# Technical Memo

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| **To** | Utah Department of Transportation and Utah Transit Authority |
| **From** | Lance Meister, Cross-Spectrum Acoustics, Inc. |
| **Date** | January 2026 |
| **Re** | North of Woods Cross Double Track Project Noise and Vibration Mitigation Assessment |

## Summary

The purpose of this memorandum is to summarize the noise and vibration mitigation assessment for the Woods Cross Double Track Project. The project consists of double tracking approximately 2.7 miles of the FrontRunner Commuter Rail system from just north of 1500 South to the existing siding at about 2000 North in West Bountiful.

Noise and vibration assessments were completed for this project in 2022[1] and 2025[2] to determine impacts from infrastructure changes (adding the double track and associated trackwork). In addition, corridor-level noise and vibration assessments were completed in 2023 and 2025[3] for the entire FrontRunner corridor to determine impacts from service increase (15-min at peak, 30-min off-peak). Noise and vibration impacts were identified, and mitigations were recommended. This mitigation assessment is a detailed review of reasonable and feasible mitigations that will be implemented as part of the project.

The results of the mitigation assessment indicate that a spring-rail frog would need to be installed on the turnout on the FrontRunner tracks just north of 1500 South for both noise and vibration mitigation. In addition, a 500-foot long ballast mat would need to be installed centered under the spring-rail frog for supplemental vibration mitigation. However, even with both vibration mitigation measures, there would still be some residual vibration impacts from the turnout. There are no other practical or cost-effective measures to eliminate the impacts. For noise, a noise barrier approximately 1,318-foot long by 12-foot tall (above top of rail) would need to be installed east of tracks along the back of 15 residential properties just north of 1500 South. With the inclusion of the spring-rail frog and the noise barrier, all the noise impacts would be mitigated.

[1] Utah Transit Authority, North of Woods Cross Double Track Project Noise and Vibration Assessment, October 2022.
[2] Utah Transit Authority, North of Woods Cross Double Track Project Noise and Vibration Assessment for Design Change to Add Turnout, June 20, 2025.
[3] Utah Transit Authority, FrontRunner Forward Corridor Level Noise and Vibration Analysis, May 18, 2023; and Utah Transit Authority, FrontRunner Forward Corridor Level Noise and Vibration Analysis Addendum, May 20, 2025.

