Cotton Belt Corridor Regional Rail
Noise and Vibration Impact Assessment
Technical Memorandum
December 2013

Prepared by URS Corporation

Prepared for Dallas Area Rapid Transit
General Planning Consultant Managed by URS Corporation
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1.0 INTRODUCTION AND SUMMARY

This technical memorandum presents the noise and vibration impact assessment for the Cotton Belt Corridor Regional Rail Project (Cotton Belt Project). This analysis was carried out for Dallas Area Rapid Transit (DART) by Harris Miller Miller & Hanson Inc. (HMMH) under subcontract to URS Corporation. The objective of the analysis was to assess the potential noise and vibration impacts of the planned Cotton Belt Project at sensitive locations along the corridor. The noise and vibration information contained in this report is in conformance with the procedures and criteria included in the Federal Transit Administration (FTA) guidance manual “Transit Noise and Vibration Impact Assessment” (Final Report No. FTA-VA-90-1003-06, May 2006), and in the DART policy document “Environmental Impact Assessment and Mitigation Guidelines for Transit Projects” (May 2012).

Summaries of the noise and vibration impact assessments are provided in the subsections below and Section 2 describes the noise and vibration prediction methodology used in the assessment. Section 3 presents the noise and vibration impact assessment results, and Section 4 describes potential mitigation measures. Appendix A and Appendix B include figures identifying the location of potential noise and vibration impacts respectively. Appendix C identifies the location of potential noise impacts with the implementation of quiet zones.

1.1 Noise Impact Assessment Summary

The results of the noise impact assessment identify noise impacts at a total of 3880 receptors without mitigation, including 2652 severe impacts and 1228 moderate impacts for the Base Alternative with the At-Grade Profile Option (Section 3-2A) and the Red Line Interface North Alternative (Section 3-4A). For the Base Alternative with the North Dallas Trench Profile Option (Section 3-2B) and the Red Line Interface North Alternative (Section 3-4A) there are a total of 1944 noise impacts without mitigation (1203 severe impacts and 741 moderate impacts). For the Base Alternative with the North Dallas Tunnel Profile Option (Section 3-2C) and the Red Line Interface North Alternative (Section 3-4A) there are a total of 1937 noise impacts without mitigation (1203 severe impacts and 734 moderate impacts). Twelve moderate noise impacts are predicted along the Cypress Waters Alternative. There are no noise impacts predicted for the Red Line Interface South Alternative with Aerial Station and Depressed Freight (Section 3-4B).

Without mitigation, the primary cause of potential noise impact for the Cotton Belt Project is noise from train horns that would be sounded at the numerous at-grade crossings along the existing rail alignment right-of-way (Cotton Belt Corridor). Thus, the primary recommended mitigation measure is the implementation of quiet zones throughout the Cotton Belt Corridor. As discussed in Section 4, over 95 percent of all noise impacts would be eliminated with the implementation of quiet zones throughout the corridor. Remaining noise impacts can be mitigated through various measures for reducing noise impacts. Appendix C identifies the location of potential noise impacts remaining after the implementation of quiet zones.
1.2 Vibration Impact Assessment Summary

The results of the vibration impact assessment identify potential ground-borne vibration impact at a total of five receptors without mitigation for the Base Alternative and at two receptors with the Cypress Waters Alternative. For the North Dallas Tunnel Profile Option, a total of 32 potential ground-borne noise impacts are identified. There are no vibration impacts predicted for the Red Line Interface South Alternative with Aerial Station and Depressed Freight (Section 3-4B).

There are various vibration mitigation measures that can be implemented. Additional analysis would be conducted during later stages of project development to determine specific vibration mitigation measures.
2.0 PROJECTION OF NOISE AND VIBRATION LEVELS

2.1 Noise Projections
The primary components of wayside noise from the train operations are engine/exhaust and cooling fan noise from the diesel multiple unit (DMU) power units and wheel/rail noise from the steel wheels rolling on steel rails. Secondary sources, such as vehicle air-conditioning and other ancillary equipment, will sometimes be audible, but are not expected to be significant factors. The projection of wayside noise from train operations was carried out using the model specified in the FTA guidance manual, supplemented by DMU noise measurement data, with the following assumptions:

