MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

HIGHWAY NOISE ABATEMENT PLANNING AND ENGINEERING GUIDELINES

FINAL

April 16, 2020

MDOT SHA HIGHWAY NOISE ABATEMENT PLANNING AND ENGINEERING GUIDELINES – April 16, 2020

The Maryland Department of Transportation (MDOT) *Noise Policy* (2020) consists of a brief policy statement, applicable to all of the MDOT Transportation Business Units. This document, the Maryland Department of Transportation State Highway Administration (MDOT SHA) *Highway Noise Abatement Planning and Engineering Guidelines* (2020), explains how to correctly apply the policy for highway projects. The purpose of this Executive Summary is to highlight some of the key elements found in the guidelines.

The 2020 Guidelines are based upon the provisions contained in Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772)[1] and replace the 2011 MDOT SHA *Highway Noise Policy* and *Highway Noise Policy Implementation Guidelines*.

For a given Type I project, the adjacent land uses are divided into one of seven possible Activity Categories, which are either noise sensitive (A through E) or not noise sensitive (F and G). Each noise sensitive category has a corresponding Noise Abatement Criteria (NAC) defined in 23 CFR 772 and MDOT SHA's impact criteria is set 1 dB(A) less than the NAC, consistent with federal regulations. Category B covers exterior impacts for residential areas and has an impact level of 66 dB(A).

Highway traffic noise impacts are identified for the affected noise sensitive land use when the subject Type I project will either result in noise levels that approach or exceed the applicable NAC, or result in an increase of 10 dB(A) or more ('substantial increase') over existing levels. Whenever impacts occur, noise abatement must be considered. However, noise abatement solutions must be both feasible and reasonable to be considered for construction.

The assessment of noise abatement feasibility, in general, focuses on whether it is physically possible to build an abatement measure (i.e. noise barrier) that achieves a minimally acceptable level of noise reduction. Barrier feasibility considers three primary factors: acoustics, safety & access, and site constraints.

- For a receptor to be considered benefited, the receptor must receive a noise reduction of at least 5 dB(A). For abatement to be considered acoustically feasible, at least 70 percent of the impacted residences must be benefited.
- Construction of a noise barrier may not be feasible where access points would prevent effective noise reduction or where the barrier would create adverse safety conditions.
- If a site constraint is present, avoidance and minimization efforts are explored to allow for the placement of the barrier.

The assessment of noise abatement reasonableness, in general, focuses on whether it is practical to build an abatement measure. Barrier reasonableness considers three primary factors: viewpoints, design goal, and cost effectiveness.

- The views and opinions of all benefited property owners and residents will be solicited through public involvement and outreach activities.
- The number of impacted residences, including equivalent residences, that must be benefited by a minimum 7 dB(A) noise reduction shall be at least three (3) or 50 percent, whichever is greater. Barrier systems that protect areas with less than three impacted residences are automatically deemed not reasonable and require no further analysis.

[1] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010

- MDOT SHA considers the quantity of noise barrier when judging cost reasonableness and sets the appropriate barrier quantity cap (evaluation threshold) based on the degree and extent that the subject Type I highway project changes the existing noise environment. The threshold can increase from a baseline allowance of 700 square footage of barrier per benefited (equivalent) residence (SF-p-r) up to a maximum possible allowance of 2700 SF-p-r based on the three conditions listed below:

    - The project increases through capacity.
    - The project increases noise levels by a minimum of 3 dB(A) from existing to future build conditions.
    - The project results in future noise levels at or above 75 dB(A).

  The evaluation threshold is 700 SF-p-r when <u>none</u> of the above conditions is present.
  The evaluation threshold is 1700 SF-p-r when <u>only one</u> of the above conditions is present.
  The evaluation threshold is 2700 SF-p-r when <u>two or more</u> of the above conditions are present.

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1.0 INTRODUCTION

The purpose of this document is to provide detailed implementation guidance, critical background information, rationale, and other comprehensive criteria to support the application of the Maryland Department of Transportation State Highway Administration (MDOT SHA) *Highway Noise Policy*. The Policy and these guidelines are based upon the provisions contained in Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772), *Procedures for Abatement of Highway Traffic Noise and Construction Noise*[1] and the Federal Highway Administration (FHWA) report FHWA-HEP-10-025, *Highway Traffic Noise: Analysis and Abatement Guidance* and subsequent revisions[2].

2.0 OVERVIEW

These Planning and Engineering Guidelines have been adopted with the approval of FHWA as meeting the intent of the provisions of 23 CFR 772 and are deemed consistent with other Federal guidance documents. Revisions to the MDOT SHA *Highway Noise Policy* and these *Planning and Engineering Guidelines* will not be retroactively applied to final Type I determinations.

Definitions of terms related to the analysis and abatement of highway traffic noise are found in **Appendix A** of these Guidelines, and in 23 CFR 772.5; an abridged list is included below:

Type I projects involve the analysis of existing and future noise conditions, assessment of noise impact, and the feasibility and reasonableness of noise abatement measures (where appropriate) related to:

(1) Construction of a highway on new location.

(2) Reconstruction or physical alteration of an existing highway where there is:

(i) Substantial horizontal alignment changes which halve the distance between the roadway (noise source) and closest receptor. This distance is measured from the edge of the nearest travel lane.

(ii) Substantial vertical alignment changes which remove existing shielding or change the topography thereby exposing the line-of-sight between the roadway (noise source) and closest receptor.

- NOTE: Removal of an existing noise barrier qualifies as a substantial vertical alteration, because that action removes shielding between a noise source and receptor[3].

(iii) Addition of one or more through-travel lanes, including lanes that would function as HOV (high-occupancy vehicle), HOT (high-occupancy toll), ETL (express toll lanes), bus, or truck climbing lanes.

(iv) Auxiliary lanes, excluding those functioning strictly as turn lanes.

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[1] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010

[2] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, December 2011

[3] Federal Highway Administration Highway Traffic Noise Frequently Asked Questions, May 2015, C.3

- NOTE: Per FHWA guidance, an auxiliary lane classifies as a Type I project if the total length of the lane is 2,500 feet or longer[4]. Auxiliary lanes less than 2,500 feet in length may require analysis.

(v) Addition or relocation of interchange ramps or lanes.

(vi) Restriping of the existing pavement to add a through-travel lane or auxiliary lane, including part-time shoulder use (consistent with current FHWA guidance).

(vii) Addition of a new, or the substantial alteration of, a weigh station, rest stop or area, ride-sharing (park and ride) lot, or toll plaza.

Type II projects are Federal or Federal-aid eligible highway projects to address existing noise impacts for communities adjacent to existing fully controlled-access highways not being expanded, where the majority of the impacted development was built prior to the original construction or approval of a highway. **Appendix B** provides details on the MDOT SHA Type II Program.

Type III projects are Federal or Federal-aid highway projects that do not meet the classifications of a Type I or Type II project. Type III projects do not require a noise analysis.

The remainder of these guidelines apply only to Type I Projects. Type II Projects are discussed separately in Appendix B.

3.0 POLICY APPLICABILITY AND FEDERAL PARTICIPATION

The MDOT SHA *Highway Noise Abatement Planning and Engineering Guidelines* apply to all Federal or Federal-aid Highway Projects authorized under Title 23, United States Code, that meet the definition of a Type I project[5]. This includes any highway project or multimodal project that:

(1) Requires FHWA approval (including Interstate Access Point Approval) regardless of funding sources, or

(2) Is funded with Federal-aid highway funds.

Table 1 Applicability of MDOT SHA Highway Noise Policy by Funding Source

Route Type	Funding Source		
	Federal	State	County/Local/Private
Federal/Interstate	Y	Y	Y
State and US Routes	Y	Y*	Y*
County/Local	Y	N	N

*Only applies to fully access-controlled roadways

Section 772.15 of 23 CFR defines the circumstances under which Federal funds may be used for noise abatement measures for Type I projects and lists the following noise abatement measures that may be considered[6]:

[4] Federal Highway Administration Highway Traffic Noise Frequently Asked Questions, May 2015, C.2
[5] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Section 7: Applicability
[6] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Section 15: Federal Participation

(1) Construction of noise barriers, including necessary acquisition of property rights, either within or outside the highway right-of-way.

NOTE: FHWA does not consider landscaping as a viable noise abatement measure.

(2) Traffic management measures, such as traffic control devices and signing for prohibition of certain vehicle types, time-use restrictions for certain vehicle types, modified speed limits, and exclusive lane designations.

(3) Alteration of roadway horizontal or vertical alignments.

(4) Acquisition of property (typically undeveloped or unimproved) for establishing a buffer zone to prevent future development which would be adversely affected by traffic noise.

(5) Noise insulation of facilities defined in 23 CFR 772 as Activity Category D (see Table 2) to address INTERIOR noise impacts. This abatement measure is ONLY applicable if:

(i) Exterior abatement is determined to be not feasible and reasonable, or

(ii) If noise sensitive exterior uses do not exist or are not impacted on the subject property.

4.0 NOISE IMPACT ASSESSMENT

The Federal regulation (23 CFR 772.7(a)) defines the types of highway improvements and projects that would require an analysis of noise levels, impact, and consideration of abatement as part of the National Environmental Policy Act (NEPA) process[7]. Analysis must be conducted on all project alternatives retained for detailed study[8]. For detailed information on modeling, see **Appendix C**.

4.1 Noise Impact Analysis Considerations

The detailed analysis of highway noise impacts will determine the following:

(1) Whether the subject project will result in noise levels that approach or exceed the applicable Noise Abatement Criteria (NAC, as defined in Table 2) for the affected land use activity categories. If noise levels already exceed the NAC under existing conditions (i.e., prior to implementation of the subject project) and would continue to exceed the NAC with the project, noise abatement would still need to be considered, subject to a feasibility-reasonableness determination.

NOTE: Noise abatement would not be required if the subject project results in a reduction in future noise levels to below the applicable NAC for the affected land use activity categories.

(2) Whether the subject project would result in a substantial increase (i.e., 10 dB(A) or more) in noise over existing levels for the affected land use/activity categories.

[7] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Section 7: Applicability

[8] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, December 2011, 772.11 Analysis of Traffic Noise Impacts, Prediction of Future Highway Traffic Noise Levels for Study Alternatives

4.2 Noise Impact Criteria

Federal guidelines require that States define impact criteria that are at least 1 dB(A) less than the NAC contained in the Code of Federal Regulations, based upon the identified type of activity or land use[9]. Table 2 shows the NAC as well as MDOT SHA's Approach Criteria; MDOT SHA's levels are set 1 dB(A) less than the NAC, consistent with Federal regulations.

Table 2 Noise Abatement Criteria (NAC) [Hourly A-Weighted Sound Level in Decibels dB(A)]

Activity Category	Activity Criteria[1] Leq(h)[2]	MDOT SHA Approach Criteria Leq(h)	Evaluation Location	Description of Activity Category
A	57	56	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	66	Exterior	Residential
C	67	66	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, daycare 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	51	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[3]	72	71	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	--	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	--	--	--	Undeveloped lands that are not permitted

1. *The Leq(h) Activity Criteria values are for impact determination only and are not design standards for noise abatement measures.*
2. *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 Leq(h) being the hourly value of Leq.*
3. *Includes undeveloped lands permitted for this activity category.*

[9] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Table 1—Noise Abatement Criteria

4.3 Noise Abatement Criteria

As provided in Table 2, land uses in each project area may be divided into seven Activity Categories designated as A through G. Activity Categories A through E are assigned specific noise level thresholds; where these thresholds are approached or exceeded, noise abatement must be considered. The following provides specific additional guidance related to each Activity Category as it relates to the determination of the degree and extent of highway traffic noise impacts and based upon the concept of the "equivalent residence" (ER) for assessing noise abatement reasonableness.

4.3.1 Activity Category A

Land uses in this category are those where serenity and quiet are of extraordinary significance and serve an important public need, and where preservation of those qualities is essential if the area is to continue to serve its intended purpose. Designation of a land use as Category A is made on a case-by-case basis with concurrence and approval of FHWA, prior to initiation of the noise analysis[10].

4.3.2 Activity Category B

This category includes exterior impacts for residences. As per FHWA guidance, for multifamily structures, each dwelling unit is counted as a separate "residence," including those on upper floors. Common use areas identified within a Category B area that would be typically available for use by residents of the entire multi-family complex would be weighted based upon the total potential users and with consideration given (as appropriate) also to the overall capacity and extent of use of the subject common area. **Appendix D** contains guidance for determining the number of equivalent residences for these common use areas.

4.3.3 Activity Category C

This category includes various non-residential outdoor land uses and activities, as well as all Section 4(f) properties. If a noise impact is identified, an appropriate ER determination will be made as part of the consideration of abatement, based on either the linear frontage of the land use or the capacity of the use area. Additional weighting may be applied based on an assessment of use-time of the subject facility or land use, as appropriate. Examples and details related to the weighting procedure are found in **Appendix D**. If noise sensitive exterior use is not found or the exterior use is not impacted, then consideration under Category D may apply.

4.3.4 Activity Category D

This category includes the INTERIOR of non-residential land uses and activities, some of which are also listed under Category C. Interior levels are only considered after a full analysis of outdoor/exterior activities (if any), or a determination that exterior abatement measures are not feasible or reasonable. ER weightings would be similarly applied as appropriate using the procedures found in **Appendix D**.

[10] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Section 11: Analysis of traffic noise impacts

4.3.5 Activity Category E

This category includes land uses such as hotels and motels, offices, and other commercial properties or activities not included in categories A-D or F. As per FHWA guidance, particular attention will be paid to context and intensity of usage; consideration may also include ER weightings (as outlined in **Appendix D**) to be applied, as appropriate and determined on a project-specific basis.

4.3.6 Activity Category F

Activities within this category are not considered noise sensitive; no noise analysis is required.

4.3.7 Activity Category G

This category includes undeveloped land that is not permitted by the date of public knowledge (DoPK). The provisions of 23 CFR 772 define the Date of Public Knowledge (DoPK) as the approval date of the applicable final environmental document, which is the official public notification of a project[11]. Undeveloped land that IS permitted would fall under the category appropriate for the permitted activity.

Date of Public Knowledge

In the conduct of environmental reevaluations, the DoPK shall remain the approval date of the applicable final environmental document. Development which may be permitted or constructed after the DoPK, but prior to the design change reevaluation, will be analyzed and existing and future noise levels will be documented, but noise abatement will not be considered. Development that postdates the DoPK may be eligible for consideration of abatement ONLY in cases where the design changes are of sufficient scope and breadth so as to warrant development of a supplemental environmental document, in which case the approval date of the supplemental environmental document becomes the new DoPK.

In the event that building permit dates for dwellings in a new development straddle the DoPK (i.e., some predate, and some postdate the DoPK), consideration will be given, on a case-by-case basis, to when the base infrastructure of the subject development was permitted/approved. Base infrastructure is primarily defined as local streets and related amenities. If the base infrastructure is in place and at least one building permit was issued prior to the DoPK, the development will be considered eligible for noise abatement consideration, should noise impacts be identified[12]. If NO building permits were issued prior to the DoPK, the development will not be considered for noise abatement, regardless of impact status.

5.0 NOISE ABATEMENT EVALUATION

In an evaluation of the effects of highway traffic noise on communities and other noise sensitive land uses and activities, three basic determinations are made:

(1) Degree and extent of noise impact (if any).

[11] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, December 2011, 772.17 Information for Local Officials, Date of Public Knowledge
[12] Federal Highway Administration Highway Traffic Noise Frequently Asked Questions, May 2015, D.8

(2) Feasibility of noise abatement to address the identified impacts. Assessment of feasibility will usually be completed prior to an assessment of reasonableness.

(3) Reasonableness of noise abatement to address the identified impacts.

Each noise study area will be evaluated to determine whether abatement is both feasible and reasonable. This evaluation will be performed during the NEPA analysis phase of project development. A statement of likelihood will be included in the final environmental document indicating that the final determination on the location, height, length, and noise reduction performance will be made during the final design phase of project development. Changes in the final design of a project will be re-evaluated for their effects on noise levels and to determine if noise abatement is still feasible and reasonable. After Semi-Final Review, there should be no further changes to the barrier alignments. If there are any modifications to the barrier alignment after Semi-Final Review, then the barrier alignments will not be evaluated further for reasonableness, unless approved by MDOT SHA, since a barrier commitment will have already been made at this point.

For detailed information on MDOT SHA's barrier performance objectives and design methodology, see **Appendix C**.

5.1 Benefited Residences

The number of (equivalent) benefited residences is used in the determination of both the feasibility and the reasonableness of an abatement measure. The total number of benefited residences will be the sum of the following:

(1) The number of impacted and non-impacted residences that receive a 5 dB(A) or greater noise reduction.

(2) The corresponding equivalent residences, consisting of impacted and non-impacted non-residential noise sensitive facilities (i.e., Category C land uses, or activities as defined in 23 CFR 772) that would benefit from abatement by receiving a 5 dB(A) or greater noise reduction.

5.2 Feasibility Criteria

Feasibility of noise abatement is defined as the engineering and acoustical ability to provide effective noise reduction, whether it is possible to construct an abatement measure (i.e., noise barrier) given site constraints, and whether a minimum acceptable level of noise reduction can be achieved. Noise abatement measures, such as noise barriers, earth berms, berm and noise barrier combinations, or soundproofing (as provided in 23 CFR 772.15 for Category D activities) to mitigate interior noise impacts, will be evaluated for all impacted sites.

The following criteria will be used in determining if noise abatement is feasible.

5.2.1 <u>Acoustical Considerations</u>

For a residence to be considered benefited, the residence must receive a noise reduction of at least 5 dB(A). For abatement to be considered feasible, at least 70 percent of the <u>impacted residences</u> must be benefited. Extensive laboratory research and testing has determined that a 5 dB(A) reduction in noise is readily discernable by the average person. Blocking the line-of-sight between the highway and adjacent residences will typically yield a 5 dB(A) noise reduction.

Where other non-highway noise sources are present (such as near aircraft flight paths or a major rail freight line, for example), a noise barrier may be judged as not feasible, if the non-highway sources dominate and the overall level of noise in the subject area remains unchanged, or marginally reduced, even with the substantial reduction of the traffic noise. Such situations would be judged on a case-by-case basis; consideration is given to such factors as the nature of the non-highway noise sources, intensity, duration, the frequency of occurrences or events and the specific conditions at the subject residence(s).

5.2.2 Safety and Access Considerations

Construction of a noise barrier may not be feasible where access from adjacent properties or local cross streets would require gaps or breaks in the barrier system, such that effective noise reduction at impacted residences cannot be achieved.

Construction of a noise barrier may not be feasible where such construction would diminish safety, such as limiting sight distance or reduction of a vehicle recovery area, for which there are no viable engineering solutions or countermeasures.

5.2.3 Site Constraints

Site constraints are circumstances or conditions associated with a potential noise barrier site that would require additional engineering solutions or expenditures in order to support the construction of the barrier. This assessment determines whether it is physically possible to construct an abatement measure in the necessary location. Possible site constraints include:

(1) Topography;

(2) Drainage (would the barrier reduce or eliminate the effectiveness of a drainage system);

(3) Utilities (would the barrier displace any major utilities); and

(4) Maintenance (would the barrier allow for necessary maintenance and inspection operations).

If a site constraint is present, avoidance and minimization efforts are explored to allow for the placement of the barrier. If it is determined that the barrier construction will require excessive atypical extra costs, an extra-cost assessment (ECA) must be completed **following approval by the MDOT SHA Noise Working Group**. An allowable budget for the extra-costs is determined using the methodology detailed in **Appendix E**. If the actual extra-costs are below the allowable budget, then the barrier meets cost effectiveness and will be carried forward.

5.3 Reasonableness Criteria

A reasonableness decision is based upon a combination of social, economic and environmental factors. The provisions of 23 CFR 772 define three specific factors that all states must consider in the determination of reasonableness: the viewpoints of benefited property owners and residents; the number of impacted residences achieving the design goal; and cost effectiveness. All three reasonableness factors must collectively be achieved for a barrier to be considered reasonable.

5.3.1 Viewpoints of Benefited Property Owners and Residents

Prior to Semi-Final Review, the views and opinions of all benefited property owners and residents (those determined to receive at least a 5 dB(A) noise reduction) will be solicited through public involvement and outreach activities to determine if the benefitted property owners/residents are "for" or "against" noise abatement for their community. If MDOT SHA receives opposing viewpoints from any impacted and benefited residents within a Noise Sensitive Area (NSA), a voting process will be administered. However, a voting process will not be administered based solely on the request of a non-impacted and benefited resident. Further details on the voting process are found in **Appendix F**.

5.3.2 Noise Abatement Design Goal

The number of impacted residences, including equivalent residences, that must be benefited by a minimum 7 dB(A) noise reduction shall be at least three (3) or 50 percent, whichever is greater. A noise abatement measure must achieve this noise abatement design goal in order to be considered reasonable, since anything less would either be protecting an area too isolated or would fail to provide design goal abatement to at least half of an impacted area. The number of non-impacted residences that must be benefited by 7 dB(A) or more is zero (0). Requiring noise abatement measures to achieve design goal abatement at non-impacted residences may unnecessarily increase costs.

While this goal is deemed the minimum acceptable, MDOT SHA may also consider a desirable goal of 10 dB(A) that will be pursued where practical. For residences with noise levels at or above 75 dB(A) (also known as "higher absolute noise levels"), the minimum design goal reduction of 7 dB(A) would not reduce the level to below 66 dB(A), leaving the residence "impacted" in the post-abatement condition. This approach would be considered on a case-by-case basis, in coordination with MDOT SHA, subject to a full assessment of the circumstances and conditions associated with the residence(s), and whether the benefits of greater noise reduction are justified.

NOTE: Barrier systems that could protect areas with less than three impacted residences are automatically deemed not reasonable and require no further analysis.

5.3.3 Cost Effectiveness

The provisions of 23 CFR 772 require each state to establish a method to judge the "cost reasonableness" of noise abatement that is uniformly and consistently applied statewide. MDOT SHA considers the quantity (square footage) of noise barrier, as opposed to a cost-based metric, since material costs fluctuate over time and there are regional variations in prices. Evaluating the *square footage of barrier per benefited residence* (SF-p-r) eliminates the issue of variable costs, while maintaining a cap on barrier quantity.

MDOT SHA sets the appropriate barrier quantity cap (*evaluation threshold*) based on the degree and extent that the subject Type I highway project changes the existing noise environment. The threshold can increase from a baseline allowance of 700 SF-p-r up to a maximum possible allowance of 2700 SF-p-r as shown in Table 3.

Table 3	Cost Reasonableness Evaluation Thresholds	
Baseline – applies to **ALL** Type I Projects	**NONE** of the conditions is present	700 SF-p-r
Condition • The project increases through capacity. • The project increases noise levels by a minimum of 3 dB(A) from existing to future build conditions. • The project results in noise levels at or above 75 dB(A).	Only **ONE** of the conditions is present	1700 SF-p-r
	TWO OR MORE of the conditions are present	2700 SF-p-r

The evaluation threshold is independently determined for each proposed barrier system based upon the project characteristics affecting the noise environment. If a studied barrier system protects areas that fall under different conditions, the analysis will use the higher evaluation threshold in the assessment of barrier reasonableness.

The maximum allowance of 2700 SF-p-r applies when improvement details are generally vague or unknown for a project in the early planning stages. However, the development of a finalized project scope of work will require an analysis revision.

Re-evaluation of Barriers Close to the Reasonableness Threshold

Barriers evaluated during the NEPA Process that are within 5 percent of the appropriate reasonableness threshold will be earmarked for re-evaluation during final design. This is due to the inherent uncertainty associated with the early stages of a project, and the fact that more detailed information available during final design could change the reasonableness determination that was made during the NEPA stage for barriers close to the threshold.

5.4 Berms

A berm is a long mound of earth with a flat top, running parallel to the highway. Berms can provide the same amount of noise reduction as a wall. Depending on the project, they can be a more cost-effective option, particularly for projects with spoils (excess fill material). However, berms can require a significant amount of right-of-way, depending on the slope, top width, etc., and therefore may not be the best choice in some areas. **Appendix G** includes guidelines for evaluating earth berms, including berm-wall combinations, as noise abatement measures.

5.5 Existing Barriers

5.5.1 Analysis of Existing Barriers

Analysis of noise impacts along an existing highway that is being improved may include evaluating the effectiveness of previously constructed (i.e., existing) noise barriers. For analyses where there are existing noise barriers within the project study area, the existing barriers are treated and defined within the Traffic Noise Model (TNM) just as any other existing geometric or structural element in the area. The existing levels (with the barrier in place) and "no barrier" levels must be determined and the effectiveness of the barrier (i.e., insertion loss provided) assessed considering current criteria. The barrier assessment will focus on whether the existing barrier system meets the current prevailing design goal noise reduction criteria under the proposed highway improvements (as described in FHWA guidance FHWA-HEP-12-051[13]). Specific considerations are as follows:

(1) If there are no noise impacts identified behind the existing barrier, no further consideration is required.

(2) If noise impacts are found behind the existing barrier, it must be determined if the design goal requirements are met; if so, no further action is required.

(3) If noise impacts are found behind the existing barrier, but the analysis shows that the design goal requirements are NOT met, then retrofitting or replacement of the existing barrier must be considered, subject to satisfying all current criteria for feasibility and reasonableness. If all feasibility and reasonableness criteria cannot be met, the existing barrier shall remain unchanged.

(4) In the assessment of reasonableness involving an existing barrier, ALL residences that were judged as benefited under the criteria in effect at the time of the original barrier approval will be included in the total benefited count.

Appendix H outlines the procedures for evaluating the acoustic performance of existing barrier systems that are associated with a Type I project.

5.5.2 Modification of Existing Barriers

If the results of the existing barrier analysis determine that a barrier modification (extension and/or profile change) is required, the performance of the modified barrier will be compared to the performance of the existing barrier in order to determine the number of benefited residences and the number meeting the design goal for only the modification. This information will establish the barrier modification's Zone of Influence (ZoI_{mod}), as described in **Appendix H**. Only the residences within the ZoI_{mod} are used in the feasibility and reasonableness determination for the barrier modification. This is done for two reasons: one, it can reduce the amount of existing barrier that needs to be modeled; and two, it ensures that benefits are not overestimated.