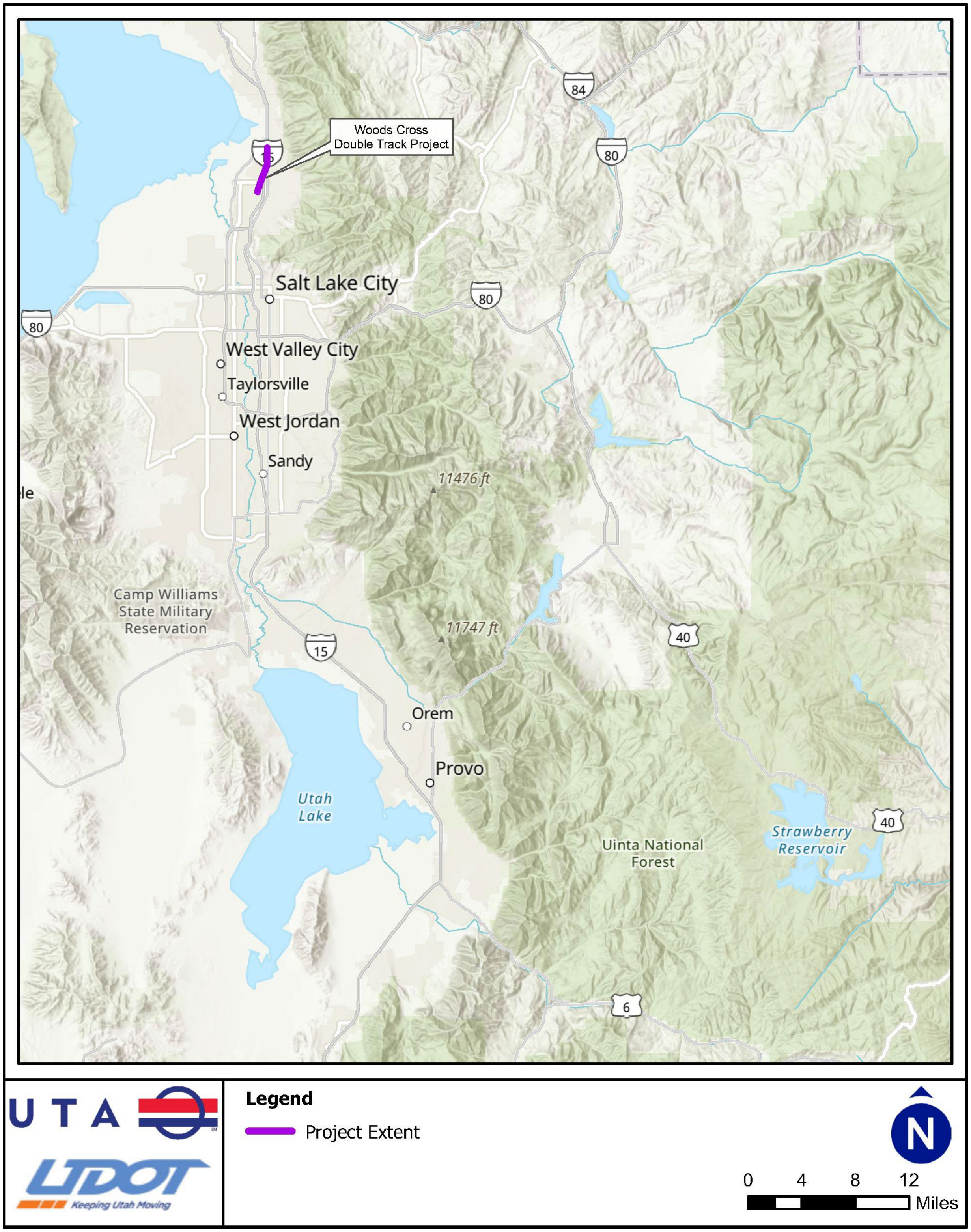


Figure 1. North of Woods Cross Double Track Project Overview

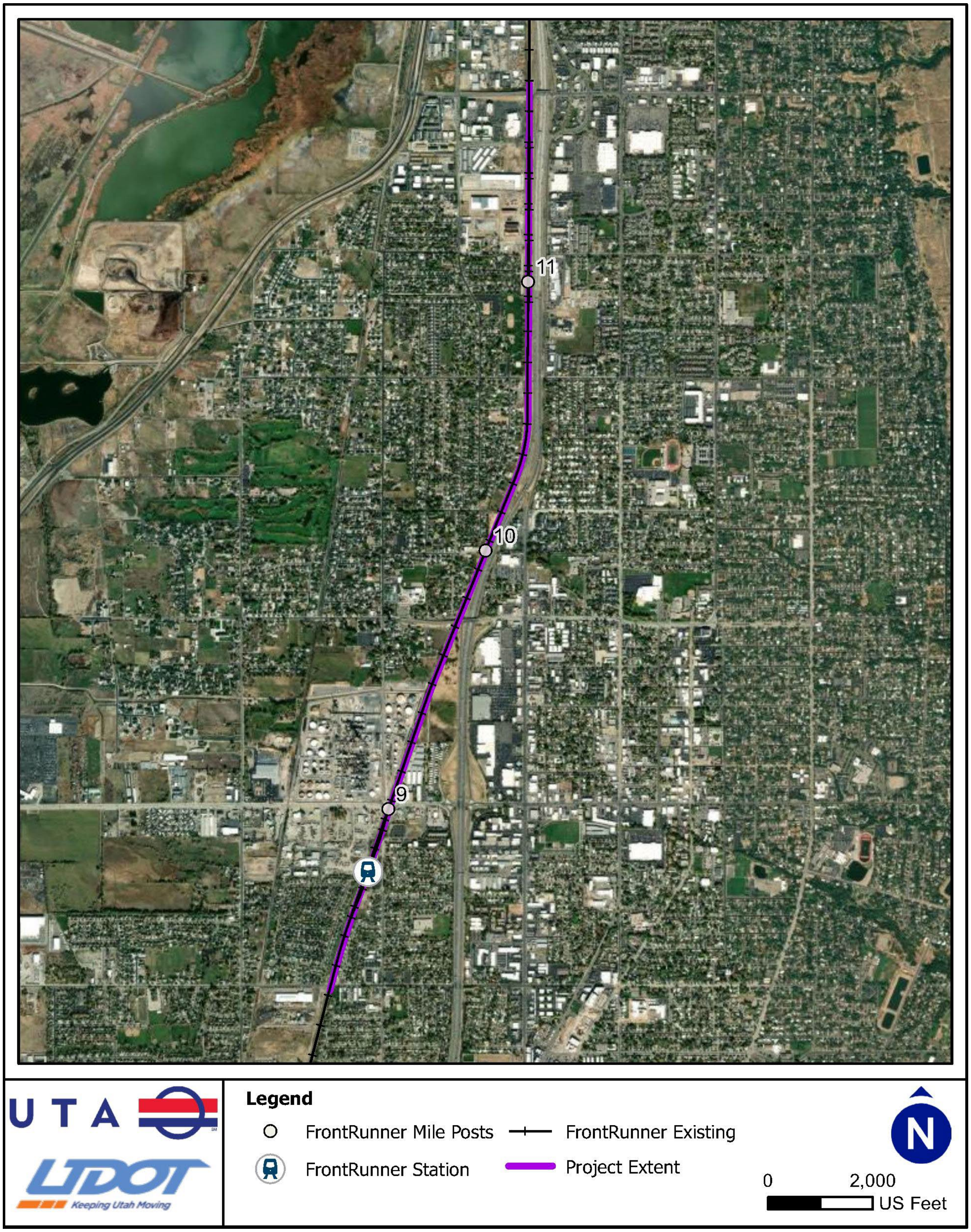


Figure 2. North of Woods Cross Double Track Project Area

# Noise

The Federal Transit Administration (FTA) noise and vibration guidance manual[4] was used in the assessment of impacts and the design of the noise mitigation. There were 10 moderate noise impacts identified in the North of Woods Cross Double Track Project area due to the combined effects of the double tracking and the service increase. The locations of the impacts are shown in Figure 2. The project would impact residents east of track, in a neighborhood located north of 1500 South in Woods Cross.

The moderate noise impacts are due to the presence of special trackwork (i.e. a new turnout) at the southern end of the project area for the FrontRunner trains and the proximity of the new track to receivers in the neighborhood to the east of the tracks at the southern end of the project area. Crossovers and turnouts have a gap in the rail for the wheel, and this gap creates additional noise as the wheel impacts the gap. The design team evaluated the location of the proposed turnout and determined that it is required at this location and cannot be relocated elsewhere[5]. Because of the close proximity of the homes to the east of the tracks, the combined effects of the new double track closer to the homes and the additional service would cause moderate impacts at 10 homes in the neighborhood.

