Noise Analysis for I-65 Added Lanes Project (Des. No. 1383339) in Tippecanoe County, Indiana

By

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INTRODUCTION

ASC Group, Inc., under contract with RQAW Inc., completed a noise assessment for the planned I-65 improvement project in Lafayette, Tippecanoe County, Indiana. This noise analysis was done to satisfy requirements of the Indiana Department of Transportation (INDOT) Traffic Noise Policy (INDOT 2011), which is INDOT's implementation of the Federal Highway Administration (FHWA) regulations found in Title 23 of the Code of Federal Regulations (CFR) Part 772 as modified on July 13, 2010. The analysis conforms to procedures specified in both the INDOT Traffic Noise Policy and in FHWA guidance (FHWA 2011).

This report is organized with a project description section following this introduction that describes the project and evaluates its project type under FHWA regulations. The next section identifies land uses in terms of FHWA activity classifications and noise abatement criteria. Within the identified land-use areas, individual receptors are identified for analysis. Noise impact criteria are also discussed in this section. The subsequent section evaluates existing and future noise levels, including descriptions of the modeling approach and input data, field measurements, and model validation/calibration. Modeling results are presented in this section for Existing, No-Build, and Build scenarios. Noise abatement measures and construction noise issues are discussed in the next section, followed by a final section that summarizes the noise analysis and its conclusions. Tables and figures are located at the end of the text before the appendices. Appendix A contains a description of noise fundamentals and terminology that may be useful to readers not already knowledgeable in traffic noise analysis. Appendix B contains field data sheets and equipment calibration certificates. Input and output files from computer modeling runs are available in electronic format.

PROJECT DESCRIPTION AND TYPE

The proposed project would improve the I-65 corridor from 0.5 mile south of the State Route (SR) 38 interchange to 0.7 mile north of the SR 26 interchange in Lafayette, Tippecanoe County, Indiana. The project entails adding a third travel lane in each direction. The new lanes will be added in the median and existing travel lanes and ramps will not be moved.

Because this project includes new travel lanes, it is considered a Type I project as defined in FHWA (2011). For Type I projects, INDOT (2011) requires that traffic noise be analyzed over an area extending 500 ft from the edge of pavement where construction will occur. The project location is shown on Figure 1.

LAND USES AND RECEPTORS

Under FHWA regulations, a traffic noise impact occurs when predicted traffic noise levels in the Build scenario approach or exceed noise abatement criteria (NAC) values or when a substantial increase is predicted to occur compared with existing noise levels. Noise abatement is considered wherever such impacts occur. NAC are defined based on land use activity categories as shown in Table 1. The NAC values are used solely to determine when noise impacts occur and when noise abatement is considered; they should not be considered Federal standards or even desirable noise levels.

INDOT (2011) defines the term “approach” to mean within 1 A-weighted decibel (dBA) of a NAC and a “substantial” increase to mean that future noise levels exceed existing levels by 15 dBA or more. Thus, for a Category B land use area with a NAC L_{eq}(h) of 67 dBA, an impact occurs at a receptor and noise abatement is considered for that receptor if predicted noise levels reach 66 dBA. However, if the existing noise level for the area is 45 dBA, then an impact would occur and noise abatement would be considered if the predicted noise level exceeded 60 dBA.

FHWA (2011) defines a receptor as a discrete or representative location of a noise sensitive area for any of the land uses listed in Table 1. In this noise analysis, receptors were located within each noise sensitive land use area and noise levels were determined at the receptors through modeling. Where possible, receptors were located in areas of frequent human use near residences and other buildings, for example, on patios and balconies. Where no area of frequent human use was observed, receptors were placed near doors or windows.

Aerial photos were used to classify land uses within the noise study area according to the categories given in Table 1 and to identify individual receptors within those land use areas. Land uses and receptor locations were verified and refined during a site visit on May 6 and 7, 2014. Land use categories present in the noise study area include Category B (residential), Category C (picnic and recreation areas and one school), Category E (hotels and offices), and Category F (retail, manufacturing, agricultural, and other land uses not considered to be sensitive to noise). Land use areas B, C, and E are shown as shaded regions on Figure 2 (Sheets 1 through 13). Three Category G (undeveloped) areas were also identified; these are not shaded on Figure 2.

Receptors used in the modeling analysis are shown on Figure 2 (Sheets 1 through 13). They are labeled with the identification number used in the modeling files and in the results tables presented later in this report.

Residential receptors in this study represent single-family houses, duplexes, and three apartment complexes: Waterford Court Apartments, Village Square Apartments, and Hawthorne Gardens. These apartment complexes are composed of two-story buildings with apartments on both floors that have outdoor use areas in the form of patios and balconies. Other residential receptors represent single-story homes and duplexes. To reduce modeling computation times, most of the multi-residence receptors represent more than one dwelling unit. Receptors were placed at a height of 5 ft above the ground for ground-level units and 15 ft above the ground for second floor apartments (receptors labeled with an "a" after the number).

Receptor 107 represents Harrison College, classified as Category C. The building appears to be a classroom/office building with no outdoor areas of frequent human use. Therefore, indoor noise levels were considered and compared with Category D NACs.

EXISTING AND FUTURE NOISE LEVELS

This section describes the modeling approach used to compute existing and future noise levels, input data used in the modeling, and field measurements used in model validation.

SCENARIOS

Three scenarios were evaluated: Existing (current conditions), No-Build (future conditions if the project is not constructed), and Build (future conditions if the project is constructed). FHWA regulations use results of the Existing and Build scenarios to determine if impacts will occur. The No-Build scenario was analyzed to provide additional information for National Environmental Policy Act (NEPA) documents. Existing and No-Build scenarios include the existing street configuration and traffic data for the years 2015 and 2035, respectively. The Build scenario includes the proposed highway configuration with added lanes and traffic data for 2035. Receptors were the same for all scenarios.

MODELING

Each scenario was modeled using the current version of the FHWA's Traffic Noise Model (TNM) version 2.5 (Anderson et al. 1998; Lau et al. 2004). Input data requirements for TNM include detailed information about roadway alignments, elevations, and traffic volumes.

In addition, other elements that may affect noise transmission between the roadways and the receptors can be specified as necessary. These other elements include topography, existing barriers, buildings, trees, and ground surfaces. TNM input data elements are described below.

Roadways

The primary source of highway noise in the study area is I-65. SR 26 (South Street) and the four ramps at the SR 26 interchange were included in the modeling in addition to I-65 because of their proximity to some receptors. Other roads in the area, including ramps, were considered to have negligible effect on noise levels at the receptors modeled. For I-65, one TNM roadway was defined for each travel lane, and traffic volumes were assigned to each lane as appropriate for the scenario being modeled. Details are given in the traffic section below.

TNM roadways were also defined for Veterans Memorial Parkway and McCarty Lane to establish terrain elevations and overpass locations in the model. Traffic volumes were not available for these roads and they are not considered significant noise sources.

Roadway elevations used in modeling were obtained from the design drawings provided by RQAW.

Traffic Data

Annual Average Daily Traffic (AADT) volumes, design hourly volumes (DHVs), and associated commercial truck fractions (TDs) were provided by INDOT for the years 2015 and 2035 (INDOT 2014a,b). Traffic volumes and fractions are shown in Table 2.

For each road segment, the TNM model uses as input data the average speed and the number of vehicles per hour for up to five vehicle classes. For this project, traffic speeds were determined from speed limits—65 mph for cars and 60 mph for trucks. However, obtaining values of vehicles per hour in the required vehicle type categories from DHVs and TDs requires certain assumptions and numerical manipulations. Traffic volumes for three of the TNM vehicle classes were estimated from the values given in Table 2: cars (vehicles with two axles and four tires such as cars, light vans, pickup trucks) and medium trucks (vehicles with two axles and six tires), and heavy trucks (vehicles with three or more axles). The other two TNM vehicle classes (buses and motorcycles) were not used because they cannot be distinguished from cars and trucks in the traffic volumes provided. The relative volumes of medium and heavy trucks were computed using the average heavy truck fraction obtained from traffic counts taken when noise measurements were made on May 6 and 7, 2014. Traffic volumes used in the TNM modeling are given in Table 3. Calculations and factors are explained in the footnotes to the table.

Topography

Terrain lines were used in the TNM model to represent significant terrain features. Locations and elevations for the terrain lines were from elevation contours shown on design drawings provided by RQAW and supplemented where necessary using data from the Google earth program. Elevations for roads and potential noise barriers at shoulders and ROW lines were also taken from the design drawings. Elevations for receptors and other TNM elements were obtained from the Google earth program.

Other TNM Data Elements

Other data elements that may be defined in TNM include building rows, tree zones, ground zones, and existing barriers. For this project, existing barriers were used to represent large buildings and building rows were used to represent rows of houses that could affect noise levels at some receptors. Ground zones and tree zones were not needed.

MEASUREMENTS AND MODEL CALIBRATION/VALIDATION

This section describes the ambient noise measurements obtained for this project and how those measurements were used to (1) characterize the ambient noise environment and (2) to validate the TNM model for this application. Sounds in the noise study area may arise from a variety of sources, of which traffic on nearby roads is only one. Other noise sources may include air conditioners, lawn mowers and other home maintenance equipment, power transformers, aircraft, animals, children, etc. TNM is only capable of modeling traffic noise, so it is important in trying to predict future noise levels to determine if traffic noise dominates the area or if other noises in the area are significant. This is done by comparing measured noise levels with modeling results at the measurement locations as discussed below.

Measurements

Noise measurements were taken at seven locations on May 6 and 7, 2014. Table 4 lists the measurement sites and gives additional information about each one. Field measurement locations are marked with yellow/black symbols on Figure 2 and labeled with the prefix "M."

Noise measurements were made using a Quest SoundPro Sound Level Meter (SLM) that met the American National Standards Institute (ANSI) SI.4-1993, TYPE II standards for accuracy (ANSI 1993) and that was capable of automatically computing L_{eq} values. SLM calibration was checked using a 114-dB calibrator before and after each measurement, and meter readings were adjusted for instrument bias and drift following FHWA procedures (Lee and Fleming 1996). Calibration certification statements for the SLM and the calibrator are shown in Appendix B. Noise measurements and calibration data are presented in Table 5.

Measurement durations were at least 15 minutes in order to adequately capture noise variations over time and obtain an accurate L_{eq} value. Distances from nearby roads, buildings, and structures were measured at each site. Sketches were made on field data sheets of each site showing the measurement location relative to roads, buildings and structures, noting terrain features and surface types. Wind speeds, temperatures, and barometric pressures during each measurement as reported on the weather underground internet site were recorded. During the May 6 measurements, wind speeds were relatively high at 15 to 18 mph from the east and east-southeast. The temperature was about 73ºF and relative humidity was about 35 percent. On May 7, conditions were similar except that wind speeds were lower at 7 to 11 mph and humidity levels were nearer 50 percent.

Traffic was recorded on a video camera during each measurement period. The videos were watched in the office to obtain vehicle counts that were entered on the field data sheets. Copies of the field data sheets are in Appendix B.

Model Validation

In order to validate the modeling setup used in this project, TNM was run at each measurement location using traffic data collected during the measurement. Roads and other TNM elements (except receptors) were the same as in the Existing scenario. As shown in Table 6, modeled values were within 3 dBA of measured values at all locations except M-7. Wind speeds were highest during this measurement with strong gusts at times. TNM is not designed to model wind effects and it is not surprising that agreement was poor for this measurement. Given that good agreement between model and measurement was obtained at the other six sites, the model is considered valid for this project.

MODELING RESULTS AND IMPACT IDENTIFICATION

Predicted noise levels are shown in Table 7 for all three scenarios. Noise impacts are predicted due to NACs being approached or exceeded at one non-residential receptor and at receptors representing numerous residences as discussed below. The non-residential impact is predicted at a basketball court located near the Subaru of Indiana Automotive (SIA) recreation center (receptor 143). Exterior noise levels at receptor 107, the only school in the study area, are predicted to exceed the impact criterion for Category C. However, as mentioned above, there are no outdoor use areas near the school building. Therefore, interior noise levels were estimated using a noise reduction factor of 25 dBA, the recommended value for masonry buildings with single glazed windows (FHWA 1995). As shown in Table 7, the interior noise level does not exceed the Category D NAC, so the school is not considered impacted.

Residential impacts occurred in three general areas. North of SR 26 and west of I-65, impacts are predicted at single-family houses represented by receptors 7–1, 56, 57, 65 and 66 and in the Village Square Apartment complex at ground floor receptors (78, 80–88, and 95) and second-floor receptors (72a, 74a, 76a, 78a–88a, 95a, and 97a). North of SR 26 and east of the interstate, impacts are predicted in Waterford Court at one ground-floor receptor (17) and four second-floor receptors (17a, 18a, 36a, and 40a). Hotels and the Visitors Center (receptor 51) were not impacted. In the area east of Veterans Memorial Parkway and north of I-65, impacts were predicted at two duplexes (124 and 125) and at two second-floor receptors in the Hawthorne Gardens complex.

NOISE ABATEMENT ALTERNATIVES

Several noise abatement measures were considered for the impacted receptors in this project. These include traffic management measures, noise insulation, alteration of alignment, acquisition of real property, and noise barrier construction. Due to limitations on INDOT’s ability to acquire property for mitigation or to mitigate sites off of state rights-of-way (ROW), the most common form of abatement is the construction of noise barriers.

Traffic Management Measures

Different traffic controls on I-65 would not be practical. Lowering speed limits may reduce noise levels, but would also reduce functionality of the road system. Therefore, additional traffic management measures are considered not feasible.

Noise Insulation

In Indiana, impacted non-profit and public buildings may be eligible for noise insulation. There is one school within the noise study area, but it is not impacted. Therefore, noise insulation is not applicable.

Alteration of Alignment

Alignment modifications generally involve orienting and/or locating the roadway sufficient distances from noise-sensitive areas to minimize noise impacts. Proposed new lanes are located immediately adjacent to existing lanes in the median. Any other location would be cost-prohibitive. Thus, neither vertical nor horizontal modifications to the proposed alignment are considered feasible or reasonable noise abatement measures for this project.

Acquisition of Real Property For Buffer Zones

Buffer zones are undeveloped open spaces that border a highway. Buffer zones are created when a highway agency purchases land or development rights in addition to the normal ROW so that future dwellings cannot be constructed near the highway in areas with the potential for excessive traffic noise. However, as mentioned above, INDOT's ability to acquire property for mitigation or to mitigate sites off of state ROW is limited, and this is not considered a suitable option.

Noise Barrier Construction

To be considered for construction, a noise barrier must be considered both feasible and reasonable as defined in INDOT (2011).

The term feasibility includes two aspects: acoustic feasibility and engineering feasibility. For a barrier to be acoustically feasible, it must achieve a 5 dBA noise reduction at a majority of impacted receptors. To meet the engineering feasibility criterion, INDOT requires that the barrier be designed based on sound engineering practices and standards and that the barrier is optimally located. If the roadway is at a higher elevation than nearby receptors, the barrier is evaluated near the shoulder. If the receptors are at a higher elevation than the roadway, the barrier is evaluated at the ROW. Engineering feasibility also takes into account topography, drainage, safety, barrier height, utilities, and access/maintenance needs.

For a barrier to be reasonable, it must meet the noise reduction design goal, it must be cost-effective, and it must be desired by the landowners and residents who would benefit from the barrier. INDOT's design goal for noise abatement is to provide at least a 7.0 dBA reduction in noise levels for at least 50 percent of impacted, first row receptors (INDOT 2011). A first row receptor is one that is located on the first land parcel directly adjacent to the highway. Effective cost is computed by dividing the total construction cost of the barrier by the number of benefited receptors. A benefited receptor is one at which noise levels are reduced by at least 5 dBA, whether or not the receptor was impacted. In an area where the majority of receptors were built prior to the roadway, an effective cost of $30,000 or less is considered reasonable. In other areas, the reasonable cost limit is $25,000 per benefited receptor. For a feasible barrier that meets the design goal and effective cost criteria, benefited residents and land-owners will be surveyed to determine desirability of the barrier as described in the public involvement section of this report.

For this project, noise barriers were considered for all impacted receptors. However, a barrier design was not developed for the basketball court located at the Subaru recreation center. Average usage of the court is unknown, but is probably no more than 10 people at a time for a few hours a day during good weather. If the daily average number of users is taken to be 10 during half the year and none for the other half of the year, then the annual average would be 5. Dividing this by 2.59 (the average number of people per household in Indiana) as described in INDOT 2011 yields two equivalent receptors. A noise barrier is unlikely to be cost-effective for two isolated receptors.

Detailed barrier designs were developed for the three areas described above where residential impacts were predicted: Village (north of SR 26 and west of I-65), Waterford (north of SR 26 and east of I-65), and Hawthorne (east of Veterans Memorial Parkway and north of I-65). For each barrier, two locations were considered—at the roadway shoulder and at the ROW line. At all locations, barriers were defined in 100-ft segments in TNM using elevations taken from the road design drawings. TNM was then used to adjust the height of each segment in 1-ft intervals and observe the effect on modeled noise levels at impacted receptors. Barrier segments were set at the lowest heights consistent with meeting INDOT's design goal and feasibility criteria. The three barriers are summarized in Table 8 and discussed further below.

Village

For impacted residences in and to the north of the Village Square Apartment complex, barrier designs were considered at both the roadway shoulder and at the ROW. The modeled barrier generally follows the ROW where elevations are higher except for one area where the ground drops quickly away from the road and then comes back up. The barrier was placed at the shoulder in this area where the shoulder is higher. A design was found that meets INDOT's acoustic feasibility requirement of providing at least 5 dBA reduction at a majority of impacted receptors. There are no access roads, driveways, or other obstacles to placing the barrier at this location. Drainage issues will have to be examined during final design where the barrier crosses from the ROW to the shoulder, but a barrier would probably be feasible.

Because a majority of homes in this neighborhood were in existence at or near the time of the current classification of the roadway, INDOT's reasonable cost limit for this area is $30,000. As shown in Table 8, the cost of this barrier is $27,300 per benefited receiver. This is lower than INDOT's reasonable cost limit, so the barrier is considered cost-effective.

The considered barrier is 3,200 ft long with heights ranging from 9 to 17 ft. As shown in Table 9, this design provides at least 7 dBA noise reduction at over 80 percent of impacted front row receptors, thereby meeting INDOT's noise reduction design goal.

Because the Village barrier meets the feasibility and reasonableness criteria discussed above, the opinions of residents and property owners at benefited receptors will be sought.

Waterford

Barrier designs were evaluated to protect impacted residences in the Waterford Court Apartment complex. Both shoulder and ROW placements were considered, but the shoulder placement was found to result in greater noise reduction. A design was found that meets INDOT's acoustic feasibility requirement of providing at least 5 dBA reduction at a majority of impacted receptors. There are no access roads, driveways, or other obstacles to placing the barrier at this location. Therefore, a barrier would be feasible.

