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VALIDATION REPORT ADDENDUM

TRAFFIC NOISE MODEL 3.2

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Washington, D.C.

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13. ABSTRACT (Maximum 200 words)

The Federal Highway Administration's Traffic Noise Model (TNM) version 3.2 was released in January 2024. The software updates in this version of TNM were focused on integrating the capabilities of the Roadway Construction Noise Model version 2.0 into the TNM 3.1 architecture. Additional bug fixes and model improvements were also included. This memo supplements the TNM 3.0 Validation Report to confirm that results produced by the latest version of the Traffic Noise Model have not significantly changed from those produced by previous versions of the TNM 3 Series. No changes to the TNM acoustic algorithms were made between versions 3.0 and 3.1 such that TNM 3.1 results are equivalent to those produced by TNM 3.0. TNM results were computed using both versions 3.1 and 3.2 for all project files in the Validation Testing and Diagnostic Testing datasets. The FHWA Automated Consistency Test Suite (ACTS) was used to evaluate project geometry and computed receiver noise levels between the two versions.

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INTRODUCTION

The Federal Highway Administration's Traffic Noise Model (TNM) version 3.2 was released in January 2024. The software updates in this version of TNM were focused on integrating the capabilities of the Roadway Construction Noise Model version 2.0 into the TNM 3.1 architecture. Additional bug fixes and model improvements were also included. For more details, see the TNM 3.1 to TNM 3.2 Change Log.

This memo is intended to supplement the TNM 3.0 Validation Report to confirm that results produced by the latest version of the Traffic Noise Model have not significantly changed from those produced by previous versions of the TNM 3 Series. No changes to the TNM acoustic algorithms were made between versions 3.0 and 3.1[1] such that TNM 3.1 results are equivalent to those produced by TNM 3.0. This memo compares TNM 3.2 against TNM 3.1 to evaluate model consistency because TNM 3.1 is compatible with the FHWA Automated Consistency Test Suite (ACTS).[2]

TNM results were computed using both versions 3.1 and 3.2 for all project files in the Validation Testing and Diagnostic Testing datasets. The ACTS was used to evaluate project geometry and computed receiver noise levels between the two versions. This tool assesses all TNM inputs for each project file pair from the two TNM versions to ensure they are identical before determining receiver level differences.

[1] See the TNM 3.0 to TNM 3.1 Change Log for more details.

[2] TNM 3.0 XML format is not compatible with the FHWA ACTS because it does not include computed results.

VALIDATION TESTING

Validation Testing results from TNM 3.2 and TNM 3.1 were compared to assess TNM modeled results that have already been evaluated against measured data in the TNM 3.0 Validation Report. All Validation Testing project files approximate real-world conditions measured at one of 15 sites throughout the country. Seven of these sites were open areas that did not contain berms or barriers, in which three had acoustically soft ground (i.e., field grass or lawn) and four had acoustically hard ground (i.e., pavement or water). The open area sites were all mostly flat, apart from one, which had undulations ranging from -20 to +3 feet in its terrain features. Eight of the sites did contain berms or barriers, in which seven had acoustically soft ground and one had a mix of acoustically soft and hard ground. Most of the sites containing berms or barriers were flat, although a few had slight inclines across the terrain and two had greater than 15-foot drop-offs between the barriers and measurement locations.

Microphones were placed at 5 and 15-foot heights at all sites. Distances from the microphones to the center of the nearest travel lane varied per site, ranging from 40 to about 1300 feet. Cruising speeds measured at each site also varied, ranging from around 30 to nearly 100 miles per hour in some lanes during some time blocks. One site included a flow control device to account for merging acceleration with a constraint speed of 40 miles per hour.

FIGURE 1 displays receiver level differences between TNM 3.1 and TNM 3.2 for both "with barrier" and "without barrier" conditions. The statistics shown for each site encompass results from all receiver distances across dozens of project files. The number of receivers across all project files for each site is shown in parenthesis after the site name on the X-axes of **FIGURE 1**. Each project file represents a time block of measured traffic from the TNM 3.0 Validation Report. A positive receiver level difference on the Y-axes of the plots in **FIGURE 1** indicates generally lower TNM 3.2 noise levels compared to TNM 3.1, when given the same inputs. The error bars approximate the spread of receiver level differences between the two TNM versions for each site. The bars extend 1.96 times the standard deviation of the receiver level delta for each site in both directions from the mean receiver level delta for each site, thus spanning a 95% confidence interval.