The moderate noise impacts meet the mitigation threshold established in the UTA noise policy[6] because the existing noise levels are above 65 dBA Ldn. The mitigation for noise from the special trackwork is to install a spring-rail frog on the turnout near Station 43832+00 on the FrontRunner tracks to eliminate the gap in the main direction of travel and the associated increase in noise. Installation of a spring-rail frog on the turnout would reduce the FrontRunner noise levels by approximately 2 dB at some of the receivers near the turnout but would not mitigate the impacts due to proximity of the new track to other receivers. Additional noise mitigation, in the form of a noise barrier, would need to be considered at this location. Where feasible or cost effective, noise barriers can be considered for noise mitigation. If noise barriers are not effective, feasible or cost effective, sound insulation would be considered. A noise barrier was assessed for this location in Woods Cross.

The noise barrier calculation is based on the equations in Table 4-28 of the FTA guidance manual. A noise barrier works by blocking the line of sight from the source of the noise to the receiver. The barrier calculations determine how effective a barrier is by calculating the path length difference and the protrusion of the barrier above the line of sight. The process for calculating the effectiveness of a noise barrier involves the following steps:

- Determining the appropriate barrier type and equation (see Table 4-28 in the FTA guidance manual).
- Determining the ground elevations of the track, barrier and receivers.
- Calculating the distance from each source of noise to the barrier and the distance from the barrier to each receiver.
- Determining the heights of the sources of noise and the height of the receivers.
- Estimating a barrier height for the calculations.
- Calculating the path length difference for each source/barrier/receiver set and then determining the insertion loss (reduction in noise level) of the barrier.