As shown in Table 8 the cost for a barrier at the shoulder is $14,750 per benefited receptor at INDOT's current price of $\$30/ft^2$. This is lower than INDOT's reasonable cost limit of $25,000, so the barrier is considered cost-effective.

The considered barrier is 2,600 ft long with heights ranging from 15 to 19 ft. As shown in Table 9, this design provides at least 7 dBA noise reduction at all impacted front row receptors, thereby meeting INDOT's noise reduction design goal.

Because the Waterford barrier meets the feasibility and reasonableness criteria discussed above, the opinions of residents and property owners at benefited receptors will be sought.

Hawthorne

For impacted residences located east of Veterans Memorial Parkway and north of I-65, barrier designs were considered at both the roadway shoulder and at the ROW. Elevations at the shoulder are generally higher than at the ROW, so a design was developed at the shoulder. A design was found that meets INDOT's acoustic feasibility requirement of providing at least 5 dBA reduction at a majority of impacted receptors. There are no access roads, driveways, or other obstacles to placing the barrier at this location. As shown in Table 8, the cost of this barrier exceeds INDOT's reasonable cost limit of $25,000. Because a cost-reasonable design was not possible at either the ROW or the shoulder, a barrier is not recommended for this location.

UNDEVELOPED AREAS

Three undeveloped areas are present within the noise study area. To evaluate noise levels in these areas, noise levels were modeled at 50-ft intervals out from the edge of the I-65 ROW (about 100 ft from the edge of pavement) to a distance of 500 ft or until developed land is encountered. Results are shown in Table 10. Noise levels are predicted to exceed 66 dBA (the impact threshold for residential land use) to distances of about 300 to 350 ft. Local officials are encouraged to consider these results for any future development in these areas.

CONSTRUCTION NOISE

All developed land uses and activities adjacent to the proposed project will be affected by the noise generated during construction activities, primarily by heavy machinery. Heavy machinery (such as front-end loaders, bulldozers, graders, dump trucks, pavers, etc.) will produce noise at levels ranging from 70 to nearly 100 dBA at a distance of 50 ft. However, it is difficult to accurately predict levels of construction noise at a particular receptor or group of receptors as the machinery is constantly moving in unpredictable patterns.

Daily construction normally occurs during daylight hours when occasional loud noises are more tolerable. No one location is expected to be exposed to construction noise of long duration; therefore, extended disruption of normal activities is not anticipated. However, provisions will be included in the plans and specifications requiring the contractor to make every reasonable effort to minimize construction noise through abatement measures such as work-hour controls and maintenance of muffler systems. Equipment will be operated in compliance with all applicable local ordinances and regulations pertaining to construction noise.

Due to the temporary nature of construction noise, no construction noise barriers are proposed for this project.

PUBLIC INVOLVEMENT

As described in the INDOT Public Involvement Manual (INDOT 2012), a public hearing may be held for this project. Factors determining whether or not a public hearing is held include the type of project, the type of NEPA document required, the amount of permanent ROW required, the amount of adverse impact the project would have on nearby property or the environment, and several other issues. A public hearing is a meeting held at a convenient time and place at which the public can learn about the proposed project and make comments which will be included in a transcript of the meeting.

Whether or not a public hearing is held, residents that would benefit from a proposed noise barrier will be surveyed by mail to inform them about the project and to solicit their opinions on whether or not a barrier should be built. If the property owner is different than the current resident, both the resident and the property owner are surveyed. This survey will include a pre-stamped, self-addressed return postcard, a brief description of the project, and descriptions of the barrier locations under consideration. It will also include a pamphlet on the basics of traffic noise.

If a public hearing is planned, the survey will include information on the upcoming hearing and a description of the decision-making process. Survey responses may be returned via mail or in person at the hearing. Responses must be expressed in writing by letter, email, or the response postcard.

If no hearing is planned, the survey will set a deadline for return of the survey. If a majority (greater than 50 percent) of benefited residents and property owners do not respond, a second survey will be sent to non-respondents.

INDOT will balance the concerns and opinions of the property owner and the unit occupants with other considerations in determining whether a barrier is appropriate for a given location. If a barrier is proposed adjacent to a business, line of sight issues will be solicited from the business and considered in determining the final barrier location.

SUMMARY AND CONCLUSIONS

Noise modeling results for the proposed additional travel lanes on I-65 are summarized in Table 7 and compared with the measured noise levels for the Existing and No-Build scenarios. This analysis identified impacted residences and one recreational area and has determined that noise abatement is likely, but not guaranteed, at two locations. Noise abatement at these locations is based upon preliminary design costs and design criteria. Noise abatement at this time has been estimated to cost $1,416,000 for the Waterford barrier and $1,230,000 for the Village barrier. These barriers will reduce the noise level by a minimum of 5 dBA at a majority of the identified impacted receptors and will meet the INDOT design goal of providing 7 dBA reduction at a majority of front-row impacted receptors. A reevaluation of the noise analysis will occur during final design. If during final design it has been determined that conditions have changed such that noise abatement is not feasible and reasonable, the abatement measures might not be provided.

The viewpoints of the benefited residents and property owners will be sought and considered in determining the reasonableness of the Waterford and Village barriers. The final decision on the installation of any abatement measures will be made upon completion of the project's final design and the public involvement processes. INDOT will incorporate highway traffic noise consideration in on-going activities for public involvement in the highway program.

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FIGURES

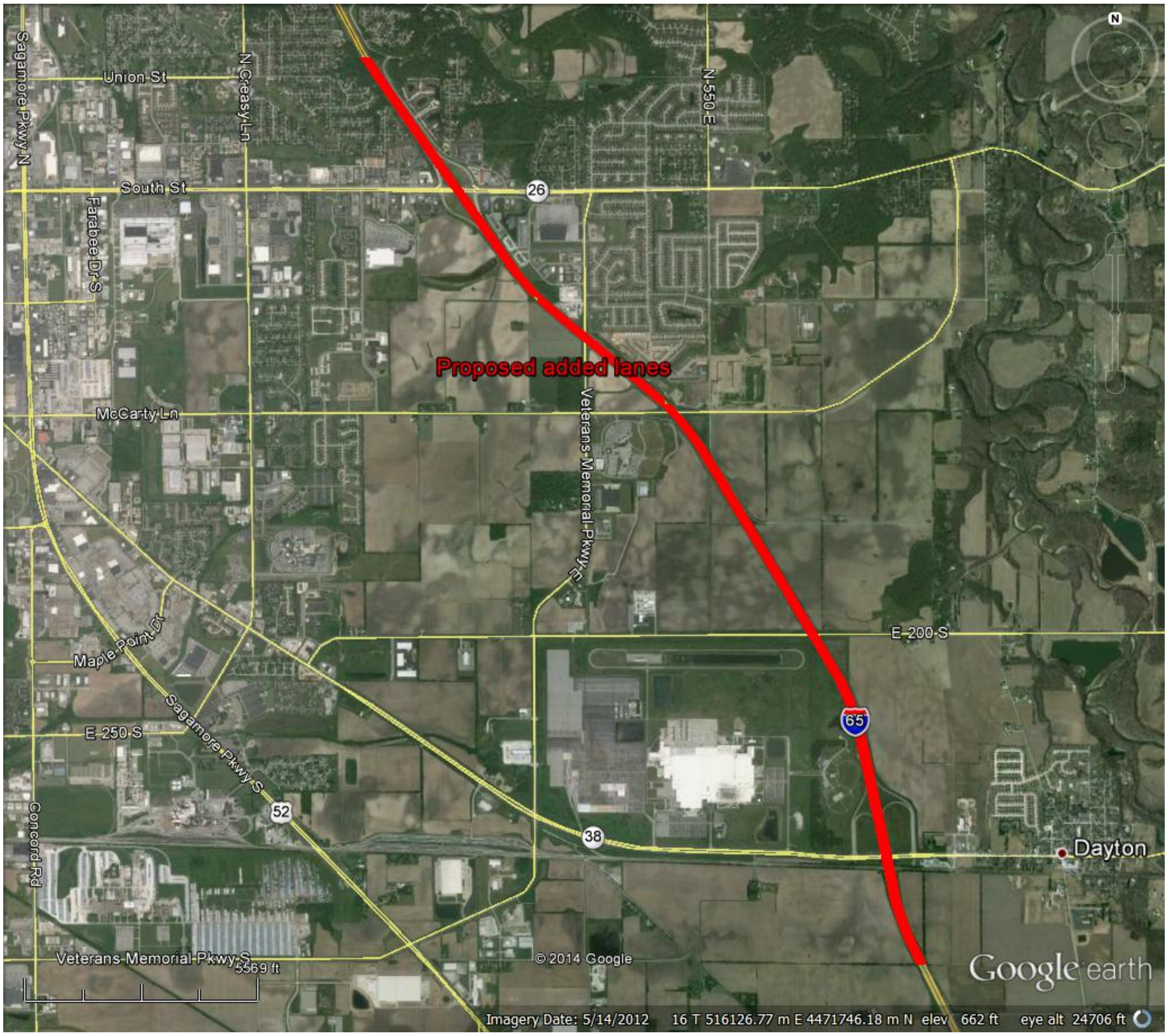
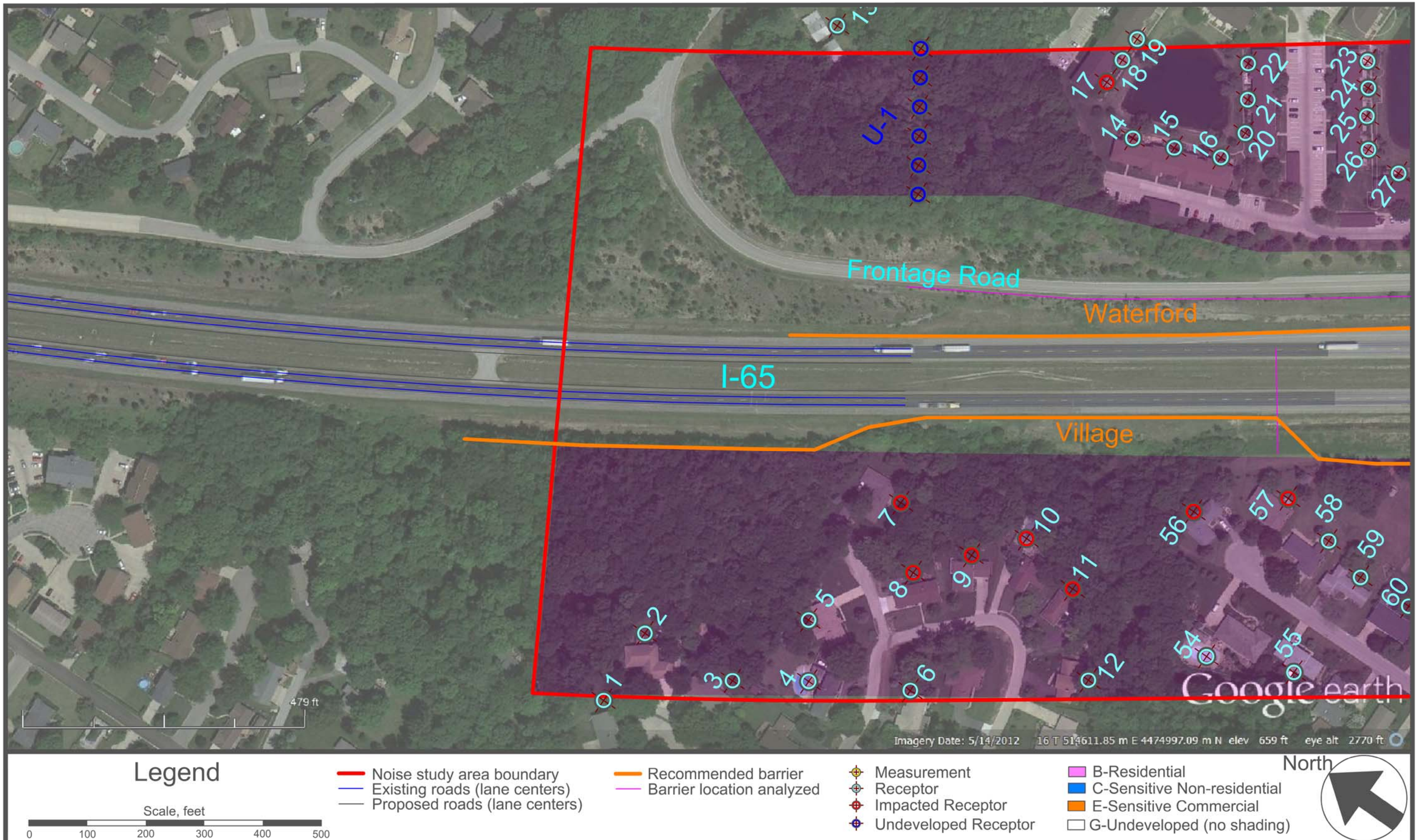


Figure 1. I-65 Project Location.

Figure 2. I-65 Noise Study Area. (13 Sheets)



Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 1 of 13.