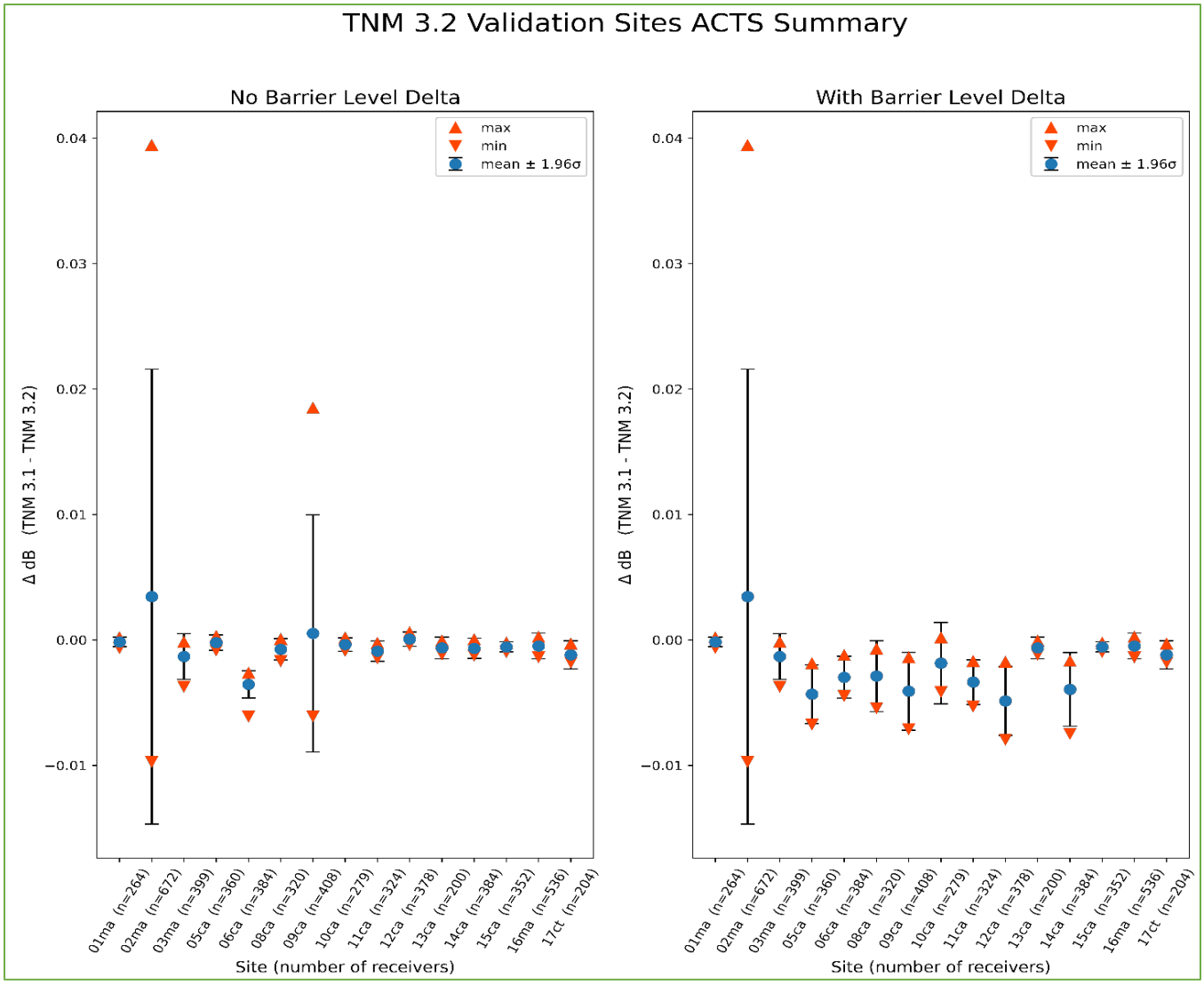

Figure 1 *TNM 3.1 - TNM 3.2 receiver level difference: Validation Testing sites without barriers (left) TNM 3.1 - TNM 3.2 receiver level difference: Validation Testing sites with barriers (right)*