5.5.3 Replacement of Existing Barriers

In cases where an existing barrier (including those built by developers, as described below in Section 5.5.4) is impacted by proposed roadway improvements, the goal is to have no net loss of protection for the impacted and benefited residences.

Note also that removal of a barrier would be considered a Type I project per 23 CFR 772 under Substantial Vertical Alteration ("removing shielding between a receptor and noise source and exposing the line-of-sight"). This would not be the case if the land use behind the barrier has changed and is no longer noise sensitive.

For barriers replaced on existing (barrier) alignment, the following objectives must be met:

(1) Sufficient protection will be provided to ensure that a property which was not impacted behind the existing barrier, remains not impacted behind the replacement barrier.

[13] FHWA-HEP-12-051, Consideration of Existing Noise Barriers in a Type I Noise Analysis, 2012

(2) Sufficient protection will be provided to ensure that a property which was benefited by the existing barrier, remains benefited by the replacement barrier.

(3) Sufficient protection will be provided to ensure that a property experiences the same level of abatement (i.e., the with-barrier noise levels will not increase).

(4) Sufficient protection will be provided to maintain line-of-sight blockage for previously benefited properties.

In cases where an existing noise barrier must be physically relocated on a new alignment, the goal is the same as above, to have no net loss of protection for the previously benefited residences. The following steps must be followed:

(1) Analyze a new barrier design according to the standard noise abatement performance objectives (**Appendix C**) and the feasibility and reasonableness criteria. If this design meets feasibility and reasonableness criteria and provides the same or better protection for the impacted and benefited residences, move forward with this design.

(2) If the barrier analyzed in Step 1 meets feasibility and reasonableness criteria but does not provide the same level of protection (i.e., insertion loss) as the original barrier, modify this design to provide the same level of protection while still meeting feasibility and reasonableness criteria. If such a design is not possible, move to Step 3.

(3) If the barrier analyzed in Step 1 and/or Step 2 was determined to not meet feasibility and/or reasonableness criteria, analyze a barrier design that, at a minimum, provides the same level of protection as the original barrier. Reasonableness is NOT considered in this barrier assessment. MDOT SHA has committed to replacing any barrier impacted by a roadway project, if it is feasible to do so.

NOTE: Should the noise-sensitive uses behind the original wall be displaced or removed, or the overall land use changes such that it is no longer noise sensitive, a new analysis would be conducted, and a full assessment of feasibility and reasonableness would be required.

5.5.4 Developer-Built Barriers

In the case of developer-built noise barriers within the MDOT SHA right-of-way for which MDOT SHA assumes ownership upon completion, and responsibility for future maintenance and potential replacement, the same specific considerations outlined above would apply.

Should a developer-built noise barrier not owned by MDOT SHA or outside of MDOT SHA right-of-way be impacted by highway expansion, compensation and the final disposition of the affected noise barrier would be handled through the normal right-of-way negotiation process.

5.5.5 Maintenance of Existing Barriers

FHWA’s Highway Traffic Noise: Analysis and Abatement Guidance (December 2011), Appendix C states, "The FHWA approved highway traffic noise abatement measures include creating buffer zones, constructing barriers, installing noise insulation in buildings, and managing traffic. With the exception of noise insulation, the highway agency must maintain the noise abatement measure in perpetuity."[14]

6.0 INNOVATIVE CONTRACTING PROJECTS

Innovative Contracting incorporates new practices to supplement traditional low-bid, design-bid-build contracting. Innovative contracting can decrease project delivery time, reduce construction time, improve safety, incorporate innovation, and reduce costs.

To allow for the maximum level of ingenuity, MDOT SHA has developed Barrier Optimization Guidelines to be used by contractors working on innovative contracting projects. Barrier Optimization Guidelines are intended to provide the contractor with a preliminary barrier design, developed during the technical analysis, along with performance specifications that must be maintained in the final barrier design. The contractor is then free to modify the horizontal and/or Top of Wall configuration of the noise barrier, within the established barrier optimization guidelines.

Appendix I provides detailed guidance for development of project-specific barrier optimization guidelines.

7.0 PRACTICAL DESIGN AND VALUE ENGINEERING

MDOT has adopted a Practical Design Policy, effective September 30, 2016.[15] The Practical Design Policy establishes the following rules:

(1) Every project will make the facility safer after its completion.

(2) The design solution shall be reached in a collaborative environment.

(3) The design solution shall match the project need(s).

(4) Designs shall use the flexibility that exists in current engineering specifications and guidance while ensuring the minimum design thresholds are achieved.

(5) The goal cannot be to shift investment costs to maintenance. Rather, the goal should be to obtain the best value for the least cost.

The policy requires that the project be designed in such a way as to fulfill the project need at the lowest cost. This can run counter to the noise barrier design process, which has a minimum performance requirement and an ideal performance objective. To account for this discrepancy, a Barrier Performance Scoring (BPS) system has been developed. The BPS system is used to evaluate the most acoustically effective (but not necessarily least expensive) barrier design as well as the lower cost minimum barrier design. The system will rate the barrier based on its acoustic effectiveness and cost effectiveness. The detailed BPS procedures are included in **Appendix J**.

[14] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, Appendix C: Highway Traffic Noise Abatement Measures, December 2011
[15] MDOT 701 Practical Design Policy, September 30, 2016

Value Engineering

Value Engineering is a systematic method of examining performance to improve the value of projects or processes. Changes made during the practical design and/or value engineering process should not jeopardize the proposed noise barrier in terms of its acoustical profile or aesthetics. Lower cost barrier materials proposed during Value Engineering are independent of the cost reasonableness determination. Typically, commitments to acoustical profiles and aesthetics occur during the public involvement process and therefore cannot be removed from the project as the result of value engineering or as the result of the contractor requesting alternatives.

8.0 PART-TIME SHOULDER USE

Part-time shoulder use (PTSU) is a transportation system management and operations (TSMO) strategy that uses shoulders to provide additional capacity when it is most needed and preserves shoulders as refuge areas during non-congestion hours.

MDOT SHA recognizes four categories of PTSU (all categories **exclude** heavy trucks from PTSU):

(1) **Static shoulder use** for most vehicles during predetermined hours of operation (i.e., during a static period of time each day).
(2) **Static-Select-Dynamic shoulder use** for most vehicles during predetermined hours of operation (i.e., during a static period of time each day) through the use of a dynamic system that allows the *option* of select use outside of the predetermined hours, based on emergency needs (i.e., crashes, snow, flooding, evacuation) or atypical traffic conditions.
(3) **Bus-only shoulder use** (Bus on Shoulder, or BOS) to improve bus travel time and reliability.
(4) **Dynamic shoulder use** for most vehicles based on need and real-time traffic conditions.

The noise impact and abatement evaluation methodology required for each category is outlined in **Appendix K**.

9.0 ADDITIONAL CONSIDERATIONS

9.1 Revisions to Guidelines

MDOT SHA will update and amend these guidelines as needed, and any changes or revisions will be discussed with FHWA prior to their implementation. MDOT SHA also has approved methodologies to ensure compliance with the noise policy and these Guidelines, which are used for conducting noise analyses and compiling technical noise reports. Since these methodologies do not involve policy interpretation, they can be revised or amended at any time independent of FHWA.

9.2 Project Grandfathering

Grandfathering refers to a provision wherein a project analyzed under a previous version of the MDOT SHA *Highway Noise Policy* continues to be subject to that older policy for future re-evaluations. This applies only to Type I projects. For a project to be eligible, there must be a finalized noise technical report. To determine the eligibility and applicability of grandfathering, consultation with the MDOT SHA Noise Working Group is required to determine whether the analysis needs to be revised according to the current policy (newest version). In most cases, a comparison of the results under the different policies will need to be prepared. The final decision on Policy applicability will be made on a case-by-case basis and will require concurrence from FHWA.

9.3 Interim Improvements and Project Phasing

For large projects that are broken into phases for design and/or construction, the following guidelines generally apply.

(1) If a large corridor study is subsequently broken down into smaller projects for design, the re-evaluation of the noise impacts and abatement must include the same limits as the NEPA re-evaluation document. For example, if a 10-mile corridor widening project received NEPA approval, but only 2 miles of corridor improvements are being advanced to final design, the noise re-evaluation should focus on that 2-mile segment. Subsequent phases of the project will be re-evaluated and re-analyzed for noise impacts when they advance to final design.

(2) For projects that are broken down into smaller contracts, primarily for ease of funding, construction of corresponding noise abatement measures must occur either in the same contract with the Type I action or within a previous construction contract. Based on the recommendation of the MDOT SHA Noise Working Group, the project manager must receive concurrence from FHWA if the construction of noise abatement is proposed to be delayed to a later phase.

9.4 Barrier Enhancements

MDOT SHA will consider aesthetic and/or functional enhancements to a proposed noise barrier made at the request of the community or local officials under certain conditions or circumstances. In general, if such enhancements are proposed, any associated additional cost would need to be borne by the requesting party or entity. Examples of such enhancements include:

(1) Use of specially designed artistic or theme-oriented concrete formliners; and

(2) Alteration of barrier design elements (length, height, location) that would require additional expense to preserve required acoustical performance.

Exceptions to this requirement include enhancements/treatments proposed as mitigation for impacts related to significant historic properties protected under Section 4(f) of the US DOT Act (1966) or Section 106 of the NHPA or the use of transparent barrier material to preserve scenic vistas of public interest or benefit.

Consideration of absorptive surface treatments for noise barriers will be given under the following circumstances:

(1) Where a detailed analysis of parallel barrier system effects indicates a degradation of at least 2 dB(A) or more at critical receptors (as defined on a project-specific basis), or where the noise barrier width-to-height ratio is less than 10:1 (as per FHWA guidance[16]). For

[16]FHWA Highway Noise Barrier Design Handbook Section 3.5.4 Barrier Design Acoustical Considerations – Reflective vs. Absorptive, February 2009

example, two barriers that average 15 feet high (relative to the roadway elevation) would need to be 150 feet or more apart to avoid potential substantial degradation of barrier effectiveness due to multiple reflections between the two walls.

(2) Where a noise barrier is proposed on the opposite side of the highway from an ineligible, or non-impacted community. Past experience has demonstrated a potential perception issue with this scenario, which elicits strong negative public reaction from the non-eligible or non-impacted residents across the highway from the barrier.

(3) Consideration of absorptive surface treatments may also be applicable to any substantially large reflective surface associated with typical highway infrastructure such as retaining walls or bridges, as determined on a case-by-case basis.

9.5 Local Government Coordination

Copies of all technical noise analysis reports (the results of which are summarized in the final environmental document) will be provided to the appropriate local jurisdiction to inform them of projected future noise levels within the project limits, and to assist and inform local officials in land use decisions and approvals that are compatible with current and future environmental noise conditions[17].

Documentation of future highway traffic noise levels is required for all Type I projects and must be shared with local officials for purposes of informing and guiding future local land use decisions. The analysis must at a minimum document the distance from the subject highway that future noise levels would reach 71 dB(A) and 66 dB(A) for Category G (undeveloped) lands.

9.6 Project/Internal MDOT SHA Coordination

For all projects, early coordination between the project manager and the Noise Abatement Design and Analysis Team is imperative. If barriers can be factored into the project design earlier in the process, projects will save time and money by eliminating costly redesigns later in the process.

[17] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Section 17: Information for Local Officials

Absorptive Noise Panel – A noise barrier panel that absorbs a substantial portion of incident sound rather than reflecting all incident sound.

Approach – Defined by MDOT SHA as one dB(A) below the set FHWA noise abatement criteria (e.g., highway traffic noise abatement consideration is warranted at 66 dB(A) for Land Use Activity Category B receptors). See **Table 2** for Noise Abatement Criteria (NAC) levels. Note that values of 65.50 to 65.9 are rounded to 66 dB(A).

Average Pavement – Related to roadway input for the FHWA Traffic Noise Model (TNM), it is a pavement type consisting of reference energy mean emission level (REMEL) data measured on dense-graded asphalt concrete (DGAC) and Portland cement concrete (PCC) pavements COMBINED. It is the default pavement type assigned to all TNM roadway geometric input.

Automobile or Light Truck – A vehicle with two axles and four wheels designed primarily for transportation of nine or fewer passengers (automobile) or transportation of cargo (light truck). Generally, the gross vehicle weight is less than 4,500 kilograms (10,000 pounds).

Auxiliary Lane – The portion of the roadway adjoining the through-traveled way for parking, speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through-traffic movement. The width of an auxiliary lane typically is equal to that of a through-traffic lane. Per FHWA guidance, an auxiliary lane classifies as a Type I project if it is 2,500 feet or longer.

Avoidance – An act of keeping away from, escaping, evading, and preventing something. In the context of highway noise analysis, any action that would limit or reduce existing or future noise levels to below a defined impact threshold.

Background Noise – Noise including ALL sources in the environment such as rustling leaves, children playing, local traffic, dogs barking, aircraft flyovers, lawn-mowing, etc. Background noise can impose a lower limit on the perceived effectiveness of a noise barrier, especially for receptors more distant from the highway where overall noise levels from the project are lower. TNM Output must be evaluated and adjusted (if necessary) for background noise so that a barrier's effectiveness is not unrealistically overstated.

Benefited Receptor – The recipient of an abatement measure that receives a noise reduction at or above the minimum threshold of 5 dB(A). A benefited receptor may be either impacted or non-impacted.

Bus/Recreational Vehicle – Any single-unit bus, articulated bus, school bus, motor home, or motor home pulling a trailer or boat.

Critical Sensitive Receptors – Critical sensitive (CS) receptors are typically defined as first-row, ground-level sites (5 feet above ground, as per standard industry practice), where worst-case noise impacts are found.

Common Noise Environment – A group of receptors within the same Activity Category in **Table 2** 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, or cross-roads.

Constructive Use – Constructive use occurs when the transportation improvement project does not incorporate land from a Section 4(f) resource but the project's proximity impacts are so severe that the protected activities, features, or attributes that qualify a resource for protection under Section 4(f) are substantially impaired. Substantial impairment occurs only when the protected activities, features, or attributes of the resource are substantially diminished. The Federal Highway Administration (FHWA) is not required to determine that there is no constructive use. However, such a determination could be made at the discretion of FHWA.

Date of Public Knowledge (DoPK) – The date of approval of the Categorical Exclusion (CE), the Finding of No Significant Impact (FONSI), or the Record of Decision (ROD), as defined in 23 CFR part 771. This is the date defined to provide official notification of the public of the adoption of the location of a proposed highway project. It also defines when the highway agency is no longer responsible for providing noise abatement for “new” development adjacent to the proposed highway project.

dB(A) – The sound pressure levels in decibels measured with a frequency-weighting network corresponding to the A-scale on a standard sound level meter as specified by ANSI S1.4-1983 (1997). The A-scale tends to suppress lower frequencies (i.e., below 1,000 Hz) and best approximates the sound as heard by the normal human ear.

Design Speed – The maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of the highway govern.

Design Year – The future year used to estimate the probable traffic volume for which a highway is designed.

Environmental Documents – Documents required by the National Environmental Policy Act (NEPA) and related legislation that detail specific impacts and the severity of those impacts on the environment. These include Categorical Exclusions (CEs), Environmental Assessments (EAs), Findings of No Significant Impact (FONSIs), Environmental Impact Statements (EISs), Records of Decision (RODs), and technical reports (including those required for completion of the Section 106 of the National Historic Preservation Act process).

Existing Noise Level – The current noise level, comprised of all natural and man-made sources, considered to be usually present within a particular area’s acoustic environment, including existing roadways.

Existing Worst-Case (EWC) Noise Level – the level resulting from existing traffic conditions that produce the loudest hourly noise level.

Feasibility – The combination of acoustical and engineering factors considered in the evaluation of a noise abatement measure.

Heavy Truck – Any vehicle having three or more axles and designed for the transportation of cargo (typically a single-unit truck, truck tractor-semi trailer combination, and truck or truck tractor with a semi-trailer in combination with a full trailer). Generally, the gross weight of a heavy truck is greater than 12,000 kilograms (26,000 pounds).

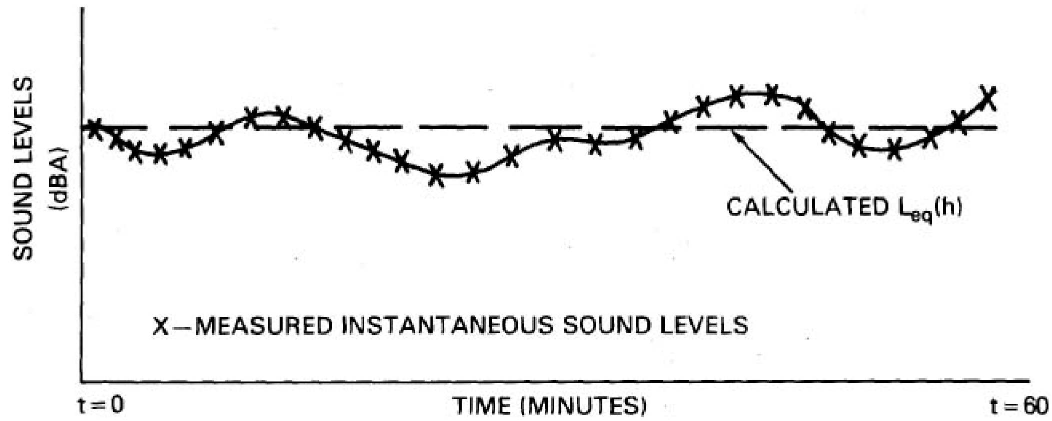
Highway Noise Contours – a graphical representation of the LOCATION or position adjacent to a roadway of a noise level of equal value, generated from highway traffic; similar conceptually to elevation contours that describe topography or terrain.

Impacted Residence – An individual residence that has a future design year noise level that approaches or exceeds the NAC and/or that experiences a substantial noise level increase of 10 dB(A) or more above existing noise levels.

Insertion Loss (IL) – The actual acoustical benefit derived from the presence of a noise barrier.

Leq(h) – The equivalent steady-state, A-weighted sound level which contains the same amount of acoustic energy as the actual time-varying, A-weighted sound level over a one-hour period, as depicted in the illustration below.

Chart A.1 Sound Level Versus Time



Source: http://www.fhwa.dot.gov/environment/noise/construction_noise/special_report/hcn02.cfm

Limit Receptors – Limit receptors are those that may have noise levels just below the NAC or may lie just outside a particular property or NSA. Limit receptors may be used in conjunction with Critical Sensitive receptors to more fully develop a barrier design. Their use helps ensure adequate protection is provided to the full extent of a targeted area when CS receptors alone could leave gaps in the coverage.

Line-of-Site (l-o-s) – An unobscured straight line between the observer location and a specific noise source.

Lmax – The highest sound pressure level, in dB(A), for a specific time period.

Loudest-Hour – A period of 60 consecutive minutes throughout a 24-hour period that reflects the peak noise hour. This period is often, but not always, associated with the peak traffic hour.

Medium Truck – A vehicle having two axles and six wheels designed for the transportation of cargo. Generally, the gross vehicle weight of a medium truck is greater than 4,500 kilograms (10,000 pounds) but less than 12,000 kilograms (26,000 pounds).

Multifamily Dwelling – A residential structure containing more than one residence. Each residence in a multifamily dwelling is counted when determining impacted and benefited residences.

National Environmental Policy Act (NEPA) – Federal legislation that establishes environmental policy for the nation. It provides an interdisciplinary framework to ensure that decision-makers adequately take environmental factors into account. The level of documentation for federally-aided projects is influenced by the impact the project may have on the surrounding natural, cultural, and social environment.

Noise Abatement Criteria (NAC) – Noise levels for various activities or land uses that represent the upper limit of acceptable highway traffic noise levels. The NAC are absolute values which, when approached or exceeded, identify highway traffic noise impacts and require the consideration of highway traffic noise abatement measures.

Noise Barrier – A physical obstruction that is constructed between the highway noise source and the noise sensitive receptor(s) that lowers the noise level. Noise barriers include stand-alone noise walls, noise berms (earth or other material), and combination berm/wall systems.

Noise Level Descriptor –The hourly equivalent sound level, Leq(h). Leq(h) is the steady-state, A-weighted sound level which contains the same amount of acoustic energy as the actual time-varying, A-weighted sound level over a one-hour period.

Noise Reduction Coefficient (NRC) – A single number rating of the sound-absorptive properties of a material.

Noise Reduction Design Goal – The optimum desired dB(A) noise reduction determined from calculating the difference between future build noise levels with abatement, to future build noise levels without abatement. While MDOT SHA has established its noise reduction design goal as 7 dB(A), it encourages designs of noise abatement measures that provide higher levels of abatement as long as those designs meet all feasibility and reasonableness criteria.

Noise Sensitive Area (NSA) – A group or grouping of like noise-sensitive land uses into common areas subject to similar noise influences throughout the entire project limits, includes Land Use Activity Categories A, B, C, D, and E.

Non Noise-Sensitive Area (non-NSA) – A group or grouping of like land uses that are not noise sensitive into common areas throughout the entire project limits, includes Land Use Activity Categories F and G.

Operating Speed – The highest overall average speed at which drivers travel on a given highway under favorable weather conditions and under prevailing traffic conditions without at any time exceeding the safe speed as determined by the design speed on a section-by-section basis.

Permitted – A term used to describe a definite commitment to develop land with an approved specific design of land use activities as evidenced by the issuance of a building permit.

Posted Speed – The maximum allowable speed limit for a specified section of highway that is posted and enforced by the appropriate law enforcement agency.

Property Owner – An individual or group of individuals that holds a title, deed, or other legal documentation of ownership of a property or a residence.

Reasonableness – The combination of social, economic, and natural environmental factors considered in the evaluation of a noise abatement measure.

Receptor – A discrete or representative location of a noise sensitive area(s), for any of the land uses listed in **Table 2**.

Reflective Noise Panel – A noise barrier panel that reflects incident sound rather than absorbing a significant portion of the incident sound.

Residence – A dwelling unit. The term can mean either a single-family residence or each dwelling unit in a multifamily dwelling.

Section 4(f) – A provision of the Department of Transportation Act (DOT Act) of 1966 that prohibits FHWA and other DOT agencies from approving the use of certain environmental resources, historical sites, and publicly-owned for highway projects unless “there is no prudent and feasible alternative” and actions are taken to minimize harm to those properties. Section 4(f) protects the following basic types of properties: publicly owned park and recreation areas that are open to the general public, publicly owned wildlife and waterfowl refuges, and public or privately-owned historic sites (including residences) that are listed in, or eligible for, the National Register of Historic Places.

Statement of Likelihood – A statement provided in the environmental clearance document based on the feasibility and reasonableness analysis completed at the time the environmental document is being approved.

Study Area – For noise study purposes, is the area within a minimum of 500 feet from the proposed edge of pavement of the roadway improvements as defined by the roadway construction limits. Highway traffic noise assessments include all receptors within the study area.

Substantial Changes in Horizontal and Vertical Alignment – Substantial horizontal alignment changes are those which halve the distance between the roadway (noise source) and closest receptor. Substantial vertical alignment changes are those which remove existing shielding or change the topography thereby exposing the line-of-sight between the roadway (noise source) and closest receptor. Removal of an existing noise barrier qualifies as a substantial vertical alignment change, because that action removes shielding between a noise source and receptor.

Substantial Noise Increase – An increase of 10 dB(A) above existing levels resulting from the Build Alternative in the design year.

Traffic Noise Impact – Design year “build” condition noise levels that approach or exceed the NAC listed in **Table 2** for the future “build” condition; or design year “build” condition noise levels that create a substantial noise increase over existing noise levels.

Through-Traffic Lane – A continuous main lane, including high-occupancy vehicle (HOV) lanes or frontage roads. Through-traffic lanes exclude lanes for parking, speed change, turning, storage for turning, weaving, and other purposes supplementary to through-traffic movement.

Type I Project –

(1) The construction of a highway on new location; or,

(2) The physical alteration of an existing highway where there is either:

> (i) Substantial Horizontal Alteration. A project that halves the distance between the traffic noise source and the closest receptor between the existing condition to the future build condition; or,
>
> (ii) Substantial Vertical Alteration. A project that removes shielding therefore exposing the line-of-sight between the receptor and the traffic noise source. This is done by either altering the vertical alignment of the highway or by altering the topography between the highway traffic noise source and the receptor; or,

(3) The addition of a through-traffic lane(s). This includes the addition of a through-traffic lane that functions as a HOV lane, High-Occupancy Toll (HOT) lane, bus lane, or truck climbing lane; or,

(4) The addition of an auxiliary lane, except for when the auxiliary lane is a turn lane; or,

(5) The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange; or,

(6) Restriping existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane; or,

(7) The addition of a new or substantial alteration of a weigh station, rest stop, ride-share lot or toll plaza.

(8) If a project is determined to be a Type I project per § 772.5 then the entire project area as defined in the environmental document is a Type I project.

Type II Project – A Federal or Federal-aid eligible highway projects to address existing noise impacts for communities adjacent to existing fully controlled-access highways not being expanded, where the majority of the impacted development was built prior to the original construction or approval of a highway. For a Type II project to be eligible for Federal-aid funding, the highway agency must develop and implement a Type II program in accordance with 23 CFR Part 772.7(e).

Type III Project – A Federal or Federal-aid highway project that does not meet the classifications of a Type I or Type II project. Type III projects do not require a noise analysis.

PURPOSE

To describe MDOT SHA's Type II Program. MDOT SHA has established a Type II, or retrofit, noise abatement program, as provided for in the Federal regulation (23 CFR 772). The Type II Program addresses existing noise impacts for communities adjacent to existing fully controlled-access highways not being expanded, where the majority of the impacted development was built prior to the original construction or approval of a highway. MDOT SHA considers eligibility and local participation requirements in administering the Type II program.