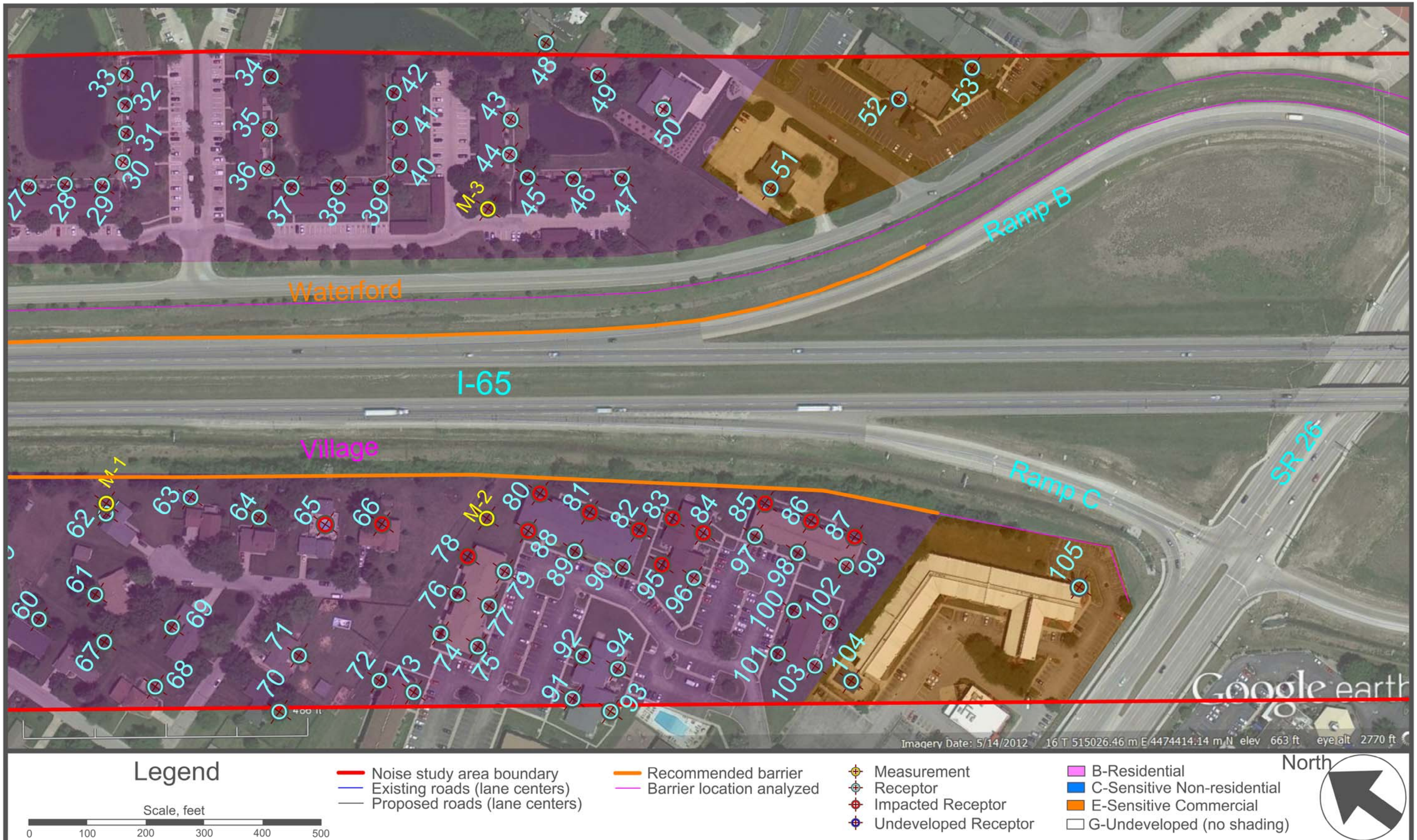


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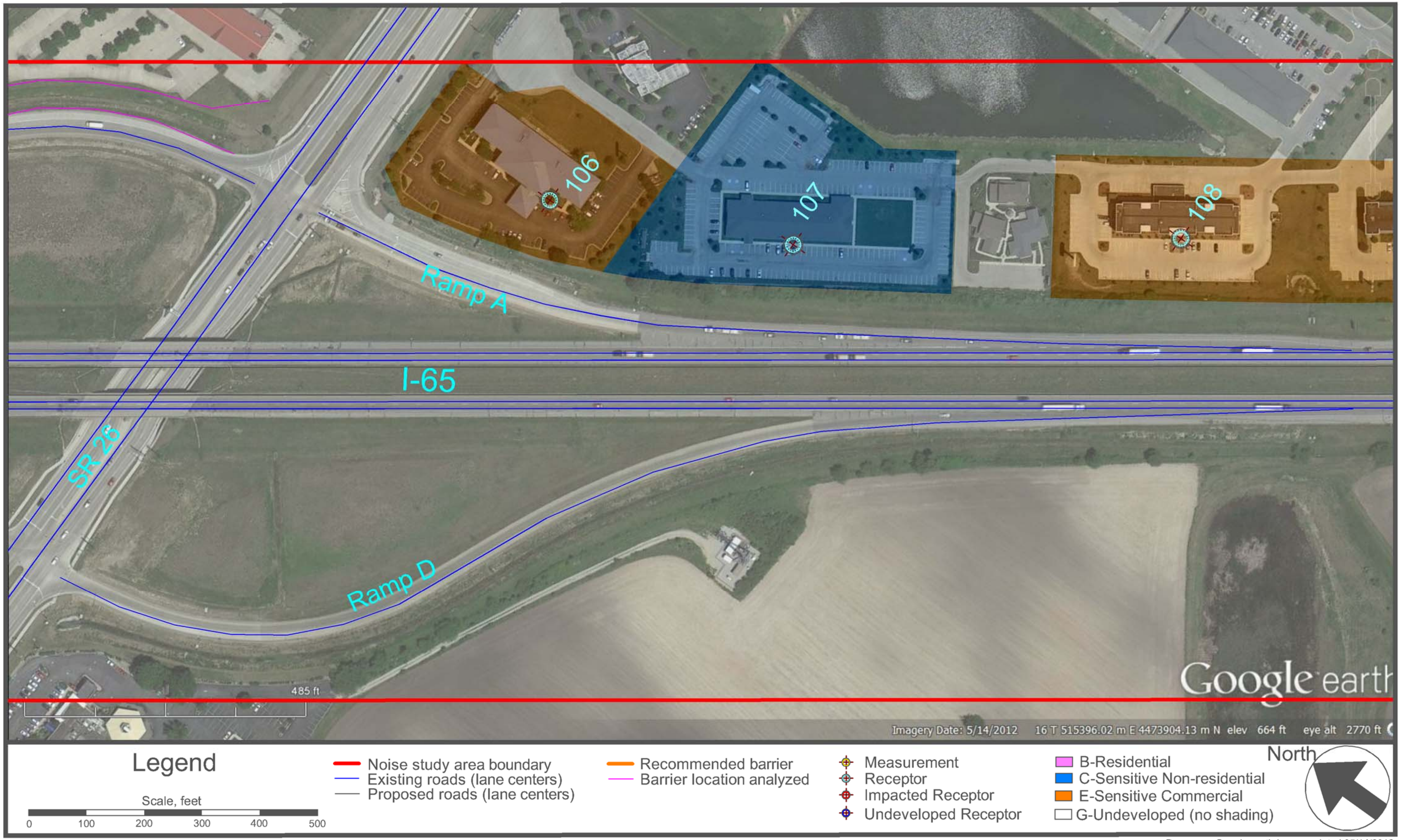
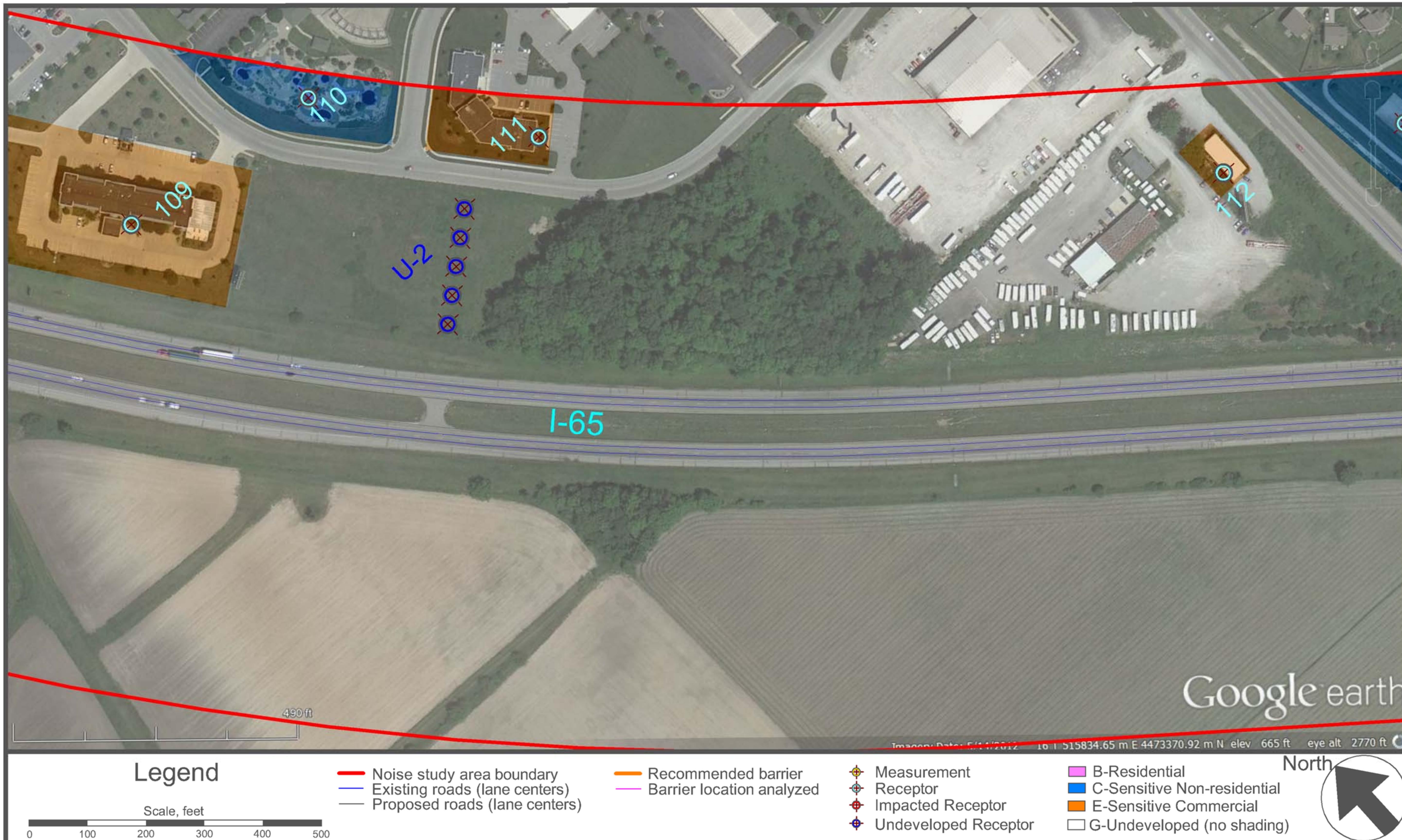
Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 2 of 13.



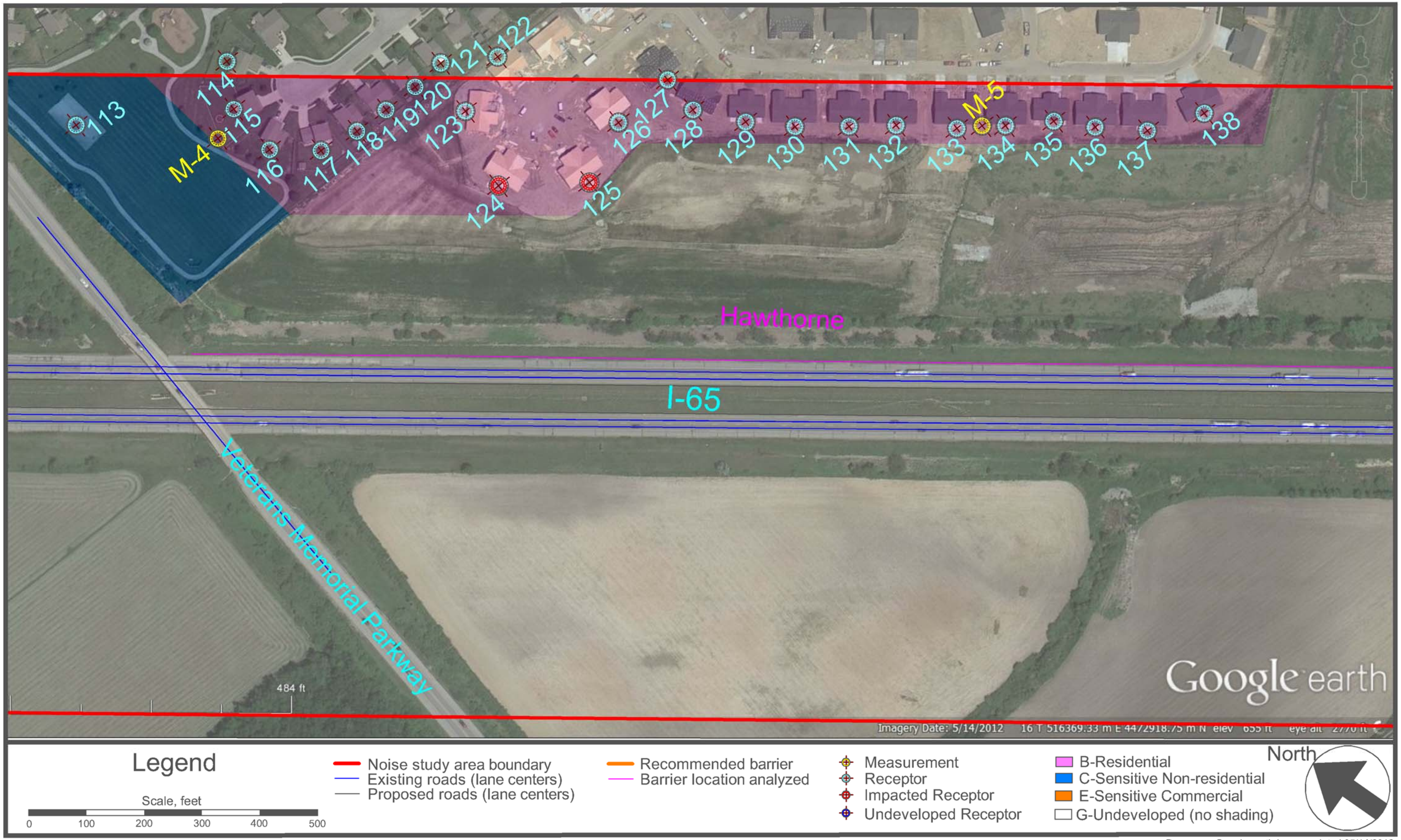
Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 3 of 13.



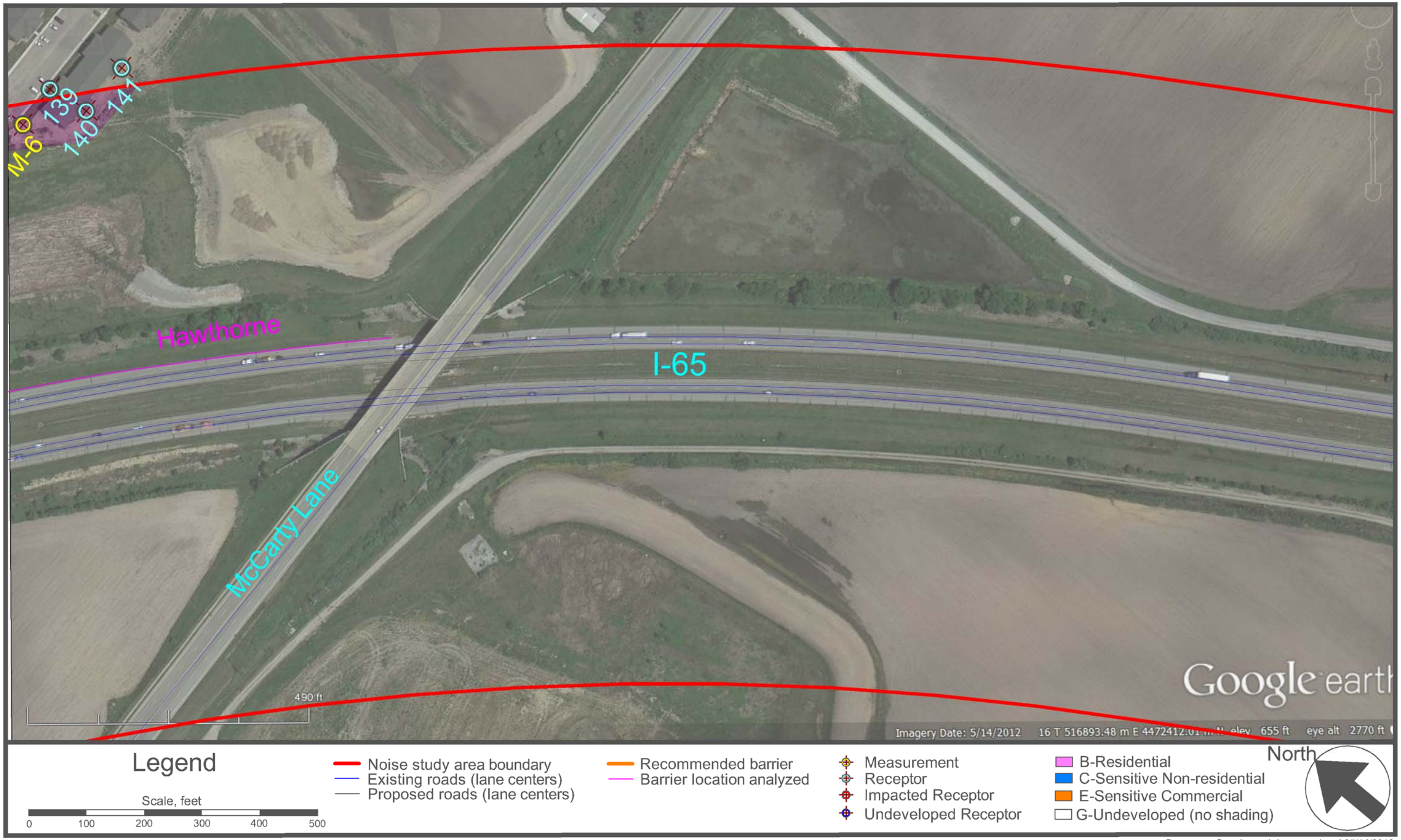
Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 4 of 13.



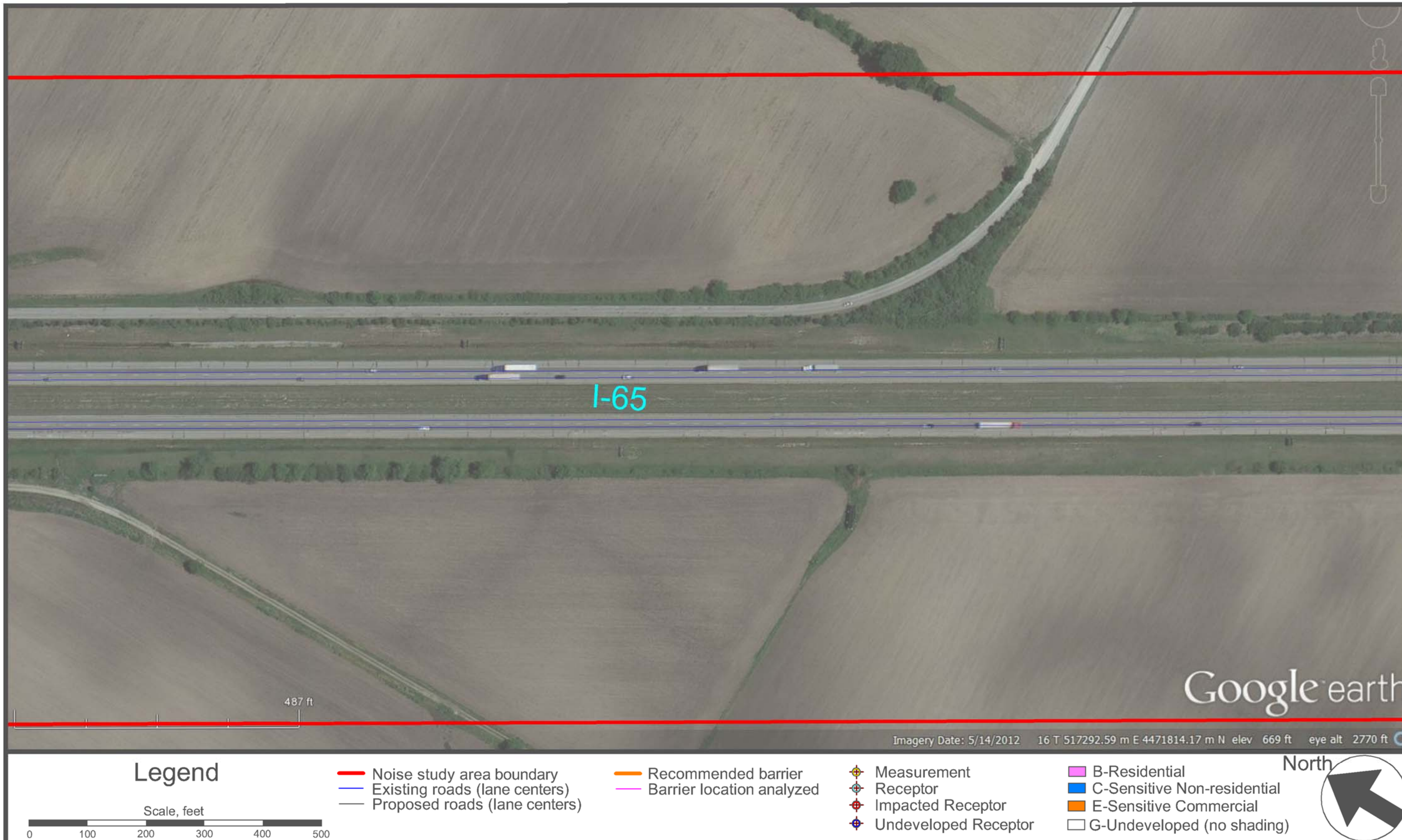
Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 5 of 13.



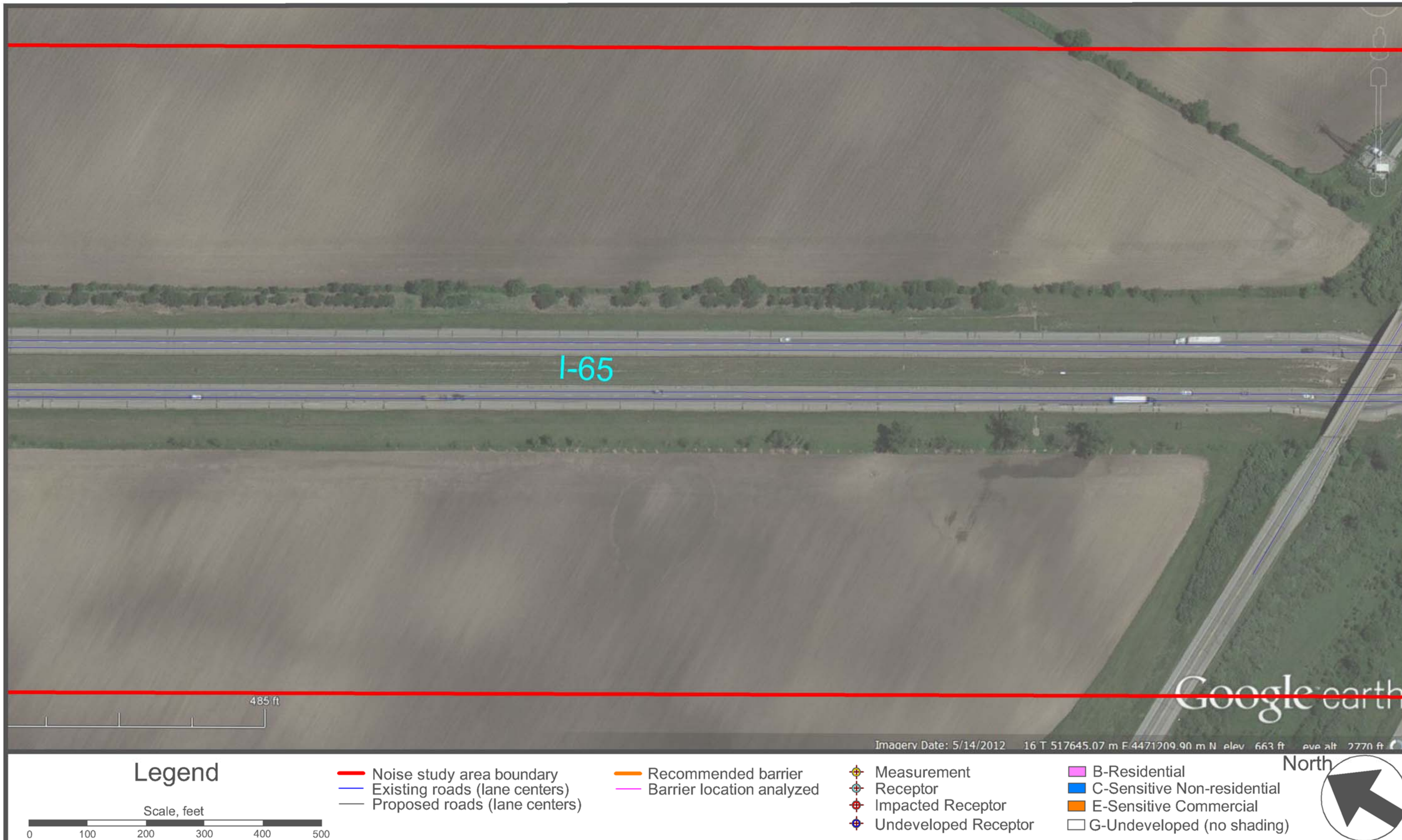
Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 6 of 13.