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[4] Federal Transit Administration, Transit Noise and Vibration Impact Assessment Manual, FTA Report No. 0123, September 2018.
[5] Utah Transit Authority/Utah Department of Transportation, Noise and Vibration – Woods Cross Switch Placement Rationale, November 2025.
[6] Utah Transit Authority Office of Capital Services SOP, No. OCS.01.01, Noise Assessment and Mitigation, May 1, 2024.

- Refining the barrier height until the desired insertion loss is achieved.
- Calculating the cost effectiveness of the barrier. The UTA noise assessment and mitigation policy sets the maximum cost of a barrier at $30,000 per benefited receiver. The UDOT noise barrier unit cost is estimated at $20/square foot.[7]

For the barrier calculations, four sources of FrontRunner noise were used. For locomotives, the main source of noise is the engine and exhaust. For cars, the main source of noise is the wheel on the rail. All heights are referenced to height above top of rail:

- Northbound locomotives – 12-foot source height
- Southbound locomotives – 12-foot source height
- Northbound cars – 2-foot source height
- Southbound cars – 2-foot source height

Based on field observations, all of the receivers were assumed to be two stories, with a receiver height of 12 feet, with the exception of one home that was assumed at a 14-foot height (these are the heights above ground level of the windows on the second floor). The ground elevation of the residences was approximately 3 feet below the top of rail elevation, and there was a small dip in the elevation of the receivers in the middle of the neighborhood.

The results of the barrier assessment for the FrontRunner trains are shown in Table 1 for a noise barrier with a height of 12 feet above the top of rail. At this height, all of the noise impacts would be mitigated. Additionally, the UTA noise assessment and mitigation policy requires that at least 50% of the receivers have at least a 5 dB reduction in noise for the barrier to be considered reasonable. Thirteen of the 15 residences would have a noise reduction greater than 5 dB, so this would be considered a reasonable barrier.

For the cost effectiveness calculation, the barrier would be approximately 1,318 feet long (as shown in Figure 3) located east of tracks along the back of 15 residential properties north of 1500 South, and 14 feet above the retaining wall planned in this area (12 feet above top of rail plus the difference in the height of the planned retaining wall and the top of rail elevation), for a total square footage of 18,452 square feet. Per UTA policy, the barrier extends to the northern end of the neighborhood, past the noise impacts to provide a logical and equitable terminus to the barrier. At $20/square foot (per UDOT barrier cost data), the barrier would have a cost of $369,040. The barrier would benefit ten moderate noise impacts, plus five additional residences in this neighborhood, for a cost effectiveness calculation of $24,603 per residence. This is below the $30,000 cost per benefited receptor, so the barrier would be cost effective.

[7] Utah Department of Transportation Noise Abatement Report, 08A2-01, May 28, 2020.

**Table 1. Noise Barrier Insertion Loss for FrontRunner Trains**

| Receiver (South to North) | Insertion Loss** Northbound Locomotive Noise, dB | Insertion Loss Southbound Locomotive Noise, dB | Insertion Loss Northbound Wheel-Rail Noise, dB | Insertion Loss Southbound Wheel-Rail Noise, dB | Total Insertion Loss, dB |
|---|---|---|---|---|---|
| 638 | --* | -- | 10.3 | 10.3 | 3.9 |
| 637 | 1.5 | 1.5 | 13.0 | 13.0 | 5.6 |
| 636 | 2.7 | 0.7 | 13.6 | 13.6 | 5.7 |
| 635 | 8.5 | 6.0 | 14.2 | 14.1 | 10.4 |
| 634 | 14.1 | 10.9 | 14.3 | 14.1 | 13.5 |
| 633 | 14.4 | 10.9 | 14.4 | 14.1 | 13.6 |
| 19 | 15.1 | 11.5 | 15.1 | 14.6 | 14.4 |
| 20 | 15.0 | 12.3 | 15.0 | 14.5 | 14.5 |
| 632 | 13.7 | 8.7 | 14.8 | 14.4 | 13.1 |
| 21 | 8.9 | 3.9 | 15.0 | 14.6 | 10.1 |
| 22 | 11.8 | 5.2 | 15.2 | 14.8 | 11.6 |
| 23 | 14.3 | 10.0 | 15.0 | 14.5 | 13.8 |
| 24 | 12.3 | 7.4 | 14.4 | 14.0 | 12.2 |
| 25 | 2.2 | -- | 14.0 | 12.6 | 5.5 |
| 675 | -- | -- | 11.7 | 9.9 | 4.0 |

* The barrier needs to be tall enough to block the line-of-sight of the individual sources on the train to reduce the noise from that source. With the height of the second story houses and the height of the locomotive, the line-of-sight from the source of the locomotive noise is not blocked for some of the receivers.
** Insertion loss is the reduction in noise level provided by the barrier.