DEFINITION

Type II projects are Federal or Federal-aid eligible highway projects for noise abatement on an existing highway. Participation in a Type II Program is voluntary; for a Type II project to be eligible for Federal-aid funding, the highway agency must develop and implement a Type II program in accordance with section 772.7(e), which includes establishing a priority rating system for Type II abatement projects[1]. Programming for the analysis, design and construction of Type II noise abatement will be based upon the availability of funds in the Maryland Department of Transportation's Consolidated Transportation Program (CTP).

ELIGIBILITY CRITERIA

(1) New Type II projects will only be approved for local jurisdictions that have implemented controls or regulations to prevent the construction of new noise sensitive development adjacent to State highways.

(2) Communities must be adjacent to an existing fully access controlled highway; where ingress and egress to the highway is via grade-separated interchanges.

(3) Since the Type II program is voluntary (not required in 23 CFR 772), potential project areas are considered based upon citizen, community or elected official request or inquiry. Requests will automatically be subject to the eligibility requirements as established in the MDOT SHA Highway Noise Policy and these planning and engineering guidelines. Only project areas meeting these basic criteria will be investigated further.

(4) A majority of the subject receptors (greater than 50%) must pre-date the original construction of the highway, OR the "system opening date," of the subject highway (as appropriate). Historically, the major highway systems were built in sections, often over a span of a number of years. As a result, many early sections when first completed functioned and served more as local transportation links, with limited overall traffic volumes and larger trucks serving primarily local destinations and purposes. Once all sections were linked, the influence of increased interstate trucking, and greater volumes of traffic in general increased the potential level and duration of noise impact. If this criterion is not met, no further action or analysis is considered.

(5) Existing noise levels must reach or exceed the NAC (as defined in Table 2 of these guidelines). In general, residential land uses (Category B) are the primary focus of Type II noise abatement. Some Category C uses (schools, places of worship, day care centers, parks, etc.) may also be included, subject to an assessment of prevailing sensitive uses, and other factors considered as part of a feasibility-reasonableness assessment.

[1] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Section 7: Applicability

LOCAL PARTICIPATION

(1) The Type II program only applies to communities in counties with development regulations or land use controls requiring the provision of noise protection for new noise sensitive development adjacent to state highways. MDOT SHA will provide assistance to local jurisdictions in the development of such regulations or controls to promote consideration of highway noise in land use and zoning decision-making. This assistance may be in the form of any of the following:

- Review of comprehensive plans, rezoning or site development or subdivision plans.
- Providing information on present and future noise levels adjacent to state highways.
- Technical support in the development of local noise control programs or regulations.

(2) At least 75% of the potentially impacted homes in a community that are adjacent to the highway must provide written concurrence before preliminary engineering will be initiated.

(3) Right-of-way that may be required for the construction or permanent location of Type II noise abatement must be donated to the State, including necessary easements for barrier maintenance, and utility relocations.

(4) The County/local jurisdiction must agree to share in 20% of the overall cost of a Type II project, subject to available State funding. To maintain consistency with the provisions of 23 CFR 772, it is reiterated that this cost-sharing provision is ONLY applicable to projects that satisfy reasonableness limits; it cannot be applied to any project that exceeds reasonableness limits[2].

EVALUATION METHODOLOGY

When a request for consideration is received, subject to the availability of CTP funding, the MDOT SHA will mail vote cards to the property owners of improved noise sensitive parcels, adjacent to the highway, informing them of the request, and will solicit a vote for or against performing an analysis. This commitment will entail a study of noise levels to determine the degree of noise impact and whether a barrier is feasible and reasonable.

As with Type I projects, three basic determinations are made in the evaluation of the effects of highway traffic noise on communities and other noise sensitive land uses and activities:

(1) Degree and extent of noise impact (if any).

The detailed analysis of highway noise impacts will determine whether the existing noise levels reach or exceed the applicable Noise Abatement Criteria (NAC, as defined in Table 2) for the affected land use/activity categories.

(2) Feasibility of noise abatement to address the identified impacts. Assessment of feasibility will usually be completed prior to an assessment of reasonableness.

The feasibility assessment process is the same as that described in Section 5.2 for Type I projects.

[2] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Section 13(j): Analysis of Noise Abatement, Third Party Funding

(3) Reasonableness of noise abatement to address the identified impacts.

The reasonableness assessment process is similar to that described in Section 5.3 for Type I projects, with two exceptions:

- *Voting is done prior to initiation of impact analysis; and*
- *The evaluation threshold used to determine cost effectiveness is* ***2700 square feet****. Cost reasonableness conditional evaluation thresholds do not apply to Type II projects because there is no proposed improvement to the subject highway.*

PRIORITY RATING SYSTEM FOR TYPE II PROJECTS

The provisions of the Federal regulation (23 CFR 772) require all states with a Type II noise abatement program to have a system to prioritize candidate projects based on a number of factors. To be compatible with the MDOT SHA provision regarding the county cost-share requirement, the statewide priority list will also be considered on a county-by-county basis.

Priority Ranking Score

The Type II Priority System is based on a Priority Ranking Score (PRS) that has a maximum possible value of 100.0 points. Three ***scoring factors*** and three multipliers are used to develop the PRS using the following equation:

$$\mathbf{PRS} = \left((\mathbf{4} \times \boldsymbol{DNI}) + (\mathbf{PDP} \times \boldsymbol{LOE}) + \boldsymbol{SFR}\right) \times \mathbf{LNO} \qquad \text{Equation B.1}$$

Each of the factors and multipliers are discussed in detail below along with examples. This score is independent of funding availability, which will vary based on the local jurisdiction’s ability and willingness to participate in the Type II program.

Degree of Noise Impact (DNI) Scoring Factor

DNI is determined from the weighted-average noise level for all impacted residences (those experiencing at least 66 dB(A)). Each non-residential impacted property will be counted as a single impacted residence. Residences are grouped within four impact ranges, increasing in 3 dB(A) increments. Typically, sound level changes between 2 and 3 dB(A) are barely perceptible if the sounds are of similar character, while a change of 5 dB(A) is readily noticeable by most people. A 10 dB(A) increase is generally perceived as a doubling of loudness (“twice as loud”).

In determining the average, the lower limit of the range plus one-and-a-half decibels (to represent the middle of the range) is used for each residence listed within the range. For example, if a residence is listed as experiencing a 72-75 dB(A) impact, then 73.5 dB(A) would be used for that residence when determining the weighted-average noise level. In order to prioritize areas experiencing higher noise levels, an exponential weighting adjustment is applied to the value for each residence.

TABLE B.1	Degree of Noise Impact (*DNI*) Scoring Factor		
Impact Range (dB[A])	**Value Used to Develop Average (dB[A])**	**Higher Noise Levels Weighting Adjustment**	**DNI Scoring Factor**
≥75	76.5	$3^{3.0}$ = 27	10
≥72 and <75	73.5	$3^{2.0}$ = 9	7
≥69 and <72	70.5	$3^{1.0}$ = 3	4
≥66 and <69	67.5	$3^{0.0}$ = 1	1

Example B.1:

An area has 17 impacted residences: two (2) are impacted at 75 dB(A) or greater noise levels, one (1) is impacted from 72 to 75 dB(A), five (5) are impacted from 69 to 72 dB(A), and nine (9) are impacted from 66 to 69 dB(A). The straight-average noise level would be 69.8 dB(A).

1. Determine weighted number of impacted residences:
   2*27 + 1*9 + 5*3 + 9*1 = 87 weighted-impacted residences

2. Determine the interim value of the weighted noise levels multiplied by the number of impacted residences for the area:
   2*27*76.5 + 1*9*73.5 + 5*3*70.5 + 9*1*67.5 = 6457.5 dB(A)-impacted receptor

3. Determine weighted-average noise level, round to nearest tenth:
   6457.5/87 = 74.22 dB(A) → 74.2 dB(A)

4. Assign DNI Scoring Factor:
   The DNI would be 7 for a weighted-average noise level of 74.2 dB(A)

Degree of Noise Impact Multiplier

The DNI is multiplied by a factor of 4 in Equation B.1 to emphasize that the State views impacts as one of the most important components in evaluating priority. The DNI scoring factor and its multiplier could represent a maximum of 40% of the total score calculated in the PRS equation (Equation B.1).

Length of Exposure (LOE) Scoring Factor

In 1954 the Baltimore-Washington Parkway (MD 295) was the first fully-controlled access highway completed in the State of Maryland. Consequently, it is the oldest highway that can be considered in the Type II program. Based on 23 CFR 772, highway projects constructed after 1995 cannot be considered for Type II abatement[3]. This means there is a maximum relative exposure length of 41 years between 1954 and 1995; any amount of time from 1995 to the present would be irrelevant for prioritization. LOE is determined from Table B.2 below, where a 20-point scale was developed by converting the ratio of the relative exposure for each highway date (see discussion below) over the maximum relative exposure length. By multiplying the result by two and then rounding the values down, the scoring factor decreases approximately every two years.

[3] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Section 15(b)(1): Federal Participation, For Type II Projects

TABLE B.2	**Length of Exposure (*LOE*) Scoring Factor**	
Highway Date	**Relative Exposure to 1995 (Years)**	**LOE Scoring Factor**
1954	41	20
>1954 and ≤1956	39	19
>1956 and ≤1958	37	18
>1958 and ≤1960	35	17
>1960 and ≤1962	33	16
>1962 and ≤1964	31	15
>1964 and ≤1966	29	14
>1966 and ≤1968	27	13
>1968 and ≤1970	25	12
>1970 and ≤1972	23	11
>1972 and ≤1974	21	10
>1974 and ≤1976	19	9
>1976 and ≤1978	17	8
>1978 and ≤1980	15	7
>1980 and ≤1982	13	6
>1982 and ≤1984	11	5
>1984 and ≤1986	9	4
>1986 and ≤1988	7	3
>1988 and ≤1990	5	2
>1990 and ≤1992	3	1
>1992 and ≤1995	0	0

Highway Dates

Historically, the major freeway highway systems were built in sections over a number of years. As a result, many sections when first completed functioned and served more as local transportation links, with limited traffic volumes and larger trucks serving more local destinations and purposes. Once all sections were linked, the influence of increased interstate trucking, and greater volumes of traffic in general increased the potential level and duration of noise impact. MDOT SHA establishes a roadway's highway date based on when the final piece of the system was completed. Type II communities can be evaluated for highway systems that were completed prior to November 28, 1995 (the date the 1995 National Highway System Designation Act was passed). Table B.2a lists the highway dates for routes originally designed as freeways. Some contiguous routes are subdivided by roadway name, route number, and/or system completion date. These highway dates are used in Table B.2 above to determine the LOE.

Additionally, some routes were studied under the NEPA (Type I) process prior to construction. MDOT SHA limits Type II projects to areas "where the majority of the impacted development was built prior to the original construction or approval of a highway." Consequently, when calculating the predate percentage, PDP (discussed below), for these routes, the highway date based on the NEPA document approval should be used instead of the construction date. However, the length of exposure is still determined from the construction date. Table B.2a lists any applicable NEPA document dates.

TABLE B.2a Highway Dates for Routes Originally Designed as Freeways (Sorted by Route)

Route	Limits		Highway Date	Based On	Roadway Name/*Notes*
	From	To			
I-70	Pennsylvania State Line	MD 144FA	1969	Highway System Opening	
	MD 144FA	1.0 Mile West of Mussetter Road	1986 ***(1976)***	Highway Relocation ***(NEPA Document Approval)***	
	1.0 Mile West of Mussetter Road	Baltimore City Line	1969	Highway System Opening	
I-81	Virginia State Line	Pennsylvania State Line	1966	Highway System Opening	Maryland Veterans Memorial Highway
I-83	Baltimore City Line	I-695	1962	Highway System Opening	Jones Falls Expressway
	I-695	Pennsylvania State Line	1962	Highway System Opening	Harrisburg Expressway
I-95/495	Virginia State Line (Woodrow Wilson Bridge)	I-495	1964	Highway System Opening	Capital Beltway
I-95	I-495	Baltimore City Line	1971	Highway System Opening	
I-95X	Weigh Station	I-95	1971	Highway System Opening	
I-97	US 50	I-895A	1995 ***(1981)***	Highway System Opening ***(NEPA Document Approval)***	*Plans Predate 1995 (1996 Completion)*
I-195	BWI Thurgood Marshall Airport	I-95	1990 ***(1981)***	Highway System Opening ***(NEPA Document Approval)***	Metropolitan Boulevard
I-270	I-495	I-70	1964	Highway System Opening	Eisenhower Memorial Highway
I-270Y	I-495	I-270	1964	Highway System Opening	"270 Spur"
I-370	I-270	Shady Grove Road	1990 ***(1982)***	Highway System Opening ***(NEPA Document Approval)***	
I-495	Virginia State Line (American Legion Bridge)	I-95	1964	Highway System Opening	Capital Beltway
I-495X	Clara Barton Parkway	I-495	1964	Highway System Opening	Cabin John Parkway
I-695	I-97	I-95 (JFK Memorial Hwy)	1962	Highway System Opening	Baltimore Beltway
I-795	I-695	MD 140	1986 ***(1977)***	Highway System Opening ***(NEPA Document Approval)***	Northwest Expressway
MD 10	MD 2	MD 695	1987 ***(1979)***	Highway System Opening ***(NEPA Document Approval)***	Arundel Expressway
MD 32	I-97	MD 295	1993 ***(1983)***	Highway System Opening ***(NEPA Document Approval)***	

TABLE B.2a Highway Dates for Routes Originally Designed as Freeways (Sorted by Route)

Route	Limits		Highway Date	Based On	Roadway Name/*Notes*
	From	To			
	MD 295	US 29	1985 ***(1983)***	Highway System Opening ***(NEPA Document Approval)***	
	US 29	MD 108	1995 ***(1989)***	Highway System Opening ***(NEPA Document Approval)***	*Plans Predate 1995 (1996 Completion)*
MD 100	US 29	Long Gate Parkway	1994 ***(1989)***	Highway System Opening ***(NEPA Document Approval)***	
	Long Gate Parkway	**I-95**	**1998** ***(1989)***	**Highway System Opening** ***(NEPA Document Approval)***	***Postdates 1995 – Ineligible for Type II***
	I-95	I-97	1995 ***(1987)***	Highway System Opening ***(NEPA Document Approval)***	*Plans Predate 1995 (1996 Completion)*
	I-97	MD 177	1965	Highway System Opening	
MD 295	US 50	Baltimore City Line	1954	Highway System Opening	Baltimore Washington Parkway
MD 695	I-95 (JFK Memorial Hwy)	US 40 (Pulaski Hwy)	1962	Highway System Opening	Baltimore Beltway
	US 40 (Pulaski Hwy)	I-97	1977	Highway System Opening	Baltimore Beltway
MD 702	MD 695	Old Eastern Avenue	1974	Highway System Opening	Southeast Boulevard

Some highways were originally constructed as a complete system, but the characteristics of the facility have changed dramatically since then, usually transitioning from a two-lane roadway, to a dualized roadway with at-grade intersections, to finally a freeway with grade-separated interchanges. Two examples of this are Maryland Route 5 (MD 5) in Prince George's County and U.S. Route 29 (US 29) in Howard County. Any community that may have been previously studied under a Type I improvement to the facility and found to be ineligible for Type I noise abatement is ineligible for Type II noise abatement **with Federal funds**[4]. Table B.2b lists the highway dates for routes that were gradually upgraded to freeways.

TABLE B.2b Highway Dates for Routes Gradually Upgraded to Freeways (Sorted by Route)

Route	Limits		Highway Date	Based On	Roadway Name/*Notes*
	From	To			
MD 5	US 301	I-95/495	1969	Highway Dualization Completion	Branch Avenue
US 29	Montgomery County Line	MD 99	1971	Highway Dualization Completion	Columbia Pike
US 50	Washington D.C. Line	MD 70	1961	Highway System Opening	John Hanson Highway
	MD 70	MD 2	1954	Highway System Opening	John Hanson Highway
	MD 2	US 301	1954	Highway System Opening	Blue Star Memorial Highway

The routes listed in both Tables B.2a and B.2b are the ones which have been currently identified and perhaps additional routes could be added to these lists in the future.

Example B.2:

The Baltimore Beltway (MD 695) from I-97 running counter clock-wise to US 40 (Pulaski Highway) has a 1977 Highway Date based on the highway system completed with the opening of the Key Bridge. The LOE would be 8, since 1977 is older than 1976, but newer than 1978.

Example B.2a:

When a community is adjacent to two different routes with differing highway dates such as at an interchange or junction, the newer date governs. I-95 in Prince George's County at the junction with I-495 near the Montgomery County line has a 1971 Highway Date, even though the Highway Date for the Capital Beltway is 1964. The LOE for the White Oak Manor community adjacent to the I-95 ramps would be 11.

Predate Percentage (PDP) Multiplier

MDOT SHA requires that a "majority of the impacted residences" predate the highway date. This majority is defined as 50% or more, which is consistent with past practices. Thus, it is appropriate to apply a multiplier to the LOE scoring factor based on the predate percentage, applying additional weight for areas where a higher percentage of residences existed prior to the highway. To prevent severe skewing of the percentage, non-residential impacts will be counted as a single impacted residence. Table B.3 below lists the PDP values, which increase by 0.1 for each five percent (5%) increase in the predate percentage. However, if the predate percentage is less than 25% for a single community, then the PDP multiplier would automatically be zero. **A PDP of zero (0) means the project is ineligible for Type II noise abatement.** The LOE scoring factor and its PDP multiplier could represent a maximum of 40% of the total score calculated in the PRS equation (Equation B.1).

[4] Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 13, 2010, Section 15(b)(3): Federal Participation, For Type II Projects

TABLE B.3	**Predate Percentage (PDP) Multiplier**
Predate Percentage	**PDP Multiplier**
100%	2.0
≥95% and <100%	1.9
≥90% and <95%	1.8
≥85% and <90%	1.7
≥80% and <85%	1.6
≥75% and <80%	1.5
≥70% and <75%	1.4
≥65% and <70%	1.3
≥60% and <65%	1.2
≥55% and <60%	1.1
≥50% and <55%	1.0
≥45% and <50%	0.9
≥40% and <45%	0.8
≥35% and <40%	0.7
≥30% and <35%	0.6
≥25% and <30%	0.5
≥20% and <25%	**0.0**
≥15% and <20%	
≥10% and <15%	
≥05% and <10%	
≥00% and <05%	

Method to Address Type II Areas with Different Dates of Development

The FHWA Guidance recognizes that "[w]hen considering funding eligibility for Type II projects, often the 'date of the existence of development' along the highway is mixed. Some development predates the existence of the highway and some development will have occurred after construction of the original highway." The Guidance also advises "the highway agency and its respective FHWA Division Office [to] jointly establish appropriate procedures to address locations with different dates of development.[5]" In response, the MDOT SHA has established the following procedure for dealing with this issue:

The "community" will be initially defined based on subdivision plats and tax maps, which can then be expanded to a logical project limit based on common streets between adjacent areas, which indicate a coherent residential area. Abatement will be analyzed to protect the "defined" predating community, regardless of the actual construction dates of individual houses within the community. All benefiting residences or equivalent residences from the proposed abatement will be included in the square-foot per residence calculation, even those inside or outside the "defined" community limits, which may postdate the highway.

In keeping with Maryland's Smart Growth laws that seek to "support development in areas where infrastructure exists," adjacent impacted communities postdating the highway that are only partially protected from the proposed noise abatement for the predating community will be evaluated to see if the barrier can be extended to protect their community more, at the discretion of the MDOT SHA Noise Working Group. For example, a noise barrier designed to protect only a predating community needs to extend in front of eight postdating houses, some of which are actually benefited from the barrier by default, leaving

[5] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, December 2011, Section 772.5 Definitions, Type II Project Requirements

four postdating homes unprotected. While the postdating community is obviously ineligible for Type II abatement, the proposed noise barrier will create a disparity of noise levels within the community and make the traffic noise more focused and potentially more annoying. If extending the wall is feasible and still cost-effective when ALL benefiting residences are included in the calculation, the barrier will be extended, regardless of the revised predate percentage of ALL impacted residences protected as long as it is not less than 25%. However, if extending the wall would make the abatement exceed cost reasonableness limits or be infeasible, then the predating community would not be penalized for trying to support a Smart Growth requirement and the barrier's original limits would be used. This procedure cannot be used to justify approving a barrier for a **single** community that has a predate percentage less than 50%.

Example B.3:

An area has 28 impacted residences: 16 predate the adjacent 1969 highway date. The predate percentage is 57.1% (16/28), rounded to the nearest tenth. The PDP would be 1.1, since the value is greater than or equal to 55%, but less than 60%.

Example B.3a:

An area has 27 impacted residences plus one impacted school. The school predates the highway. The total number of impacted residences is 28, including the school, which counts as one impacted residence: 16 predate the adjacent highway date. The predate percentage is 57.1% (16/28), rounded to the nearest tenth. The PDP would be 1.1.

Example B.3b:

An area has 27 impacted residences plus one impacted school. The school postdates the highway. The total number of impacted residences is 28, including the school, which counts as one impacted residence: 15 predate the adjacent highway date. The predate percentage is 53.6% (15/28), rounded to the nearest tenth. The PDP would be 1.0.

Example B.3c:

An area has 17 impacted residences: all 17 predate the adjacent highway date. The predate percentage is 100.0% (17/17), rounded to the nearest tenth. The PDP would be 2.0.

Example B.3d:

A defined community has a predate percentage of 60% (6/10) based on six predating and four postdating impacted residences. A reasonable and feasible barrier is analyzed, which will protect (by default) an additional four impacted residences within an adjacent postdating community, leaving six unprotected. If the barrier is extended, the revised predate percentage would be 30% (6/20) based on six predating and fourteen postdating impacted residences. The barrier would be extended providing the cost criterion were met.

Example B.3e:

A defined community is located along a highway that was constructed after going through the NEPA approval process. However, the NEPA document did not state that noise abatement was not feasible or reasonable for the area (perhaps the area was not impacted or wasn't studied at all). If the area had been denied a barrier in the NEPA document, then the community would be ineligible for Type II consideration. The NEPA document approval date is 1977 and the highway construction date is 1986 based on the highway system opening. If the majority of the impacted residences predate the 1977 approval date, then the community is Type II eligible. However, if the majority of the community postdates the approval date then it is ineligible for Type II consideration. For further details see the following scenarios:

Scenario 1: The five impacted residences have the following year built dates: one at 1969, one at 1970, one at 1978, and two at 1983. The predate percentage is 40% (2/5=0.40) compared to the approval date and the community would be ineligible for Type II consideration.

Scenario 2: The five impacted residences have the following year built dates: one at 1969, one at 1970, one at 1972, and two at 1978. The predate percentage is 60% (3/5=0.60) compared to the approval date and the PDP would be 1.1. The LOE would be 4.

Square-Footage per Residence (SFR) Scoring Factor

The metric used to determine cost reasonableness is the square-footage (or area) per benefited residence (SF-p-r). This is calculated by dividing the total area (square-footage) of the proposed noise barrier or barrier system by the number of benefited residences and/or equivalent residences. Additionally, MDOT SHA requires that local jurisdictions must agree to fund 20% of the total engineering and construction costs before the State will consider programming funding. Accordingly, the SFR uses a 20-point scale that could represent a maximum of 20% of the total score calculated in the PRS equation (Equation B.1).

Type II projects with a lower SF-p-r are ranked higher, because they are more cost-effective. This also usually relates to the density of the community.

Projects with a square-footage per benefited residence less than 700 are rare, so the scoring factors were established between 700 and 2700. Within this range the scoring factor decreases for every 100 SF-p-r increase. This ensures that similar projects will be scored equally based on cost-effectiveness. **An SFR score of zero (0) means the project is ineligible for Type II noise abatement.**

TABLE B.4	**Square-Footage per Residence (*SFR*) Scoring Factor**
Square-Footage per Residence (SF-p-r)	**SFR Scoring Factor**
≤ 700	20
800 - 900	19
900 - 1000	18
1000 - 1100	17
1100 - 1200	16
1200 - 1300	15
1300 - 1400	14
1400 - 1500	13
1500 - 1600	12
1600 - 1700	11
1700 - 1800	10
1800 - 1800	9
1900 - 2000	8
2000 - 2100	7
2100 - 2200	6
2200 - 2300	5
2300 - 2400	4
2400 - 2500	3
2500 - 2600	2
2600 - 2700	1
> 2700	**0**

Example B.4:

Areas C, D, and E are each eligible for Type II noise abatement. Each has a square-footage per benefited residence of 1522, 1695, and 1379, respectively. The SFR would be 12 for area C, because 1522 is greater than or equal to 1500, but less than 1600. The SFR would be 11 for area D, because 1695 is greater than or equal to 1600, but less than 1700. For area E, the SFR would be 14, because 1379 is greater than or equal to 1300, but less than 1400.

Example B.4a:

An area has a square-footage per benefited residence of 2457. The SFR would be 3 for this area, because 2457 is greater than or equal to 2400, but less than 2500.

Local Noise Ordinance (LNO) Scoring Multiplier

MDOT SHA only funds Type II projects within local jurisdictions where there are development regulations and/or land use controls requiring provision of noise protection for new noise sensitive development adjacent to state highways. To highlight to the public and elected officials the need for local noise ordinances, the LNO is included in the Priority Ranking Score equation, making it either negative or positive (see Table B.5 below). A negative LNO will make the potential project plummet toward the bottom of the statewide priority list. However, this condition will change immediately upon the local jurisdiction enacting appropriate noise controls. Maintaining a list of potential Type II projects dependent on the local jurisdiction's actions will allow the State to better gauge the magnitude that such a change would make on the program and the priority list.

TABLE B.5	**Local Noise Ordinance (LNO) Multiplier**
Local Jurisdiction has an approved Noise Ordinance?	**LNO Multiplier**
Yes	+1
No	-1

Example B.5:

An area has a Priority Ranking Score (PRS) of -60.0, because the county does not have a local noise ordinance and the LNO is -1. However, if the county passed a local noise ordinance, then the LNO would be updated to +1 and the area's Priority Ranking Score would change to 60.0.

Priority Ranking Score Example

Using several of the examples listed above, the PRS can now be calculated from Equation B.1.