FIGURE 1 illustrates that the roadway noise receiver results produced by TNM 3.2 are essentially identical to those produced by TNM 3.1. Both the "with barrier" and "without barrier" conditions display an average level difference of less than 0.01 dB at all measurement locations. Furthermore, the 95% confidence interval on the mean level difference at most measurement locations also spans less than 0.01 dB for both barrier conditions. Among all measurement locations, the greatest level difference between TNM versions for a single receiver is less than 0.04 dB for both barrier conditions. **The negligible noise level differences yielded from the comparison presented in FIGURE 1 demonstrate validation of the TNM 3.2 results in accordance with the TNM 3.0 Validation Report.**

DIAGNOSTIC TESTING

Diagnostic Testing results from TNM 3.2 and TNM 3.1 were compared to assess implementation of modeling conditions in TNM 3.2. Each Diagnostic Testing "Set" designates a group of similar TNM project files intended to test a single parameter that impacts the TNM acoustics. For example, Set 2 contains several test cases with identical geometry that differ only in default ground type. Each ground type test in Set 2 contains two project files with only auto or heavy truck traffic input, respectively, to isolate the acoustic impact of each ground type at various frequencies.[3] The Diagnostic Testing cases are not included in the TNM 3.0 Validation Report because they do not include measured data to compare against. The geometry of the Diagnostic Testing project files may not represent real-world conditions as the test cases were created for the purpose of diagnosis, not validation.

FIGURE 2 displays receiver level differences between TNM 3.1 and TNM 3.2 for both "with barrier" and "without barrier" conditions for each set on the X-axes. The statistics shown encompass results from all receiver distances across all project files in each Diagnostic Testing set. The number of receivers across all project files in each set is shown in parenthesis after the set number on the X-axes of **FIGURE 2**. A positive receiver level difference on the Y-axes of the plots in **FIGURE 2** indicates generally lower TNM 3.2 noise levels compared to TNM 3.1, when given the same inputs. The error bars approximate the spread of receiver level differences between the two TNM versions for each set. The bars extend 1.96 times the standard deviation of the receiver level delta for each set in both directions from the mean receiver level delta for each set, thus spanning a 95% confidence interval.

[3] For details on all parameters tested in each set, see this report.