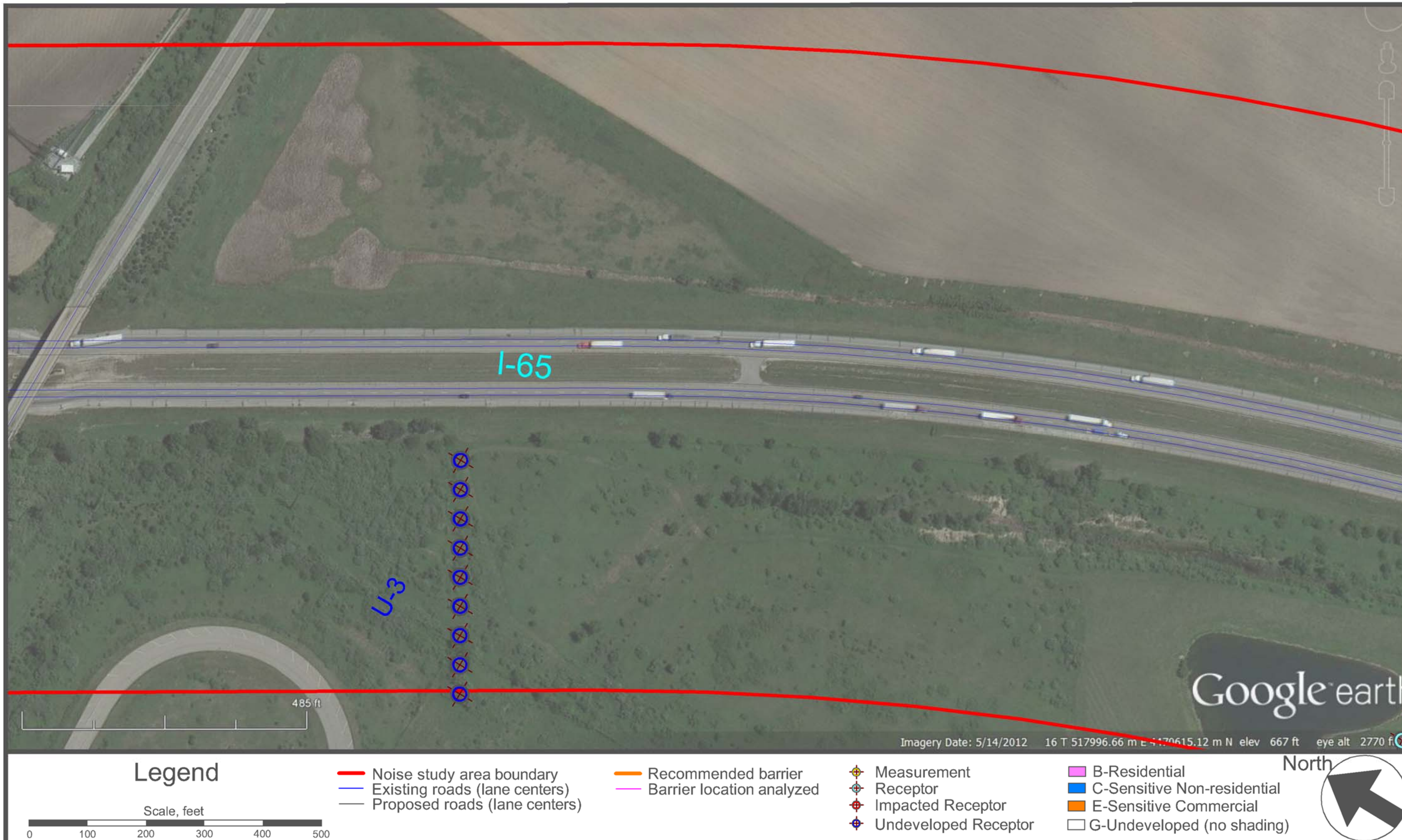
Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 7 of 13.



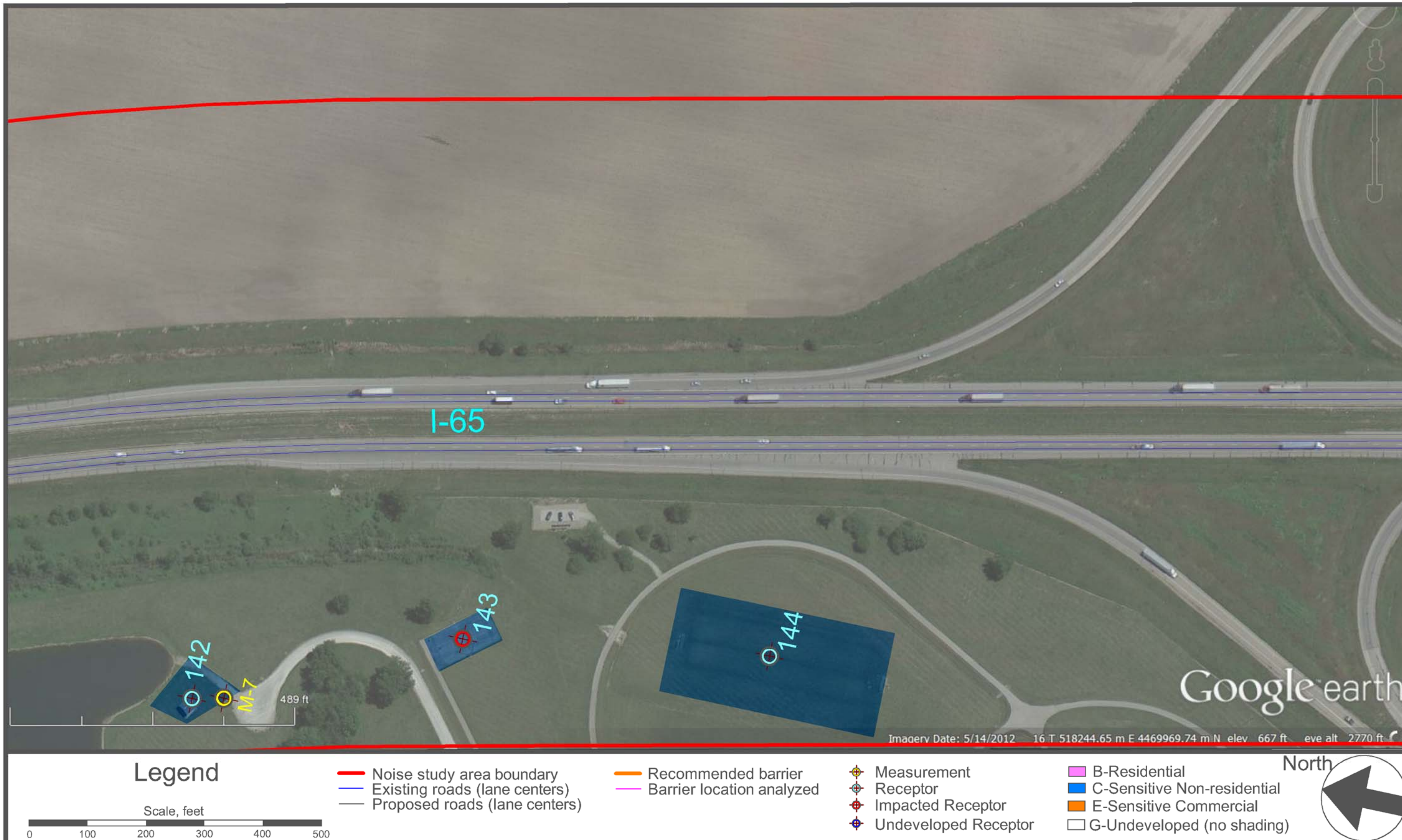
Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 8 of 13.



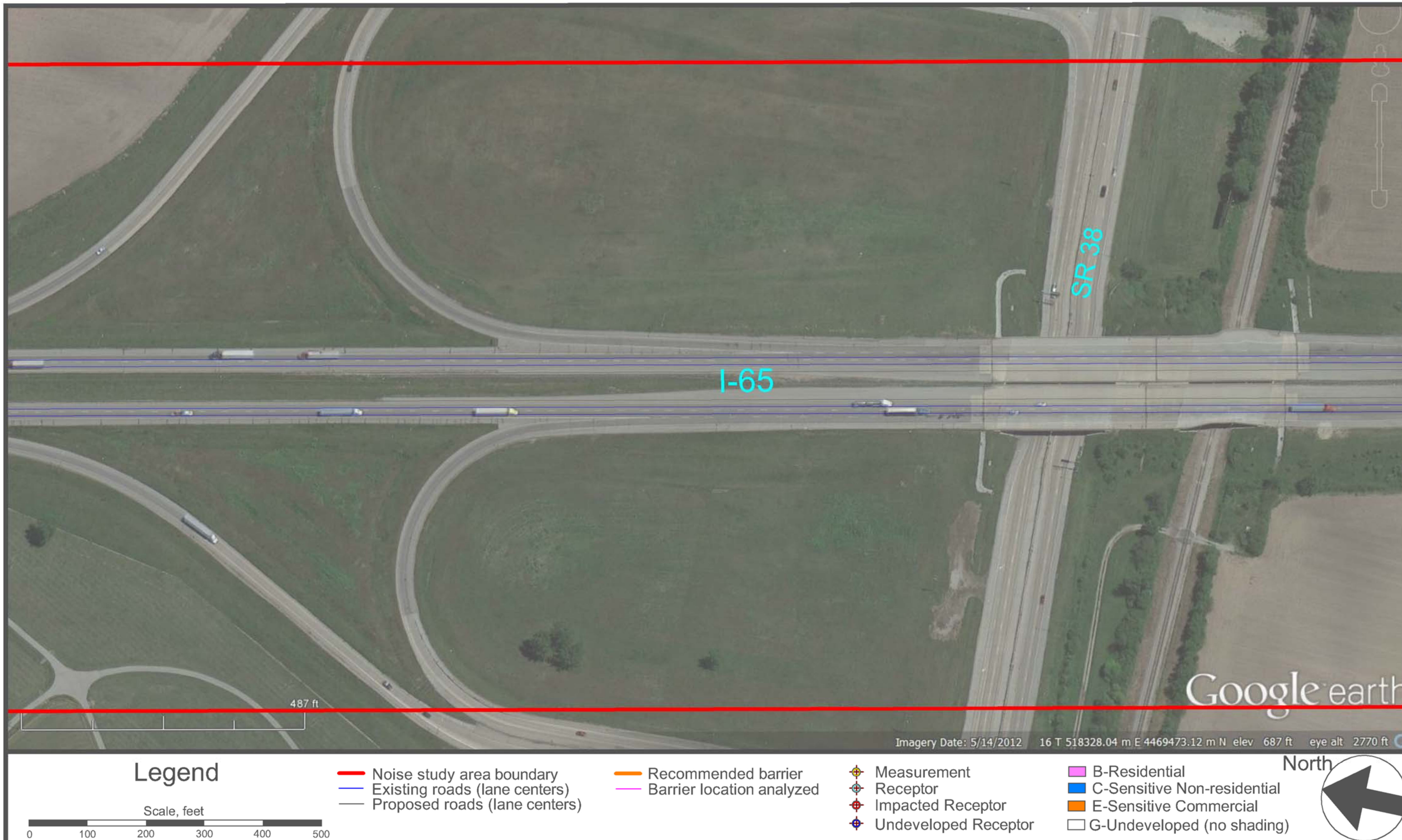
Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 9 of 13.



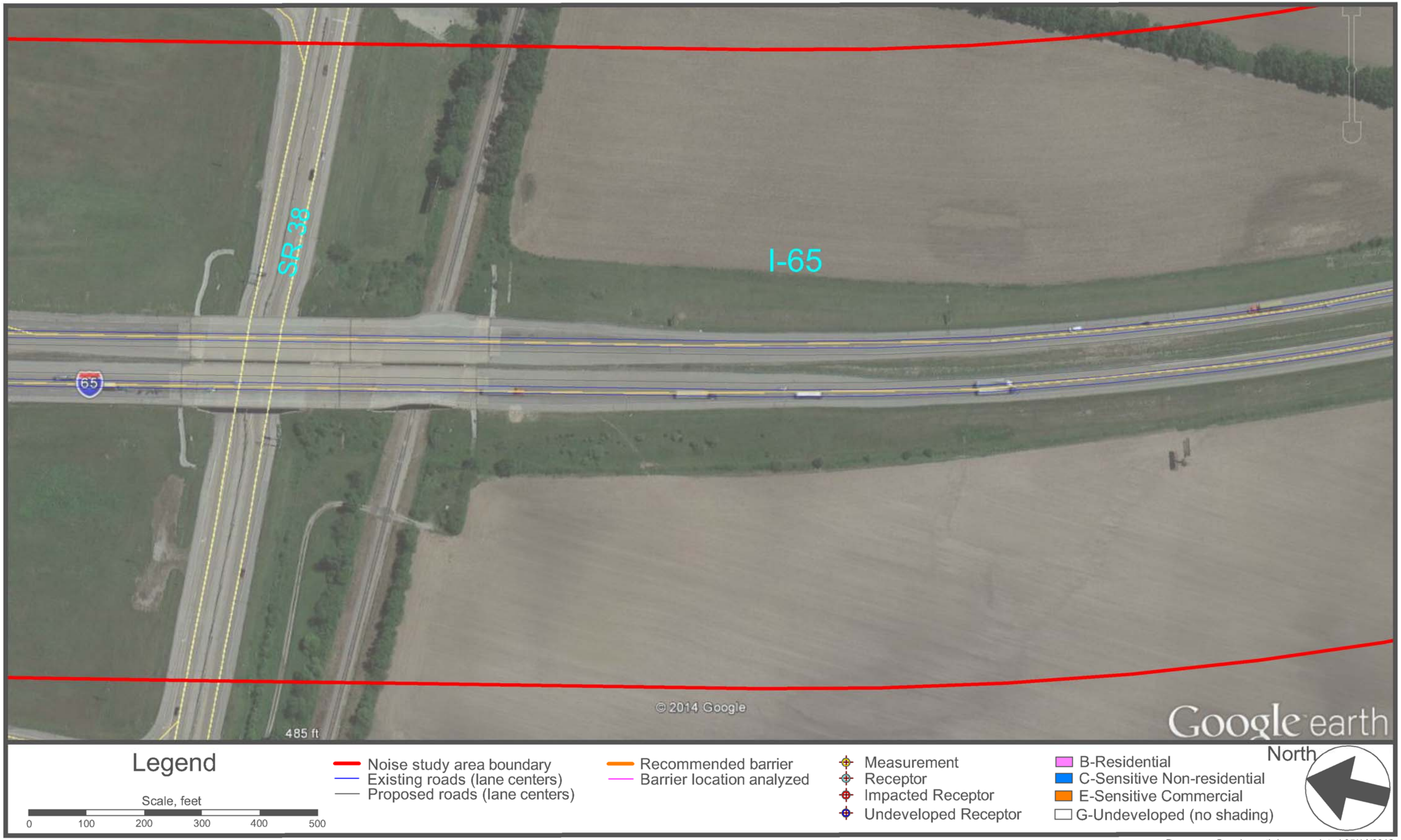
Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 10 of 13.



Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 11 of 13.



Basemap: Google earth imagery dated 05/14/2012

Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 12 of 13.

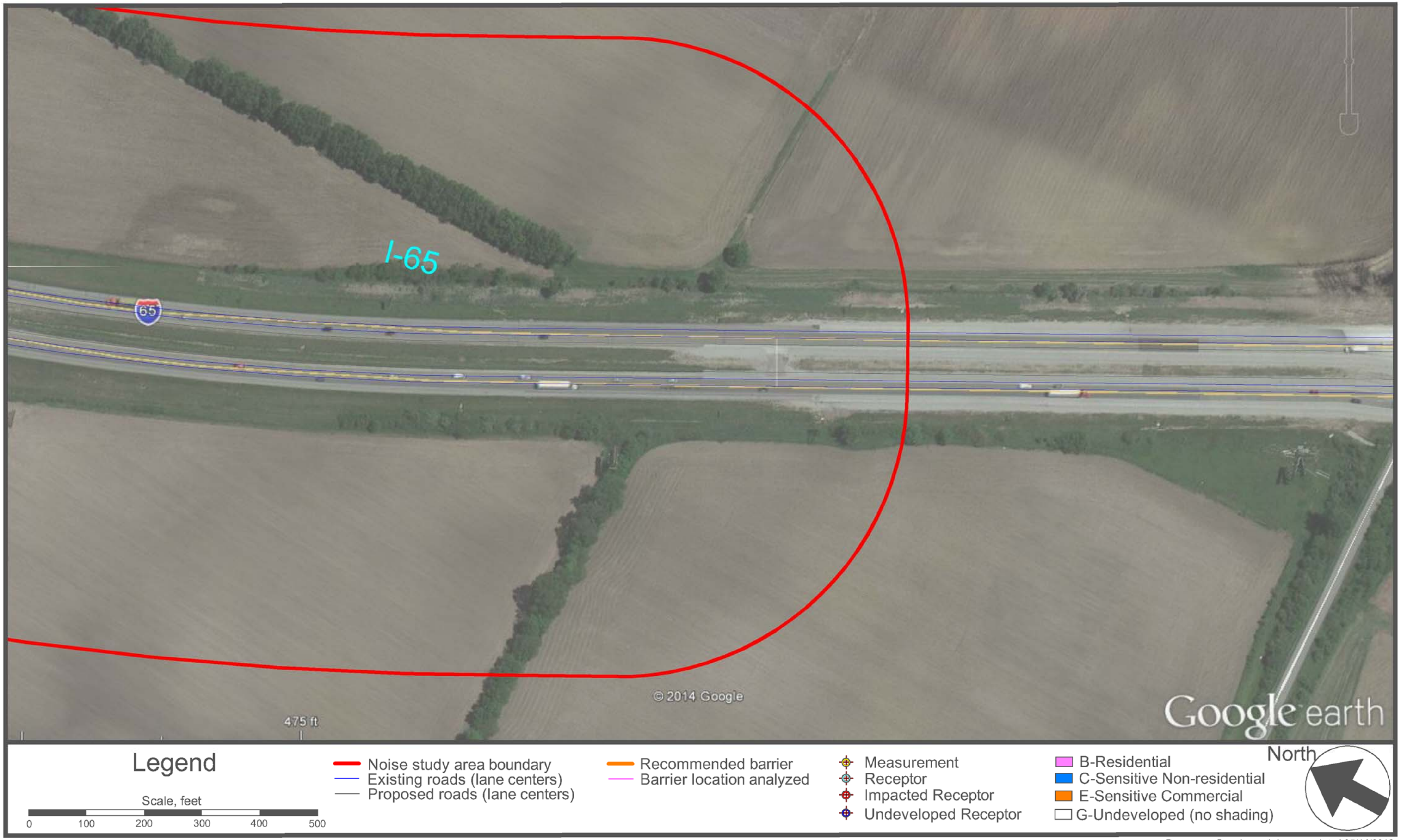


Figure 2. Noise Analysis Map for I-65 SR 38 to SR 26-Sheet 13 of 13.