From Example B.1, the DNI is 7.

From Example B.2a, the LOE is 11.

From Example B.3c, the PDP is 2.0.

From Example B.4b, the SFR is 3.

The LNO is +1.

$$\mathbf{PRS} = \big((\mathbf{4} \times \mathbf{7}) + (\mathbf{2.0} \times \mathbf{11}) + \mathbf{3}\big) \times \mathbf{1}$$
$$\mathbf{PRS} = \big((\mathbf{28}) + (\mathbf{22.0}) + \mathbf{3}\big) \times \mathbf{1}$$
$$\mathbf{PRS} = \mathbf{53.0}$$

If either the LOE or the SFR is zero (0), then the project is ineligible for Type II noise abatement and the PRS will be zero (0).

Priority Ranking Score Tie Breaking Guidelines

It is possible with this system for projects to receive an identical PRS, creating a tie. This is a reasonable outcome whether the projects are similar or dissimilar in nature. One area could have high impacts (DNI), but the cost-effectiveness may be low (SFR). Another could have lower impacts but be highly cost effective. The length of exposure (LOE) may be greater for one project, but the predate percentage could be lower (PDP) and another project may have a higher predate percentage with a shorter length of exposure. No single factor governs, which is consistent with the FHWA Guidance, which states that “highway agencies should base implementation of a Type II program upon a wide range of varying considerations.”

In order to break a tie, the following guidelines will be used:

1. The project with the highest combined LOE and PDP points is given priority. If the tie is still unbroken, then

2. The project with the higher DNI is given priority. If the tie is still unbroken, then

3. The project with the highest SFR is given priority.

A sequential “letter” will be added to the PRS to reflect the revised ranking. For example, two projects have a PRS of 65.0. The project with the higher PDP*LOE is given a PRS of “65.0a” and the other project is given a PRS of “65.0b”.

Type II Priority List Updates

The Type II Priority List will be updated whenever a new project is added to or removed from the list; or whenever more detailed information is available for a particular project; or every five (5) years, whichever occurs first. Once engineering funding is allocated for a particular project, the project will be removed from the priority list and placed on a funding schedule list. This will prevent “new” projects from placing above a funded project on the priority list.

APPENDIX C – PERFORMANCE OBJECTIVES AND BARRIER DESIGN METHODOLOGY

PURPOSE

To describe MDOT SHA's Performance Objectives and Barrier Design methodology, which is used to develop Top of Wall acoustic profiles for noise barrier designs.

TNM MODELING

Pursuant to Section 772.9 of the Federal regulation, MDOT SHA requires use of the latest approved version of the FHWA Traffic Noise Model (TNM) for the prediction of highway traffic noise levels (existing and future), and the design of highway noise barriers[1]. In addition, the following assumptions and procedures shall apply to the application of TNM:

(1) In the prediction of future noise levels as part of the National Environmental Policy Act (NEPA) process, use of average pavement is required, unless FHWA approval has been obtained for use of a different pavement type for the subject project.

(2) For TNM model validation against existing measured data, attention should be paid to all existing conditions, including pavement type, to assure that the modeling input parameters are consistent with existing conditions. For example, if an existing highway has a concrete surface, the TNM model should assume concrete for validation purposes only; once validation is confirmed, the model input should be adjusted for all TNM predictions for future conditions and alternatives back to AVERAGE pavement[2]. As per FHWA guidance, a TNM model is considered validated, if predicted and measured noise levels are within plus or minus 3 dB(A)[3].

(3) Use of highway noise contours may be permitted for the conveyance of information to local officials for future land use planning purposes for undeveloped land; use will be determined on a case-by-case basis, subject to the particular conditions and circumstances associated with the subject land parcel. Per FHWA, highway noise contours may not be used to determine impacts[4].

(4) Future noise level predictions will be based on loudest-hour traffic conditions. These correspond to the combination of the highest traffic volumes and percentages of heavy-duty trucks traveling at the optimum speed, as determined by the travel forecaster; the "loudest-hour traffic" may or may not correspond to the peak or rush hour period, due to the potential for variable or reduced travel speeds and lower percentages of trucks. As appropriate or applicable, seasonal variations in traffic should be considered to determine the worst-case noise impacts.

NOISE BARRIER DESIGN PROCESS

The noise barrier design process typically includes the following steps:

1. Identifying issues (such as access) that would make a barrier system not feasible.

2. Establishing the noise barrier alignment(s) for study while avoiding or minimizing site constraints where possible.

[1] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, December 2011, Section 9: Traffic Noise Prediction
[2] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, December 2011, Section 9: Traffic Noise Prediction
[3] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, December 2011, Section 11: Analysis of Traffic Noise Impacts, Model Validation
[4] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, December 2011, Section 9: Traffic Noise Prediction

3. Modeling receptors with enough density to understand the extent of the impacts within an NSA and the benefits generated by the studied barrier system.

4. Checking line-of-sight and setting appropriate noise reduction goals for critical sensitive and limit receptors.

5. Testing various Top of Wall (ToW) profiles to see how well performance objectives can be achieved after background noise level adjustments are applied.

6. Preparing the barrier analysis results graphically and in tabular form to determine if the noise barrier design is feasible and reasonable.

PERFORMANCE OBJECTIVES

The performance objectives established by MDOT SHA are used to guide the noise barrier design process. These objectives, which maintain consistency with past MDOT SHA design practice, are primarily focused on impacted properties with the aim to comprehensively eliminate all impacts. Accordingly, the objectives consider multiple factors simultaneously, rather than being based on a single criterion. These objectives are:

(1) Blocking line-of-sight (l-o-s) – Acoustically, when a barrier blocks the line-of-sight between a critical sensitive or limit receptor and the stack height of a Heavy Truck, typically 12-feet above pavement level, the receptor is more likely to be benefited. Psychologically, residents are more apt to be <u>dissatisfied</u> with a noise abatement measure if traffic can still be seen. Regardless of the actual abatement provided, the reduction will be perceived as less effective. Because of its vital importance, establishing the minimum line-of-sight heights is foundational to all noise barrier designs.

(2) Eliminating impacts – Achieving the design goal noise reduction of 7 dB(A) at impacted receptors will not eliminate all impacts if the predicted noise levels are higher than 72 dB(A). Consequently, a greater noise reduction between 8 and 15 dB(A) needs to be pursued for higher noise levels. The objective for these receptors with higher levels is to reach a with-barrier noise level of 64 dB(A) or less, which should be perceptibly distinct from the Category B NAC.

(3) Minimizing “hot-spots” – In order to prevent “hot spots”, the with-barrier uniformity range for neighboring properties within an NSA, ideally, should be 3 dB(A) or less. This means that one property’s with-barrier levels should not be perceptibly different from an adjacent property. Establishing a maximum with-barrier level, such as 64 dB(A), for the critical sensitive and limit receptors usually is sufficient in accomplishing this objective.

(4) Considering profile aesthetics – MDOT SHA’s Level-Top barrier analysis methodology allows for the acoustic profile to be modeled as the barrier Top of Wall with level elevation changes (steps) per panel along the alignment. This means that aesthetic and engineering considerations can be incorporated into the noise barrier design. If the minimum line-of-sight heights indicate a 3-foot elevation change between panels, then this difference would need to be reduced to at least 1.5 feet (by raising the height of the lower panel) to meet current barrier design standards. Other aesthetic considerations could warrant even smaller steps.

The objectives are interdependent; the acoustic profile is established by blocking line-of-sight with aesthetic step considerations while attempting to eliminate impacts and minimize “hot-spots”.

In seeking to accomplish these performance objectives, the noise analyst can better understand "what does it take" to achieve an optimum barrier design, as well as, identify where objectives cannot be reasonably met. This knowledge helps direct any subsequent profile modifications, so that deviations from meeting the objectives can be minimized or at least documented. This "top-down" approach could continue until a reasonable barrier is found or until only the bare minimum criteria are met, whichever occurs first. The criteria define the minimally acceptable design, which should only be pursued if it is the only solution left that would be feasible and reasonable.

LEVEL-TOP METHODOLOGY

Background

MDOT SHA has developed and implemented a refined method for establishing a noise barrier acoustic profile within TNM, called "Level-Top Methodology." This method seeks to develop the most comprehensive acoustic profile for the stage of the barrier analysis (whether during the NEPA stage or final design). This method incorporates some of the engineering final design considerations, such as the Top of Wall (ToW) stepping, into the acoustic design process to generate more representative barrier quantities (i.e., square footage) for evaluating cost-eligibility and noise reduction design goals.

Previously, MDOT SHA would generate acoustic profiles within TNM using the *"Uniform-Height"* method[5]. This method would utilize a single (uniform) input height, which would parallel the ground line. Usually these acoustical barrier designs would be based on preliminary horizontal alignments made up of larger and variable length (e.g. 50 feet or more) segments. The TNM barrier designs would be developed by perturbing each barrier segment either up or down by a defined increment (usually 1 or 2 feet) from the input height profile until the noise reduction design goal (typically 7 to 10 decibels) was met at a critical sensitive receptor[6]. Finally, line-of-sight[7] would be checked for the targeted receptors, by a geometric module within TNM. This method often generates irregular profiles with segments having different barrier heights and consequently different sloped top of wall elevations (see Figure C.1 on page C.5). In order for these profiles to be depicted on Structural plan and elevation sheets as a continuous "smooth" line, the jagged top of wall corners of the barrier segment would be connected. Then in final design, the engineered top of wall stepping scheme would require being laid out above this line.

The primary limitation to the uniform-height method was that it could underestimate the square-footage of barrier. Noise walls that were deemed eligible in the planning phase could wind up having a significantly higher square-footage in the design phase. Another limitation was the change to the amount of abatement (noise reduction) reported in the technical noise report. Generally, this resulted in a more conservative design, but the shortfall was that any additional noise reduction resulting from the engineered top of wall was undocumented and could have been incorporated into the acoustic profile, yielding a more efficient design.

Methodology

The Level-Top method seeks to develop the most comprehensive acoustic profile for the stage of the barrier analysis (be it planning or final design) by utilizing horizontal alignments that consider the known engineering constraints and acoustic profiles that account for engineering top-of-wall steps.

[5] This method has been named for convenience and comparison purposes. It is unnamed in general practice.
[6] A receptor (also called a receiver in TNM) is set approximately 5 feet from the ground to represent an average person's eye line and ear line.
[7] To block line-of-sight the barrier segment needs to obscure a heavy truck's stack height (approximately 12 feet above the pavement) at a distance (i.e. radius) up to 500 feet from the receptor. In some instances, an 800-foot radial line-of-sight may be checked.

The first step of the process is to develop a minimum line-of-sight profile from the critical sensitive receptors using 16-foot barrier segments to more closely follow the horizontal alignment and ground line. Typically, the line-of-sight assessment uses one-foot perturbations. This initial profile could be slightly irregular and any obvious segment or barrier "panel" that is an isolated low point is "smoothed out." The noise analyst then uses this smooth profile as the foundation for the other acoustic design considerations, which include meeting noise reduction goals, achieving uniformity in with-barrier levels within the subject community, and getting noise levels below the impact threshold at targeted receptors.

Any profile that matches or exceeds the minimum line-of-sight and meets the design goals is a valid acoustic profile. While the line-of-sight is fixed, alternative acoustic profiles can be developed to achieve the same or similar goals. Therefore, it is prudent to consider the top of wall elevations using consistent and aesthetic stepping schemes as the second step of the process. For example, if the line-of-sight profile showed a three-foot jump between segments/panels, this could be resolved in several ways:

1. The three-foot step is maintained. However, the standard noise barrier plans show that a 1.5-foot step is the maximum allowed (in a typical design) for a 16-foot panel. Thus, this option is not viable.
2. The difference could be accomplished with two 1.5-foot steps or three one-foot steps. However, this may yield to an abrupt transition that isn't aesthetically pleasing.
3. Alternatively, a more gradual 6-inch stepping scheme could be used, or some other solution.

The additional benefit from considering the top-of-wall is now accounted for in the acoustic design. This step alone may achieve the desired goal at some receptors. However, as a general rule of thumb the barrier may need to be one to three feet higher than the line-of-sight profile (when it doesn't govern) to achieve all of the design goals.

Through an iterative process the acoustic profile is set to ensure that the design goals are met satisfactorily. This finished acoustic profile can now represent the top of wall as shown on the plans and directly corresponds to the TNM barrier design (see Figure C.2 on page C.5). Note that Figures C.1 & C.2 are for the same barrier system.

Any further modification above the profile is unnecessary from an acoustical standpoint. **However, any modification below the stepped acoustic profile will have to be checked by the Noise Team to ensure that the line-of-sight and the acoustical design goals are still maintained.**

Application

The Level-Top methodology has been the official standard of MDOT SHA since 2014 and shall be used for all[8] barrier analyses. The Noise Team has developed and maintains various spreadsheet tools that expedite and facilitate the process, which also shall be used. See the Noise Team for further guidance.

[8] Limited exceptions may be granted as approved by the Noise Team for projects of a very preliminary nature or for rough screening exercises.

Figure C.1 **TNM Barrier View showing Acoustic Profile using uniform height method and large barrier segments**

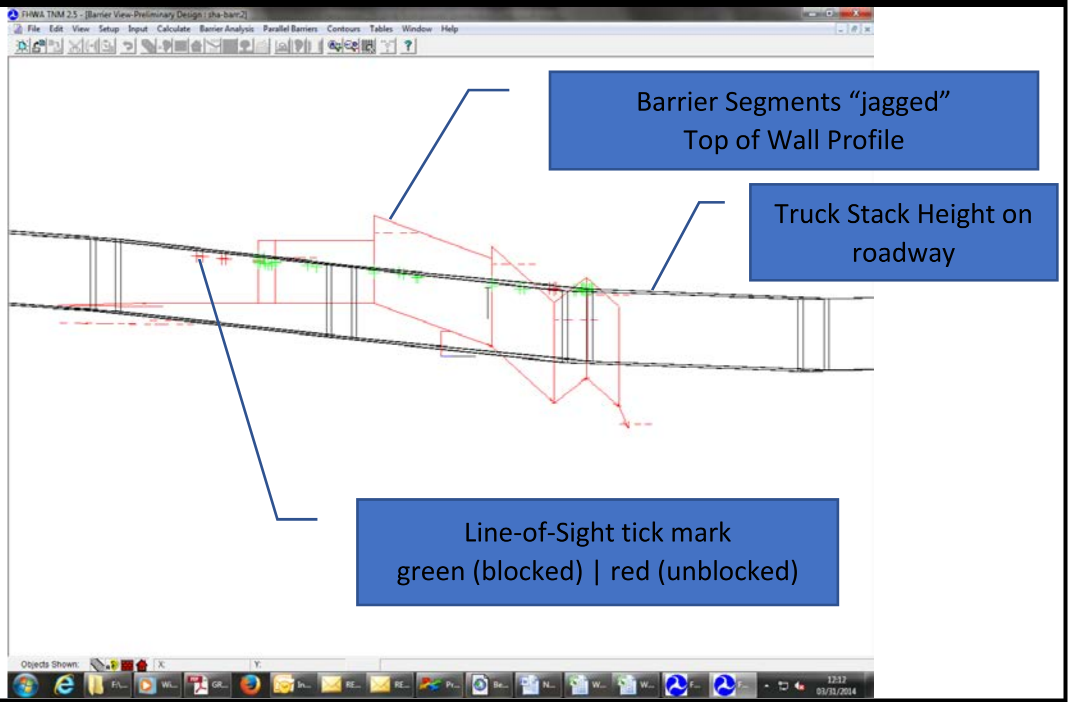
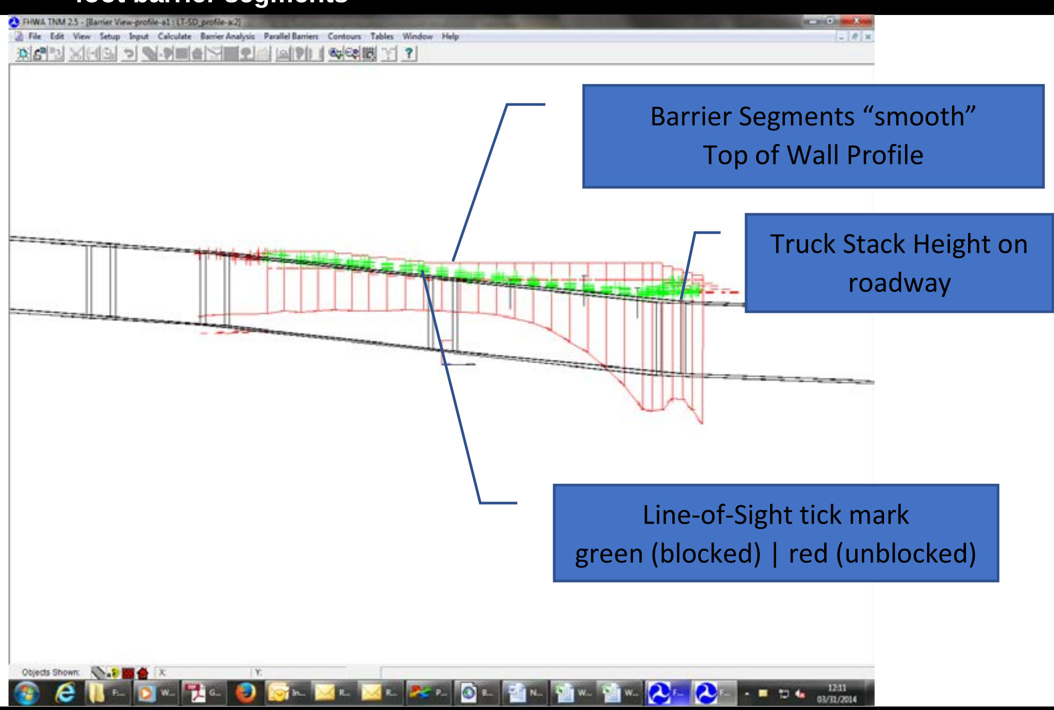


Figure C.2 **TNM Barrier View showing Acoustic Profile using level-top method and 16-foot barrier segments**



PURPOSE

To provide guidance for determining the number of equivalent residences for outdoor noise sensitive uses.

BACKGROUND

The Noise Abatement Criteria (NAC) table within 23 CFR 772 lists numerous land use descriptions according to seven specific FHWA Activity Categories. It is important that outdoor noise sensitive uses (ONSU) within these categories be acoustically evaluated realistically and consistently, based on their context and intensity of use. A single residence (as defined under Category B) is used as the basis for any comparison to residential common areas also within Category B or non-residential noise sensitive uses, whether external (Categories A, C, & E) or internal (Category D). Since the use at a single residence can occur at any time and for any duration, a residence is considered to be effectively occupied or "used" year-round and all-day. The initial number of equivalent residences (ER) for each ONSU is determined based on capacity and/or linear frontage, as appropriate, which is then reduced according to the relevant use-time percentage.

CONTEXT DETERMINATION

MDOT SHA has developed a methodology for determining the number of equivalent residences for each outdoor noise sensitive use, which can either be location-specific or random, as explained below. The initial ER determination always rounds up to the nearest whole number.

Capacity Assessment (Location-Specific) [ER_C]

Where a location-specific use is identified (such as an amphitheater), the ER determination is based upon the capacity (i.e. of the number of people) that could be accommodated within the subject use area. The table below shows the Category C and D areas that are **only** governed by capacity:

Table D.1 Category C and D Areas Governed ONLY by Capacity

Description of Land Use	Activity Category							Equivalent Residence (ER) Determination	
	A	B	C	D	E	F	G	Linear Frontage ER_L	Capacity ER_C
amphitheaters			✓					N	Y
auditoriums			✓	✓				N	Y
public meeting rooms			✓	✓				N	Y

Linear Frontage Assessment (Random) [ER_L]

Where typical use is random and widespread across a broad area (such as school ball fields or parkland with several hiking trails), the ER determination is based upon the *linear-frontage* of the use area along the subject roadway[1] using the metric of one equivalent residence for every 125 linear feet of frontage. This linear frontage value resulted from an extensive review of numerous past highway noise studies, community plans, and other real estate and tax agency data to establish an approximate average lot size. The table below shows the Category C and D areas that are **only** governed by linear frontage:

[1] Linear frontage is measured along the near edge of shoulder as projected perpendicularly from the property extents or use, as appropriate and according to the specific acoustic evaluation.

Table D.2 Category C and D Areas Governed ONLY by Linear Frontage

Description of Land Use	Activity Category							Equivalent Residence (ER) Determination	
								Linear Frontage ER_L	Capacity ER_C
	A	B	C	D	E	F	G		
cemeteries			✓					Y	N
daycare centers			✓	✓				Y	N
parks			✓					Y	N
places of worship			✓	✓				Y	N
playgrounds			✓					Y	N
radio stations			✓	✓				Y	N
recording studios			✓	✓				Y	N
schools			✓	✓				Y	N
television studios			✓	✓				Y	N
trail crossings			✓					Y	N
trails			✓					Y	N

Use-Specific Assessment

For some outdoor noise sensitive uses it depends on the specifics of use. The ER determination could be based on capacity **or** linear frontage, whatever makes the most sense. The table below shows the Category C and D areas that could be governed by **either** capacity **or** linear frontage:

Table D.3 Category C and D Areas Governed by EITHER Linear Frontage OR Capacity

Description of Land Use	Activity Category							Equivalent Residence (ER) Determination	
								Linear Frontage ER_L	Capacity ER_C
	A	B	C	D	E	F	G		
active sport areas			✓					Y	Y
campgrounds			✓					Y	Y
hospitals			✓	✓				Y	Y
libraries			✓	✓				Y	Y
medical facilities			✓	✓				Y	Y
picnic areas			✓					Y	Y
public or nonprofit institutional structures			✓	✓				Y	Y
recreation areas			✓					Y	Y
Section 4(f) sites			✓					Y	Y

Category C: Section 4(f) Residential Sites (Historic Residences)

As stated in the original Section 4(f) legislation of 1966 and its revisions (1968 and 1983), Section 4(f) protects the following basic types of properties: publicly owned park and recreation areas that are open to the general public, publicly owned wildlife and waterfowl refuges, and public or privately-owned historic sites (including residences) that are listed in, or eligible for, the National Register of Historic Places. According to FHWA Guidance[2], "Section 4(f) properties must be analyzed as Activity Category C", which would include privately-owned residences. The ER determination for these "historic residences" is based upon the capacity, which is defined as the number of actively-used residential dwellings on each property. This means that the ER value would be the same as if these properties had been evaluated as regular Category B residences.

Category B and E Common Use Areas

For Category B or E common outdoor use areas the number of equivalent residences will primarily be defined by capacity. This may be based either on the number of potential users (units/rooms) or the particular capacity of the use (including seating capacity), whichever is smaller (See Example D.3 below). However, the number of equivalent residences for indeterminate outdoor use areas, such playgrounds, will be evaluated using linear frontage. If the outdoor use is accessible from an adjacent room that has a defined capacity, then that capacity can be applied to the outdoor use. The table below shows the Category B and E areas that could be governed by **either** capacity **or** linear frontage:

Table D.4 Category B and E Areas Governed by EITHER Linear Frontage OR Capacity

Description of Land Use	Activity Category							Equivalent Residence (ER) Determination	
	A	B	C	D	E	F	G	Linear Frontage ER_L	Capacity ER_C
hotels					✓			Y	Y
motels					✓			Y	Y
offices					✓			Y	Y
other developed (not in A-D or F)					✓			Y	Y
residential		✓						Y	Y
restaurants/bars					✓			Y	Y

Acoustic Evaluation

The initial ER determination is intrinsically related to the type of acoustic evaluation. Location-specific uses are typically evaluated with discrete receptors and random uses are typically evaluated by area (as defined by multiple receptors) (see Example D.4 below); however, the actual approach may vary and should be made in consultation with MDOT's Noise Abatement Design & Analysis Team.

[2] FHWA-HEP-10-025, Highway Traffic Noise: Analysis and Abatement Guidance, Section 772.11 Analysis of Traffic Noise Impacts, Activity Category C, December 2011

INTENSITY OF USE DETERMINATION

The intensity of use is comprised of two components: the sufficiency evaluation and the use-time percentage.

Sufficiency Evaluation

In order to be deemed noise sensitive, uses associated with the subject land area must be of sufficient frequency, duration, or permanence, where abatement would be deemed reasonable to pursue to preserve the intended use of the land (See Example D.1 below).

In order to avoid unnecessary barrier analyses, outdoor noise sensitive uses are evaluated during the development of the noise sensitive area (NSA) descriptions. If it is determined that the only ONSU present within an NSA is NOT of sufficient frequency, duration, or permanence, then no further consideration is required, beyond identifying its use.

If the use is sufficient, then the time of use must coincide with the period when the noise impact occurs or is anticipated (See Example D.5 below). Impacts must be assessed during a property's time of use, even if the loudest-hour occurs at a different time. However, for part-time shoulder use (PTSU) projects (see Appendix K), an impact would have to occur not only during the property's time of use, but also during the hours of operation of the part-time shoulder.

Use-Time Percentage (UTP)

Once the initial ER determination is made for an ONSU, an adjustment is applied based upon an assessment of the time of use. This adjustment yields a decimal ER value, which is NOT rounded to the nearest whole number. Since ONSU do not actually consist of residences, their usage by definition is not automatically year-round or all-day. Consequently, the use-time percentage (UTP) must be estimated to account for the actual duration of use, so the number of equivalent residences is neither overstated nor understated. The key element to this process is to establish a percentage that is rational, realistic, and readily defensible. More detailed or specific use-time determinations can also be used, if available, provided there is substantial documentation from users or other entities associated with the land use.