The mitigation recommendation is to install a spring-rail frog near Station 43832+00 on the FrontRunner tracks to eliminate the gap in the main direction of travel and the associated increase in noise and to construct a 12-foot tall noise barrier (above top of rail) to the east of the tracks at the back of 15 residential properties north of 1500 South from approximately Station 43829+70 to 43842+88 for an approximate length of 1,318 feet. Noise barrier length and location should take into account sight distance near the railroad crossing (at 1500 South) to meet safety standards. The spring-rail frog would reduce noise levels by approximately 2 dB but would not fully mitigate the impacts.  With the inclusion of the spring-rail frog and the noise barrier, all the noise impacts would be mitigated.

# Noise Impact Location – Woods Cross


Figure 3. North of Woods Cross Double Track Project

# Vibration

The FTA noise and vibration guidance manual was used in the assessment of impacts and the design of the vibration mitigation. At most locations, the change in vibration levels due to the additional track would not be above the impact threshold for an increase of 3 VdB, due to the small change in distance to sensitive receivers. However, crossovers and turnouts have a gap in the rail for the wheel, and this gap creates additional vibration as the wheel impacts the gap. There are five residences at the southern end of the segment with vibration impacts near a proposed turnout on the FrontRunner tracks, as shown in Figure 4. Per FTA guidance, buildings within 100 feet of a turnout have an increase in vibration level of 10 VdB and buildings between 100 and 200 feet of a turnout have an increase in vibration of 5 VdB. With the installation of a spring-rail frog at this location, the vibration levels for 50% of the trains (those traveling in the main direction) would be below the impact threshold of a 3 VdB increase.

For the remaining 50% of the trains (those traveling in the diverging direction), the wheels would still travel through the gap in the rail, the spring-rail frog would not reduce the vibration levels, and the vibration from those trains would still be 5 VdB above the vibration from the existing trains for four of the receivers and 10 VdB above the vibration levels from the existing trains for one of the receivers. At this location, a 500-foot ballast mat would need to be installed centered under the spring-rail frog from Station 43830+00 to 43835+00 to provide additional vibration mitigation.

In order to determine the existing vibration levels and the potential effectiveness of a ballast mat in Woods Cross, vibration measurements of FrontRunner trains were conducted on July 29, 2025, in Town Center Park south of the grade crossing at 1500 South in Woods Cross, as shown in Figure 5. The vibration measurements followed the procedures outlined in Section 6.5 of the FTA guidance manual. Accelerometers were mounted on paving bricks set on the ground 75 feet from the FrontRunner tracks and a series of passbys of FrontRunner trains were measured, in both the northbound and southbound directions. The measurements included:

- 3 trains in the northbound direction
- 4 trains in the southbound direction

The data was analyzed to determine the maximum overall vibration levels and the vibration levels at each frequency band between 6.3 Hz and 250 Hz (the frequency data is summed to get the overall vibration level). The result of the measurement is shown by the orange line in Figure 7 and the first row in Table 2. The vibration consists of significantly more low frequency vibration (below 40 Hz) than was found in American Fork[8] and Provo[9]. Low frequency vibration is much harder to mitigate and standard measures, such as ballast mats, are not as effective at low frequencies.

To document the field performance of existing FrontRunner ballast mats, vibration measurements of existing FrontRunner trains were conducted in July 2025 in Lehi in the North of American Fork Project area. The ballast mat at this location was installed as a part of the Front Runner South project (2008-2012) to provide vibration mitigation for that project. Measurements collected in Lehi included those from an area near the track where a ballast mat is present and a nearby area without a ballast mat. The vibration measurements followed the procedures outlined in Section 6.5 of the FTA guidance manual. Details regarding the measurements can be found in the North of American Fork Double Track Project

[8] Utah Department of Transportation and Utah Transit Authority, North of American Fork Double Track Project Noise and Vibration Mitigation Assessment, January 2026.