TABLES

Table 1. Noise Abatement Criteria.

Activity Category	L_{eq}(h) dBA	Description of Activity Category
A	57 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (Exterior)	Residential
C	67 (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 (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 (Exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A–D or F.
F	--	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	--	Undeveloped lands that are not permitted

Table 2. Traffic Volume Estimates.

Road	TD[a]	DHV[b]		
		Existing 2015	No-Build 2035	Build 2035
I-65 N. of SR 26: NB	0.2717	2,009	2,659	2,659
I-65 N. of SR 26: SB	0.2717	2,120	2,805	2,805
I-65 Between SR 26 ramps: NB	0.2800	1,368	1,895	1,895
I-65 Between SR 26 ramps: SB	0.2800	1,342	1,942	1,942
I-65 N. of SR 38: NB	0.2717	1,691	2,293	2,293
I-65 N. of SR 38: SB	0.2717	1,810	2,454	2,454
I-65 Between SR 38 ramps: NB	0.3141	1,316	1,789	1,789
I-65 Between SR 38 ramps: SB	0.3141	915	1,411	1,411
SR 26/South St. W. of ramps: EB	0.0293	1,685	2,089	2,089
SR 26/South St. Between ramps: EB	0.0293	1,836	1,836	1,836
SR 26/South St. E. of ramps: EB	0.0293	1,336	1,657	1,657
SR 26/South St. W. of ramps: WB	0.0293	1,103	1,368	1,368
SR 26/South St. Between ramps: WB	0.0293	952	952	952
SR 26/South St. E. of ramps: WB	0.0293	963	1,194	1,194
Ramp C I65 SB to SR 26	0.0300	658	801	801
Ramp B SR 26 to I65 NB	0.0430	741	764	764
Ramp A I65 NB to SR 26	0.0300	323	398	398
Ramp D SR 26 to I65 SB	0.0140	356	373	373

NA = Not Applicable.

a TD = Fraction of vehicles in the design hour that are commercial trucks (INDOT 2014)

b DHV = number of vehicles in the design hour. DHV values were computed from annual average daily traffic (AADT) volumes using DHV percentages from INDOT (2014).

Table 3. Traffic Volumes for TNM Modeling.

Road	Existing 2015			No-Build 2035			Build 2035		
	Cars	Med. Trucks	Heavy Trucks	Cars	Med. Trucks	Heavy Trucks	Cars	Med. Trucks	Heavy Trucks
I-65 N. of SR 26: NB	1463	47	499	1936	62	660	1936	62	660
I-65 N. of SR 26: SB	1544	50	526	2043	66	696	2043	66	696
I-65 Between SR 26 ramps: NB	985	33	350	1364	46	485	1364	46	485
I-65 Between SR 26 ramps: SB	966	32	343	1398	47	497	1398	47	497
I-65 N. of SR 38: NB	1217	41	433	1651	55	587	1651	55	587
I-65 N. of SR 38: SB	1303	44	463	1767	59	628	1767	59	628
I-65 Between SR 38 ramps: NB	903	36	378	1227	48	514	1227	48	514
I-65 Between SR 38 ramps: SB	628	25	263	968	38	405	968	38	405
SR 26/South St. W. of ramps: EB	1636	4	45	2028	5	56	2028	5	56
SR 26/South St. Between ramps: EB	1783	5	49	1783	5	49	1783	5	49
SR 26/South St. E. of ramps: EB	1297	3	36	1608	4	44	1608	4	44
SR 26/South St. W. of ramps: WB	1071	3	29	1328	3	37	1328	3	37
SR 26/South St. Between ramps: WB	924	2	25	924	2	25	924	2	25
SR 26/South St. E. of ramps: WB	935	2	26	1159	3	32	1159	3	32
Ramp C I65 SB to SR 26	638	2	18	776	2	22	776	2	22
Ramp B SR 26 to I65 NB	709	3	29	731	3	30	731	3	30
Ramp A I65 NB to SR 26	313	1	9	386	1	11	386	1	11
Ramp D SR 26 to I65 SB	351	0	5	368	0	5	368	0	5

NOTE: Traffic volumes for the different vehicle types were calculated from the values in Table 2 as follows:
Cars = DHV x (1 - TD).
Heavy Trucks = DHV x TD x HeavyTruckFraction
Medium Trucks = DHV x TD (1 – HeavyTruckFraction)
HeavyTruckFraction = 0.87 based on traffic counts taken during site visit on February 27,2014.

Table 4. Existing Noise Measurement Sites.

Site ID	Location	Description
M-1	563 Jonathan Avenue	residence
M-2	4273 Sunburst	residence-Village Square Apartments
M-3	Waterford Court	residence
M-4	5002 Pioneer Drive	residence
M-5	5173 Pimlico Lane	residence
M-6	5531 Thornapple	residence-Hawthorne Properties
M-7	Subaru Recreation Area	picnic area

Table 5. Measurements of Existing Noise Levels.

Site ID	Date and Time	Noise Readings L_{eq} (dBA)	Calibrator Readings (dBA)		Drift Correction[a]	Corrected L_{eq} (dBA)
			Initial	Final		
M-1	5/7/14 10:00 AM	69.9	114.0	113.8	0.1	70.0
M-2	5/7/14 9:15 AM	67.7	114.1	113.9	0	67.7
M-3	5/7/14 8:30 AM	65.2	114.0	114.1	-0.05	65.2
M-4	5/6/14 5:30 PM	63.1	113.9	114.0	0.05	63.2
M-5	5/6/14 5:00 PM	65.6	113.9	113.9	0.1	65.7
M-6	5/6/14 4:20 PM	61.3	114.0	113.8	0.1	61.4
M-7	5/6/14 3:40 PM	70.8	114.0	113.9	0.05	70.9

a Drift Correction = Reference Level (114.0) - 1/2 (Final + Initial), per Section 3.1.4 of FWHA Manual, Measurement of Highway-Related Noise, Lee et al 1996.

Table 6. Model Validation Results.

Site ID	Measured Noise Levels ($L_{eq(1hr)}$, dBA)	Modeled Noise Levels Using TNM ($L_{eq(1hr)}$, dBA)	Difference (Meas. - TNM) (dBA)
M-1	70.0	71.9	-1.9
M-2	67.7	69.8	-2.1
M-3	65.2	67.7	-2.5
M-4	63.2	61.7	1.5
M-5	65.7	62.8	2.9
M-6	61.4	62.4	-1.0
M-7	70.9	63.8	**7.1**

Table 7. Noise Modeling Results.

Receptor	Description	Activity Category	Impact Criterion	Modeled Sound Levels (dBA)		
				Existing	No-Build	Build
1	residence	B	66.0	60.4	61.6	61.8
2	residence	B	66.0	63.1	64.3	64.4
3	residence	B	66.0	61.8	63.0	63.2
4	residence	B	66.0	62.0	63.2	63.4
5	residence	B	66.0	64.1	65.3	65.5
6	residence	B	66.0	61.9	63.1	63.5
7	residence	B	66.0	70.8	72.1	72.5
8	residence	B	66.0	66.6	67.9	68.4
9	residence	B	66.0	67.7	68.9	69.5
10	residence	B	66.0	68.9	70.1	70.7
11	residence	B	66.0	65.7	67.0	67.4
12	residence	B	66.0	62.2	63.4	63.8
13	residence	B	66.0	56.4	57.6	57.8
14	residence-Waterford Court Apartments	B	66.0	51.5	52.8	52.7
15	residence-Waterford Court Apartments	B	66.0	52.0	53.3	53.2
16	residence-Waterford Court Apartments	B	66.0	55.9	57.3	57.4
17	residence-Waterford Court Apartments	B	66.0	64.6	65.8	66.1
18	residence-Waterford Court Apartments	B	66.0	63.4	64.6	64.9
19	residence-Waterford Court Apartments	B	66.0	62.5	63.7	64.1
20	residence-Waterford Court Apartments	B	66.0	61.4	62.6	62.6
21	residence-Waterford Court Apartments	B	66.0	58.2	59.4	59.5
22	residence-Waterford Court Apartments	B	66.0	58.3	59.5	59.7
23	residence-Waterford Court Apartments	B	66.0	54.3	55.6	55.9
24	residence-Waterford Court Apartments	B	66.0	55.1	56.5	56.7
25	residence-Waterford Court Apartments	B	66.0	56.5	57.8	57.9
26	residence-Waterford Court Apartments	B	66.0	58.8	60.2	60.2
27	residence-Waterford Court Apartments	B	66.0	56.5	57.7	58.1
28	residence-Waterford Court Apartments	B	66.0	54.6	55.9	55.8
29	residence-Waterford Court Apartments	B	66.0	57.5	58.9	58.8
30	residence-Waterford Court Apartments	B	66.0	60.3	61.7	61.9
31	residence-Waterford Court Apartments	B	66.0	57.0	58.3	58.4
32	residence-Waterford Court Apartments	B	66.0	55.6	56.9	56.9
33	residence-Waterford Court Apartments	B	66.0	54.1	55.4	55.5
34	residence-Waterford Court Apartments	B	66.0	54.8	56.2	56.2
35	residence-Waterford Court Apartments	B	66.0	57.2	58.5	58.7
36	residence-Waterford Court Apartments	B	66.0	62.3	63.6	63.8
37	residence-Waterford Court Apartments	B	66.0	54.5	55.7	56.0
38	residence-Waterford Court Apartments	B	66.0	51.1	52.4	51.8
39	residence-Waterford Court Apartments	B	66.0	58.3	59.6	59.9
40	residence-Waterford Court Apartments	B	66.0	60.1	61.5	61.3
41	residence-Waterford Court Apartments	B	66.0	58.9	60.3	60.3
42	residence-Waterford Court Apartments	B	66.0	54.0	55.4	55.5
43	residence-Waterford Court Apartments	B	66.0	59.0	60.3	60.3
44	residence-Waterford Court Apartments	B	66.0	61.6	63.0	62.9
45	residence-Waterford Court Apartments	B	66.0	57.8	59.1	59.2

Table 7. Noise Modeling Results.

Receptor	Description	Activity Category	Impact Criterion	Modeled Sound Levels (dBA)		
				Existing	No-Build	Build
46	residence-Waterford Court Apartments	B	66.0	52.1	53.3	52.6
47	residence-Waterford Court Apartments	B	66.0	62.2	63.5	63.6
48	residence	B	66.0	58.2	59.5	60.0
49	residence	B	66.0	60.1	61.4	61.8
50	residence	B	66.0	62.6	64.0	64.3
51	office-Visitors Center	E	71.0	67.3	68.6	68.9
52	hotel-Townplace Suites	E	71.0	64.1	65.5	65.8
53	hotel-Baymont Inn	E	71.0	63.6	64.9	65.3
54	residence	B	66.0	62.7	64.0	64.3
55	residence	B	66.0	61.6	62.9	63.2
56	residence	B	66.0	70.1	71.3	71.6
57	residence	B	66.0	71.7	73.0	72.9
58	residence	B	66.0	43.2	44.5	44.9
59	residence	B	66.0	40.6	41.9	42.2
60	residence	B	66.0	38.9	40.2	40.3
61	residence	B	66.0	39.9	41.2	41.5
62	residence	B	66.0	45.9	47.3	47.0
63	residence	B	66.0	47.5	48.9	48.4
64	residence	B	66.0	45.7	47.1	46.7
65	residence	B	66.0	69.2	70.6	70.7
66	residence	B	66.0	69.7	71.1	71.0
67	residence	B	66.0	63.2	64.5	64.6
68	residence	B	66.0	61.2	62.5	62.5
69	residence	B	66.0	63.6	64.9	65.0
70	residence	B	66.0	60.3	61.6	61.7
71	residence	B	66.0	61.9	63.3	63.3
72	residence-Village Square Apartments	B	66.0	60.5	61.9	62.0
73	residence-Village Square Apartments	B	66.0	59.6	61.0	60.9
74	residence-Village Square Apartments	B	66.0	61.6	63.0	63.1
75	residence-Village Square Apartments	B	66.0	55.6	57.0	56.9
76	residence-Village Square Apartments	B	66.0	64.1	65.4	65.4
77	residence-Village Square Apartments	B	66.0	57.9	59.3	59.2
78	residence-Village Square Apartments	B	66.0	66.8	68.2	67.9
79	residence-Village Square Apartments	B	66.0	62.7	64.1	63.7
80	residence-Village Square Apartments	B	66.0	72.0	73.5	73.1
81	residence-Village Square Apartments	B	66.0	70.3	71.7	71.4
82	residence-Village Square Apartments	B	66.0	68.7	70.2	70.1
83	residence-Village Square Apartments	B	66.0	69.2	70.6	70.7
84	residence-Village Square Apartments	B	66.0	66.1	67.6	67.6
85	residence-Village Square Apartments	B	66.0	70.5	72.0	71.8
86	residence-Village Square Apartments	B	66.0	69.2	70.7	70.8
87	residence-Village Square Apartments	B	66.0	68.4	69.8	70.0
88	residence-Village Square Apartments	B	66.0	65.3	66.7	66.6
89	residence-Village Square Apartments	B	66.0	59.4	60.8	61.1
90	residence-Village Square Apartments	B	66.0	57.0	58.4	58.8

Table 7. Noise Modeling Results.

Receptor	Description	Activity Category	Impact Criterion	Modeled Sound Levels (dBA)		
				Existing	No-Build	Build
91	residence-Village Square Apartments	B	66.0	56.2	57.6	57.5
92	residence-Village Square Apartments	B	66.0	57.8	59.2	59.1
93	residence-Village Square Apartments	B	66.0	56.6	58.0	58.0
94	residence-Village Square Apartments	B	66.0	57.9	59.3	59.0
95	residence-Village Square Apartments	B	66.0	65.6	67.0	66.8
96	residence-Village Square Apartments	B	66.0	61.7	63.1	62.9
97	residence-Village Square Apartments	B	66.0	64.2	65.6	65.4
98	residence-Village Square Apartments	B	66.0	58.3	59.7	59.3
99	residence-Village Square Apartments	B	66.0	60.9	62.3	62.3
100	residence-Village Square Apartments	B	66.0	60.1	61.5	61.5
101	residence-Village Square Apartments	B	66.0	57.4	58.8	58.8
102	residence-Village Square Apartments	B	66.0	59.8	61.3	61.1
103	residence-Village Square Apartments	B	66.0	57.5	58.9	58.8
104	hotel-Clarion Inn	E	71.0	53.8	54.9	54.8
105	hotel-Clarion Inn pool	E	71.0	67.3	68.6	68.4
106	hotel-Comfort Inn	E	71.0	66.5	67.9	67.9
107	school-Harrison College	D	51.0	43.4	44.8	45.3
108	hotel-Candlewood Suites	E	71.0	68.4	69.8	70.5
109	hotel-La Quinta Inn	E	71.0	68.6	69.9	70.7
110	recreation-Precision Putt-Putt	C	66.0	61.7	63.0	63.7
111	office-BL Anderson	E	71.0	62.7	64.0	64.9
112	office-veterinarian	E	71.0	63.9	65.2	65.8
113	recreation area-basketball court	C	66.0	61.4	62.7	63.2
114	residence	B	66.0	60.2	61.5	62.3
115	residence	B	66.0	61.4	62.7	63.3
116	residence	B	66.0	62.8	64.1	64.7
117	residence	B	66.0	63.2	64.5	65.0
118	residence	B	66.0	62.6	64.0	64.5
119	residence	B	66.0	62.0	63.3	64.0
120	residence	B	66.0	61.4	62.7	63.6
121	residence	B	66.0	60.8	62.1	63.0
122	residence-duplex	B	66.0	60.7	62.0	62.9
123	residence-duplex	B	66.0	62.2	63.5	64.2
124	residence-duplex	B	66.0	64.8	66.1	66.5
125	residence-duplex	B	66.0	64.7	66.1	66.5
126	residence-duplex	B	66.0	62.6	63.9	64.6
127	residence-duplex	B	66.0	61.3	62.6	63.6
128	residence-duplex	B	66.0	62.1	63.5	64.3
129	residence-duplex	B	66.0	62.5	63.8	64.6
130	residence-duplex	B	66.0	62.6	63.9	64.7
131	residence-duplex	B	66.0	62.5	63.9	64.7
132	residence-duplex	B	66.0	62.5	63.8	64.7
133	residence-duplex	B	66.0	62.5	63.8	64.7
134	residence-duplex	B	66.0	62.8	64.1	64.8
135	residence-duplex	B	66.0	62.4	63.7	64.6

Table 7. Noise Modeling Results.