UTP Equation:

The UTP equation calculates the use-time percentage based on the number of months-per-year, days-per-week, and/or hours-per-day the use operates. The component factors can be used individually or collectively, depending on the reliability of the information (See Example D.2 below).

$$UTP = \left\{ {}^{m}\!/_{12\ months} \times {}^{d}\!/_{7\ days} \times {}^{h}\!/_{24\ hours} \right\} \qquad \text{Equation D.1}$$

$$\begin{aligned} UTP &= use - time\ percentage \\ m &= number\ of\ months - per - year\ the\ use\ operates \\ d &= number\ of\ days - per - week\ the\ use\ operates \\ h &= number\ of\ hours - per - day\ the\ use\ operates \end{aligned}$$

ER Equation:

The ER equation calculates the number of equivalent residences based on capacity or linear-frontage multiplied by the use-time percentage.

$$ER = (ER_C\ or\ ER_{L}) \times UTP \qquad \text{Equation D.2}$$

EXAMPLES

Example D.1: *An eating area for a fast-food restaurant is surrounded by drive-through traffic. This type of use is transitory, lacking sufficient duration. Additionally, the nature of the establishment requires visibility from the roadway, which would cause any abatement measure to conflict with the restaurant's vitality. Furthermore, the local drive-through traffic would compromise the integrity of any proposed abatement measure. Therefore, it is not reasonable to pursue abatement for this land use; the use will be identified in the technical report and no further action will be taken.*

Example D.2: *A park is open 9 months of the year, 7 days a week, from dawn to dusk. The use-time percentage (UTP) is calculated as follows.*

$$UTP = \left\{ {}^{9}/_{12\ months} \times {}^{7}/_{7\ days} \times {}^{12}/_{24\ hours} \right\}$$
$$UTP = \{0.75 \times 1 \times 0.5\}$$
$$UTP = 0.375$$

However, due to the uncertainty (variability) in the hours of operation, the hourly component is removed to yield a more ***<u>defensible</u>*** *value.*

$$UTP = \left\{ {}^{9}/_{12\ months} \times {}^{7}/_{7\ days} \right\}$$
$$UTP = \{0.75 \times 1\}$$
$$UTP = 0.75$$

Example D.3: *An apartment complex consisting of 185 units contains an outdoor pool with a capacity of 100 people. The pool is opened daily from 12:00 pm to 8:00 pm for three months per year. The loudest-hour occurs from 11:00am to 12:00 pm. Impacts occur from 2:00 pm to 5:00 pm. The ER value is calculated as follows.*

<u>GIVEN:</u>

Pool is impacted.

$$ER_C = 100; 100 \leq 185$$
$$m = 3\ months$$
$$d = 7\ days$$
$$h = 8\ hours$$

<u>UTP Calculation:</u>

$$UTP = \left\{ {}^{3}/_{12\ months} \times {}^{7}/_{7\ days} \times {}^{8}/_{24\ hours} \right\}$$
$$UTP = \{0.25 \times 1 \times 0.333\}$$
$$UTP = 0.08325$$

<u>ER Calculation:</u>

$$ER = ER_C \times UTP$$
$$ER = 100 \times 0.08325$$
$$ER = 8.325 \rightarrow 8.33$$

Example D.4: *A local park has a series of ball courts along the roadway side of the property. The linear frontage of the park property extents is over 1,100 feet, with the impacted portion being 240 feet. Sporting activities would be limited to 9 months of the year. The impacted ER value is calculated as follows.*

GIVEN:

$$ER_L = {}^{240\ LF}/_{125} \rightarrow 1.92 \rightarrow 2$$
$$m = 9\ months$$
$$d = not\ specified$$
$$h = not\ specified$$

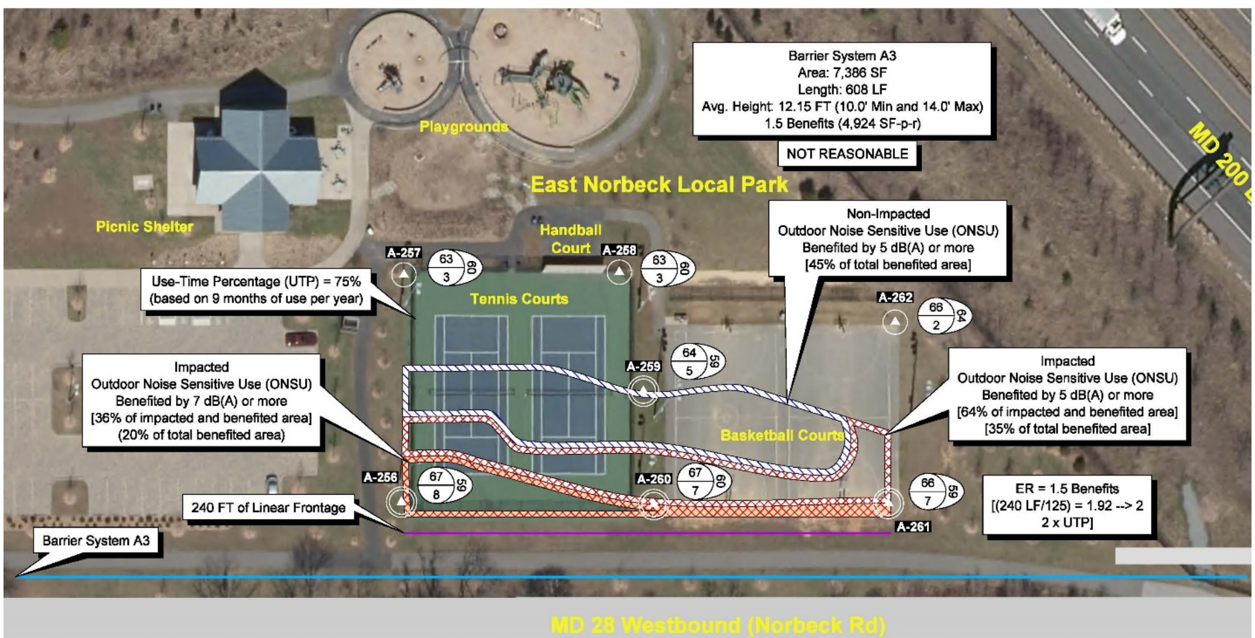
UTP Calculation:

$$UTP = \left\{ {}^{9}/_{12\ months} \times {}^{?}/_{7\ days} \times {}^{?}/_{24\ hours} \right\}$$
$$UTP = \left\{ {}^{9}/_{12\ months} \times omit \times omit \right\}$$
$$UTP = 0.75$$

Impacted ER Calculation:

$$ER = ER_L \times UTP$$
$$ER = 2 \times 0.75$$
$$ER = 1.5$$

A barrier system, 608 feet long, is proposed to protect the impacted park. Using impacted and benefited areas, it is determined that 100% of the impacted portion of the courts are benefited. However, only 36% of the impacted area is meeting the design goal. Therefore, the barrier system FAILS Design Goal reasonableness.



Example D.5: *A place of worship has a playground with a blacktop area and a large field, which is only used during game time (approximately 1-hour duration) for groups meeting on Wednesday and Sunday evenings (6:30 pm to 8:30 pm), roughly six months out of the year during favorable weather (Labor Day to Memorial Day). The average group size is 60 on Wednesdays and 20 on Sundays. The property is impacted weekdays from 7:00 am to 10:00 am with the loudest-hour occurring between 8:00 am and 9:00 am. The property does not experience impacts during its time of use; therefore the use will be documented in the technical report and no further action will be taken.*

Appendix E – SITE CONSTRAINTS AND ATYPICAL EXTRA-COST ASSESSMENTS

PURPOSE

To provide guidance for evaluating site constraints with regard to noise barrier feasibility and atypical extra-cost assessments with regard to noise barrier cost reasonableness. If it is determined that a barrier can be constructed despite the presence of site constraints, but the construction will require excessive atypical costs, an Extra-Cost Assessment must be completed, as described below. **An Extra-Cost Assessment will only be completed following approval by the MDOT SHA Noise Working Group.**

SITE CONSTRAINTS

Site constraints are circumstances or conditions associated with determining whether a potential noise barrier site would require additional engineering solutions or expenditures in order to support the construction of the barrier. Site constraints are identified as part of the noise barrier feasibility evaluation. If site constraints are present, the project team must evaluate alternatives that avoid or minimize impacts to the site constraint. This could include shifting the barrier alignment to avoid a conflict or looking at modifications to the roadway design that would either avoid the noise impact or allow for barrier construction. If a substantial additional expenditure is unavoidable, an extra-cost assessment is initiated (as detailed below). Engineering solutions or alternatives of comparable or lesser expense can be adopted to avoid or minimize the site constraint conflict or establish the viability of the subject design solutions or physical elements in terms of engineering feasibility and cost reasonableness limits and criteria (see below).

Site constraints may be identified early on in the NEPA process, with the identification/evaluation process completed prior to Semi-Final Review. After Semi-Final Review, there should be no further changes to the barrier alignments. However, if there are design modifications after Semi-Final Review, then the barrier alignments will not be evaluated further for reasonableness, unless approved by MDOT SHA, since a barrier commitment will have already been made at this point.

After identifying site constraints, an analysis is completed to determine the allowable “extra-costs” for the barrier under consideration. The following information is required in order to complete the extra-cost analysis: the barrier square footage, the number of benefited residences, and the unit cost (either the CTP unit cost or the all-inclusive cost derived from the engineer’s estimate). Using the methodology detailed below, an allowable budget for the extra costs is determined. The barrier will meet the cost-effectiveness criteria and will be carried forward **only if** the actual extra costs are less than the allowable budget.

ATYPICAL EXTRA COST ASSESSMENTS

FHWA requires that state agencies make every feasible and reasonable effort to provide substantial noise reduction when highway traffic noise impacts occur. An atypical extra cost assessment (ECA) is triggered when it is determined that there are circumstances or conditions associated with a potential noise barrier site that would require the expenditure of substantial additional funds, which would be considered beyond the scope and extent of that associated with a “typical” noise barrier installation. Examples include:

Typical costs:

- Post, panel and foundation (i.e., materials costs)
- Grading, excavation, fill material
- Maintenance of Traffic
- Reseeding, landscaping
- Right-of-way for construction and maintenance

- Barrier-specific drainage systems and stormwater management (*note that conflict with SWM designs is not a given feasibility issue – barrier alignments are generally known prior to SWM design, and should be factored into that process*)

Atypical costs:

- Significant utility relocations involving such elements as primary electrical lines, primary water distribution systems, or primary sanitary sewer systems. *Note that if utilities are located on MDOT SHA right-of-way, and MDOT SHA has prior rights, the utilities can likely be moved at no cost to the project. This information should be available at the Preliminary Investigation stage.*
- Major drainage systems to accommodate changed drainage patterns or to avoid floodplain impacts.
- Alteration of major existing structures or the need for major new structures to accommodate noise barrier placement.

The ECA should be conducted in close coordination with the MDOT SHA Noise Working Group. Not all "typical" and "atypical" costs are listed above; the atypical costs for any project will need to be evaluated on a case-by-case basis. Results of all ECAs will be presented to the MDOT SHA Noise Working Group for approval.

If no such conditions or circumstances are identified that would require substantial additional expenditures beyond what is considered "typical", an ECA would not be performed.

If substantial atypical costs are unavoidable during the NEPA analysis stage, an extra cost analysis is completed using the most current CTP costs. **<u>However, CTP costs will not be used if a construction cost estimate is available.</u>** The extra cost analysis will determine the allowable extra cost that can be incurred by the proposed barrier and still meet the cost reasonableness criteria. (See Example E.1 below.) A description of site constraints and a table summarizing the extra cost analysis will be included in the noise report.

Post-NEPA, and prior to Semi-Final Review, a "final" ECA will be completed, if necessary. Potential atypical extra costs identified during planning, as well as any additional atypical extra costs identified earlier in design from newly discovered or revised site constraints, will be included in the assessment. (See Example E.2 below.) A description of efforts made to avoid or minimize impacts to the site constraint <u>must</u> be included. A detailed construction cost estimate will be completed for the proposed barrier, and this detailed estimate will be used to perform the extra cost analysis. **Contingency costs should not be factored into the extra cost analysis.**

If the barrier is determined to be not reasonable, additional avoidance and minimization efforts will be required. This could include engineering alternatives of comparable or lesser expense that may be adopted to avoid or minimize the noise impact. It may also include revisiting the barrier Top of Wall (ToW) profile and its acoustical performance. Any changes to the barrier reasonableness that result from the final ECA must be approved by FHWA.

Example E.1: *Barrier System X protects NSA 1. NSA 1 is located adjacent to an existing highway that is being widened with noise levels projected to increase by at least 3 dB(A). This barrier system qualifies for an allowance of 2,700 square-footage per benefited residence (SF-p-r). At first glance, this barrier meets the cost reasonableness criteria with a base SF-p-r of 2,000.*

Table E.1	**Noise Barrier Design Technical Summary – Barrier System X**					
Noise Barrier Description		**Length (feet)**	**Height (feet)**			**Area (square feet)**
			Minimum	**Average**	**Maximum**	
		1,000	10	16	20	16,000
Noise Barrier Performance	**TOTAL Impacted**	Impacted NOT Benefited	Impacted and Benefited	Non-Impacted and Benefited	Benefited Equivalent Residences	**TOTAL Benefited**
	5	0	5	3	0	8
	Minimum 7 dB(A) noise reduction		5	0	0	62.5%
Noise Barrier Eligibility Cost	Baseline Noise Barrier Square Footage per Benefited Residence (SF-p-r)					**2,000**

However, it was determined during the NEPA analysis that this barrier may require the relocation of a major water line, an ***atypical*** *extra cost. Therefore, an extra cost analysis was completed using the current CTP unit cost of $60 per square-foot.*

The following table calculates the <u>allowable budget</u> that could be spent for extra costs. The proposed barrier SF-p-r is subtracted from the threshold limit to get the allowable extra cost SF-p-r. The allowable extra cost SF-p-r is multiplied by the number of benefited residences to calculate the allowable equivalent area. The allowable equivalent area is multiplied by the unit cost to generate the allowable budget. The allowable budget would then be compared to the actual extra cost (in this case, utility relocation) estimate, when it is available.

Table E.2	**Barrier System X Extra Cost Assessment (ECA) Allowable Budget [Using $60/SF CTP Unit Cost]**								
Barrier System	Area (SF)	Benefited Residences	Square-Footage per Benefited Residence (SF-p-r)			Allowable Equivalent Area (SF)	ECA Cost		Barrier Reasonable
			Proposed	Threshold	Allowable Extra Cost		Allowable Budget	Actual Estimate (worst-case)	
Barrier System X	16,000	8	2,000	2,700	700	5,600	$336,000	TBD	TBD

Although the utility relocation costs aren't known at this stage, we now know that ***any extra costs below the $336,000 allowable budget will still allow this barrier to meet the cost reasonableness criteria****.*

MDOT SHA has developed an Excel template, which will calculate any allowable extra costs for a barrier. If the extra cost resulting from the site constraint is input into the template, then the results will also indicate whether the barrier meets the reasonableness criteria or not. Alternatively, Equation E.1 below can be used to establish the allowable budget.

<u>Allowable Budget Equation:</u>

$$\boldsymbol{budget_{allow}} = \left(\boldsymbol{SFR_{gvrn}} - \boldsymbol{SFR_{barr_{RAW}}}\right) \times \boldsymbol{numBEN} \times \boldsymbol{unitCOST} \qquad \textit{Equation E.1}$$

$numBEN = total\ number\ of\ Benefited\ residences$

$SFR_{barr_{RAW}} = Barrier\ System\ square - footage\ per\ benefited\ residence\ (\boldsymbol{before}\ any\ Extra - Costs)$

$SFR_{gvrn} = Evaluation\ Threshold\ square - footage\ per\ benefited\ residence$

$unitCOST = barrier\ unit\ cost\ per\ square - foot$

This equation calculates the allowable budget for any substantial atypical extra-costs. The equation is shown below using values from Table E.2:

$$\$\mathbf{336{,}000} = (\mathbf{2700} - \mathbf{2000}) \times \mathbf{8} \times \$\mathbf{60}$$

Example E.2: *Post-PI, a detailed engineer's estimate was completed for Barrier System X. The total (neat) construction cost is estimated to be $1,440,000.00. The revised all-inclusive unit cost of $90 per square-foot was determined by dividing the total construction cost by the square footage of the barrier (16,000 SF). The estimated cost of the utility relocation is $360,000.*

The extra cost is converted to an equivalent square-footage of barrier by dividing the amount by the all-inclusive unit cost for this specific barrier system. This extra square-footage is added to the engineer's estimate barrier square-footage. The total value is then divided by the number of benefited residences to generate the revised SF-p-r, which is then compared to the appropriate threshold:

$360,000 ÷ $90/SF = 4,000 SF
4,000 SF + 16,000 SF = 20,000 SF
20,000 SF ÷ 8 res = 2,500 SF-p-r ≤ 2700 SF-p-r

Including the extra cost of the utility relocation, the square footage per benefited residence is now 2,500 SF-p-r, which is still below the 2,700 SF-p-r threshold.

This can also be summarized in the table below by focusing on the estimated extra cost versus the extra cost allowable budget. The revised extra cost allowable budget for Barrier System X is now $504,000 using the all-inclusive unit cost of $90/SF. The utility relocation cost is less than the extra cost allowance, so this barrier meets the cost reasonableness criteria.

Table E.3 Barrier System X Extra Cost Assessment (ECA) Reasonableness Summary [Using $90/SF All-Inclusive Unit Cost]

Barrier System	Area (SF)	Benefited Residences	Square-Footage per Benefited Residence (SF-p-r)			Allowable Equivalent Area (SF)	ECA Cost		Barrier Reasonable
			Proposed	Threshold	Allowable Extra Cost		Allowable Budget	Actual Estimate (worst-case)	
Barrier System X	16,000	8	2,000	**2,700**	700	5,600	$504,000	$360,000	YES

In the examples shown above, the extra cost allowable budget increased in the design phase from the planning phase. This was a result of an increased unit cost due to the more detailed engineers estimate. **Even if extra costs had not been identified, the final design barrier system would still need to have an SF-p-r that was at or below the evaluation threshold. This could require a redesign of the barrier's acoustical performance to keep the base SF-p-r in design from exceeding the threshold.**

PURPOSE

To describe MDOT SHA's Voting Methodology, by which the viewpoints of benefited residences are solicited in determining the reasonableness of a proposed barrier system.

VOTING METHODOLOGY

Prior to Semi-Final Review, the views and opinions of all benefited property owners and residents (those determined to receive at least a 5 dB(A) noise reduction) will be solicited through public involvement and outreach activities to determine if the benefitted property owners/residents are "for" or "against" noise abatement for their community. <u>If MDOT SHA receives opposing viewpoints from any impacted and benefited residents within a Noise Sensitive Area (NSA), a voting process will be administered.</u> However, a voting process will not be administered based solely on the request of a non-impacted and benefited resident.

(1) The voting process may also apply to barrier extents, rather than the entire barrier system. For example, an impacted apartment complex seeks to have the barrier length reduced, so that their visibility from the highway is maintained. However, the length of barrier that would be voted upon cannot compromise the acoustical performance objectives that were achieved at a neighboring NSA. This limits the scope of the reduction. This scenario would only apply to barrier termini; voting shall not be pursued where it would create a "gap" in the barrier system.

(2) Votes will be documented in writing, regardless of the methodology used to collect them (i.e., via certified mailing, public workshop, targeted community meeting, etc.).

Weighting Votes

Votes will be solicited for EACH benefited dwelling unit (residence). If a property, such as a commercial or industrial site, does not have a noise sensitive use, then that property is excluded from the voting. Voters fall into three categories: property-owner resident, property-owner non-resident, and renter resident. The votes obtained for impacted and benefited properties will count twice as much as the votes obtained for non-impacted and benefited properties. An owner resident vote also has a base count of three: two for being an owner and one for being a resident. To ensure that a property owner's viewpoint is fairly considered, a non-resident owner is permitted a vote for each benefited dwelling unit they own. For example, an apartment complex has 12 benefited dwelling units. The non-resident owner would get 12 votes that count twice and each of the 12 renter residents would get one vote that counts once. Whether a unit is occupied by an individual, a family, or a group of individuals, only one resident vote will be accepted for any benefited residence by a person at least 18 years old who can provide proof of residency (deed, lease, utility bill, driver's license, etc.).

Each benefited use of a special land use area (such as Category C) has a single vote, regardless of the number of benefiting equivalent residences (ER) for each use. The votes obtained for impacted and benefited uses will count twice as much as the votes obtained for non-impacted and benefited uses. These uses would be considered as "property-owner resident votes" (as detailed above). For example, an impacted and benefited pool of an apartment complex equates to 5 ER and a non-impacted and benefited playground equates to 1 ER. Both the pool and the playground have a single vote, but the pool vote counts twice, since it is impacted. This brings the total vote count for the recreational area of the apartment complex to 3.

A vote tally of more than 50 percent AGAINST the proposed noise abatement is required for the barrier measure to be rejected. If a single individual or entity is responsible for all negative votes, then MDOT SHA will consider on a case-by-case basis as to whether the percentage requirement is met. Tables F.1 and F.2 demonstrate the tally of weighted votes for two sample projects.

Table F.1 SAMPLE Benefited Viewpoints Voting – Greater Than 50% AGAINST needed for Barrier Rejection

Benefited Dwelling Units	Type of Dwelling Unit	Impacted? (Yes/No)	Impacted Multiplier	Owner Occupied? (Yes/No)	Owner Resident Vote (Yes/No)	Owner Non-Resident Vote (Yes/No)	Renter Resident Vote (Yes/No)	Number of "No" Votes per Dwelling Unit	Weighted Number of "No" Votes per Dwelling Unit	Total Weighted Number of Possible Dwelling Unit Votes
1200 House Avenue	single-family	Yes	2	Yes	Yes			0	0	6
1202 House Avenue	single-family	Yes	2	Yes	No			3	6	6
5432 Condo Place (Unit A)	condominium	Yes	2	No		Yes	Yes	0	0	6
5432 Condo Place (Unit B)	condominium	Yes	2	No		Yes	No	1	2	6
9876 Apartment Way (#301)	apartment	Yes	2	No		No	Yes	2	4	6
9876 Apartment Way (#302)	apartment	Yes	2	No		No	No	3	6	6
1204 House Avenue	single-family	No	1	Yes	Yes			0	0	3
1206 House Avenue	single-family	No	1	Yes	No			3	3	3
5434 Condo Place (Unit A)	condominium	No	1	No		Yes	Yes	0	0	3
5434 Condo Place (Unit B)	condominium	No	1	No		Yes	No	1	1	3
9880 Apartment Way (#301)	apartment	No	1	No		No	Yes	2	2	3
9880 Apartment Way (#301)	apartment	No	1	No		No	No	2	2	3
									26	**54**
									48.1%	
									BARRIER APPROVED	

Table F.2 SAMPLE Benefited Viewpoints Voting – Greater Than 50% AGAINST needed for Barrier Rejection

Benefited Dwelling Units	Type of Dwelling Unit	Impacted? (Yes/No)	Impacted Multiplier	Owner Occupied? (Yes/No)	Owner Resident Vote (Yes/No)	Owner Non-Resident Vote (Yes/No)	Renter Resident Vote (Yes/No)	Number of "No" Votes per Dwelling Unit	Weighted Number of "No" Votes per Dwelling Unit	Total Weighted Number of Possible Dwelling Unit Votes
1200 House Avenue	single-family	Yes	2	Yes	Yes			0	0	6
1202 House Avenue	single-family	Yes	2	Yes	No			3	6	6
5432 Condo Place (Unit A)	condominium	Yes	2	No		Yes	Yes	0	0	6
5432 Condo Place (Unit B)	condominium	Yes	2	No		Yes	No	1	2	6
9876 Apartment Way (#301)	apartment	Yes	2	No		No	Yes	2	4	6
9876 Apartment Way (#302)	apartment	Yes	2	No		No	No	3	6	6
1204 House Avenue	single-family	No	1	Yes	No			3	3	3
1206 House Avenue	single-family	No	1	Yes	No			3	3	3
5434 Condo Place (Unit A)	condominium	No	1	No		Yes	Yes	0	0	3
5434 Condo Place (Unit B)	condominium	No	1	No		Yes	No	1	1	3
9880 Apartment Way (#301)	apartment	No	1	No		No	Yes	2	2	3
9880 Apartment Way (#301)	apartment	No	1	No		No	No	2	2	3
									29	**54**
									53.7%	
									BARRIER REJECTED	

A confirmation letter will be sent prior to advertisement of the project to all benefitted property owners to reiterate that a noise barrier has been approved as part of the project. Benefited property owners will be given 30 days to respond to this letter. This provision is NOT intended to reopen or revisit the previously expressed community consensus. It is to assure that the barrier recipients are fully aware of the State's intent, and to avoid any last-minute objections or changes to the project plans and details. However, should opposition to a particular noise barrier be revealed during this confirmation process, MDOT SHA will reassess whether the subject noise barrier should ultimately be included in the project on a case-by-case basis.

(1) If a benefited property changes ownership after voting and prior to the construction of the barrier, only the original owner's vote will be considered.

(2) The voting process should occur prior to Semi-Final Review and cannot occur once a project is in construction.

PURPOSE

To provide guidance for evaluating earth berms, including berm-wall combinations, as noise abatement measures by providing information on the maximum allowable dimensions (height and width) and the methodology for determining cost reasonableness.