[9] Utah Department of Transportation and Utah Transit Authority, North of Provo Double Track Project Noise and Vibration Mitigation Assessment, January 2026.

Noise and Vibration Mitigation Assessement[4], and the results are shown in Figure 6 and in the second row of Table 2.

The measurements were used to determine the performance of the existing ballast mat, and to determine if the existing ballast mat has a resonance frequency that might increase vibration levels[10]. The ballast mat performance, shown in Figure 6, shows that there is only a small reduction in vibration levels at frequencies below 50 Hz, and more significant reductions at 80 Hz and above, which is consistent with typical ballast mat performance. Additionally, there is a potential small resonance at 31.5 Hz, but the increase is less than 1 VdB.

The data shown in Figure 7 and Table 2 represent the average of the FrontRunner passbys, including the overall level and each frequency. The ballast mat performance measured in Lehi was applied to this measurement by frequency to calculate the effect a ballast mat would have on the overall vibration levels. The third row in Table 2 and the blue line in Figure 7 represent the vibration levels with the ballast mat. Due to the higher levels of vibration in the lower frequencies (below 40 Hz), installing a ballast mat at this location would reduce the overall vibration from the FrontRunner trains by only 1 VdB compared to the 2-5 VdB expected in Lehi.

With the application of the spring-rail frog and a 500-foot ballast mat installed under and centered on the spring-rail frog (from about Station 43830+00 to 43835+00) for the FrontRunner trains, 50% of the trains would not have an increase of more than 3 VdB and the remaining 50% would have an increase in vibration of 4 VdB, or 1 VdB above the impact threshold, for four of the homes and an increase in vibration of 9 VdB, or 6 VdB above the impact threshold, for one of the homes. There are no other practical or cost-effective measures to reduce the vibration below the impact threshold at this location. Because of the properties of ballast mats, other types of ballast mats would have a similar performance and would not be expected to reduce vibration at the lower frequencies to fully mitigate the impacts.

[10] A resonance occurs when the input vibration from the train matches the ballast mat's natural resonant frequency. This resonance provides an excitation which increases the vibration levels at that frequency and can increase the overall vibration levels, depending on the frequency content of the vibration. All vibration mitigation materials have a resonance frequency. Generally, below that frequency, the mitigation does not provide any reduction in vibration levels.

**Table 2. Vibration Measurement Results by Frequency**

| | Vibration Level (VdB) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Vibration Results** | **Train Speed (mph)** | **Overall Vibration Level** | **6.3 Hz** | **8 Hz** | **10 Hz** | **12.5 Hz** | **16 Hz** | **20 Hz** | **25 Hz** | **31.5 Hz** | **40 Hz** | **50 Hz** | **63 Hz** | **80 Hz** | **100 Hz** | **125 Hz** | **160 Hz** | **200 Hz** | **250 Hz** |
| Measured Vibration Level*** | 50 | 76 | 50.2 | 60.5 | 65.3 | 61.2 | 64.2 | 69.3 | 71.8 | 66.9 | 65.5 | 48.5 | 37.3 | 31.4 | 31.5 | 31.1 | 25.9 | 14.5 | 16.9 |
| Ballast Mat Performance**** | -- | -- | 0.0* | 0.0* | 0.0* | 1.6 | 2.6 | 0.7 | 1.6 | -0.5 | 2.6 | 1.2 | 2.5 | 9.8 | 12.5 | 9.5 | 15.0** | 15.0** | 13.5 |
| Mitigated Vibration Level | 50 | 75 | 50.2 | 60.5 | 65.3 | 59.6 | 61.6 | 68.6 | 70.2 | 67.4 | 63.0 | 47.3 | 34.8 | 21.6 | 18.9 | 21.7 | 10.9 | -0.5 | 3.4 |

*The data at 6.3 Hz, 8 Hz and 10 Hz was excluded from the ballast mat performance calculation and set at 0. At very low frequencies, the data at close distances can have unusual results which are not valid. In this case, the on ballast mat measurements in American Fork at 75 mph are showing a significant reduction in the vibration levels at these frequencies, which is not possible with a ballast mat. The data was excluded at these frequencies, and the performance was set to zero. Because the vibration levels are much lower at these frequencies, there is no effect on the overall vibration level.
**For the purposes of ballast mat performance for other locations, a maximum reduction of 15 VdB was applied at each frequency. Reductions greater than 15 VdB at any frequency are not typical for ballast mats.
*** Data gathered in Woods Cross for the North of Woods Cross Double Track Project, July 2025.
**** Data gathered in Lehi for the North of American Fork Double Track Project, July 2025.