- DMU noise is predicted as a function of speed and throttle setting based on noise measurements of a set of Stadler diesel-electric GTW 2/6 articulated DMU rail vehicles on the Denton County Transportation Authority (DCTA) A-Train system. These measurements are summarized in a report prepared for DART titled *Noise and Vibration Test Program for the DCTA Stadler DMU* (May 13, 2013). The measurements indicate that a single DMU vehicle operating at up to 50% full throttle generates a sound exposure level (SEL) that varies with speed (in mph) as follows:

\[
\text{SEL(50-ft)} = 10.63 \times \log_{10}(\text{mph}) + 63.74 \text{ (in dBA)}
\]

At full throttle, the SEL is assumed to be 84 dBA, independent of speed, and the SEL for intermediate throttle settings is estimated by interpolating between the 0-50% and full throttle SEL values. Because specific throttle setting information for the project was not available at this time, the vehicle was assumed to operate at full throttle where accelerating.

- Based on measurement data, a minimum speed of 35 miles per hour (mph) was used to predict noise from DMU vehicles decelerating to a stop at train stations to account for additional noise caused by regenerative braking.

- The operating period for Cotton Belt Project service is expected to be between 5:30 AM and 12:15 AM on weekdays. The trains would operate with headways of 20 minutes during peak periods (approximately 5:30 A.M. to 9:30 A.M. and 3:30 P.M. to 7:00 P.M.) and with headways of 60 minutes during all other times.

- Trains would consist of two powered DMU vehicles during all time periods.

- Vehicle operating speeds are based on speed profiles generated for the project with speeds of up to 60 mph along the Cotton Belt Corridor. The DMU throttle settings were assumed to be 100% when accelerating and 50% or less when at constant speed or when decelerating.
• DMU horns are assumed to generate a sound level of 104.5 dBA at 100 feet, corresponding to an SEL of 113.5 dBA at 50 feet. The high horn noise level is based on compliance measurements conducted on the Stadler DMU rail vehicles on the DCTA A-Train system summarized in the test report “Acoustic Warning Devices” (Document No. TR: 0487, July 12, 2011). It is assumed that the horns would begin to be sounded 20 seconds, but not more than ¼ mile, in advance of grade crossings in accordance with Federal Railroad Administration (FRA) regulations.

• Warning bells on the trains are sometimes activated as trains enter and leave passenger stations. This potential noise source was not included in this analysis because detailed information regarding the use of train bells was not available. In any case, this source would not be expected to be a major contributor to the overall noise exposure.

• Stationary warning bells, generating a sound level of 73 dBA at 50 feet, would be sounded at all gated crossings before and after each train pass-by for a total duration of 30 seconds.

• Wheel impacts at track crossovers and turnouts are assumed to cause localized noise increases of 6 dBA up to a distance of 50 feet, dropping off linearly to zero increase at a distance of 300 feet. Crossovers locations have not yet been determined and were therefore not included in this analysis. Turnout locations were determined based on preliminary project plans that indicate where Cotton Belt Project trains would travel between single and double-track portions of the Cotton Belt Corridor. The final location of crossovers and turnouts should be included in noise analyses during future stages of project development.

• It was assumed that there would be no significant change in freight rail operations due to the implementation of the Cotton Belt Project. Small shifts in the location of freight rail tracks were not considered in this analysis.

Examples of the projected unshielded Ldn from train operations, without horn noise and with horn noise, are shown in Figure 2-1 and Figure 2-2, respectively, as a function of distance from the track centerline. As shown in Figure 2-1, the DMU noise exposure at lower throttle settings increases with increasing speed. Figure 2-1 also shows that the DMU noise exposure at full throttle is the same for all speeds. In addition, because horn noise is not a function of speed, the noise exposure decreases at higher speeds due to the reduced exposure time as shown in Figure 2-2. As seen by comparing the two figures, horn noise dominates the noise exposure in the vicinity of grade crossings.
Figure 2-1
Projected 24-Hour Noise Exposure from Train Operations (Without Horns)

Figure 2-2
Projected 24-Hour Noise Exposure from Train Operations (With Horns)
2.2 Vibration Projections

The projection of ground-borne vibration and ground-borne noise from train operations was carried out using the model specified in the FTA guidance manual, supplemented by DMU vibration measurement data, with the following assumptions:

- Vibration source levels were based on test data for Stadler diesel-electric GTW 2/6 articulated DMU rail vehicles measured on the DCTA A-Train system as summarized in the report “Noise and Vibration Test Program for the DCTA Stadler DMU” (May 13, 2013).