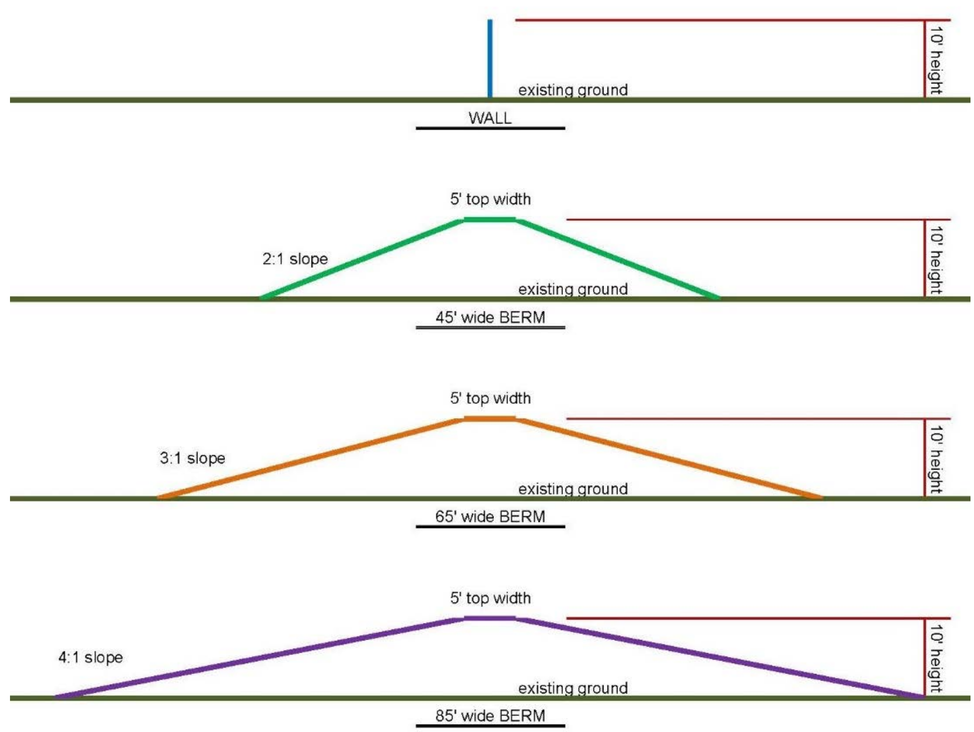
DIMENSIONS

The dimensions of a berm can vary by slope, top width, tapering end conditions, length, and the existing ground foundation on which it is placed. In order to more readily compare differences, variations were simplified by using the following assumptions:

- equal left and right slopes (limited to 2:1, 3:1, and 4:1)
- five-foot top width
- no tapering end conditions
- 125 feet of linear frontage (typical Maryland lot size)
- level ground foundation.

Figure G.1 below shows typical sections of a 10-foot wall and a 10-foot berm with different side slopes.

Figure G.1 Wall and Berm Typical Sections (10' Height)



Equations

The equations below are used to calculate berm dimensions and quantities; a brief description follows each.

Berm Height by Width Equation:

$$h = \frac{(w-5)}{2m} \qquad \text{Equation G.1}$$

$$h = maximum\ berm\ height$$
$$w = available\ width\ for\ berm$$
$$m = berm\ side\ slope; m = 2\ for\ 2:1\ slope$$

This equation calculates the maximum berm height for a given width and side slope.

*Example G.1: If the available width for a berm was 65-feet, then the maximum height would be **15-feet** using 2:1 side slopes, 10-feet using 3:1 side slopes, and 7.5-feet using 4:1 side slopes.*

Berm Quantity and Equivalent Wall Area Equations:

$$Area_x = mh^2 + 5h \qquad \text{Equation G.2}$$

$$Area_x = berm\ cross - sectional\ area$$
$$h = berm\ height$$
$$m = berm\ side\ slope; m = 2\ for\ 2:1\ slope$$

This equation calculates the cross-sectional area for a given berm height and side slope. The "5" represents the top width.

*Example G.2: If the berm height is 14 feet and the side slope is 2:1, then the cross-sectional area would be **462 SF**.*

$$Length_s = 2\left[\sqrt{h^2 + (mh)^2}\right] + 5 \qquad \text{Equation G.3}$$

$$Length_s = berm\ surface\ length$$
$$h = berm\ height$$
$$m = berm\ side\ slope; m = 2\ for\ 2:1\ slope$$

This equation calculates the surface length, measured along the perimeter of the berm (left side slope + top width + right side slope) for a given berm height and side slope. The "5" represents the top width.

*Example G.3: If the berm height is 14 feet and the side slope is 2:1, then the surface length would be **67.61 FT**.*

$$Area_B = \frac{f}{u_W}\left(\frac{u_{CB}}{27}Area_x + \frac{u_{TG}}{9}Length_s\right) \qquad \text{Equation G.4}$$

$Area_B = berm\ equivalent\ wall\ area$
$Area_x = berm\ cross-sectional\ area$
$Length_s = berm\ surface\ length$
$f = linear\ frontage$
$u_W = unit\ cost, Wall$
$u_{CB} = unit\ cost, Common\ Borrow$
$u_{TG} = unit\ cost, Turf\ Grass$

This equation calculates the equivalent wall area for a berm by dividing the berm cost by the wall unit cost. The berm cost consists of the common borrow volume plus the turf grass surface area, multiplied by their respective unit costs, which is converted from yards to feet.

Example G.4: *If the Wall unit cost is $60/SF, the Common Borrow unit cost is $30/CY, and the Turf Grass unit cost is $20/SY, then the berm equivalent wall area, using 125 feet of linear frontage and the quantities calculated in Examples G.2 and G.3 above, would be **1382.45 SF**.*

Wall Height on top of Berm Equation:

$$h_{W_{max}} = \frac{(T - Area_B)}{f} \qquad \text{Equation G.5}$$

$h_{W_{max}} = maximum\ wall\ height\ on\ top\ of\ berm$
$T = governing\ Threshold\ (SF-p-r)$
$f = linear\ frontage$

This equation calculates the maximum wall height allowed on top of a berm based on the cost reasonableness evaluation threshold.

Example G.5: *If the Evaluation Threshold is 2700 SF-p-r, then the maximum wall height on top of the berm would be **10.54 FT**, using 125 feet of linear frontage and the quantity calculated in Example G.4 above.*

$$h_{W_{max}} = -0.0369h^2 - 0.2606h + 21.425 \qquad \text{Equation G.6}$$

$h_{W_{max}} = maximum\ wall\ height\ on\ top\ of\ berm$
$h = berm\ height$

This equation also calculates the maximum wall height allowed on top of a berm; however, it is simply based on the berm height. This particular equation only applies to 2:1 slopes under the 2700 SF-p-r threshold using the unit costs from the examples above, and was obtained from a plotted curve on Chart G.2.

Charts

The charts shown on the next two pages summarize an iterative analysis comparing wall heights and berm heights at 0.1-foot increments; more details follow the charts.

Chart G.1 Berm Area & Width by Slope versus Wall Area

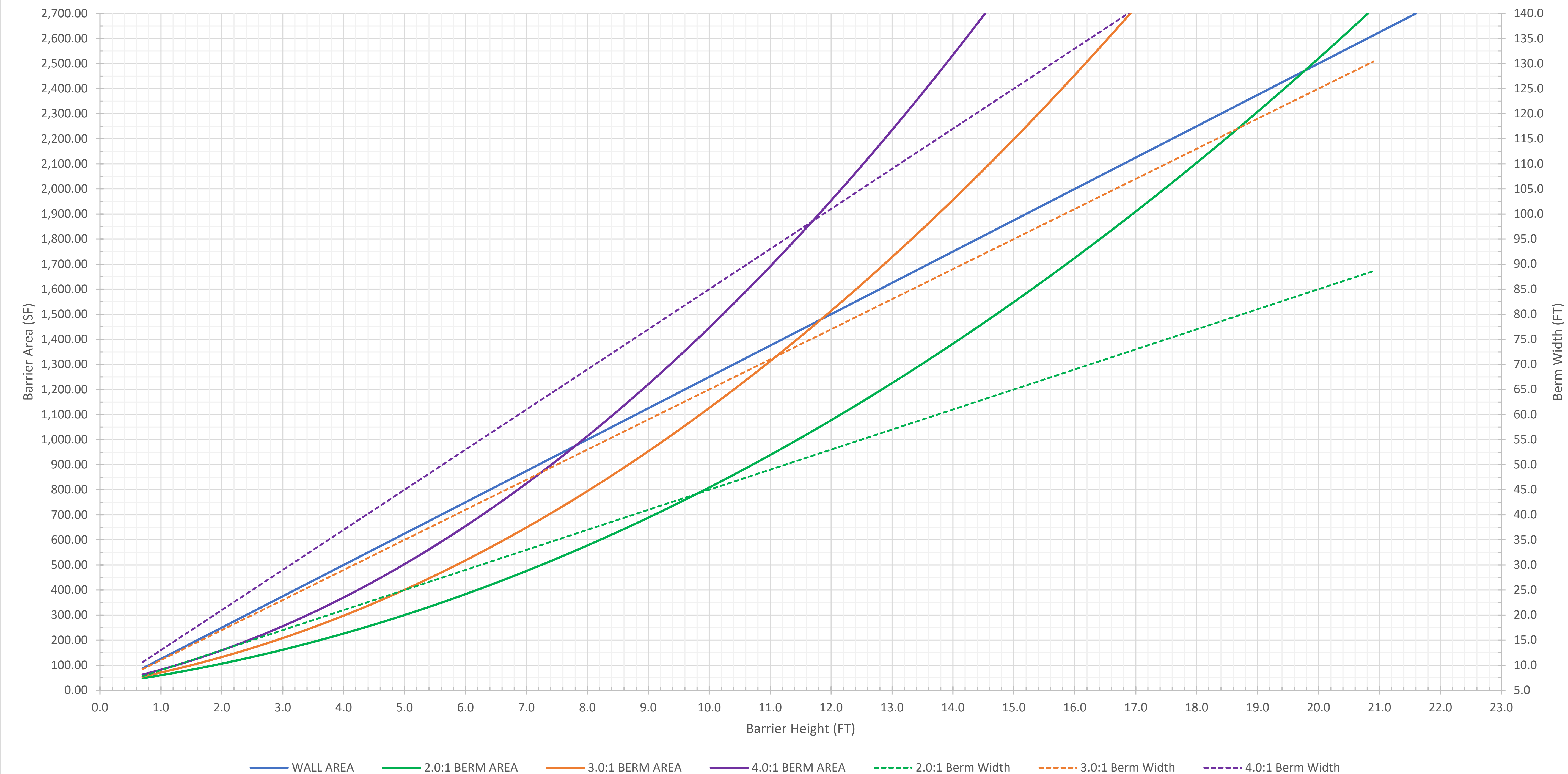


Chart G.2 **Barrier Heights and Areas for Walls, Berms, Berm-Wall Combinations using 2:1 side slopes, 125 LF of Frontage, and the 2700 SF-p-r Threshold**

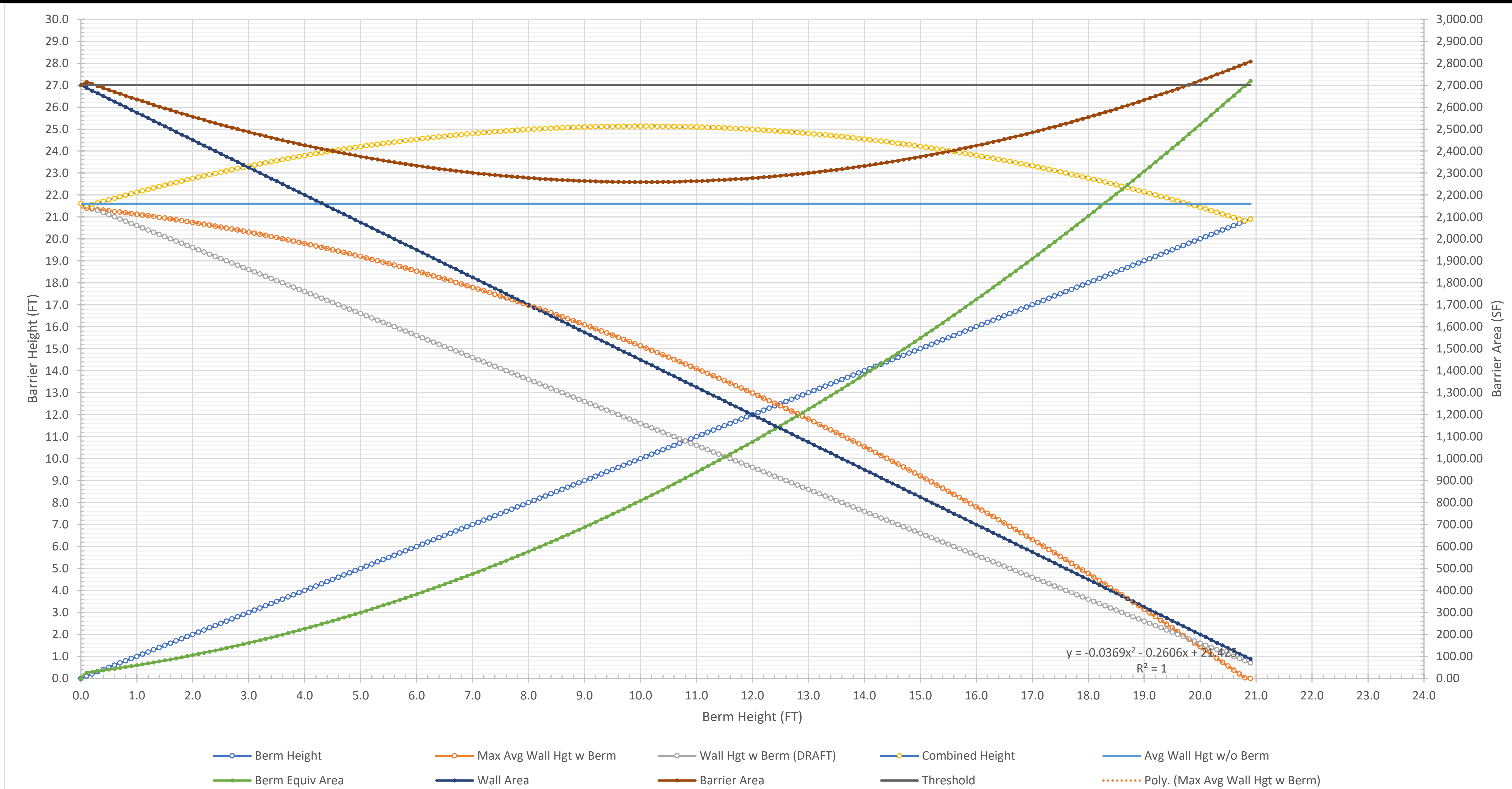


Chart G.1 Observations

Chart G.1 plots the berm area and width (by side slope) versus the wall area for varying heights. The point of wall area equivalency, when the wall area equals the equivalent berm area, occurs where the berm area curve crosses the wall area line. This is the height where the berm becomes more costly (requires greater area) than a wall of the same height. Table G.1 below summarizes the maximum berm heights and widths obtained from the chart. This information can be used to understand the general constraints for placing a berm in a given location (see Examples G.6 & G.7 after the table).

Table G.1 Berm Maximum Heights and Widths by Slope

Berm Slope	2700 Threshold		1700 Threshold		700 Threshold		Wall Area Equivalency	
	Maximum Height (FT)	Maximum Width (FT)	Maximum Height (FT)	Maximum Width (FT)	Maximum Height (FT)	Maximum Width (FT)	Maximum Height (FT)	Maximum Width (FT)
2:1	20.8	88.2	15.8	68.2	9.0	41.0	*19.7*	*83.8*
3:1	16.9	106.4	12.8	81.8	7.3	48.8	*11.8*	*75.8*
4:1	14.5	121.0	11.0	93.0	6.2	54.6	*7.8*	*67.4*

Notes:

- *The maximum height (rounded to the nearest tenth) will yield an equivalent berm square-footage just below the evaluation threshold. Associated area values (not shown) are based on $60/SF for walls, $30/CY for common borrow, and $20/SY for Turf Grass.*
- *Each maximum width includes a 5-foot level-top. The width for a 4-foot berm would be 21-feet using a 2:1 slope, 29-feet using a 3:1 slope, and 37 feet using a 4:1 slope.*
- *The maximum height listed below Wall Area Equivalency represents the height where the berm area and wall area are equal, meaning that berm heights in excess of these values will have higher areas than a wall at the same height.*

Example G.6: If the evaluation Threshold is 700 SF-p-r, and the needed height for a 2:1 berm is 10 feet, then the berm is not a viable solution, since the maximum height cannot exceed 9 feet and still meet cost reasonableness. Similarly (using the same parameters), if the needed width for a berm was 50 feet, then the berm is not viable, since the maximum width cannot exceed 41 feet. Chart G.1 and Equation G.1 show that the maximum height for a 50-foot wide berm would actually be ***11.25 feet****.*

Example G.7: A 14-foot berm is proposed using 3:1 side slopes. Only under the 2700 threshold would the berm potentially be reasonable. (It would require a width of 89 feet using a variation of Equation G.1.) Even if it were reasonable, a 14-foot tall wall would generally be more cost effective since the berm becomes more expensive above 11.8 feet. However, if the berm cost was partially offset by project spoils, then that may make it have a lower cost than a wall of the same height (see Example G.11 below).

Chart G.2 Observations

Chart G.2 plots barrier heights and areas for walls, berms, and berm-wall combinations. This chart is specifically limited to berms with 2:1 side slopes under the 2700 threshold using the unit costs previously listed. The chart illustrates two significant trends:

- The allowable wall height that can be placed on top of a given berm height can be significantly greater than just the maximum wall height minus the berm height.

Example G.8: The maximum wall height (for every 125 LF of frontage) under the 2700 threshold is 21.6 feet. If a 10-foot berm is proposed to offset the construction costs, the maximum wall height on top of the berm is not 11.6 feet, but rather 15.13 feet (using Equation G.6), which is derived from the "Max Avg Wall Hgt w Berm" curve on Chart G.2.

- The barrier area that adds the wall area to the berm equivalent wall area in a berm-wall combination can be significantly less than maximum wall or berm area for the evaluation threshold.

Example G.9: A 21.6-foot wall at 125 LF has a barrier area of 2700 SF; and a 20.8-foot tall berm at 125 LF has an equivalent wall area of 2700 SF. However, a 10-foot tall berm with an 11.6-foot wall (total barrier height = 21.6 feet) only has an area of 2258.90 SF.

This amount of reduction varies by the berm-wall combination as Chart G.2 shows. The chart suggests the most cost-effective solution. Even a minimum 4-foot tall berm can result in savings of over 200 SF per 125 LF. Additional equations can be derived for other thresholds.

Adding a berm to a wall can minimize costs or allow for higher total barrier heights. Both factors should be carefully evaluated, whenever berms are feasible, since it may aid it achieving cost reasonableness.

COST REASONABLENESS

Methodology

As alluded to in the previous discussion, the cost reasonableness of a berm is determined by converting the berm “cost[1]” into an equivalent wall square footage that is divided by the number of benefited residences, which is then compared to the cost reasonableness evaluation threshold. If the barrier consists of a berm-wall combination, the berm equivalent wall area is added to the actual wall area to generate a combined total barrier area, which is then divided by the number of benefited residences and compared to the threshold.

Project Spoils (Earthwork “Waste”)

<u>If the berm “cost” is partially or completely offset by project spoils, then the square-footage per benefited residence (SF-p-r) would be reduced accordingly</u>. **This means that for every wall that fails cost reasonableness, the viability of a berm or berm-wall combination in that location must be assessed.** The berm/berm-wall assessment should conclude that the alternative measure is one of the following:

- not feasible and/or not reasonable
- feasible and *contingently* not reasonable, where project spoils could change the reasonableness
- feasible and reasonable
  - The alternative measure then governs, even if the wall-only option was not feasible and/or not reasonable.

Examples

Example G.10: A berm that is predicted to benefit 10 residences is expected to cost $900,000. The cost is converted into an equivalent wall area by dividing it by the wall unit cost of $60/SF, which equates to 15,000 SF. Dividing the area by the number of benefited residences yields an SF-p-r of 1500, which is under the 1700 SF-p-r evaluation threshold. Therefore, the berm would meet cost reasonableness.

Example G.11: A berm that is predicted to benefit 8 residences is expected to cost $900,000. The cost is converted into an equivalent wall area by dividing it by the wall unit cost of $60/SF, which equates to 15,000 SF. Dividing the area by the number of benefited residences yields an SF-p-r of 1875, which is over the 1700 SF-p-r evaluation threshold. Therefore, the berm would NOT meet cost reasonableness.

However, project spoils later indicate an excess of fill material, which can be used to offset $500,000 of the berm cost. The revised equivalent wall area is $400,000 divided by $60/SF, which equates to 6,667 SF. Dividing the area by the number of benefited residences yields a revised SF-p-r of 833, which is under the 1700 SF-p-r evaluation threshold. Therefore, the berm would meet cost reasonableness.

[1] Berm costs for typical planning level (NEPA) assessments are defined in Equation G.4. More detailed berm costs may be developed during final design, if necessary.

PURPOSE

To outline the procedure for evaluating existing barrier systems that are associated with a proposed Type I project to determine whether no further action is required, or if a barrier modification needs to be investigated. Barrier modifications could comprise of extensions to the existing system (lengthening) and/or raising the profile (height changes).

ASSESSMENT PROCEDURE FOR EXISTING NOISE BARRIERS

The assessment procedure for evaluating the feasibility and reasonableness of replacing or improving existing noise barriers is defined in the FHWA guidance *Consideration of Existing Noise Barriers in a Type I Noise Analysis* (FHWA-HEP-12-051)[1]. No further consideration is necessary when noise impacts are not predicted behind the existing barrier **or** when impacts are predicted, the barrier system is meeting the design goals as defined under the current noise policy of the highway agency. If the barrier fails to satisfy the noise policy requirements, the highway agency should strive to develop a new noise abatement design that does meet them. However, the new design must still be evaluated for feasibility and reasonableness. If the cost of retrofitting or replacing an existing barrier is not reasonable, then the existing barrier should remain unaltered.

Impact Determination

In order to determine if impacts are expected to occur behind or adjacent to the extents of an existing noise barrier, the following approaches are acceptable:

1) Reliable field measurements provide evidence of levels exceeding the NAC (Preliminary determination ONLY).

2) The existing barrier (or at least the relevant portion) must be modeled in TNM.

   a) If the existing barrier is a noise wall, then the Top of Wall profile shall be obtained from As-Built plans (if available) and input into TNM using MDOT SHA's Level-Top methodology where in most cases the existing ground will be defined by the best available digital terrain model (DTM) surface.
      i) Impacts will be defined by the with-barrier noise levels with the existing barrier in-place.

   b) If the existing barrier is a berm, then the berm will be modeled with terrain lines. The before-berm condition will also be approximated with terrain lines.
      i) Impacts will be defined as the no-barrier noise levels with the berm in-place.

   c) If the existing barrier is a wall-berm combination, then a synthesis of "a" and "b" above will be necessary.

3) Any other approach or approximation will have to be granted approval from the Noise Team beforehand.

[1] FHWA-HEP-12-051, Consideration of Existing Noise Barriers in a Type I Noise Analysis, 2012

Preliminary impacts may be determined using Existing Worst-Case (EWC) traffic in a well-constructed TNM model that may or may not have been validated[2]. Final impacts are determined from loudest-hour Build condition traffic.

Barrier Performance

If impacts are determined, then further consideration is necessary per FHWA guidance and the existing barrier's performance needs to be evaluated. Simplistically, this is accomplished in three ways:

1) For a noise wall: The insertion losses generated from the TNM Output for the existing barrier will help define the barrier's acoustic performance.

2) For a berm: A comparison of the two conditions (before-berm and after-berm) will help define the berm's acoustic performance.

3) For a wall-berm combination, then a synthesis of "1" and "2" above will be necessary.

Effective Barrier Zone of Influence (ZoI_{eff})

However, in order to accurately evaluate the existing barrier's performance, the portion of the barrier deemed most effective for the impacted residences is determined, usually from TNM's "Diagnosis by Barrier Segment" function. This effective barrier length is then set to zero-height in TNM to obtain the noise reduction specifically supplied by it. By comparing the insertion losses provided by the full-length existing barrier to the reduced barrier length, the effective barrier contribution can be calculated.

The full-length existing barrier performance is ascertained by analyzing it like a "new" barrier. Impacts are based on pre-barrier (no-barrier) noise levels with benefits and design goal compliance based on the provided noise reduction. A *zone of influence* (ZoI_{eff}) is established based on the 3-dB(A) insertion loss contour associated with the effective barrier. **The purpose of the** ZoI_{eff} **is to focus the evaluation on the impacted region.** Since a 3-dB(A) change in noise levels is considered barely perceptible, all benefiting properties significantly outside the ZoI_{eff} are excluded from the targeted evaluation.

Example H.1: *Six residences are predicted to be impacted behind an existing barrier. The effective barrier portion is determined to be 672 linear feet, beginning at the northernmost barrier extent. Only 13 residences reside within the* ZoI_{eff}.

Within the zone of influence, 12 of the 13 impacted residences (based on no-barrier levels) are benefited, meaning the effective barrier is providing acoustically feasible abatement to more than 92 percent. Nine of these benefited properties meet or exceed the 7-dB(A) design goal, meaning the effective barrier is providing acoustically reasonable abatement to at least 75 percent. Therefore, the existing noise barrier achieves an abatement design that is acceptable under the MDOT SHA Highway Noise Policy (2020) and no further action is necessary per FHWA guidance. (See Figure H.1)

Example H.2: *Sixteen residences are predicted to be impacted behind an existing berm. The entire berm is deemed effective. Therefore, the* ZoI_{eff} *includes every impacted and/or benefited residence.*

[2] Model validation can be suspect when measurements are collected behind an existing noise barrier where reflective tree canopies above the barrier can increase the noise level above what TNM can predict using the same traffic parameters. Also, it may not always be practical to conduct a full validation for an existing barrier, where only a few spot locations can be reasonably validated.

The berm eliminates impacts at 18 of the 34 impacted residences and benefits 17 of them, achieving the design goal at 10 of the residences. This would have met MDOT SHA's previous Highway Noise Policy (2011) by benefiting at least 50% of the impacted residences [53%] and achieving the design goal for at least 50% of the benefited [59%]. Therefore, no further consideration is required per FHWA guidance. (See Figure H.2.) However, it would NOT meet the current MDOT SHA Highway Noise Policy (2020).

