled site, not benefited and not impacted
A00	Modeled site, not benefited and impacted
A00	Modeled site, benefited and not impacted
A00	Modeled site, benefited and impacted
SITE 1	Field Measurement Site
	66 dB(A) Leq Setback
	71 dB(A) Leq Setback
	Feasible and Reasonable Noise Barrier
	Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 8

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan



Legend

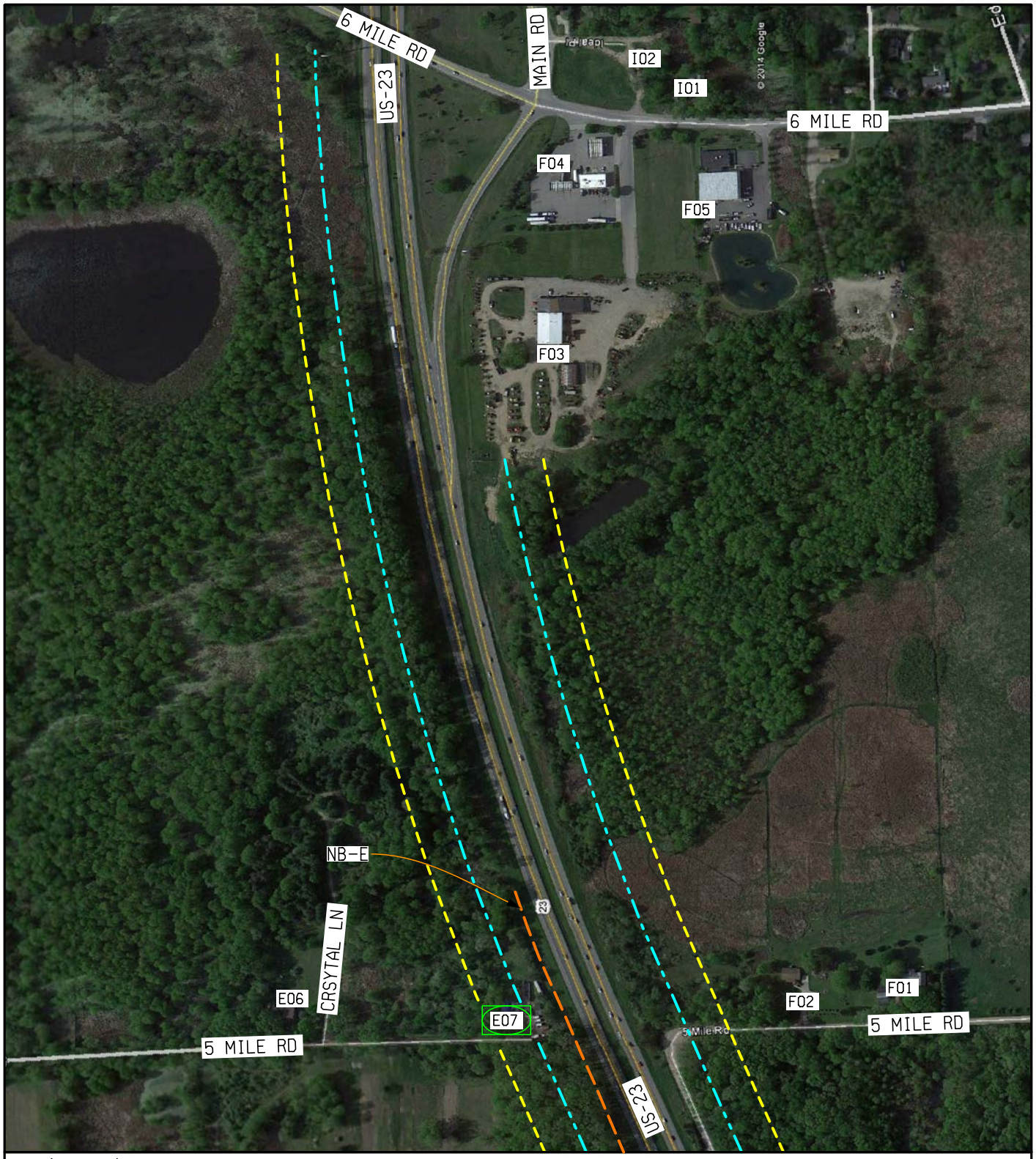
A00	Modeled site, not benefited and not impacted
A00	Modeled site, not benefited and impacted
A00	Modeled site, benefited and not impacted
A00	Modeled site, benefited and impacted
SITE 1	Field Measurement Site
	66 dB(A) Leq Setback
	71 dB(A) Leq Setback
	Feasible and Reasonable Noise Barrier
	Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 9

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan



Legend

A00	Modeled site, not benefited and not impacted
A00	Modeled site, not benefited and impacted
A00	Modeled site, benefited and not impacted
A00	Modeled site, benefited and impacted
SITE 1	Field Measurement Site
	66 dB(A) Leq Setback
	71 dB(A) Leq Setback
	Feasible and Reasonable Noise Barrier
	Evaluated Noise Barrier

N

0 75 150 300 450 600

Figure 10

Noise Analysis
US-23
M-14/US-23 to Silver Lake Road
Washtenaw & Livingston County
Michigan