- Vibration propagation tests were conducted at representative sites along the corridor near sensitive receptors, as described in the No...memorandum. The results of these tests were combined with the Stadler DMU vibration source level measurement data to provide projections of vibration levels from trains operating on the Cotton Belt Corridor.

- Vehicle operating speeds are based on speed profiles generated for the project with speeds of up to 60 mph along the Cotton Belt Corridor.

- Wheel impacts at track crossovers and turnouts are assumed to cause localized vibration increases of 10 VdB up to a distance of 50 feet, dropping off linearly to zero increase at a distance of 300 feet. Crossovers locations have not yet been determined and were therefore not included in this analysis. Turnout locations were determined based on preliminary project plans that indicate where Cotton Belt trains would travel between single and double-track portions of the rail alignment. The final location of crossovers and turnouts should be included in noise analyses during future stages of project development.

- A safety factor of three vibration decibels (VdB) was included in the projected vibration levels along the corridor.

- It was assumed that the Cotton Belt Corridor is currently an infrequently used rail corridor, defined by FTA as typically having fewer than 5 existing trains per day. Therefore, the projected vibration levels from rail operations were compared directly to the FTA impact criteria.

- It was assumed that there would be no significant change in freight rail operations due to the implementation of the Cotton Belt Project. Small shifts in the location of freight rail tracks were not included in this analysis.

- The potential for ground-borne noise impact from train operations was assessed at receptors in the North Dallas Tunnel Profile Option Section (3-2C) using FTA criteria. Ground-borne noise levels were projected using current FTA methodology and were then reduced by 5 dBA based on the findings of recent research sponsored by the U.S. Transportation Research Board (Final Report for TCRP Project D-12, J.A. Zapfe, et al, Ground-Borne Noise and Vibration in Buildings Caused by Rail Transit, December 2009).
The assumed vehicle vibration characteristics are represented by the force density level (FDL) spectra at specific speeds in Figure 2-3 below. The levels at intermediate speeds were obtained by interpolation and the levels at speeds above 60 mph were obtained by adding an adjustment factor of \(+20\times\log_{10}(\text{mph/60})\) to the 60 mph FDL spectrum. The results were combined with the ground vibration propagation test results (represented by transfer mobility spectra) to project vibration levels as a function of distance for each of the 10 test sites.

**Figure 2-3**
DMU Force Density Level Spectra

The resulting projections of maximum ground vibration levels from Cotton Belt Project operations at 60 mph for each of the 10 test sites are provided in Figure 2-4. Each of the curves has a different level vs. distance characteristic, which determines the impact distance in each of the regions. The results show that beyond 60 feet from the track at all sites except Site V-1, the projected vibration levels at maximum speed are all below the FTA residential vibration annoyance criterion for Cotton Belt Project (75 VdB based on a total of 30-70 trains per day). The actual vibration levels at sensitive sites are calculated in individual one-third octave bands and compared to the detailed impact criteria of 72 VdB to determine potential impact. However, it should be noted that vibration impacts could extend to greater distances from the track at locations in proximity to crossovers and turnouts.
Figure 2-4
Projected Maximum Ground Vibration Levels at 60 mph

Projected DMU Ground-Borne Vibration Levels at 60 mph
3.0 NOISE AND VIBRATION IMPACT ASSESSMENT

A detailed noise and vibration impact assessment was carried out based on the criteria discussed in the *Noise and Vibration Existing Conditions Technical Memorandum* and the projections described in Section 2. The assessment results are presented below.

3.1 Transit Noise Impact Assessment

Comparisons of the existing and future noise levels are presented in Table 3-1 and Table 3-2. Table 3-1 includes ranges of results for FTA Category 2 (residential) receptors with both daytime and nighttime sensitivity to noise, and Table 3-2 includes ranges of results for FTA Category 3 (institutional) receptors with primarily daytime and evening use. In addition to the distances to the track and proposed train speeds, Table 3-1 and Table 3-2 include the existing noise levels, the projected noise levels from rail operations, the predicted total noise levels and projected noise increases due to the Cotton Belt Project within each section along the Cotton Belt Corridor. Based on a comparison of the predicted Cotton Belt Project noise levels with the impact criteria, the table also includes an inventory of the number of moderate and severe noise impacts in each section. In sections where impacts are projected, the data provided in the table represent a range for the impacted receptors. In sections where no impacts are projected, the data are for the receptor located closest to the rail alignment.