Figure 4. Woods Cross Vibration Impact Location


Figure 5. Woods Cross Vibration Measurement Location

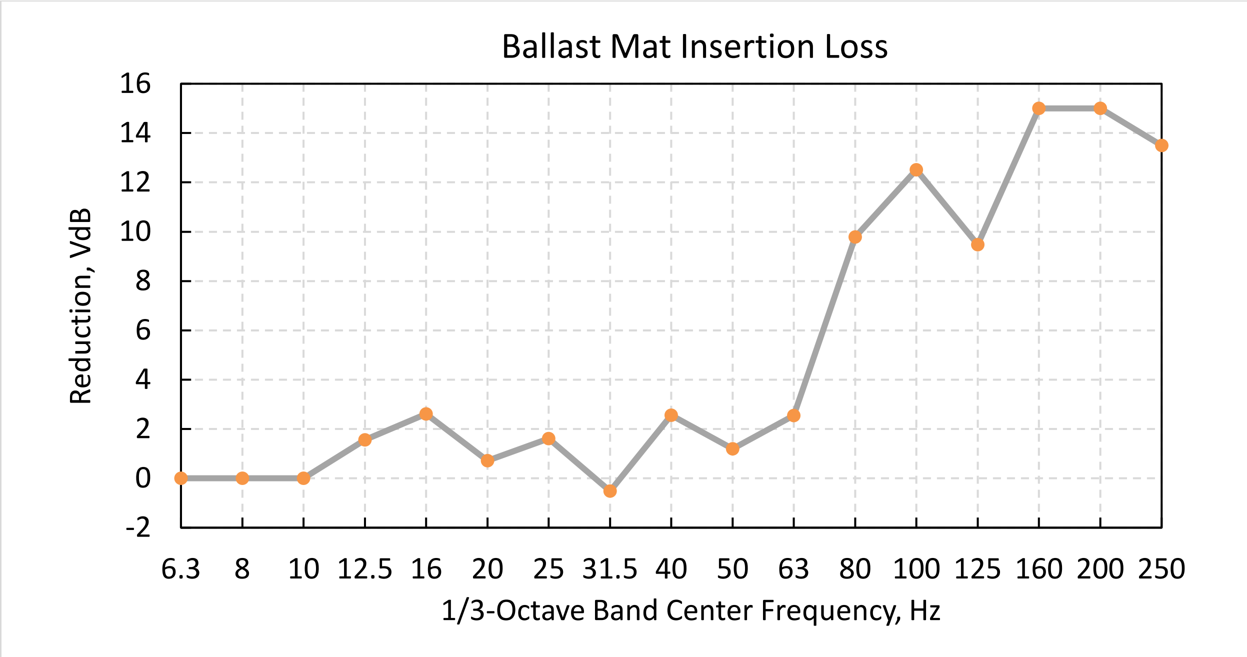


Figure 6. Existing Ballast Mat Performance
(From field data collected in Lehi, July 2025)