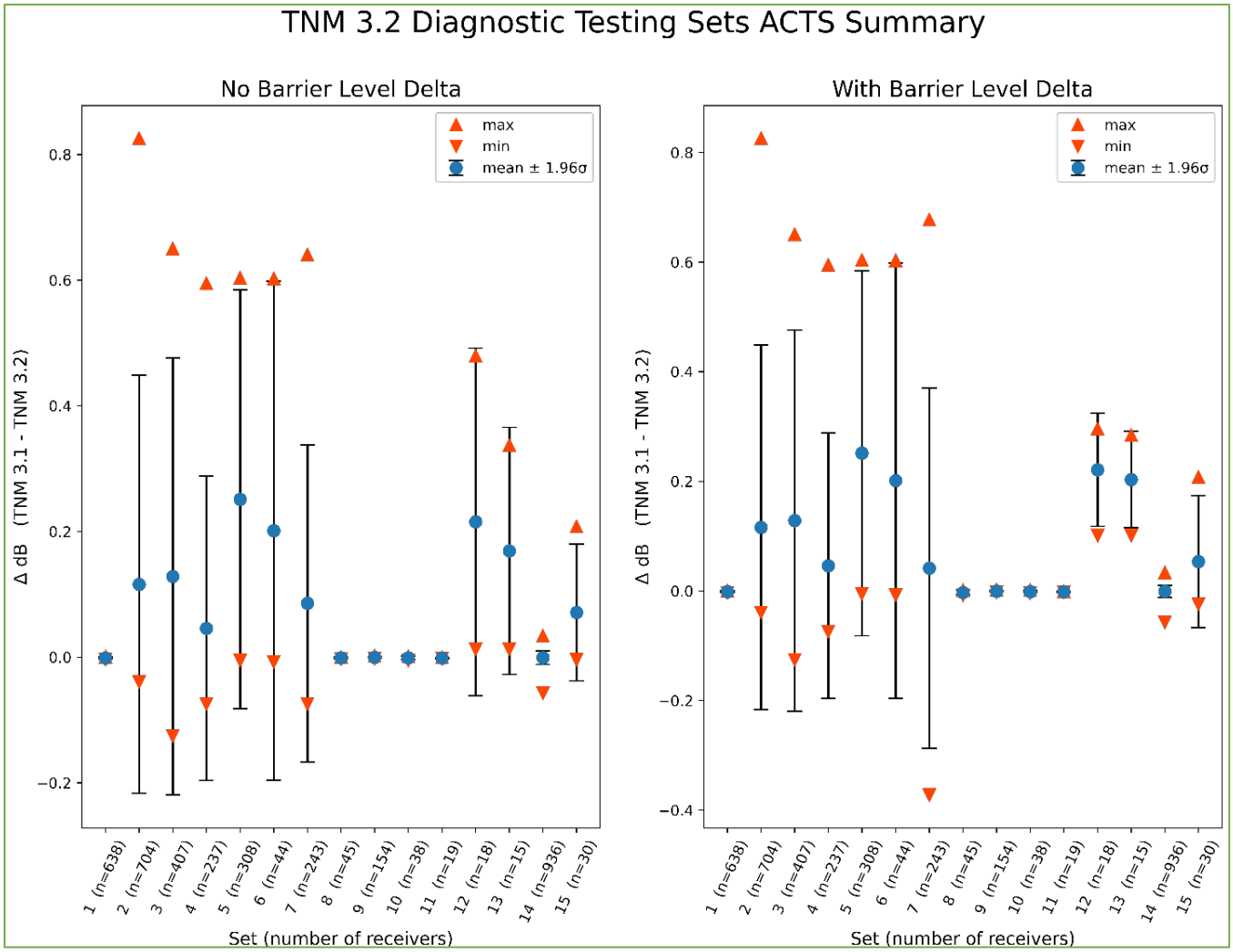

Figure 2 *TNM 3.1 – TNM 3.2 receiver level difference: Diagnostic Testing sets without barriers (left) TNM 3.1 – TNM 3.2 receiver level difference: Diagnostic Testing sets with barriers (right)*

FIGURE 2 illustrates that the roadway noise receiver results produced by TNM 3.2 are essentially identical to those produced by TNM 3.1 for Set 1 and sets 8 through 11. Both the "with barrier" and "without barrier" conditions display an average level difference of less than 0.01 dB for these sets. The mean noise level differences for all sets 1 through 15 under both barrier conditions are well below the 0.5 dB consistency threshold established by the ACTS, with the highest mean noise level difference of all sets at 0.25 dB. However, 96 out of 3742 receivers evaluated in **FIGURE 2** (about 2.5% of all receivers in the Diagnostic Testing project files) do exceed this threshold for both barrier conditions. These outliers are all within sets 2 through 7.

When receiver results deviate between versions, TNM 3.2 results are generally lower than those produced by TNM 3.1. The few receiver level difference outliers above the 0.5 dB threshold occur when the default ground type is acoustically soft. The magnitude of the noise level difference between TNM 3.2 and TNM 3.1 increases as the effective flow resistivity (EFR) of the default ground type decreases[4], given identical inputs for all other modeling parameters. The noise level differences are due to an

[4] See Table 8 in the TNM 3.2 Technical Manual for the EFR value corresponding to each ground type option in TNM.

interaction between a bug that effects how overlapping roadway pavement ground zones are handled in prior versions of TNM and an intentional programmatic change in TNM 3.2 to make the conversion from feet to meters consistent throughout the code.[5] The reason this bug did not impact any of the Validation Testing results, nor the Diagnostic Testing results in Set 1 and sets 8 through 11, is the differing roadway geometry between the project files, as demonstrated in the following three figures.