Figure H.1 Effective Barrier Zone of Influence Map for Example H.1

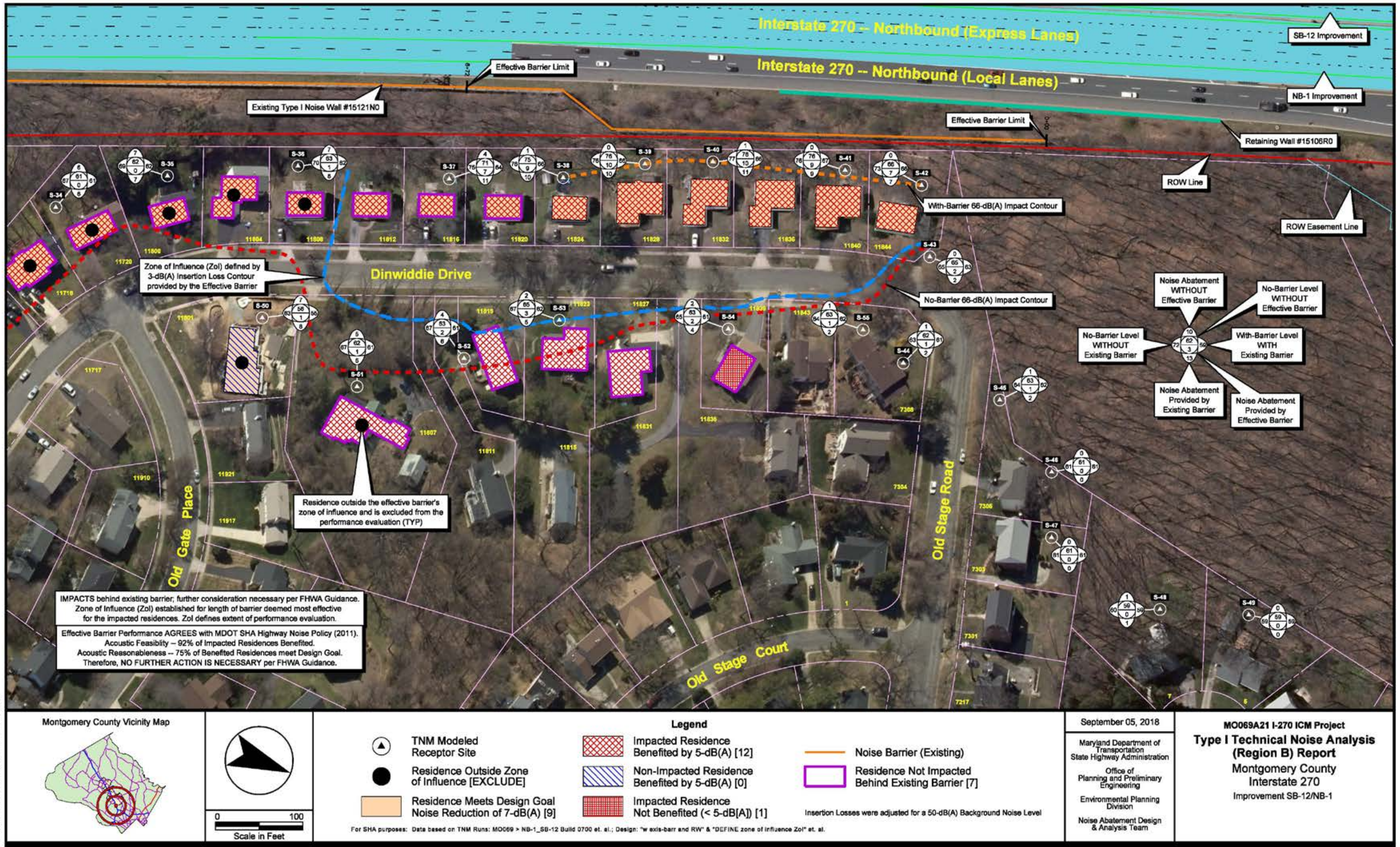
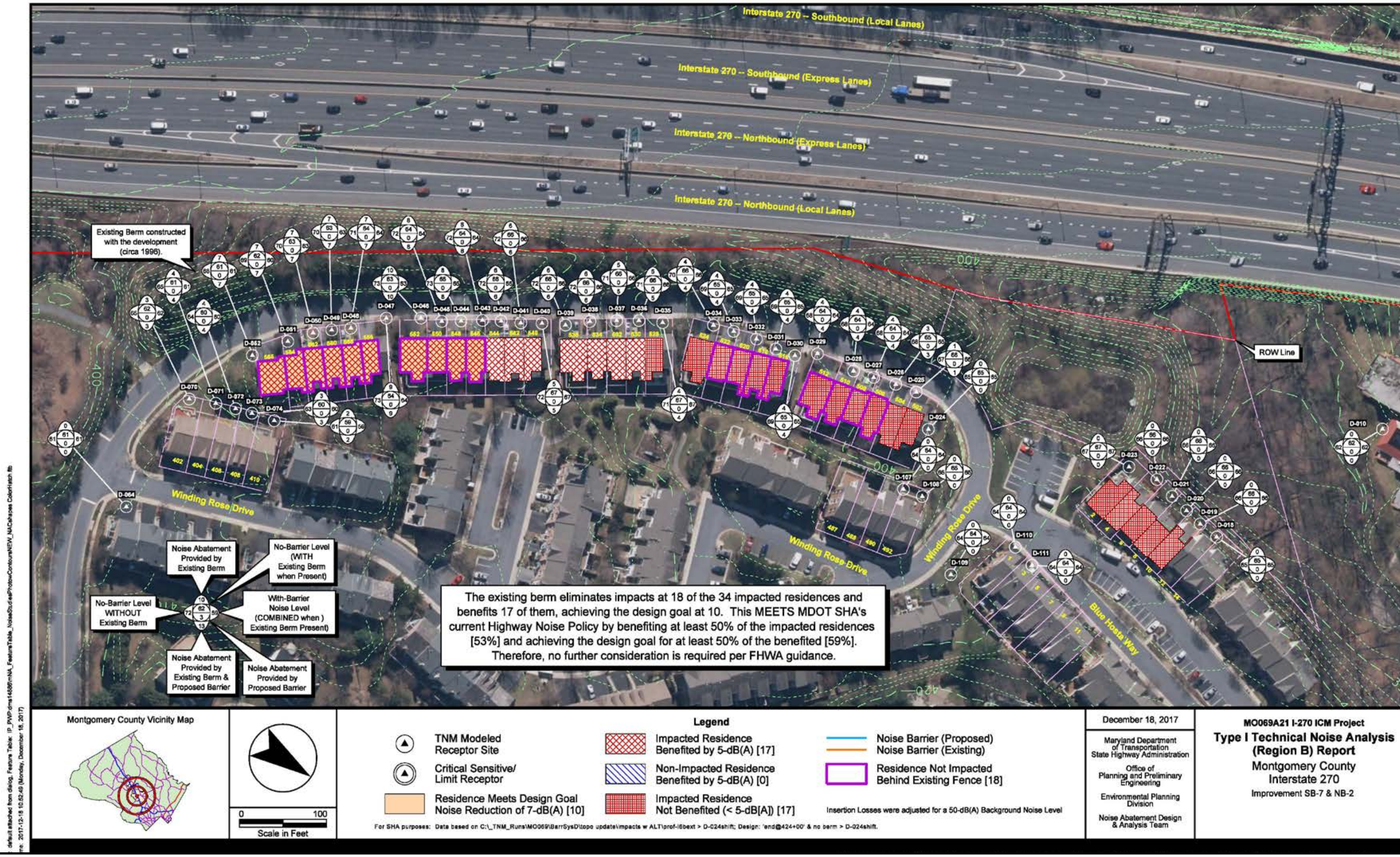


Figure H.2 Effective Barrier Zone of Influence Map for Example H.2



Barrier Modification Zone of Influence (ZoI_{mod})

By comparing the noise abatement provided by the existing barrier with the proposed modification (whether an extension and/or profile change) to the noise abatement provided only from the existing barrier, the number of benefited residences and the number meeting the design goal can be calculated for only the proposed modification.

Like the Effective Barrier Zone of Influence described above, the Barrier Modification Zone of Influence conservatively evaluates the proposed barrier modification's performance by excluding from the evaluation any property that is not experiencing at least a 3-dB(A) insertion loss from the proposed action. This is done for two reasons: one, it can reduce the amount of existing barrier that needs to be modeled; and two, it ensures that benefits are not overestimated. Once the filtered list of residences is determined, **only those** with a combined noise reduction of 5-dB(A) or greater can be counted as benefited and **only those** with a noise reduction of 7-dB(A) or greater can be counted as achieving the design goal.

Example H.3: *Four residences are impacted adjacent to the end of an existing barrier. A proposed barrier extension can protect three of them with one unprotected due to local road access that needs to be maintained. A comparison of the barrier extension to the existing barrier indicates that up to 9 residences are receiving a combined noise reduction of 5-dB(A) or more in the vicinity. However, two residences are getting less than a 3-dB(A) improvement from the modification, so they fall outside the* ZoI_{mod}.

The barrier cost reasonableness is based on the 7 benefiting residences within the ZoI_{mod}. *The proposed extension is providing acoustically feasible abatement to 3 of the 4 impacted properties and acoustically reasonable abatement to 5 of the 7 benefiting properties. This meets MDOT SHA's Highway Noise Policy (2020) by benefiting at least 70% of the impacted residences [75%] and achieving the design goal for at least 70% of the benefited residences [71%]. (See Figure H.3 after this page.)*

Example H.4: *Sixteen residences are predicted to be impacted behind an existing berm. A barrier is proposed to tie-in to the berm to eliminate all the impacts. A comparison of the barrier extension to the existing berm indicates that up to 39 residences are receiving a combined noise reduction of 5-dB(A) or more in the vicinity. However, 10 residences are getting less than a 3-dB(A) improvement from the modification, so they fall outside the* ZoI_{mod}.

The barrier cost reasonableness is based on the 29 benefiting residences within the ZoI_{mod}. *The proposed extension is providing acoustically feasible abatement to all of the 16 impacted properties and acoustically reasonable abatement to 23 of the 29 benefiting properties. This meets MDOT SHA's Highway Noise Policy (2020) by benefiting at least 70% of the impacted residences [100%] and achieving the design goal for at least 70% of the benefited residences [79%]. (See Figure H.4 after the page following.)*

Figure H.3 Barrier Modification Zone of Influence Map for Example H.3

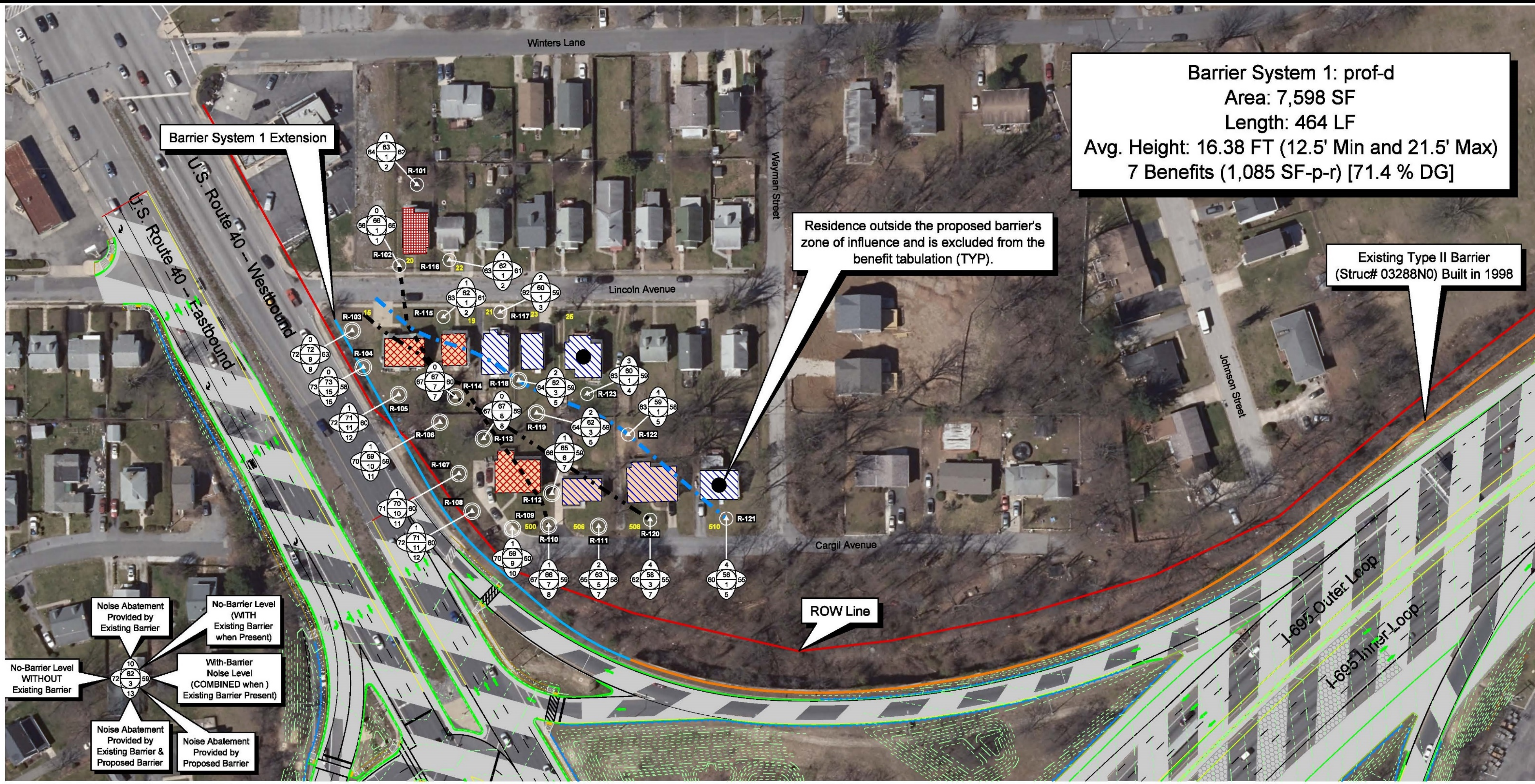
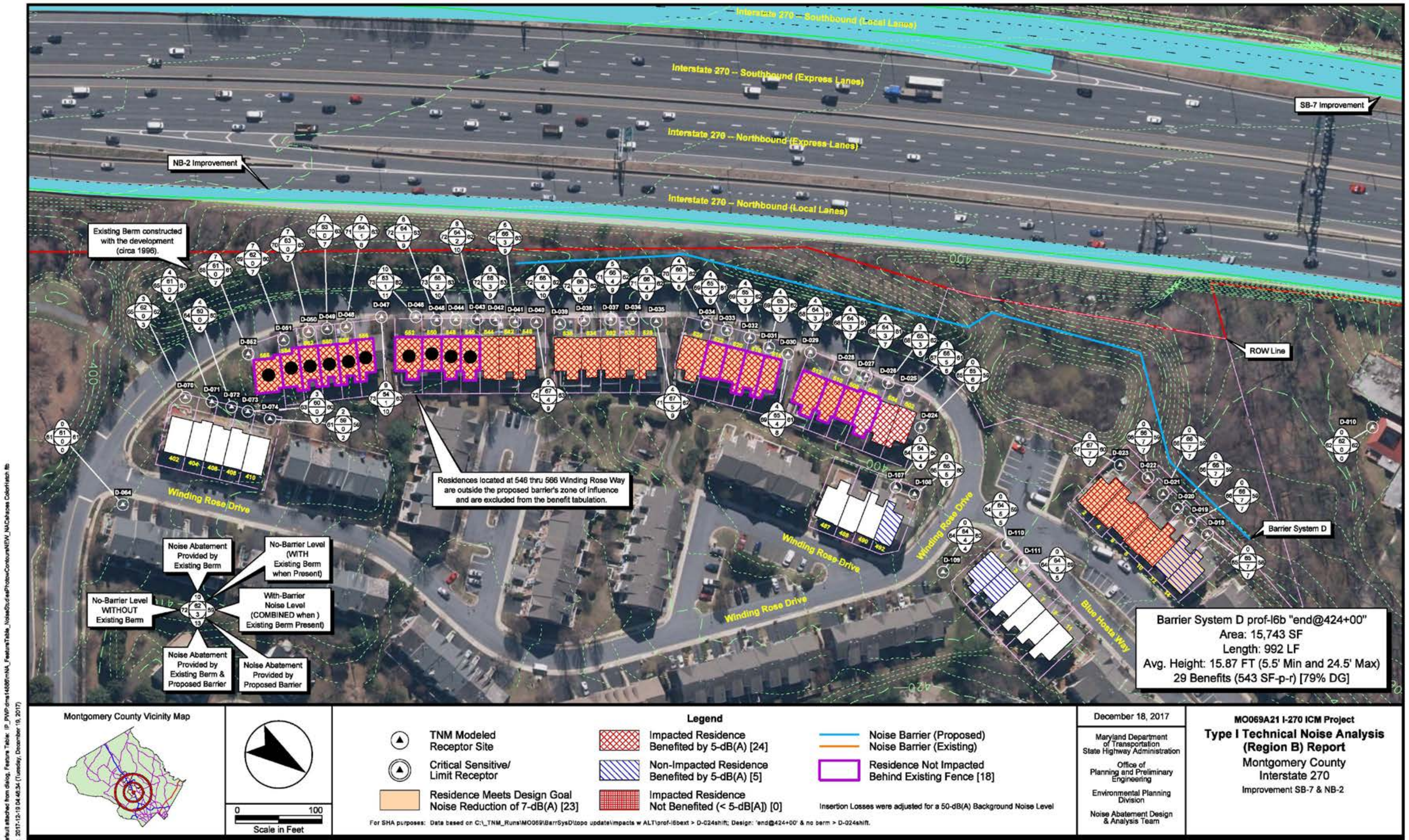


Figure H.4 Barrier Modification Zone of Influence Map for Example H.4



Appendix I – BARRIER OPTIMIZATION GUIDANCE FOR INNOVATIVE CONTRACTING PROJECTS

MDOT SHA HIGHWAY NOISE ABATEMENT PLANNING AND ENGINEERING GUIDELINES – ***April 16, 2020***

PURPOSE

To provide general guidance for barrier optimization during the final design phase for Innovative Contracting Projects by providing the rationale for minimum acceptable noise reductions per receptor and the minimum top of wall elevations needed to block line-of-sight at critical sensitive and limit receptors. This information should be included in one of the noise report appendices. However, if barrier optimization guidance is not included in the noise report, then any proposed barrier optimization must maintain or improve upon the results cited in the noise report.

BARRIER OPTIMIZATION

The barrier analysis designs detailed in approved noise reports are developed in accordance with MDOT SHA's *Highway Noise Policy* (2020), and *Highway Noise Abatement Planning and Engineering Guidelines [Guidelines]* (2020). While the goal during the noise analysis was to establish a realistic Top of Wall profile for each barrier system, which was feasible and reasonable, it is recognized that the barrier systems could potentially be further optimized without sacrificing the intended noise reduction.

Noise Abatement Performance Specifications

When a noise barrier system is being constructed as part of an Innovative Contracting Project (ICP), such as under a design-build (D-B) contract, the scope of work for the contract is included in the special provisions. The portion that governs the barrier design is listed in the Noise Abatement Performance Specifications (TC 3.18). An excerpt focusing on barrier optimization is included below:

The Design-Build Team may modify the horizontal and/or Top of Wall configuration of the noise barrier systems provided:

a) The line-of-sight break provided by the noise barrier system for any benefited residence or benefited outdoor noise sensitive use (ONSU) is not reduced from that provided by the preliminary engineering barrier system, AND

b) The noise reduction provided by the noise barrier system at any benefited residence or benefited outdoor noise sensitive use (ONSU) is not reduced from that provided by the preliminary engineering barrier system.

c) If changes are being proposed along the conceptual design Top of Wall profile, then the analysis of these changes shall be conducted in consultation with and approved by the MDOT SHA Noise Abatement Design & Analysis Team (Noise Team) and, where required, revisions to the barrier design shall be developed so as to satisfy the provisions established under items "a." and 'b." above.

This approach is further based on the Federal Regulations, 23 CFR 772.13(i):

(i) For design-build projects, the preliminary technical noise study shall document all considered and proposed noise abatement measures for inclusion in the NEPA document. ***Final design of design-build noise abatement measures shall be based on the preliminary noise abatement design developed in the technical noise analysis.*** *Noise abatement measures shall be considered, developed, and constructed in accordance with this standard and in conformance with the provisions of 40 CFR 1506.5(c) and 23 CFR 636.109.*

Application

Due to the potential vagueness in the terms "based on" and "not reduced from" listed in the regulation and specification above, the next section specifically defines how to meet these guidelines as related to the noise report results and data. The intent of any provided barrier optimization guidance is to permit limited design flexibility, while constraining the amount a revised barrier design can deviate from the established results reported as part of the NEPA process.

MINIMUM ACCEPTABLE NOISE REDUCTION

Receptor Data

The barrier analysis designs focus on impacted and benefited residences or equivalent residences (ER). This is accomplished by using the collective *receptor* data for a particular NSA or property. In some instances, a single receptor may be adequate for evaluating a property. In other cases, multiple receptors are necessary. Receptors are generally placed throughout an area so that results per residence can be obtained either directly, by interpolation, or by extrapolation of the discrete data. Additional "new" receptors could be analyzed to better understand regions where benefits were originally defined by interpolation and extrapolation to help justify proposed optimization changes.

Table I.1 below illustrates the headings needed to document the analysis results for each receptor studied for a given barrier system. The tables should include the minimum acceptable insertion losses and the calculated difference between the report data and what would be allowable through optimization during final design.

Rationale

The rationale behind the reduced noise abatement is defined below and is included to help explain why noise reduction may have been allowed at some receptors, but not others:

1. According to the "Noise Abatement Design Goal" section in the *Guidelines*, MDOT SHA has a minimum noise reduction design goal of 7 dB(A) for impacted residences, but it also has a desirable noise reduction goal of 10 dB(A) "where practical". Consequently, if the insertion losses (after background noise level adjustments) were between 7 to 10 dB(A) for impacted receptors, then the noise reduction goal can *sometimes* be reduced, provided it does not lower the number of impacted residences achieving design goal abatement or compromise other performance objectives.

   Example I.1a: A receptor with a noise level of 68 dB(A) is shown to have an insertion loss of 9 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is 7 dB(A), meaning any revised barrier design must provide at least that amount.

   Example I.1b: A receptor with a noise level of 68 dB(A) is shown to have an insertion loss of 9 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is still 9 dB(A), meaning any revised barrier design must provide at least that amount. Consequently, no further reduction is allowed.

2. In order to maintain consistency with past MDOT SHA design practice, the concept of with-barrier uniformity is utilized to reduce "hot spots" within the NSA. A "hot spot" is a location within an NSA that has a noticeably (4+ decibel) higher with-barrier noise level than neighboring locations. Ideally, after the barrier is in place, the variation in with-barrier highest noise levels should be less than 3 dB(A), since a 3-decibel difference is approximately the amount where most people will start to perceive a change in noise levels. Similarly, MDOT SHA strives to make the top of the with-barrier uniformity range to be 63 or 64 dB(A), so that it will be around 3 decibels below the residential (Category B) noise abatement criteria of 66 dB(A). Consequently, receptors with higher noise levels (75 dB[A] or greater) often need to have insertion losses greater than 10 dB(A) to reach the acceptable with-barrier noise level.

   Example I.2a: *A receptor with a noise level of 75 dB(A) is shown to have an insertion loss of 13 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is 11 dB(A), which yields a 64 dB(A) with-barrier noise level.*

   Example I.2b: *A receptor with a noise level of 76 dB(A) is shown to have an insertion loss of 13 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is <u>still</u> 13 dB(A), meaning any revised barrier design must provide <u>at least</u> that amount, which yields a 63 dB(A) with-barrier noise level. Consequently, <u>no further reduction is allowed</u>.*

3. In order to maintain the same number of benefited residences *achieving a minimum 7 dB(A) insertion loss*, <u>non-impacted</u> receptors that have insertion losses (after background noise level adjustments) between 7 and 10 dB(A) can *sometimes* be reduced, provided that the noise reduction achieved at nearby impacted properties is not unacceptably changed.

   Example I.3a: *A receptor with a noise level of 64 dB(A) is shown to have an insertion loss of 8 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is 7 dB(A), meaning any revised barrier design must provide <u>at least</u> that amount.*

   Example I.3b *A receptor with a noise level of 64 dB(A) is shown to have an insertion loss of 8 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is <u>still</u> 8 dB(A), meaning any revised barrier design must provide <u>at least</u> that amount. Consequently, <u>no further reduction is allowed</u>.*

4. In order to maintain at least the same *number* of benefitted residences (for cost reasonableness), receptors that have a benefiting insertion loss <u>less than</u> 7 dB(A), can *sometimes* be reduced if they are still benefited.

   Example I.4a *A receptor with a noise level of 64 dB(A) is shown to have an insertion loss of 6 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is 5 dB(A), meaning any revised barrier design must provide <u>at least</u> that amount.*

   Example I.4b *A receptor with a noise level of 64 dB(A) is shown to have an insertion loss of 6 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is <u>still</u> 6 dB(A), meaning any revised barrier design must provide <u>at least</u> that amount. Consequently, <u>no further reduction is allowed</u>.*

5. An allowable noise reduction goal is generally not applicable (“n/a”) for any impacted or non-impacted receptor that has an insertion loss less than 5 dB(A) in the noise report, unless specifically noted otherwise.

Example I.5a *A receptor with a noise level of 64 dB(A) is shown to have an insertion loss of 2 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is not applicable (“n/a”), meaning any revised barrier design can provide any amount, including 0 dB(A).*

Example I.5b *A receptor with a noise level of 66 dB(A) is shown to have an insertion loss of 4 dB(A). The barrier optimization guidance indicates that the minimum acceptable noise reduction is still 4 dB(A), meaning any revised barrier design must provide at least that amount. Consequently, no further reduction is allowed.*

Allowable Optimized Noise Reduction Goals

Note: Many of the noise reductions cited in a report are the result of line-of-sight requirements and/or goals being achieved at neighboring receptors with higher noise levels. Therefore, there is no guarantee that reduced noise abatement can actually be achieved at each receptor.

Tables with the headings listed in Table I.1 below would be organized according to each Barrier System Map, so that the table can be directly cross-referenced with the map. Those receptors that are depicted on more than one map part would appear twice in the table, marked with a note and gray shading. Background noise level adjustments are applied to the TNM results using MDOT SHA’s standard barrier analysis spreadsheets.