Receptor	Description	Activity Category	Impact Criterion	Modeled Sound Levels (dBA)		
				Existing	No-Build	Build
136	residence-duplex	B	66.0	62.4	63.8	64.7
137	residence-duplex	B	66.0	62.9	64.2	64.9
138	residence-duplex	B	66.0	62.6	63.9	64.5
139	residence-Hawthorne Gardens	B	66.0	61.8	63.1	63.4
140	residence-Hawthorne Gardens	B	66.0	62.9	64.2	64.3
141	residence-Hawthorne Gardens	B	66.0	61.2	62.5	62.9
142	recreation area-Subaru	C	66.0	63.6	64.9	65.5
143	recreation area-Subaru	C	66.0	64.2	65.6	66.2
144	recreation area-Subaru	C	66.0	63.4	64.9	65.6
14a	residence-Waterford Court Apartments-2nd floor	B	66.0	55.7	57.0	57.0
15a	residence-Waterford Court Apartments-2nd floor	B	66.0	57.0	58.3	58.3
16a	residence-Waterford Court Apartments-2nd floor	B	66.0	61.2	62.6	62.3
17a	residence-Waterford Court Apartments-2nd floor	B	66.0	65.8	67.1	67.2
18a	residence-Waterford Court Apartments-2nd floor	B	66.0	64.6	65.9	66.0
19a	residence-Waterford Court Apartments-2nd floor	B	66.0	63.7	65.0	65.2
20a	residence-Waterford Court Apartments-2nd floor	B	66.0	64.5	65.7	65.9
21a	residence-Waterford Court Apartments-2nd floor	B	66.0	61.0	62.2	62.4
22a	residence-Waterford Court Apartments-2nd floor	B	66.0	60.4	61.6	61.7
23a	residence-Waterford Court Apartments-2nd floor	B	66.0	57.9	59.3	59.2
24a	residence-Waterford Court Apartments-2nd floor	B	66.0	58.9	60.3	60.1
25a	residence-Waterford Court Apartments-2nd floor	B	66.0	60.2	61.5	61.4
26a	residence-Waterford Court Apartments-2nd floor	B	66.0	63.1	64.5	64.2
27a	residence-Waterford Court Apartments-2nd floor	B	66.0	60.2	61.5	61.7
28a	residence-Waterford Court Apartments-2nd floor	B	66.0	57.8	59.1	58.9
29a	residence-Waterford Court Apartments-2nd floor	B	66.0	60.5	61.8	61.7
30a	residence-Waterford Court Apartments-2nd floor	B	66.0	63.6	65.0	64.7
31a	residence-Waterford Court Apartments-2nd floor	B	66.0	60.3	61.6	61.7
32a	residence-Waterford Court Apartments-2nd floor	B	66.0	59.0	60.3	60.2
33a	residence-Waterford Court Apartments-2nd floor	B	66.0	57.5	58.8	58.8
34a	residence-Waterford Court Apartments-2nd floor	B	66.0	57.8	59.2	59.1
35a	residence-Waterford Court Apartments-2nd floor	B	66.0	60.5	61.9	61.8
36a	residence-Waterford Court Apartments-2nd floor	B	66.0	65.2	66.6	66.2
37a	residence-Waterford Court Apartments-2nd floor	B	66.0	58.7	59.9	60.1
38a	residence-Waterford Court Apartments-2nd floor	B	66.0	54.9	56.2	55.8
39a	residence-Waterford Court Apartments-2nd floor	B	66.0	64.0	65.4	65.3
40a	residence-Waterford Court Apartments-2nd floor	B	66.0	65.6	66.9	66.8
41a	residence-Waterford Court Apartments-2nd floor	B	66.0	63.2	64.6	64.5
42a	residence-Waterford Court Apartments-2nd floor	B	66.0	57.8	59.1	59.0
43a	residence-Waterford Court Apartments-2nd floor	B	66.0	61.6	63.0	62.6
44a	residence-Waterford Court Apartments-2nd floor	B	66.0	64.3	65.6	65.2
45a	residence-Waterford Court Apartments-2nd floor	B	66.0	62.2	63.5	63.4
46a	residence-Waterford Court Apartments-2nd floor	B	66.0	55.7	56.9	56.6
47a	residence-Waterford Court Apartments-2nd floor	B	66.0	64.5	65.9	65.8
72a	residence-Village Square Apartments-2nd floor	B	66.0	65.2	66.5	66.5
73a	residence-Village Square Apartments-2nd floor	B	66.0	64.3	65.7	65.6

Table 7. Noise Modeling Results.

Receptor	Description	Activity Category	Impact Criterion	Modeled Sound Levels (dBA)		
				Existing	No-Build	Build
74a	residence-Village Square Apartments-2nd floor	B	66.0	66.5	67.9	67.5
75a	residence-Village Square Apartments-2nd floor	B	66.0	58.2	59.6	59.4
76a	residence-Village Square Apartments-2nd floor	B	66.0	67.9	69.3	69.0
77a	residence-Village Square Apartments-2nd floor	B	66.0	60.7	62.1	61.9
78a	residence-Village Square Apartments-2nd floor	B	66.0	69.6	71.0	70.8
79a	residence-Village Square Apartments-2nd floor	B	66.0	65.3	66.7	66.2
80a	residence-Village Square Apartments-2nd floor	B	66.0	74.0	75.5	75.1
81a	residence-Village Square Apartments-2nd floor	B	66.0	72.5	73.9	73.7
82a	residence-Village Square Apartments-2nd floor	B	66.0	71.1	72.6	72.4
83a	residence-Village Square Apartments-2nd floor	B	66.0	71.9	73.3	73.1
84a	residence-Village Square Apartments-2nd floor	B	66.0	68.7	70.2	70.0
85a	residence-Village Square Apartments-2nd floor	B	66.0	73.1	74.5	74.2
86a	residence-Village Square Apartments-2nd floor	B	66.0	72.0	73.4	73.2
87a	residence-Village Square Apartments-2nd floor	B	66.0	71.0	72.4	72.2
88a	residence-Village Square Apartments-2nd floor	B	66.0	68.1	69.5	69.1
89a	residence-Village Square Apartments-2nd floor	B	66.0	63.5	64.9	64.6
90a	residence-Village Square Apartments-2nd floor	B	66.0	61.5	62.9	62.7
91a	residence-Village Square Apartments-2nd floor	B	66.0	59.8	61.1	61.0
92a	residence-Village Square Apartments-2nd floor	B	66.0	61.2	62.6	62.3
93a	residence-Village Square Apartments-2nd floor	B	66.0	59.3	60.6	60.5
94a	residence-Village Square Apartments-2nd floor	B	66.0	60.5	61.9	61.7
95a	residence-Village Square Apartments-2nd floor	B	66.0	68.3	69.7	69.7
96a	residence-Village Square Apartments-2nd floor	B	66.0	64.3	65.7	65.6
97a	residence-Village Square Apartments-2nd floor	B	66.0	66.8	68.2	68.2
98a	residence-Village Square Apartments-2nd floor	B	66.0	60.9	62.3	62.2
99a	residence-Village Square Apartments-2nd floor	B	66.0	63.2	64.6	64.4
100a	residence-Village Square Apartments-2nd floor	B	66.0	62.5	64.0	63.9
101a	residence-Village Square Apartments-2nd floor	B	66.0	60.4	61.8	61.8
102a	residence-Village Square Apartments-2nd floor	B	66.0	61.4	62.8	62.9
103a	residence-Village Square Apartments-2nd floor	B	66.0	60.2	61.5	61.4
139a	residence-Hawthorne Gardens-2nd floor	B	66.0	64.3	65.6	66.4
140a	residence-Hawthorne Gardens-2nd floor	B	66.0	64.9	66.3	67.0
141a	residence-Hawthorne Gardens-2nd floor	B	66.0	63.7	65.0	65.8

Color Definitions:

Pink	FHWA impact: Build noise level exceeds criterion or substantially exceeds Existing level.
Yellow	Predicted noise level approaches or exceeds NAC.

Table 8. Summary of Noise Barriers.

Barrier Name	Acoustically Feasible?[a]	Average Height (ft)	Length (ft)	Area (sq. ft)	Total Barrier Cost	No. of Benefited Receptors[b]	Cost per Benefited Receptor[c]
Village	Yes	12.8	3,200	41,000	$1,230,000	45	$27,300
Waterford	Yes	18.2	2,600	47,200	$1,416,000	96	**$14,750**
Hawthorne	Yes	17.4	2,600	45,100	$1,353,000	48	$28,200

a A barrier is considered acoustically feasible if it can achieve at least 5 dBA noise reduction at a majority of impacted receivers.

b The number of benefited units includes all units receiving at least 5 dBA noise reduction whether impacted or not.

c A blue background indicates that the barrier cost is considered reasonable. A cost reasonable barrier does not exceed $30,000 per benefited receptor in areas where most of the receptors were present before the highway was constructed, such as the Village Apartments, and $25,000 per benefited receptor in other areas.

Table 9. Noise Reduction Feasible and Reasonable Barrier Designs.

Modeled Receptor ID	**No. of Receptors Represented**	**Modeled Noise Levels (dBA)**		**Noise Reduction (dBA)**	**No. of Benefited Receptors**
		No Barrier	**With Barrier**		
Village Barrier—ROW					
1	1	61.8	58.1	3.7	0
2	1	64.4	59.8	**4.6**	**1**
3	1	63.2	58.5	**4.7**	**1**
4	1	63.4	58.5	**4.9**	**1**
5	1	65.5	60.0	**5.5**	**1**
6	1	63.5	58.6	**4.9**	**1**
7	1	**72.5**	63.4	**9.1**	**1**
8	1	**68.4**	61.7	**6.7**	**1**
9	1	**69.5**	62.5	**7.0**	**1**
10	1	**70.7**	63.4	**7.3**	**1**
11	1	**67.4**	61.1	**6.3**	**1**
12	1	63.8	58.7	**5.1**	**1**
54	1	64.3	59.4	**4.9**	**1**
55	1	63.2	58.7	**4.5**	**1**
56	1	**71.6**	63.7	**7.9**	**1**
57	1	**72.9**	65.9	**7.0**	**1**
58	1	**69.9**	63.6	**6.3**	**1**
59	1	**67.2**	62.2	**5.0**	**1**
60	1	65.3	60.8	**4.5**	**1**
61	1	**66.5**	61.7	**4.8**	**1**
62	1	**72.0**	65.0	**7.0**	**1**
63	1	**73.4**	65.6	**7.8**	**1**
64	1	**71.7**	64.7	**7.0**	**1**

Table 9. Noise Reduction Feasible and Reasonable Barrier Designs.

Modeled Receptor ID	No. of Receptors Represented	Modeled Noise Levels (dBA)		Noise Reduction (dBA)	No. of Benefited Receptors
		No Barrier	With Barrier		
65	1	**70.7**	63.2	**7.5**	**1**
66	1	**71.0**	64.0	**7.0**	**1**
67	1	64.6	60.5	4.1	0
68	1	62.5	58.7	3.8	0
69	1	65.0	60.6	4.4	0
70	1	61.7	58.6	3.1	0
71	1	63.3	59.1	4.2	0
72	1	62.0	57.8	4.2	0
73	1	60.9	57.4	3.5	0
74	1	63.1	58.5	**4.6**	**1**
75	1	56.9	54.8	2.1	0
76	2	65.4	60.2	**5.2**	**2**
77	2	59.2	55.9	3.3	0
78	1	**67.9**	62.0	**5.9**	**1**
79	1	63.7	58.4	**5.3**	**1**
80	1	**73.1**	63.9	**9.2**	**1**
81	2	**71.4**	64.0	**7.4**	**2**
82	1	**70.1**	62.9	**7.2**	**1**
83	2	**70.7**	62.8	**7.9**	**2**
84	2	**67.6**	60.6	**7.0**	**2**
85	1	**71.8**	62.2	**9.6**	**1**
86	2	**70.8**	63.3	**7.5**	**2**
87	1	**70.0**	64.3	**5.7**	**1**
88	1	**66.6**	60.4	**6.2**	**1**
89	2	61.1	57.7	3.4	0
90	1	58.8	56.5	2.3	0
91	2	57.5	54.8	2.7	0
92	2	59.1	56.5	2.6	0
93	2	58.0	55.8	2.2	0
94	2	59.0	56.7	2.3	0
95	2	**66.8**	60.7	**6.1**	**2**
96	2	62.9	58.5	4.4	0
97	1	65.4	58.7	**6.7**	**1**
98	2	59.3	56.2	3.1	0
99	1	62.3	61.5	0.8	0

Table 9. Noise Reduction Feasible and Reasonable Barrier Designs.

Modeled Receptor ID	No. of Receptors Represented	Modeled Noise Levels (dBA)		Noise Reduction (dBA)	No. of Benefited Receptors
		No Barrier	With Barrier		
100	2	61.5	59.9	1.6	0
101	2	58.8	55.9	2.9	0
102	2	61.1	60.8	0.3	0
103	2	58.8	58.8	0.0	0
104	1	54.8	54.7	0.1	0
105	1	**68.4**	68.3	0.1	0
72a	1	**66.5**	63.3	3.2	0
73a	1	65.6	62.2	3.4	0
74a	1	**67.5**	64.1	3.4	0
75a	1	59.4	57.7	1.7	0
76a	2	**69.0**	65.6	3.4	0
77a	2	61.9	59.5	2.4	0
78a	1	**70.8**	67.7	3.1	0
79a	1	**66.2**	63.4	2.8	0
80a	1	**75.1**	75.1	0.0	0
81a	2	**73.7**	73.0	0.7	0
82a	1	**72.4**	70.3	2.1	0
83a	2	**73.1**	71.3	1.8	0
84a	2	**70.0**	67.6	2.4	0
85a	1	**74.2**	73.6	0.6	0
86a	2	**73.2**	72.4	0.8	0
87a	1	**72.2**	71.5	0.7	0
88a	1	**69.1**	66.8	2.3	0
89a	2	64.6	62.5	2.1	0
90a	1	62.7	61.0	1.7	0
91a	2	61.0	58.6	2.4	0
92a	2	62.3	60.1	2.2	0
93a	2	60.5	59.4	1.1	0
94a	2	61.7	60.3	1.4	0
95a	2	**69.7**	66.6	3.1	0
96a	2	65.6	63.1	2.5	0
97a	1	**68.2**	65.0	3.2	0
98a	2	62.2	60.6	1.6	0
99a	1	64.4	64.0	0.4	0
100a	2	63.9	62.6	1.3	0

Table 9. Noise Reduction Feasible and Reasonable Barrier Designs.

Modeled Receptor ID	No. of Receptors Represented	Modeled Noise Levels (dBA)		Noise Reduction (dBA)	No. of Benefited Receptors
		No Barrier	With Barrier		
101a	2	61.8	59.3	2.5	0
102a	2	62.9	62.9	0.0	0
103a	2	61.4	61.4	0.0	0
Waterford Barrier—ROW					
13	1	57.8	51.6	**6.2**	**1**
14	2	52.7	49.2	3.5	0
15	4	53.2	49.7	3.5	0
16	2	57.4	52.2	**5.2**	**2**
17	2	**66.1**	61.1	**5.0**	**2**
18	2	64.9	60.5	4.4	0
19	2	64.1	59.8	4.3	0
20	2	62.6	54.4	**8.2**	**2**
21	2	59.5	53.6	**5.9**	**2**
22	2	59.7	57.5	2.2	0
23	2	55.9	50.1	**5.8**	**2**
24	2	56.7	50.7	**6.0**	**2**
25	2	57.9	51.6	**6.3**	**2**
26	2	60.2	53.3	**6.9**	**2**
27	2	58.1	54.5	3.6	0
28	2	55.8	52.9	2.9	0
29	2	58.8	53.6	**5.2**	**2**
30	2	61.9	54.7	**7.2**	**2**
31	2	58.4	51.9	**6.5**	**2**
32	2	56.9	50.9	**6.0**	**2**
33	2	55.5	49.6	**5.9**	**2**
34	2	56.2	50.9	**5.3**	**2**
35	4	58.7	52.4	**6.3**	**4**
36	2	63.8	55.4	**8.4**	**2**
37	2	56.0	52.2	3.8	0
38	2	51.8	48.6	3.2	0
39	2	59.9	54.5	**5.4**	**2**
40	2	61.3	56.9	4.4	0
41	2	60.3	54.1	**6.2**	**2**
42	2	55.5	49.8	**5.7**	**2**
43	2	60.3	56.3	4.0	0

Table 9. Noise Reduction Feasible and Reasonable Barrier Designs.

Modeled Receptor ID	No. of Receptors Represented	Modeled Noise Levels (dBA)		Noise Reduction (dBA)	No. of Benefited Receptors
		No Barrier	With Barrier		
44	2	62.9	55.6	**7.3**	**2**
45	2	59.2	53.4	**5.8**	**2**
46	2	52.6	50.1	2.5	0
47	2	63.6	58.6	**5.0**	**2**
48	1	60.0	56.6	3.4	0
49	1	61.8	58.2	3.6	0
50	1	64.3	59.5	**4.8**	**1**
51	4	**68.9**	62.1	**6.8**	**4**
52	4	65.8	63.7	2.1	0
53	4	65.3	64.3	1.0	0
14a	2	57.0	53.3	3.7	0
15a	4	58.3	54.1	4.2	0
16a	2	62.3	56.3	**6.0**	**2**
17a	2	**67.2**	62.2	**5.0**	**2**
18a	2	**66.0**	61.6	4.4	0
19a	2	65.2	60.9	4.3	0
20a	2	65.9	56.2	**9.7**	**2**
21a	2	62.4	55.4	**7.0**	**2**
22a	2	61.7	58.5	3.2	0
23a	2	59.2	52.5	**6.7**	**2**
24a	2	60.1	53.3	**6.8**	**2**
25a	2	61.4	54.2	**7.2**	**2**
26a	2	64.2	57.0	**7.2**	**2**
27a	2	61.7	58.1	3.6	0
28a	2	58.9	56.7	2.2	0
29a	2	61.7	57.5	4.2	0
30a	2	64.7	57.3	**7.4**	**2**
31a	2	61.7	54.3	**7.4**	**2**
32a	2	60.2	53.1	**7.1**	**2**
33a	2	58.8	51.9	**6.9**	**2**
34a	2	59.1	53.0	**6.1**	**2**
35a	4	61.8	55.4	**6.4**	**4**
36a	2	**66.2**	57.5	**8.7**	**2**
37a	2	60.1	55.9	4.2	0
38a	2	55.8	52.6	3.2	0

Table 9. Noise Reduction Feasible and Reasonable Barrier Designs.

Modeled Receptor ID	No. of Receptors Represented	Modeled Noise Levels (dBA)		Noise Reduction (dBA)	No. of Benefited Receptors
		No Barrier	With Barrier		
39a	2	65.3	59.9	**5.4**	**2**
40a	2	**66.8**	61.6	**5.2**	**2**
41a	2	64.5	57.6	**6.9**	**2**
42a	2	59.0	52.3	**6.7**	**2**
43a	2	62.6	58.9	3.7	0
44a	2	65.2	57.9	**7.3**	**2**
45a	2	63.4	57.1	**6.3**	**2**
46a	2	56.6	54.3	2.3	0
47a	2	65.8	62.6	3.2	0

Color Definitions:

Blue	Front row receptor.
Pink	Impacted receptor—noise level with no barrier approaches or exceeds NAC.
Green	Benefited Receptor—noise reduction due to barrier is at least 4.5 dBA (4.5-4.9 dBA rounded to 5.0 dBA).