FIGURE 3 includes a screenshot of a TNM Section View for one of the project files representing Validation Testing Site 01ma. The pavement widths of two roadways are annotated to illustrate that lane 1 (dashed blue lines) overlaps lane 2 (solid orange lines) by a few inches.

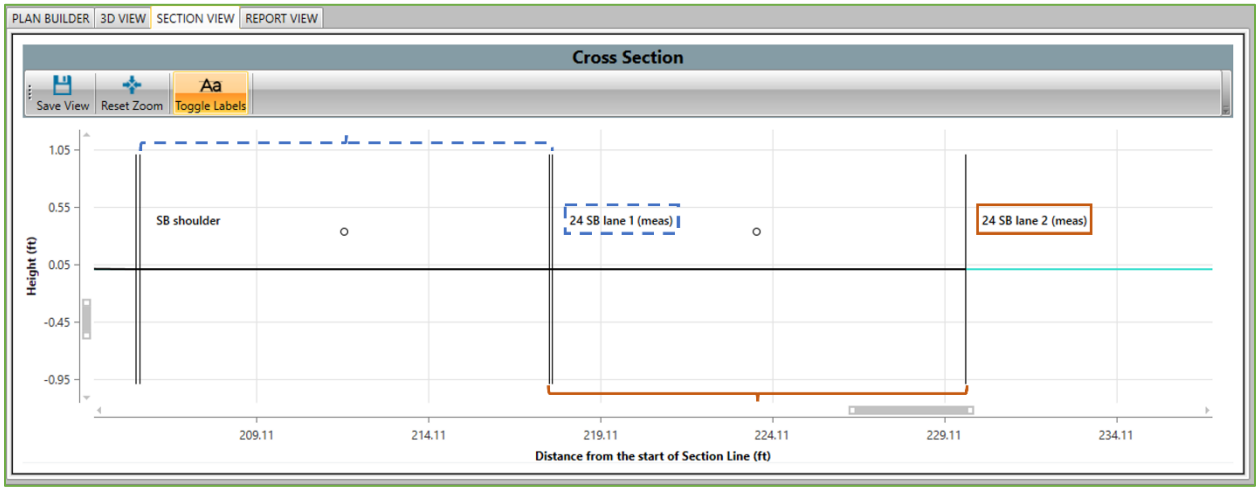

Figure 3 *Validation Testing Site 01ma annotated roadway cross section*

FIGURE 4 includes a screenshot of a TNM Section View for one of the project files within Diagnostic Testing Set 8. The pavement widths of two roadways are annotated to illustrate that Roadway 5 (dashed blue lines) also overlaps Roadway 1 (solid orange lines) by a few inches.