Table I.1 Barrier System Minimum Acceptable Noise Reduction Goals (HEADINGS ONLY)

REPORT Map	REPORT TNM Modeled Receptor	REPORT Modeled Noise Level (dB[A])	REPORT Insertion Loss after Background Noise Level Adjustment (dB[A])	MINIMUM ACCEPTABLE Noise Reduction Goal after Background Noise Level Adjustment (dB[A])	Difference (dB[A])	Critical Sensitive (CS)/Limit Receptor	Notes

MINIMUM LINE-OF-SIGHT REQUIREMENTS

Top of Wall Profile Development

The minimum line-of-sight elevations for each barrier segment are generally determined by checking each of the critical sensitive and limit receptors using 1-foot perturbations in TNM. These results are then compiled into a line-of-sight profile, which is smoothed out and then used as a foundation for developing the Top of Wall (ToW) profiles for each barrier system. Often, the noise reduction goals and the realistic engineering stepping scheme govern the design profile, rather than the line-of-sight.

An aesthetic run of barrier “steps” can sometimes cause the Top of Wall elevation to be lower than the established minimum line-of-sight. This condition may still be acceptable because the initial line-of-sight was checked with such a large perturbation (12 inches), meaning that the line-of-sight could potentially be refined further. Rather than creating a more precise line-of-sight profile for all of the targeted receptors, only the receptors in question need to be rechecked against the Top of Wall profile.

Barrier Segment Line-of-Sight and Top of Wall Elevations

Tables with the headings listed in Table I.2 below would compare the minimum line-of-sight elevation with the barrier system top of wall elevation. The segment names and ground elevations would coincide with the TNM models listed in Appendix C of the noise report. This information is intended to document the difference between the two profiles to aid in any barrier optimization efforts. Only the governing receptors that set the line-of-sight elevation for a particular barrier segment would be included. Other receptors may still require line-of-sight to be blocked for a given segment, just at a lower elevation. Additional information would be contained in MDOT SHA's barrier analysis spreadsheets.

Note: If the noise barrier alignments are significantly modified during final design, then many of the line-of-sight requirements would have to be reassessed for the critical sensitive and limit receptors.

Table I.2 — **Barrier System Minimum Acceptable Line-of-Sight Elevations (HEADINGS ONLY)**

TNM Barrier Segment Name	TNM Ground Elevation (Z)	REPORT Critical Line-of-Sight Height	REPORT Line-of-Sight Elevation	Governing Receptor	REPORT Top of Wall Elevation	Difference	Notes

SUMMARY

Any modified top-of-wall profile that meets the minimum acceptable noise reduction goals and the minimum line-of-sight requirements will generally be acceptable, providing the other performance specifications requirements are followed, including coordination with the Noise Team.

PURPOSE

To describe MDOT SHA's barrier performance score, which is a tool that can aid in the ranking of different acoustic designs.

DEFINITION

The *barrier performance score* (BPS) allows for alternative acoustic profiles to be objectively compared by balancing acoustical performance with cost-effectiveness. The score can range from 0 to 100, where zero (0) represents the minimally acceptable performance and cost of a feasible and reasonable barrier system under MDOT SHA's *Highway Noise Policy* (2020). A score of one-hundred (100) represents the highest performance that is most cost-effective. The acoustic portion consists of two parts: acoustic feasibility and acoustic reasonableness. Both the acoustic portion and the cost portion can achieve a maximum of fifty (50) points, which means that the two considerations have equal weight in the total score. The components of the score are explained in detail below.

Percentage of Impacted Benefited (PIB) [Acoustic Performance]

MDOT SHA requires that at least 70 percent of the impacted residences[1] be benefited by 5-dB(A) or more, which represents the minimum acoustic feasibility of a barrier system. However, one factor of MDOT SHA's performance objectives seeks to eliminate all impacts; therefore, a reasonable consideration would be to at least benefit 100 percent of the impacted residences. (However, this still would not necessarily eliminate all impacts.) The PIB equation generates points, ranging from 0 to 30, based on how well the barrier system achieves this consideration.

PIB Equation:

Equation J.1

$$\boldsymbol{PIB_{pnts}} = (\boldsymbol{PIB_{pcnt}} \times \mathbf{100}) - (\mathbf{100} - \mathbf{30})$$

Maximum 30 points

$$\boldsymbol{PIB_{pcnt}} = \boldsymbol{Percentage\ of\ impacted\ residences\ that\ are\ benefited\ by\ 5\ dB(A)\ or\ more;\ valid\ when} \geq \mathbf{70}\%$$

Design Goal Percentage (DGP) [Acoustic Performance]

MDOT SHA requires that at least three (3) of the impacted residences, or at least 50 percent of the impacted residences, whichever is greater, be benefited by 7-dB(A) or more, which represents the minimum acoustic reasonableness of a barrier system. Ideally, a barrier system should provide design goal abatement at each of the impacted residences; however, this is not always possible or practical. The DGP equation generates points, ranging from 0 to 20, based on how many impacted residences meet the design goal over-and-above the minimum.

[1] Benefited Outdoor Noise Sensitive Uses (ONSU) for Land Use Activity Category B, C, D, and E areas are converted into equivalent benefited residences (ER) based on either linear frontage or capacity as described in **Appendix D**. The PIB and DGP equations only consider the initial ER determination values per use. Any use-time percentage (UTP) adjustments on the ER values would be reflected in the SFR equation. See example J.2 for details.

DGP Equation:

$$DGP_{pnts} = \left(\frac{\left((DGP_{pcnt} \times 100) - 50 \right)}{50} \right) \times 20 \qquad \textit{Equation J.2}$$

Maximum 20 points

$$DGP_{pcnt} = \textbf{Percentage of impacted residences that are benefited by 7 dB(A) or more};$$
$$\textbf{valid when } \geq 50\% \textbf{ AND}$$
$$\textbf{when number of Impacted residences that are benefited by at least 7 dB(A)} \geq 3$$

Square-Footage per Residence (SFR) [Cost-Effectiveness]

These guidelines establish an evaluation threshold for cost reasonableness based on the specifics of the Type I project and the noise sensitive areas (NSAs) being protected by a barrier system. The "cost" of a barrier system is evaluated based on the quantity of barrier area per benefited residence (including any benefited equivalent residences from protected Category C, D, or E areas). The SFR equation generates points, ranging from 0 to 50, based on the cost-effectiveness of the barrier system by comparing the barrier SFR to the evaluation threshold SFR. Zero (0) points would mean that the barrier SFR is equal to the evaluation threshold, which would be the least cost-effective. Fifty (50) points would mean that the barrier SFR is 500 or less, which would be very cost-effective.

SFR Equation:

$$SFR_{pnts} = \left(\frac{50}{(SFR_{gvrn} - 500)} \right) \times (SFR_{gvrn} - SFR_{barr}) \qquad \textit{Equation J.3}$$

Maximum 50 points

$$SFR_{barr} = \textit{Barrier System square} - \textit{footage per benefited residence (includes any Extra} - \textit{Costs)};$$
$$\textbf{valid when} \geq 500 \text{ and } \leq SFR_{gvrn}$$
$$\textit{If } SFR_{barr} < 500, \textit{then } SFR_{pnts} = 50$$
$$SFR_{gvrn} = \textit{Governing Threshold square} - \textit{footage per benefited residence}$$

Barrier Performance Score (BPS)

The BPS equation totals the points from the three equations listed above. When comparing two or more acoustic profiles, a higher score always means a better barrier. The score can represent a minimally performing barrier that has low cost-effectiveness (BPS = 0), a maximum performing barrier that is highly cost-effective (BPS = 100), or some combination in-between where increased acoustical performance may be offset by decreased cost effectiveness or vice versa.

BPS Equation:

$$BPS = PIB_{pnts} + DGP_{pnts} + SFR_{pnts} \qquad \textit{Equation J.4}$$

Maximum 100 points
Minimum 0 points

Potential Recommendation Considerations

While the BPS score provides an effective measure for comparing alternative acoustic profiles for a barrier system, there may be other considerations that need to be evaluated before a final recommendation can be made.

Breaking Ties

If the BPS score for acoustic profiles of a barrier system yield the same result (or a rounded tie), then generally the one with the least square-footage would be recommended, since it would likely cost less.

Checking Close Scores

If the BPS score for acoustic profiles of a barrier system are less than **3 points** apart (unrounded), then the difference between the areas is divided by the difference between the number of benefited. The square-footage per benefited residences (SF-p-r) difference is compared to the evaluation threshold. If the difference exceeds the threshold or there is zero difference in the number of benefited, then the barrier with the lower square-footage is recommended. If the difference is less than or equal to the threshold, then the barrier with the higher BPS is recommended, regardless of the difference in barrier system square-footage, unless the logical termini should be compared (see below).

Comparing Logical Termini

Sometimes the scope of a barrier system's protection needs to be evaluated based on the length of coverage. Since one of MDOT SHA's performance objectives is to eliminate all impacts, a barrier system will typically be studied so that it is long enough to potentially achieve this objective. This is also tied into the logical termini of the barrier system. However, there have been instances where a group of impacted residences have been more isolated, and the barrier length needs to be extended significantly in order to protect them. It is appropriate in that scenario to evaluate whether the extended length is reasonable or not, even if the overall barrier system appears to be feasible and reasonable and the BPS yields the highest score.

The difference between the areas is divided by the difference between the number of benefited. The square-footage per benefited residences (SF-p-r) difference is compared to the evaluation threshold. If the difference exceeds the threshold or there is zero difference in the number of benefited, then the barrier with the lower square-footage is recommended. If the difference is less than or equal to the threshold, then the barrier with the higher BPS is recommended, regardless of the difference in barrier system square-footage.

EXAMPLES

Define Terms

$numIMP = number\ of\ Impacted\ residences\ (initial\ ER\ values)$

$numIMPben5 = \ number\ of\ Impacted\ residences\ that\ are\ benefited\ by\ at\ least\ 5\ dB(A)\ (initial\ ER\ values)$

$numIMPben7 = \ number\ of\ Impacted\ residences\ that\ are\ benefited\ by\ at\ least\ 7\ dB(A)\ (initial\ ER\ values)$

$numBEN = total\ number\ of\ Benefited\ residences\ (ER\ values\ multiplied\ by\ use - time\ percentage\ [UTP])$

$PIB_{pcnt} = numIMPben5/numIMP$

$DGP_{pcnt} = \ numIMPben7/numIMP$

Example J.1: Barrier L1 versus Barrier L2

Barrier L1

Given:

$Area = 158{,}318\ SF$

$numIMP = 37$

$numIMPben5 = 37$

$numIMPben7 = 37$

$numBEN = 59$

$SFR_{barr} = 2{,}684 = \frac{Area}{numBEN}$

$SFR_{gvrn} = 2{,}700$

Calcs:

$PIB_{pnts} = (PIB_{pnts} \times 100) - (100 - 30)$

$PIB_{pnts} = ({}^{37}/_{37} \times 100) - (70)$

$PIB_{pnts} = (1 \times 100) - (70)$

$PIB_{pnts} = (100) - (70)$

$\boldsymbol{PIB_{pnts} = 30.00}$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((DGP_{pnts} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{(({}^{37}/_{37} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((1 \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{50}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = (1) \times 20}$$

$$\boldsymbol{DGP_{pnts} = 20.00}$$

$$SFR_{pnts} = \left(\frac{50}{(SFR_{gvrn} - 500)}\right) \times (SFR_{gvrn} - SFR_{barr})$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}700 - 500)}\right) \times (2{,}700 - 2{,}684)$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}200)}\right) \times (16)$$

$$\boldsymbol{SFR_{pnts} = 0.36}$$

$BPS = PIB_{pnts} + DGP_{pnts} + SFR_{pnts}$

$BPS = 30.0 + 20.0 + 0.36 = 50.36$

$\boldsymbol{BPS = 50.36}$

Barrier L2 - Reduced Length

Given:

$Area = 128{,}476\ SF$

$numIMP = 37$

$numIMPben5 = 36$

$numIMPben7 = 36$

$numBEN = 56$

$SFR_{barr} = 2{,}295 = \frac{Area}{numBEN}$

$SFR_{gvrn} = 2{,}700$

Calcs:

$PIB_{pnts} = (PIB_{pnts} \times 100) - (100 - 30)$

$PIB_{pnts} = ({}^{36}/_{37} \times 100) - (70)$

$PIB_{pnts} = (0.9730 \times 100) - (70)$

$PIB_{pnts} = (97.30) - (70)$

$\boldsymbol{PIB_{pnts} = 27.30}$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((DGP_{pnts} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{(({}^{36}/_{37} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((0.9730 \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((97.30) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{47.3}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = (0.946) \times 20}$$

$$\boldsymbol{DGP_{pnts} = 18.92}$$

$$SFR_{pnts} = \left(\frac{50}{(SFR_{gvrn} - 500)}\right) \times (SFR_{gvrn} - SFR_{barr})$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}700 - 500)}\right) \times (2{,}700 - 2{,}295)$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}200)}\right) \times (405)$$

$$\boldsymbol{SFR_{pnts} = 9.20}$$

$BPS = PIB_{pnts} + DGP_{pnts} + SFR_{pnts}$

$BPS = 27.30 + 18.92 + 9.20 = 55.42$

$\boldsymbol{BPS = 55.42}$

L2 scores more than 3 points higher than L1; therefore, L2 would be recommended.

Example J.2: Barrier T2 versus Barrier T1

Barrier T2

Given:

$$Area = 57{,}105\ SF + \mathbf{36{,}270\ SF} = 93{,}375\ SF$$

$$numIMP = 13 + 3\ ER = 16;$$

$$\frac{376\ LF}{125} = 3\ ER$$

$$numIMPben5 = 13 + 3\ ER = 16$$

$$numIMPben7 = 13 + 3\ ER = 16$$

$$numBEN = 40 + 0.05ER = 40.05;$$

$$UTP = \left(\frac{2}{12} \times \frac{4}{7} \times \frac{4}{24}\right) = 0.01587$$

$$SFR_{barr} = 2{,}332 = \frac{Area}{numBEN}$$

$$SFR_{gvrn} = 2{,}700$$

Calcs:

$$PIB_{pnts} = (PIB_{pnts} \times 100) - (100 - 30)$$

$$PIB_{pnts} = ({}^{16}/_{16} \times 100) - (70)$$

$$PIB_{pnts} = (1 \times 100) - (70)$$

$$PIB_{pnts} = (100) - (70)$$

$$\boldsymbol{PIB_{pnts} = 30.00}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((DGP_{pnts} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{(({}^{16}/_{16} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((1 \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{50}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = (1) \times 20}$$

$$\boldsymbol{DGP_{pnts} = 20.00}$$

$$SFR_{pnts} = \left(\frac{50}{(SFR_{gvrn} - 500)}\right) \times (SFR_{gvrn} - SFR_{barr})$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}700 - 500)}\right) \times (2{,}700 - 2{,}332)$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}200)}\right) \times (368)$$

$$\boldsymbol{SFR_{pnts} = 8.36}$$

$$BPS = PIB_{pnts} + DGP_{pnts} + SFR_{pnts}$$

$$BPS = 30.00 + 20.00 + 8.36 = 62.00$$

$$\boldsymbol{BPS = 58.36}$$

Barrier T1 - Reduced Length (does not protect impacted park)

Given:

$$Area = 38{,}264\,SF + \mathbf{16{,}442\,SF} = 54{,}706\,SF$$

$$numIMP = 13 + 3ER = 16;$$

$$\frac{376\,LF}{125} = 3\,ER$$

$$numIMPben5 = 13$$

$$numIMPben7 = 10$$

$$numBEN = 30$$

$$SFR_{barr} = 1{,}824 = \frac{Area}{numBEN}$$

$$SFR_{gvrn} = 2{,}700$$

Calcs:

$$PIB_{pnts} = (PIB_{pnts} \times 100) - (100 - 30)$$

$$PIB_{pnts} = ({}^{13}/_{16} \times 100) - (70)$$

$$PIB_{pnts} = (0.8125 \times 100) - (70)$$

$$PIB_{pnts} = (81.25) - (70)$$

$$\mathbf{PIB_{pnts} = 11.25}$$

$$\mathbf{DGP_{pnts}} = \left(\frac{((\mathbf{DGP_{pnts}} \times \mathbf{100}) - \mathbf{50})}{\mathbf{50}}\right) \times \mathbf{20}$$

$$\mathbf{DGP_{pnts}} = \left(\frac{(({}^{\mathbf{10}}/_{\mathbf{16}} \times \mathbf{100}) - \mathbf{50})}{\mathbf{50}}\right) \times \mathbf{20}$$

$$\mathbf{DGP_{pnts}} = \left(\frac{((\mathbf{0.625} \times \mathbf{100}) - \mathbf{50})}{\mathbf{50}}\right) \times \mathbf{20}$$

$$\mathbf{DGP_{pnts}} = \left(\frac{((\mathbf{62.50}) - \mathbf{50})}{\mathbf{50}}\right) \times \mathbf{20}$$

$$\mathbf{DGP_{pnts}} = \left(\frac{\mathbf{12.50}}{\mathbf{50}}\right) \times \mathbf{20}$$

$$\mathbf{DGP_{pnts}} = (\mathbf{0.25}) \times \mathbf{20}$$

$$\mathbf{DGP_{pnts} = 5.00}$$

$$SFR_{pnts} = \left(\frac{50}{(SFR_{gvrn} - 500)}\right) \times (SFR_{gvrn} - SFR_{barr})$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}700 - 500)}\right) \times (2{,}700 - 1{,}824)$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}200)}\right) \times (876)$$

$$\mathbf{SFR_{pnts} = 19.91}$$

$$BPS = PIB_{pnts} + DGP_{pnts} + SFR_{pnts}$$

$$BPS = 11.25 + 5.00 + 19.91 = 36.16$$

$$\mathbf{BPS = 36.16}$$

Barrier T2 is more than 3 points higher than Barrier T1; therefore, Barrier T2 is recommended.

Example J.3: “SHORT” align versus “LONG” align

“SHORT” align

Given:

$Area = 44{,}605\ SF$

$numIMP = 33$

$numIMPben5 = 30$

$numIMPben7 = 28$

$numBEN = 43$

$SFR_{barr} = 1{,}038 = \frac{Area}{numBEN}$

$SFR_{gvrn} = 2{,}700$

Calcs:

$PIB_{pnts} = (PIB_{pnts} \times 100) - (100 - 30)$

$PIB_{pnts} = ({}^{30}/_{33} \times 100) - (70)$

$PIB_{pnts} = (0.9091 \times 100) - (70)$

$PIB_{pnts} = (91.91) - (70)$

$\boldsymbol{PIB_{pnts} = 21.91}$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((DGP_{pnts} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{(({}^{28}/_{33} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((0.8485 \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((84.85) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{34.85}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = (0.697) \times 20}$$

$$\boldsymbol{DGP_{pnts} = 13.94}$$

$$SFR_{pnts} = \left(\frac{50}{(SFR_{gvrn} - 500)}\right) \times (SFR_{gvrn} - SFR_{barr})$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}700 - 500)}\right) \times (2{,}700 - 1{,}038)$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}200)}\right) \times (1{,}662)$$

$$\boldsymbol{SFR_{pnts} = 37.77}$$

$BPS = PIB_{pnts} + DGP_{pnts} + SFR_{pnts}$

$BPS = 20.91 + 13.94 + 37.77 = 72.62$

$\boldsymbol{BPS = 73.62}$

<u>"LONG" align</u>

Given:

$Area = 59{,}402\ SF$

$numIMP = 33$

$numIMPben5 = 33$

$numIMPben7 = 31$

$numBEN = 46$

$SFR_{barr} = 1{,}292 = \frac{Area}{numBEN}$

$SFR_{gvrn} = 2{,}700$

Calcs:

$PIB_{pnts} = (PIB_{pnts} \times 100) - (100 - 30)$

$PIB_{pnts} = (^{33}/_{33} \times 100) - (70)$

$PIB_{pnts} = (1 \times 100) - (70)$

$PIB_{pnts} = (100) - (70)$

$\boldsymbol{PIB_{pnts} = 30.00}$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((DGP_{pnts} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((^{31}/_{33} \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((0.9394 \times 100) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{((93.94) - 50)}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = \left(\frac{43.94}{50}\right) \times 20}$$

$$\boldsymbol{DGP_{pnts} = (0.8788) \times 20}$$

$$\boldsymbol{DGP_{pnts} = 17.58}$$

$$SFR_{pnts} = \left(\frac{50}{(SFR_{gvrn} - 500)}\right) \times (SFR_{gvrn} - SFR_{barr})$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}700 - 500)}\right) \times (2{,}700 - 1{,}292)$$

$$SFR_{pnts} = \left(\frac{50}{(2{,}200)}\right) \times (1{,}408)$$

$$\boldsymbol{SFR_{pnts} = 32.00}$$

$$BPS = PIB_{pnts} + DGP_{pnts} + SFR_{pnts}$$

$$BPS = 30.00 + 17.58 + 32.00 = 79.58$$

$$\boldsymbol{BPS = 79.58}$$

*The "LONG" alignment scores nearly 6 points higher than the "SHORT" alignment; therefore, <u>"LONG" would be recommended</u>. **However**, the logical termini should be compared since the wall extends significantly to protect three impacted residences:*

Difference in SF: "LONG" Area – "SHORT" Area = 59,402 – 44,605 = 14,797 SF

Difference in numBEN: "LONG" numBEN – "SHORT" numBEN = 46 – 43 = 3 residences

Difference SF-p-r = 14,797 SF/3 residences = 4,932 SF-p-r > 2700

Therefore, <u>"SHORT" align is recommended</u>.

PURPOSE

To outline MDOT SHA's policy for the evaluation of noise resulting from Part-Time Shoulder Use.

BACKGROUND

Part-time shoulder use (PTSU) is a transportation system management and operations (TSMO) strategy that uses shoulders to provide additional capacity when it is most needed and preserves shoulders as refuge areas during non-congestion hours.

In 2016, FHWA published Document #FHWA-HOP-15-023, Use of Freeway Shoulders for Travel — Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy. These guidelines outline the process by which noise analyses should be completed for PTSU projects. Federal actions, including federal funding and design exceptions required for PTSU projects, will require federal concurrence, and therefore projects will be subject to 23 CFR 772 (the FWHA noise regulation). In order to comply with 23 CFR 772, a noise analysis is required for all projects that are defined as Type I. Although there are eight parts to the Type I project definition, FHWA identifies three that may encompass a PTSU project:

- "The physical alteration of an existing highway where there is…substantial horizontal alteration. A project that halves the distance between the traffic noise source and the closest receptor between the existing condition and the future build condition."
- "The addition of a through-traffic lane(s). This includes the addition of a through-traffic lane that functions as a high-occupancy vehicle (HOV) lane, High-Occupancy Toll (HOT) lane, bus lane, or truck climbing lane."
- "Restriping the existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane."
    - Note: For the addition of an auxiliary lane to be considered a Type I project, it must have a minimum length of 2500 feet.

PTSU CATEGORIES

MDOT SHA recognizes four categories of PTSU (all categories **exclude** heavy trucks from PTSU):

- **Static shoulder use** for most vehicles during predetermined hours of operation (i.e., during a static period of time each day).
- **Static-Select-Dynamic shoulder use** for most vehicles during predetermined hours of operation (i.e., during a static period of time each day) through the use of a dynamic system that allows the *option* of select use outside of the predetermined hours, based on emergency needs (i.e., crashes, snow, flooding, evacuation) or atypical traffic conditions.
- **Bus-only shoulder use** (Bus on Shoulder, or BOS) to improve bus travel time and reliability.
- **Dynamic shoulder use** for most vehicles based on need and real-time traffic conditions.

NOISE IMPACT AND ABATEMENT EVALUATION METHODOLOGY

Based on FHWA's approval for other State DOTs, specifically Washington State DOT, the following part-time shoulder use solutions are **exempt** from noise analyses, since they are unlikely to have any effect on the noise environment:

- *Static and Static-Select-Dynamic, inside shoulder use* that does not shift existing lanes of traffic closer to noise sensitive receptors.
- *Dynamic, inside or outside shoulder use* where posted speeds would be reduced to 35 mph or lower.

All other part-time shoulder use solutions would require a noise analysis. The level of noise analysis necessary will depend upon the type of part-time shoulder use.

- *Bus-only use of shoulders* (Bus on Shoulder, or BOS) to improve bus travel time: analyze noise qualitatively (without modeling) because the additional vehicles and changes in speed are small and/or nonexistent.
- *Dynamic, inside or outside shoulder use,* where posted speeds are not reduced to 35 mph or lower, will require a noise analysis similar to a conventional Type I project.
- *Static and Static-Select-Dynamic, outside shoulder use* will require a noise analysis, similar to a conventional Type I project. Heavy trucks will be prohibited from using the shoulder during static operating hours.

The determination of noise impacts depends on peak noise conditions. The peak noise may or may not correspond with peak volume conditions (when shoulder lanes are typically open), and analysis will determine whether part-time shoulder use affects peak noise levels. In compliance with FHWA guidance, noise abatement must be considered and implemented (if found to be feasible and reasonable), when part-time shoulder use **increases** peak noise and there are **impacts** associated with it. The following parameters will be followed for determining impact.

- The build condition peak hour noise level must be at or above the appropriate NAC level, which is currently defined as approaching the NAC or 66dBA or more.
- There must be a perceptible increase in peak hour noise level (at least 3 dBA) from the existing condition to the proposed build condition in the design year.

Table K.1 Noise Analysis Determination for Part-Time Shoulder Use

PTSU Type	PTSU Location	
	Inside Shoulder	Outside Shoulder
Static	N	Y
Less than 35mph	N	N
Static-Select-Dynamic	N	Y
Less than 35mph	N	N
Dynamic	Y	Y
Less than 35mph	N	N
Bus Only	Q[1]	Q[1]

[1]Bus-only PTSU requires a qualitative, or narrative, analysis of the existing and future noise environments
NOTE: All categories exclude heavy trucks from part-time shoulder use