The results in Table 3-1 identify noise impacts without mitigation at a total of 3861 residences, with severe impact at 2637 residences and moderate impact at 1224 residences for the Base Alternative. The pre-mitigation noise impact assessment assumes that train horns would not be sounded in the vicinity of three existing quiet zone grade crossings in Richardson (Waterview Parkway, Custer Parkway, and Alma Road), and the existing quiet zone grade crossings in Plano (all Cotton Belt crossings in Plano). Table 3-1 also identifies noise impacts for the Cypress Waters Southwestern Boulevard Alternative, the North Dallas Profile Options, and the Red Line Interface Alternatives. The noise impacts for each alternative and profile option are discussed in more detail below. The Cypress Waters South Alternative is discussed qualitatively below.

The results in Table 3-2 identify noise impacts without mitigation at a total of 19 Category 3 receptors, with severe impact at 15 locations and moderate impact at 4 locations. The noise impacts for each alternative and profile option are discussed in more detail below.

Most of the noise impacts from the Cotton Belt Project are due to the sounding of train horns at the numerous at-grade crossings along the Cotton Belt Corridor. The locations of the potential impacts without mitigation are shown in Appendix A.
### Table 3-1
Summary of FTA Category 2 (Residential) Noise Impacts Without Mitigation

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<thead>
<tr>
<th>Section</th>
<th>Alternative/Profile Option</th>
<th>Distance to Track (ft)</th>
<th>Train Speed, (mph)</th>
<th>Existing Noise Level</th>
<th>Project Noise Level&lt;sup&gt;1&lt;/sup&gt; Predicted&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Impact Criteria</th>
<th>Total Noise Level&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Noise Level Increase&lt;sup&gt;1&lt;/sup&gt;</th>
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<td>58</td>
<td>63-64</td>
<td>62-72</td>
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**Base Noise Impact Summary (with At-Grade Profile Option.)**

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<sup>1</sup> Noise levels are based on Ldn and measured in dBA.

<sup>2</sup> Predicted levels include horn and bell noise, where applicable (rounded to the nearest decibel.)

<sup>3</sup> There are no noise-sensitive receptors of this type in this section.

<sup>4</sup> There are no impacted receptors in this section. Data are for the receptor located closest to the alignment.

Source: Harris Miller Miller & Hanson Inc., June 2013
## Table 3-2

### Summary of FTA Category 3 (Institutional) Noise Impacts Without Mitigation

<table>
<thead>
<tr>
<th>Section</th>
<th>Alternative/Profile Option</th>
<th>Distance to Track (ft)</th>
<th>Train Speed (mph)</th>
<th>Existing Noise Level</th>
<th>Project Noise Level(^1)</th>
<th>Impact Criteria</th>
<th>Total Noise Level(^1)</th>
<th>Noise Level Increase (^1)</th>
<th>Number of Impacts</th>
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<td></td>
<td></td>
<td></td>
<td>Mod.</td>
<td>Sev.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-1(^3)</td>
<td>Basel</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1-2A(^3)</td>
<td>Base</td>
<td>420</td>
<td>55</td>
<td>56</td>
<td>40</td>
<td>61</td>
<td>67</td>
<td>56</td>
<td>&lt;1</td>
</tr>
<tr>
<td>1-2B</td>
<td>Cypress Waters (SW Blvd.)</td>
<td>130</td>
<td>40</td>
<td>56</td>
<td>76</td>
<td>61</td>
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<td>1-3</td>
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<td>57-60</td>
<td>62</td>
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<tr>
<td>2-1</td>
<td>Base</td>
<td>230</td>
<td>55-57</td>
<td>64</td>
<td>70</td>
<td>65</td>
<td>71</td>
<td>71</td>
<td>7</td>
</tr>
<tr>
<td>2-2</td>
<td>Base</td>
<td>440</td>
<td>25-35</td>
<td>61</td>
<td>69</td>
<td>63</td>
<td>69</td>
<td>70</td>
<td>9</td>
</tr>
<tr>
<td>2-3</td>
<td>Base</td>
<td>55-690</td>
<td>23-60</td>
<td>50-55</td>
<td>63-79</td>
<td>58-60</td>
<td>65-66</td>
<td>63-79</td>
<td>8-28</td>
</tr>
<tr>
<td>3-1(^3)</td>
<td>Base</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>3-2A</td>
<td>Baseline/At-Grade</td>
<td>60-500</td>
<td>40-50</td>
<td>47-51</td>
<td>64-82</td>
<td>57-59</td>
<td>64-65</td>
<td>64-82</td>
<td>15-34</td>
</tr>
<tr>
<td>3-2B(^3)</td>
<td>Base/Trench</td>
<td>60</td>
<td>50</td>
<td>48</td>
<td>53</td>
<td>58</td>
<td>64</td>
<td>54</td>
<td>6</td>
</tr>
<tr>
<td>3-2C(^3)</td>
<td>Base/Tunnel</td>
<td>90</td>
<td>35</td>
<td>51</td>
<td>44</td>
<td>59</td>
<td>65</td>
<td>52</td>
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<td>3-3(^3)</td>
<td>Base</td>
<td>250</td>
<td>50</td>
<td>51</td>
<td>46</td>
<td>59</td>
<td>65</td>
<td>52</td>
<td>1</td>
</tr>
<tr>
<td>3-4A(^3)</td>
<td>Base (North Alt.)</td>
<td>150</td>
<td>30</td>
<td>56</td>
<td>46</td>
<td>61</td>
<td>67</td>
<td>56</td>
<td>&lt;1</td>
</tr>
<tr>
<td>3-4B(^3)</td>
<td>South Alt.</td>
<td>535</td>
<td>25</td>
<td>56</td>
<td>32</td>
<td>61</td>
<td>67</td>
<td>56</td>
<td>&lt;1</td>
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<tr>
<td>3-5(^3)</td>
<td>Base</td>
<td>155</td>
<td>55</td>
<td>46</td>
<td>48</td>
<td>57</td>
<td>64</td>
<td>50</td>
<td>4</td>
</tr>
</tbody>
</table>