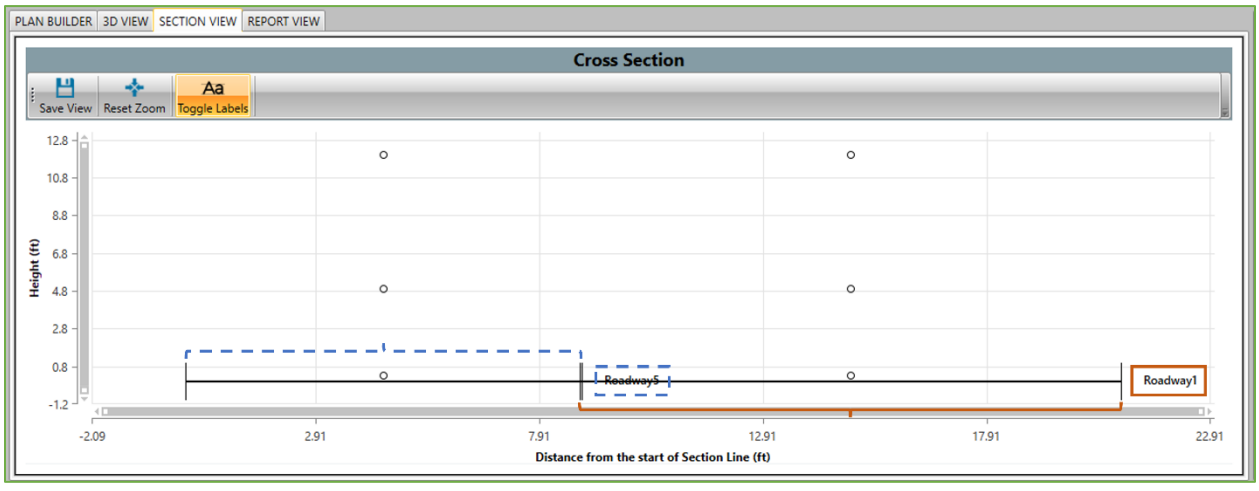

Figure 4 *Diagnostic Testing Set 8 annotated roadway cross section*

[5] TNM 3.1 and earlier versions sometimes use 0.305 and sometimes use 0.3048. TNM 3.2 uses 0.3048 throughout the code base.

FIGURE 5 includes a screenshot of a TNM Section View for one of the project files within Diagnostic Testing Set 2. The pavement widths of two roadways are annotated to illustrate that Roadway 1 (dashed blue lines) overlaps Roadway 3 (solid orange lines) by approximately 20 feet.

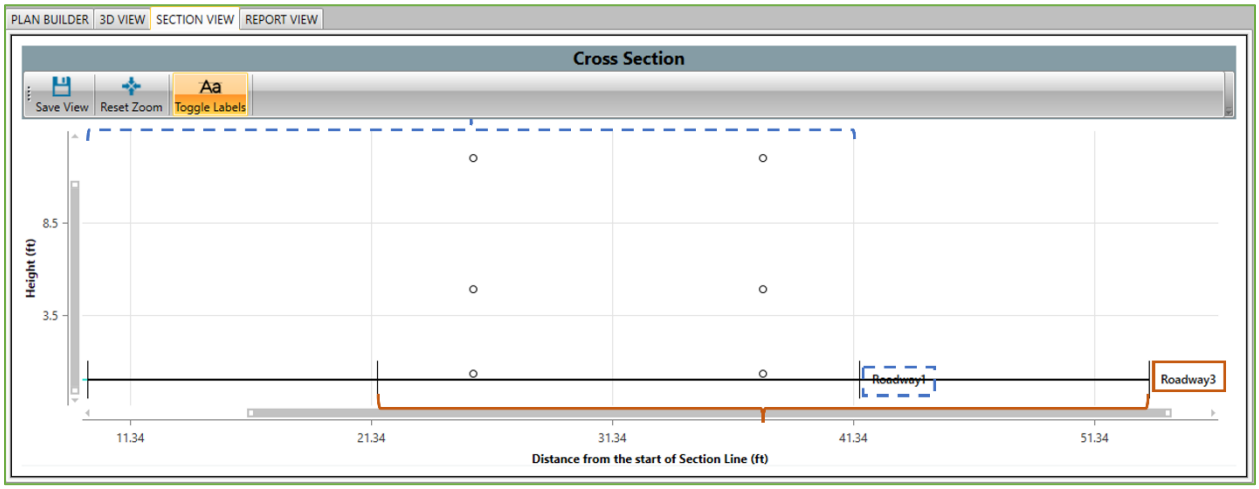

Figure 5 *Diagnostic Testing Set 2 annotated roadway cross section*

The degree of roadway pavement overlap corresponds to the magnitude of noise level differences between TNM versions 3.2 and 3.1. The mean receiver level differences for the Validation Testing Site 01ma and Diagnostic Testing Set 8 are less than 0.01 dB for both barrier conditions, while the mean level difference for Diagnostic Testing Set 2 is 0.12 dB for both barrier conditions. Noise level differences between TNM versions in the Diagnostic Testing Set 2 project files containing the field grass default ground type are as high as 0.83 dB for individual receivers due to the low default ground EFR value. Handling of this issue will be improved in TNM 3.3. In the meantime, it is recommended to avoid overlapping roadway pavement widths by more than a few inches, especially for sites with acoustically soft ground.