Table 10. Noise Levels in Undeveloped Area.

Location ID[a]	Modeled Sound Level (dBA)
Undeveloped Area 1 (see Figure 2, Sheet 1)	
U1-250	72.8
U1-300	70.3
U1-350	63.8
U1-400	61.1
U1-450	60.9
U1-500	61.7
Undeveloped Area 2 (see Figure 2, Sheet 4)	
U2-100	75.0
U2-150	72.3
U2-200	70.5
U2-250	68.8
U2-300	67.4
Undeveloped Area 3 (see Figure 2, Sheet 9)	
U3-100	75.0
U3-150	72.3
U3-200	70.5
U3-250	68.8
U3-300	67.3
U3-350	66.3
U3-400	65.4
U3-450	64.5
U3-500	63.7

a) In the location ID, U# refers to the undeveloped area and the following number shows how far the receptor is from the nearest edge of pavement.

APPENDIX A: NOISE FUNDAMENTALS

This Appendix describes basic acoustical principles and terminology as they are applied to highway noise. Noise is often defined as undesirable sound. Some sounds (such as music or birds singing) are not considered noise by most people, but other sounds from sources such as trucks on a highway or planes passing overhead are typically considered noise. This report focuses on the noises associated with highway traffic, though other noises may have been included in some measured noise levels. Traffic noises arise due to vehicle engines and exhausts, tire vibration, horns, brakes, etc. Each noise source produces its own combination of sounds. In the following paragraphs, some basic principles of sound are discussed in the context of highway noise analysis.

Loudness

Sound is created when a source vibrates in air, creating pressure pulses that move through the air or other medium away from the source in waves. When these pressure waves reach a receiver like the human ear, the pressure variations are interpreted as sounds. More forceful vibrations mean higher pressures in the sound waves, and these are interpreted by the human ear as louder or more intense sounds.

Sound pressures to which people may be exposed can vary greatly. For example, the sound pressure of leaves rustling at night might be 200 micropascals (μPa), and the sound pressure of a jet plane passing overhead might be 6,000,000 μPa. To simplify handling such large ranges of numbers, loudness is usually expressed as a Sound Pressure Level (SPL), which is expressed in units called decibels (dB). The dB is defined based on a logarithmic scale relative to a defined reference level. Mathematically, the SPL in dB is defined in Equation (1).

$$\text{SPL (in dB)} = 20 \log_{10} (p/p_o) \qquad (1)$$

Where p= the sound pressure in μPa;

p_o= the reference sound pressure (normally 20 μPa, the typical hearing threshold of a young adult).

In the example given above, leaves rustling at 200 μPa would give an SPL of about 20 dB and a jet plane at 6,000,000 μPa would have an SPL of about 110 dB. Decibel levels associated with other common noises include a quiet bedroom at night (30 dB), normal speech with someone 3 ft away (67 dB), and a gasoline-powered lawn mower from 3 ft away (90 dB).

Because of the way the decibel is defined mathematically and the way human ears respond to sound intensities, comparing the “noisiness” of two sounds based on their dB values is not straightforward. For example, a truck passing on the highway might be generating a sound pressure level of 90 dB at a listener. However, the addition of a second identical truck will not produce 180 dB, nor will it double the apparent loudness to the listener. In fact, the second truck would only produce an additional 3 dB (for a total SPL of 93 dB) and the average listener would just barely be able to discern any difference in loudness. It would require 10 identical trucks to double the apparent loudness for the listener, at which point the SPL would increase by 10 to a value of 100 dB. Thus, for most highway applications, two rules of thumb are commonly used:

- A change of less than 3 dB is not noticeable to most people, and
- An increase of 10 dB will sound twice as loud and a decrease of 10 dB will sound half as loud.

Frequency

In addition to loudness, sounds can also be described by how fast the pressure changes over time. Increasing the vibration rate at the source (more beats per minute) will cause the air pressure to change at a higher frequency. The human ear perceives the frequency of the sound pressure wave as pitch. For example, different notes played on a piano have different frequencies. Lower frequencies are perceived as being lower in pitch while higher frequencies are perceived as being higher in pitch.

Frequency is measured in units of Hertz (Hz), which represent the number of times the pressure changes per second. Normal human ears can detect frequencies ranging from approximately 30 Hz to 16,000 Hz. However, the ear is best at hearing mid-range frequencies (around 1000 Hz). For example, if a person hears two sounds that have the same pressure level (same dB value), but one sound is at 200 Hz and the other is at 1000 Hz, the 1000 Hz sound will seem to be much louder.

In recognition of this human hearing phenomenon, a frequency-weighting scheme called A-weighting is used in representing highway sound levels. In the A-weighting scheme, sound levels from various frequencies are weighted using the factors shown in Table A-1 to essentially subtract out portions of the sounds (mostly in the lower frequencies) that human ears do not hear well. Then the weighted sounds are added together to yield a single value (designated dBA) that approximately simulates the overall loudness that the human ear would perceive. All noise levels presented in this report are A-weighted values.

Duration

In addition to the relatively quick pressure variations (hundreds or thousands per second) that are measured as frequency, sound levels may also vary over longer time periods of minutes or hours. Noise measurements made at regular time intervals at the same location will generally vary widely, making it difficult to compare overall noise levels associated with a highway project at two or more locations or traffic scenarios.

One option for describing a varying sound environment is to measure the sound exposure level (SEL), which is the total sound energy of a single sound event and takes into account both its intensity and duration. One way to understand SEL is to think of it as the sound level you would experience if all of the sound energy of a sound event occurred in one second. This normalization to a duration of one second allows the direct comparison of sounds of different durations.

Another alternative is to look at average noise levels over a specified time period. Several noise descriptors or metrics are used to describe time-averaged noise levels. The L_{eq} is a single number that describes the mean sound intensity level during a specified time period. The time period can be one hour or several hours. The symbol L_{eq}(h) is typically used to denote an L_{eq} for the noisiest hour of the day. L_{eq}(day) and L_{eq}(night) refer to averages over daylight and nighttime hours, respectively. L_{dn} is essentially a weighted average of L_{eq}(day) and L_{eq}(night) values where nighttime sounds are weighted more heavily than daylight sounds. Another descriptor that is occasionally used is L_{10}(h), which is the sound level exceeded 10 percent of the time over a one-hour period. The noise measurements and modeling results presented in this report are L_{eq}(h) values.

Noise Measurement

Noise levels for highway projects are measured following FHWA guidance (Lee and Fleming 1996). A Sound Level Meter (SLM) that meets or exceeds American National Standards Institute (ANSI) S1.4-1993, TYPE II standards for accuracy (ANSI 1993) is required. The SLM detects sounds using a microphone that converts the sound pressure levels into electrical signals. The electrical signals are then amplified and recorded or displayed. Typically, the SLM measures sounds of all frequencies within its operating range and add these together to produce a single sound level measurement. Filtering circuitry is included to automatically give

A-weighted results. In addition, some SLMs have integrating capabilities built in so that L_{eq} values can be obtained directly.

Calibration of the SLM is important to ensure that accurate measurements are obtained. In addition to annual calibration in the lab, a calibrator is also used before and after field measurements. The calibrator generates a known volume sound level at a single frequency (typically either 94 or 114 dB at 1000 Hz). By placing the calibrator over the SLM microphone and obtaining a reading, accuracy of the SLM can be checked. If SLM readings obtained using the calibrator are off by less than 1 dB, the measurement readings can be corrected for instrument drift. If the calibration readings are off by more than 1 dB, the measurement readings must be discarded.

In the field, the SLM is situated with the microphone pointing up so that highway sounds all impinge on the membrane at the end of the microphone at an incidence angle of 90 degrees (grazing incidence). The microphone is situated atop a tripod or other support at a height of 5 ft above the ground to simulate the height of the average listener's ears. A windscreen is placed over the microphone to eliminate wind noise from the measurements. Measurement periods of at least 15 minutes are used to obtain a good estimate of the L_{eq}(h).

While noise measurements are being made, traffic counts are obtained for nearby roadways. Counts are made of different vehicle types in each travel direction. In situations where traffic volumes are too large to count using a tally sheet, a video camera may be used to record the traffic so it can be counted later.

A number of environmental factors can affect noise readings in the field, including meteorological conditions (wind speed and direction, humidity, temperature, precipitation), terrain, ground surface (paved, grass, etc.), distance to nearby roads, and the presence of structures and buildings that may block or reflect traffic noise. All of these things should be measured and/or described when field measurements are taken.

Noise Modeling

Noise modeling is the calculation of noise levels at one or more receptor locations using complex mathematical equations representing the physics of sound propagation. Various parameters must be known or estimated to use these equations. Such parameters include the physical relationship of source to receptor (distance, height differences, intervening terrain, type of ground surface, locations of barriers, etc.) and the noise emissions of the source.

For highway noise modeling, the latest version of the Traffic Noise Model (TNM), TNM 2.5, is used. This model was developed by the FHWA for use in highway noise analyses and is accepted by most state transportation authorities. As described in its User's Manual (Anderson et al. 1998; Lau et al. 2004), TNM calculates noise levels at user-specified receptor locations using the volume, speed, and vehicle mix of traffic on nearby roadways. Noise emissions profiles for various vehicle types are built into the model and are used with site-specific traffic data to define the noise source term. TNM then calculates the propagation of noise from one or more sources to user-specified receptors, taking into account terrain and ground surface variations and the presence of existing buildings and natural noise barriers. TNM also contains tools for designing noise barriers and evaluating their effectiveness.

Table A-1. A-Weighted Frequency Response Factors.

Center of Frequency Range (Hz)	A-Weighted Response Factor (dB)
31.5	-39
63	-26
125	-16
250	-9
500	-3
1000	0
2000	+1
4000	+1
8000	-1
16000	-7

APPENDIX B: FIELD DATA

Includes:

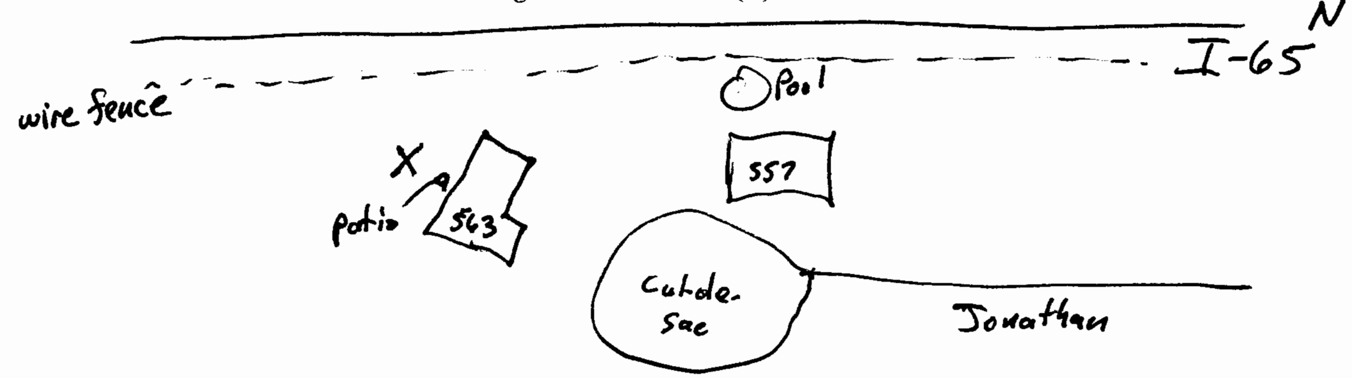
- Field Data Sheets for Noise Measurements
- Calibration Certification for Quest SoundPro Sound Level Meter
- Calibration Certification for Quest Model QC-10 Calibrator

Field Data Sheet for Noise Measurements

Project	Personnel	Date	Location	Site ID
I-65 ATL 38-26/IN-531-07	M. Stafford	5/7/2014	563 Jonathan Ave	M- 1

Temp (F)	Rel Hum	Wind Dir	WS (mph)	Sky	Source of Wind/Temp Data:
75	53	SW	11	clear	www.wunderground.com

Sketch of site including locations of SLM (X) and north direction arrow



Road 1: I-65		Speed (mph): 65/60
	Traffic From Left: SB No. of Lanes: 2	Traffic From Right: NB No. of Lanes: 2
Cars:	7+15+10+15+15+14+17+9+16+9+8+12 8+15+7+14+10+12+7	12+18+5+7+8+10+8+19+17+9+17+12 6+9+16+7
Med. Trucks:	||||| ||||	||||| ||||| ||
Heavy Trucks:	[illegible]	[illegible]
Buses:	|||		
Motorcycles:			

Road 2:		Speed (mph):
	Traffic From Left: ______ No. of Lanes: ______	Traffic From Right: ______ No. of Lanes: ______
Cars:		
Med. Trucks:		
Heavy Trucks:		
Buses:		
Motorcycles:		

SLM Model:	Serial No.	Cal. Cert. Date	Weight	Response	Height (ft)	Calibrator Model	Serial No.	Cal. Cert. Date
Quest Soundpro	BIF090005	2/27/14	A	Slow	5	QC-10	QE3090032	9/27/13

Init. Cal.	Final Cal.	Leq	Lmax	Lmin	Start Time	(min)
114.0	113.8	69.9	78.1	53.7	10:00	15:01

Comments:

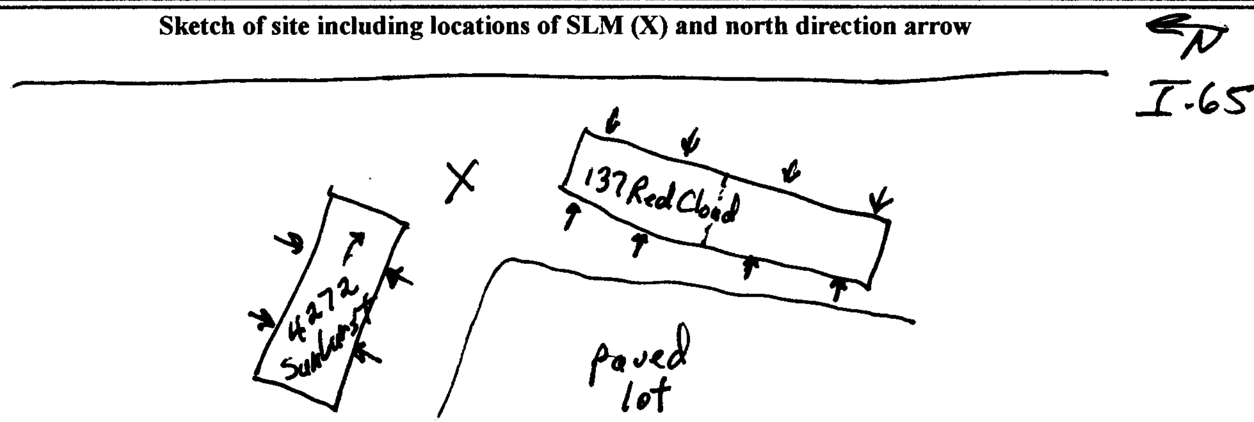
ASC Group, Inc.

Field Data Sheet for Noise Measurements

Project	Personnel	Date	Location	Site ID
I-65 ATL 38-26/IN-531-07	M. Stafford	5/7/2014	4272 Sunburst - Village Sq.	M- 2

Temp (F)	Rel Hum	Wind Dir	WS (mph)	Sky	Source of Wind/Temp Data:
61	49	E	7	clear	www.wunderground.com

Sketch of site including locations of SLM (X) and north direction arrow



Road 1:	I-65		Speed (mph): 65/60
	Traffic From Left: SB No. of Lanes: 2	Traffic From Right: NB No. of Lanes: 2	
Cars:	12+12+8+6+14+6+11+14+8+15+5+8+11 11+10+12+6+7+9+9+8+15+5	16+11+4+12+6+8+15+8+9+10+9+6 6+17+13+12+8+11+5+10+13	
Med. Trucks:	卌 II	卌 III	
Heavy Trucks:	卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 II	卌 III	
Buses:		I	
Motorcycles:			

Road 2:			Speed (mph):
	Traffic From Left: ____ No. of Lanes: ____	Traffic From Right: ____ No. of Lanes: ____	
Cars:			
Med. Trucks:			
Heavy Trucks:			
Buses:			
Motorcycles:			

SLM Model:	Serial No.	Cal. Cert. Date	Weight	Response	Height (ft)	Calibrator Model	Serial No.	Cal. Cert. Date
Quest Soundpro	BIF090005	2/27/14	A	Slow	5	QC-10	QE3090032	9/27/13

Init. Cal.	Final Cal.	Leq	Lmax	Lmin	Start Time	(min)
114.1	113.9	67.7	77.4	52.8	9:15	15:00

Comments: patios/balconies shown with →'s 2sty bldgs w/8 apts/bldg : 4up/4dn 4 front/4 rear

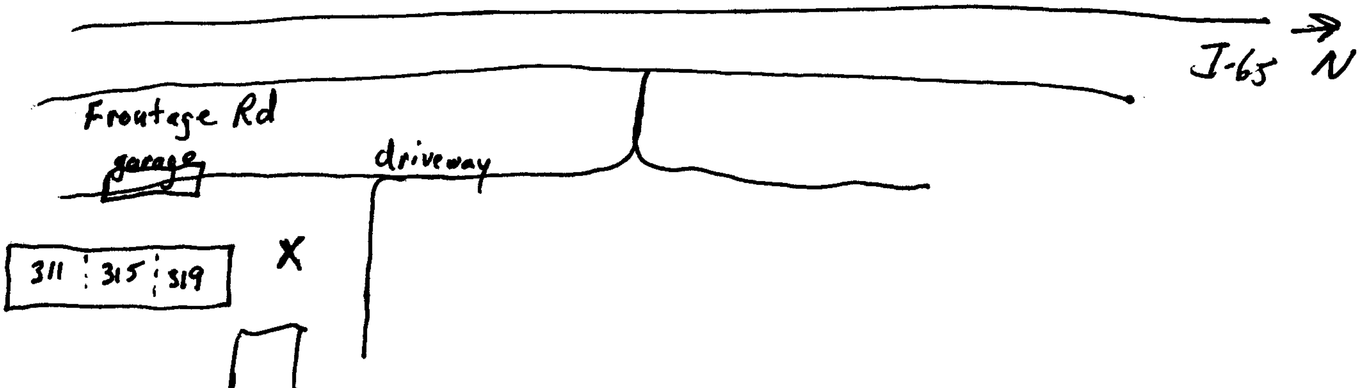
ASC Group, Inc.