**Baseline Noise Impact Summary (with At-Grade Alt.)**

1 school, 3 churches

**Baseline Noise Impact Summary (with Trench Alt.)**

1 school, 2 churches

---

\(^1\) Data for noise levels and impacts are based on the FTA 2012 Noise and Vibration Source Levels.

\(^2\) Predicted noise levels are calculated using the FTA Source Levels.

\(^3\) Section numbers indicate different segments of the Cotton Belt Corridor.
<table>
<thead>
<tr>
<th>Summary</th>
<th>Baseline Noise Impact Summary (with Tunnel Alt.)</th>
<th>Cypress Waters Southwestern Boulevard Alternative Summary</th>
<th>South Alternative Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 parks, 1 cemetery</td>
<td>1 school, 2 churches, 3 schools, 3 churches, 3 parks, 1 cemetery</td>
<td>0, 1 church</td>
</tr>
<tr>
<td></td>
<td>1 school, 2 churches</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1 Noise levels are based on Leq and measured in dBA.
2 Predicted levels include horn and bell noise, where applicable (rounded to the nearest decibel.)
3 There are no noise-sensitive receptors of this type in this section.
4 There are no impacted receptors in this section. Data are for the receptor located closest to the alignment.

Source: Harris Miller Miller & Hanson Inc., June 2013
3.1.1 Base Alternative

As indicated in Table 3-1 above, for the Cotton Belt Project Base Alternative with the At-Grade Profile Option (Section 3-2A) and the Red Line Interface North Alternative (Section 3-4A) there are a total of 3861 residential noise impacts without mitigation, with severe impact at 2637 residences and moderate impact at 1224 residences. There are also a total of 19 Category 3 receptors identified with noise impact without mitigation, with severe impact at 15 locations (5 schools, 5 churches, 3 parks, and 1 cemetery) and moderate impact at 4 locations (1 school, and 3 churches).

The noise impacts are caused primarily by the sounding of train horns at the numerous at-grade crossings along the existing rail alignment in the Cotton Belt Corridor. The remaining impacts are due to the train operation and the receptor proximity to potential turnout locations and wayside grade crossing bells.

3.1.2 Cypress Waters Alternatives

Cypress Waters Southwestern Boulevard Alternative (Section 1-2B)

There are a total of 12 noise impacts without mitigation identified for the Cypress Waters Southwestern Boulevard Alternative (Section 1-2B), with severe impact at 11 residences and one school. All of the impacts in the Cypress Waters Alternative are caused by the sounding of train horns near at-grade crossings along the proposed rail alignment.