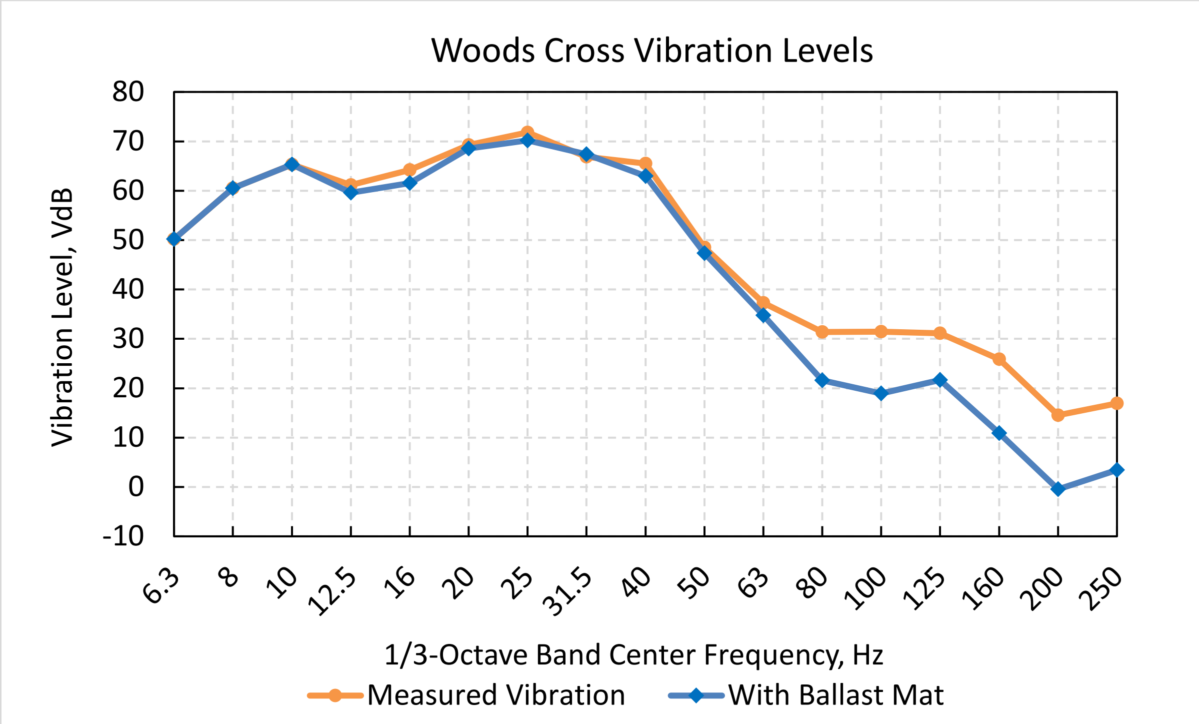


Figure 7. Projected Ballast Mat Vibration Reduction – Woods Cross
(From field data collected in Woods Cross and Lehi, July 2025)

# Memo

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| **To** | UTA/UDOT |
| **From** | HDR |
| **Date** | November 18, 2025 |
| **Re** | Noise & Vibration – Woods Cross Switch Placement Rationale |


## Summary

The Utah Transit Authority (UTA) and the Utah Department of Transportation (UDOT) are constructing a second track along approximately 2.2 miles of existing single track on the FrontRunner commuter rail line around of the Woods Cross Frontrunner Station in Wood Cross, Davis County, Utah. The anticipated track work includes a 0.3-mile double track extension south of the existing station and installation of a new high-speed switch to replace the existing. This new infrastructure is needed to move the switch further from the platform and improve signaling operations, which includes increasing train speeds as they approach the station. Relocating the switch south to the proposed location would result in five moderate noise impacts and five vibration impacts to residences adjacent to the turnout. The purpose of this memorandum is to summarize the potential feasibility of moving the location of the switch as it pertains to noise and vibration impacts to adjacent residences.


The new switch is located approximately 1,700 feet south of the existing station just north of 1500 South in Woods Cross City. The following alternatives for the switch location were reviewed.

<u>Alternative A – Between 1500 South and the Woods Cross Station</u>

There is no location between 1500 South and the Woods Cross station where the switch could be relocated away from adjacent sensitive receptors, and the switch cannot be located any closer to the station and still meet the operational needs in this section.

<u>Alternative B – South of 1500 South</u>

A conceptual track layout to move the switch for the turnout south of 1500 South is presented in Figure 1. Based on standard practice, the switch must be located about 310 feet away of the at-grade crossing (shown as the turnout limit on Figure 1) This alternative would result in impacts to Town Center Park (about 15 feet of the property would be needed) which is a city park listed in the Woods Cross Parks, Trails, and Open Space Master Plan (August 2024) and therefore a protected resource under Section 4(f) of the U.S. Department of Transportation Act. There would be one residence within the 200-foot potential vibration impact buffer and 13 residences within the 300-foot potential noise impact buffer (see Figure 1). Additionally, this alternative would require construction of additional track length, alterations to the at-grade crossing of 1500 South, track signal design, and other construction impacts resulting in additional costs to the project. These costs would be in the rough order of magnitude of about 2 million dollars.

For these reasons, the location of the new high-speed switch and double tracking approximately 1,700 feet south of the existing station is appropriate and no avoidance alternative is feasible.

Figure 1. Alternative B Turnout Relocation