Field Data Sheet for Noise Measurements

Project	Personnel	Date	Location	Site ID
I-65 ATL 38-26/IN-531-07	M. Stafford	5/7/2014	Waterford Ct 319	M-3

Temp (F)	Rel Hum	Wind Dir	WS (mph)	Sky	Source of Wind/Temp Data:
61	49	E	7	clear	www.wunderground.com

Sketch of site including locations of SLM (X) and north direction arrow



Road 1:	I-65		Speed (mph):	65/60
	Traffic From Left: NB	No. of Lanes: 2	Traffic From Right: SB	No. of Lanes: 2
Cars:	14+12+20+14+15+15+6+12+18+8+12 9+8+8+13+9+7+4		6+21+19+10+12+11+13+12+13+21+16+12 11+22+7+7+11+9+6+8+6+12+13	
Med. Trucks:	卌 II		卌 III	
Heavy Trucks:	[illegible] 卌 卌 卌 III		[illegible] 卌 卌 卌 卌 卌 卌 IIII	
Buses:	II			
Motorcycles:			I	

Road 2:			Speed (mph):	
	Traffic From Left: ______	No. of Lanes: ______	Traffic From Right: ______	No. of Lanes: ______
Cars:				
Med. Trucks:				
Heavy Trucks:				
Buses:				
Motorcycles:				

SLM Model:	Serial No.	Cal. Cert. Date	Weight	Response	Height (ft)	Calibrator Model	Serial No.	Cal. Cert. Date
Quest Soundpro	BIF090005	2/27/14	A	Slow	5	QC-10	QE3090032	9/27/13

Init. Cal.	Final Cal.	Leq	Lmax	Lmin	Start Time	(min)
114.0	114.1	65.2	84.2	57.1	8:30	15:00

Comments: 2sty bldgs - 1sty garages - 4apts per address# - 2up/2dn - patios & decks behind bldg (away from I-65)

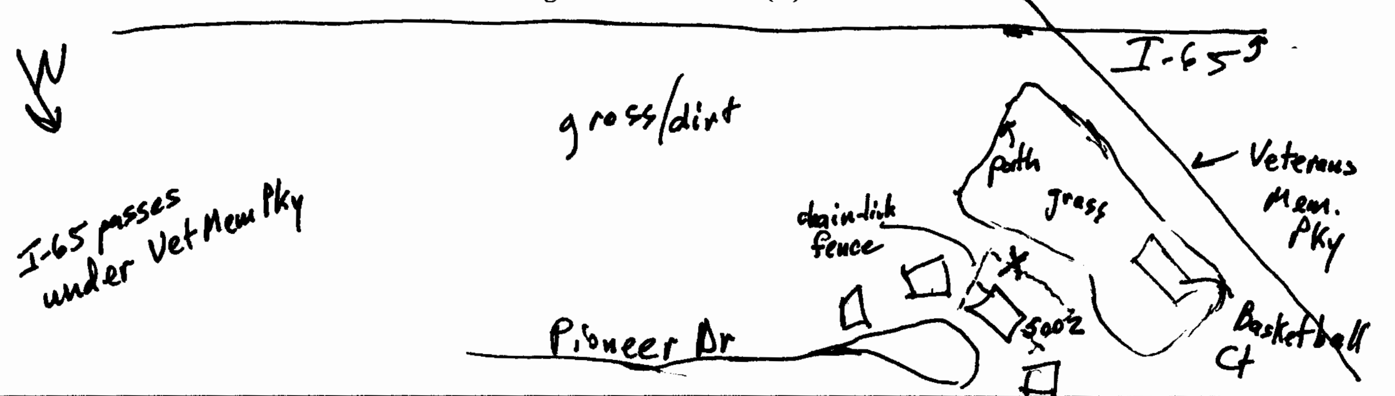
ASC Group, Inc.

Field Data Sheet for Noise Measurements

Project	Personnel	Date	Location	Site ID
I-65 ATL 38-26/IN-531-07	M. Stafford	5/6/2014	5002 Pioneer Dr.	M- 4

Temp (F)	Rel Hum	Wind Dir	WS (mph)	Sky	Source of Wind/Temp Data:
73	35	ESE	15	clear	www.wunderground.com

Sketch of site including locations of SLM (X) and north direction arrow



Road 1: I65		**Speed (mph):** 65/60
	Traffic From Left: NB **No. of Lanes:** 2	**Traffic From Right:** SB **No. of Lanes:** 2
Cars:	18+30+6+13+17+7+12+18+11+9+11+9 11+18+10+3+9+4+11+8+5+1	13+18+4+10+9+11+8+4+12+9+16+14 8+6+8+5+8+7+23+11+3
Med. Trucks:	|||	||||
Heavy Trucks:	[illegible]	[illegible]
Buses:			
Motorcycles:			

Road 2:		**Speed (mph):**
	Traffic From Left: ______ **No. of Lanes:** ______	**Traffic From Right:** ______ **No. of Lanes:** ______
Cars:		
Med. Trucks:		
Heavy Trucks:		
Buses:		
Motorcycles:		

SLM Model:	Serial No.	Cal. Cert. Date	Weight	Response	Height (ft)	Calibrator Model	Serial No.	Cal. Cert. Date
Quest Soundpro	BIF090005	2/27/14	A	Slow	5	QC-10	QE3090032	9/27/13

Init. Cal.	Final Cal.	Leq	Lmax	Lmin	Start Time	(min)
113.9	114.0	63.1	71.9	55.6	5:30	15:00

Comments:

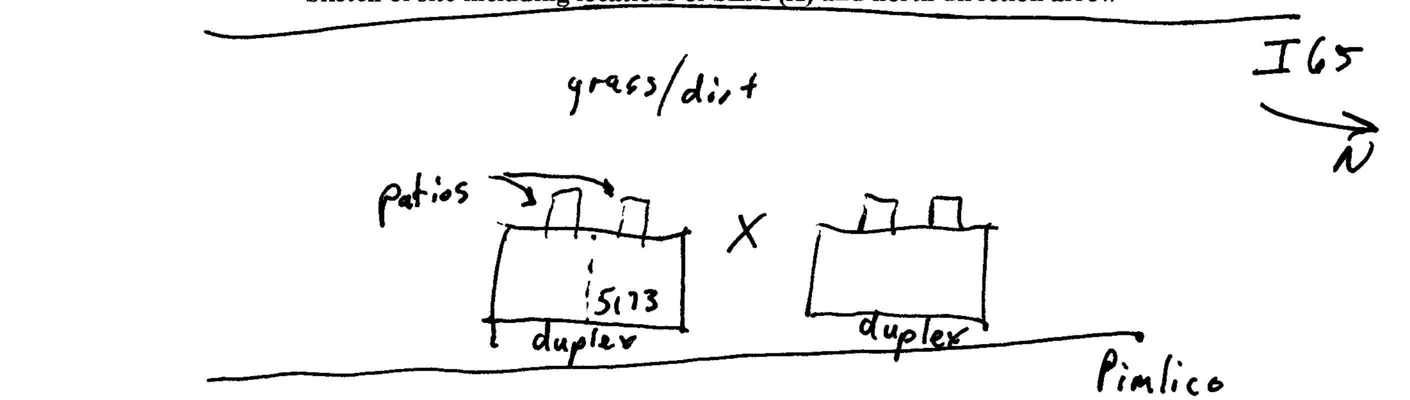
ASC Group, Inc.

Field Data Sheet for Noise Measurements

Project	Personnel	Date	Location	Site ID
I-65 ATL 38-26/IN-531-07	M. Stafford	5/6/2014	5173 Pimlico Ln	M-5

Temp (F)	Rel Hum	Wind Dir	WS (mph)	Sky	Source of Wind/Temp Data:
73	35	ESE	15	clear	www.wunderground.com

Sketch of site including locations of SLM (X) and north direction arrow



Road 1:	I-65	**Speed (mph):** 65/60
	Traffic From Left: NB **No. of Lanes:** 2	**Traffic From Right:** SB **No. of Lanes:** 2
Cars:	12+14+10+6+7+15+4+10+11+6+28+6+2 9+11+12+13+22+13+19+12+16+15+4	20+4+5+14+9+7+18+15+17+10+4+14+7 8+20+12+4+9+8+2+12+9+9
Med. Trucks:	||	卌
Heavy Trucks:	[illegible]	[illegible]
Buses:		
Motorcycles:		

Road 2:		**Speed (mph):**
	Traffic From Left: ______ **No. of Lanes:** ______	**Traffic From Right:** ______ **No. of Lanes:** ______
Cars:		
Med. Trucks:		
Heavy Trucks:		
Buses:		
Motorcycles:		

SLM Model:	Serial No.	Cal. Cert. Date	Weight	Response	Height (ft)	Calibrator Model	Serial No.	Cal. Cert. Date
Quest Soundpro	BIF090005	2/27/14	A	Slow	5	QC-10	QE3090032	9/27/13

Init. Cal.	Final Cal.	Leq	Lmax	Lmin	Start Time	(min)
113.9	113.9	65.6	81.4	57.0	5:00	15:00

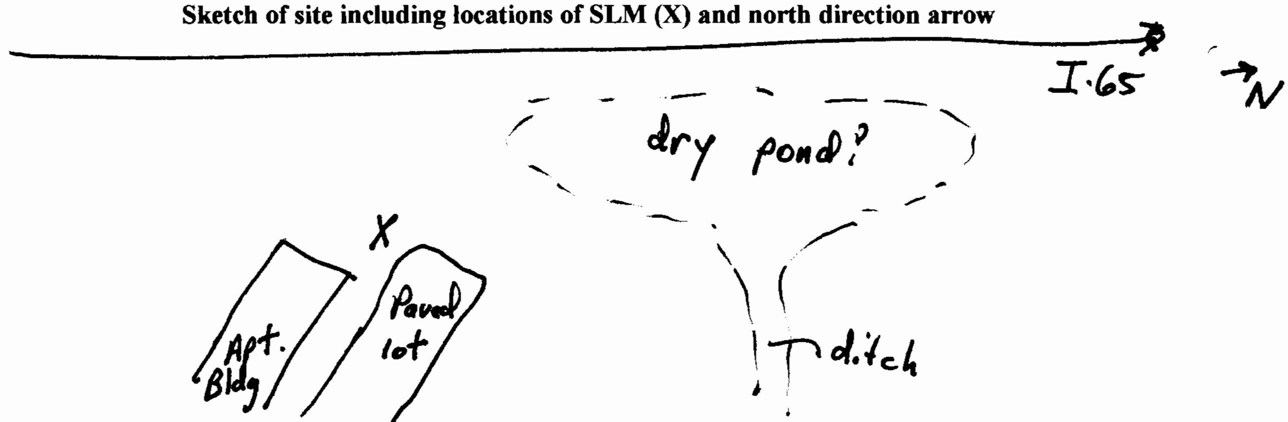
Comments:

Field Data Sheet for Noise Measurements

Project	Personnel	Date	Location	Site ID
I-65 ATL 38-26/IN-531-07	M. Stafford	5/6/2014	5531 Thornapple	M- 6

Temp (F)	Rel Hum	Wind Dir	WS (mph)	Sky	Source of Wind/Temp Data:
73	35	ESE	15	clear	www.wunderground.com

Sketch of site including locations of SLM (X) and north direction arrow



Road 1: I-65		**Speed (mph):** 65/60
	Traffic From Left: NB **No. of Lanes:** 2	**Traffic From Right:** SB **No. of Lanes:** 2
Cars:	15+12+15+10+10+20+21+11+17+9+ 14+14+13+15+10+17+13	16+13+11+7+11+12+17+13+10+15+ 19+12+20+11+10+10+10+14+18+11+ 4
Med. Trucks:	卌 III	卌 卌 II
Heavy Trucks:	卌 卌	卌 卌
Buses:	卌 卌 II	I III
Motorcycles:	II	

Road 2:		**Speed (mph):**
	Traffic From Left: ___ **No. of Lanes:** ___	**Traffic From Right:** ___ **No. of Lanes:** ___
Cars:		
Med. Trucks:		
Heavy Trucks:		
Buses:		
Motorcycles:		

SLM Model:	Serial No.	Cal. Cert. Date	Weight	Response	Height (ft)	Calibrator Model	Serial No.	Cal. Cert. Date
Quest Soundpro	BIF090005	2/27/14	A	Slow	5	QC-10	QE3090032	9/27/13

Init. Cal.	Final Cal.	Leq	Lmax	Lmin	Start Time	(min)
114.0	113.8	61.3	67.6	53.3	4:20	15:00

Comments: 16 units/bldg – half on 2nd floor – all have either balcony or patio

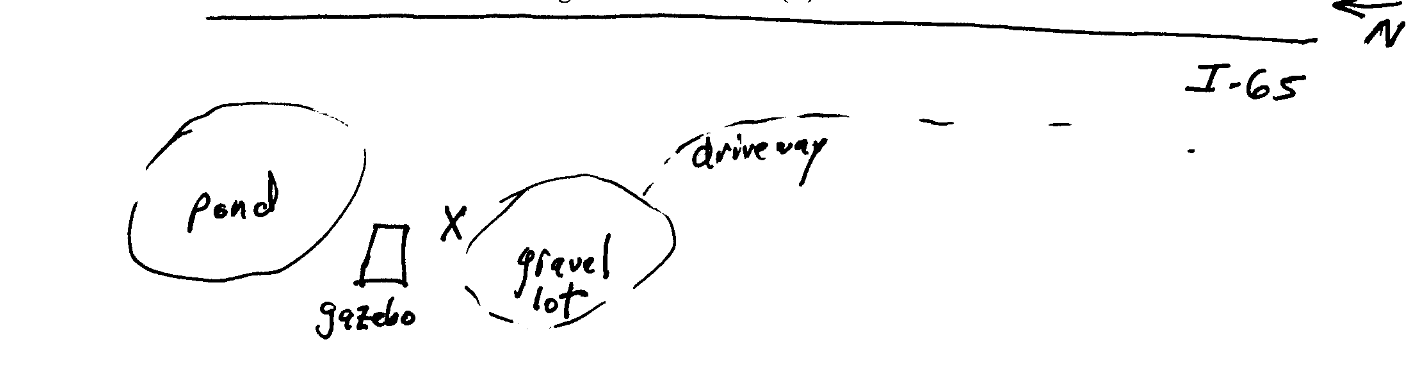
ASC Group, Inc.

Field Data Sheet for Noise Measurements

Project	Personnel	Date	Location	Site ID
I-65 ATL 38-26/IN-531-07	M. Stafford	5/6/2014	gazebo @ SIA rec. center	M-7

Temp (F)	Rel Hum	Wind Dir	WS (mph)	Sky	Source of Wind/Temp Data:
72	34	E	18	clear	www.wunderground.com

Sketch of site including locations of SLM (X) and north direction arrow



Road 1:	I-65			Speed (mph): 65/60
	Traffic From Left: SB	No. of Lanes: 2	Traffic From Right: NB	No. of Lanes: 2
Cars:	7+15+7+9+12+7+15+9+5+15+14 12+7+11+6+8+12+5+11+8+12+13 10+9+12+12+6+5+8+8+4		8+5+15+14+11+24+9+9+19+10+10 13+5+10+18+9+7+5+10+9+10+13+7 9+10+9+8	
Med. Trucks:	𝍸 𝍸		𝍸 𝍸 |	
Heavy Trucks:	𝍸 |		𝍸 |	
Buses:	||		|	
Motorcycles:	|		|||	

Road 2:				Speed (mph):
	Traffic From Left: ______	No. of Lanes: ______	Traffic From Right: ______	No. of Lanes: ______
Cars:				
Med. Trucks:				
Heavy Trucks:				
Buses:				
Motorcycles:				

SLM Model:	Serial No.	Cal. Cert. Date	Weight	Response	Height (ft)	Calibrator Model	Serial No.	Cal. Cert. Date
Quest Soundpro	BIF090005	2/27/14	A	Slow	5	QC-10	QE3090032	9/27/13

Init. Cal.	Final Cal.	Leq	Lmax	Lmin	Start Time	(min)
114.0	113.9	70.8	88.7	61.5	3:40	15:00

Comments: very windy – loud car on driveway 2X for ~1min.

ASC Group, Inc.

IE MONITORING INSTRUMENTS

7410 Worthington-Galena Road
Worthington, Ohio 43085
Phone: (614) 436-4933
Fax: (614) 436-9144

Industrial Environmental Monitoring Instruments, Inc.

Website: www.ierents.com

Certificate of Calibration

Submitted By: IE Monitoring Instruments
7410 Worthington-Galena Road
Worthington, OH 43085

Serial No: BIF090005
Model: Quest Soundpro

Date Received: 2/27/2014
Date Issued: 2/27/2014
Valid Until: 2/27/2015

Test Conditions:
Temperature 68.0° F
Humidity 22.9 %
Barometric Pressure 29.017"Hg

Model Conditions:
As Received: Fully Functional and In Tolerance
Final Condition: Fully Functional and In Tolerance

Test Results:
A & C Weightings +/- .5 dB
Linearity +/- .2 dB

Type II Accuracy: +/- 2 dB
Linearity Accuracy: +/- .5dB

Octave Band Filter Check:
Bandwidth Peak 12.5Hz – 20 KHz meets manufacturer's specifications.
Frequency output meets manufacturer's specifications.

Reference Standards:

Device	Serial Number	Last Calibration	Date Calibration Due
Quest SoundPro Type I	BKL120001	1/21/2014	1/21/2015
Quest AC-300	AC300002327	1/14/2014	1/14/2015

Calibrated By: Sam Shults, Service Manager

This report certifies that all calibration equipment used in the test is traceable to the NIST, and applies only to the unit identified above. All tolerances of accuracy are within the manufactures specifications.

MONITORING INSTRUMENTS

7410 Worthington-Galena Road
Worthington, Ohio 43085
Phone: (614) 436-4933
Fax: (614) 436-9144

Industrial Environmental Monitoring Instruments, Inc.

Website: www.ierents.com

Certificate of Calibration

Submitted By: IE Monitoring Instruments
7410 Worthington-Galena Road
Worthington, Oh 43085

Serial No: QE3090032
Model: QC-10

Date Received: 9/27/2013
Date Issued: 9/27/2013
Valid Until: 9/27/2014

Test Conditions:
Temperature 72.4 F
Humidity 59.0 %
Barometric Pressure 28.906"Hg

Model Conditions:
As Received: Fully Functional and In Tolerance
Final Condition: Fully Functional and In Tolerance

Test Results:
Output: 114.0 dB   Frequency: 1.00585 Khz   VAC: 1.0034 v

Reference Standards:

Device	Serial Number	Last Calibration	Date Calibration Due
Quest SoundPro Type 1	BKL120001	2/13/2013	2/13/2014
Agilent 34401A	MY41002352	9/29/2011	9/29/2013

Calibrated By: **Sam Shults, Service Manager** **9/27/2013**

This report certifies that all calibration equipment used in the test is traceable to the NIST, and applies only to the unit identified above. All tolerances of accuracy are within the manufactures specifications.