Cypress Waters South Alternative (Section 1-2B)

For this analysis, the Cypress Waters South Alternative (Section 1-2B) was considered qualitatively. There would likely not be additional noise impacts with this alternative compared to the Cypress Waters Southwestern Boulevard Alternative. However, the projected future sound levels at noise-sensitive receiver locations with this alternative would be different due to the different distances to the alignment. Regardless, any impacts with this alternative would be caused by the sounding of train horns near at-grade crossings.

3.1.3 North Dallas Profile Options

At-Grade Profile Options (Section 3-2A)

For this analysis, the North Dallas At-Grade Profile Option (Section 3-2A) is considered part of the Base Alternative previously summarized. There are a total of 1937 residential noise impacts without mitigation identified for the At-Grade Profile Option in this Section, with severe impact at 1444 residences and moderate impact at 493 residences. There are also a total of 6 Category 3 receptors identified with noise impact without mitigation, with severe impact at 5 locations (1 park, 2 schools, and 2 churches) and moderate impact at 1 church.

The noise impacts are caused primarily by the sounding of train horns at the numerous at-grade crossings along the rail alignment in the Cotton Belt Corridor. The remaining impacts are due to train operation and the receptor proximity to potential turnout locations and wayside grade crossing bells.
**Trench Profile Option (Section 3-2B)**

Without mitigation, there are a total of 7 noise impacts identified for the Trench Profile Option (Section 3-2B), with moderate impact at 7 residences. The noise impacts are caused primarily by the proximity of the receptors to train operations (the impacted receptors in this section are all located less than 60 feet from the rail alignment). The locations of the impacted receptors are shown in Appendix A.

**Tunnel Profile Option (Section 3-2C)**

No noise impacts are predicted for the Tunnel Profile Option (Section 3-2C).

### 3.1.4 Red Line Interface Alternatives

**North Alternative (Section 3-4A)**

For this analysis, the Red Line Interface North Alternative (Section 3-4A) is considered part of the Base Alternative as previously summarized. There are no noise impacts predicted in this Section. Because of the existing quiet zone at-grade crossings in this section, the Cotton Belt Project trains would not sound their horns at the crossings.

**South Alternative with Aerial Station and Depressed Freight (Section 3-4B)**

There are no noise impacts predicted for the Red Line Interface South Alternative with Aerial Station and Depressed Freight (Section 3-4B). Because of the existing quiet zone at-grade crossings in this section, the Cotton Belt Project trains would not sound their horns at the crossings.

### 3.2 Transit Vibration Impact Assessment

The approach used for assessing vibration impact generally follows the approach used for noise impact, except that existing vibration is typically not considered when evaluating impact. For a general assessment, the FTA impact threshold for “occasional events” (i.e. in the range of 30-70 trains per day) is 75 VdB for residential buildings (Category 2) and 78 VdB for institutional buildings (Category 3); park lands are not considered vibration sensitive. For a detailed analysis, as was used for the Cotton Belt Project, the corresponding FTA one-third octave band impact thresholds are 72 VdB for Category 2 land use and 78 VdB for Category 3 land use.

*Table 3-3* provides a summary of the projected ground-borne vibration impacts at residential receptors. No ground-borne vibration impacts are predicted at Category 3 receptors. In sections where impacts are projected, the data provided in the table represent a range for the impacted receptors. In sections where no impacts are projected, the data are for the receptor located the closest to the rail alignment. The table includes the distance to the near track, maximum speed, the impact criteria, and the projected future ground-borne vibration levels.

The vibration impacts are caused by the proximity of the receptors to train operations and to potential turnout locations. The locations of potential impacts are shown in Appendix B.
### Table 3-3
Summary of Ground-Borne Vibration Impacts Without Mitigation

<table>
<thead>
<tr>
<th>Section</th>
<th>Alternative/Profile Option</th>
<th>Distance to Track (ft)</th>
<th>Train Speed, (mph)</th>
<th>Project Vibration Level</th>
<th>Vibration Impact Criterion</th>
<th>Number of Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Base</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1-2A</td>
<td>Base</td>
<td>60-70</td>
<td>50-55</td>
<td>73-76</td>
<td>72</td>
<td>5</td>
</tr>
<tr>
<td>1-2B</td>
<td>Cypress Waters</td>
<td>40</td>
<td>40</td>
<td>74</td>
<td>72</td>
<td>2</td>
</tr>
<tr>
<td>1-3&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Base</td>
<td>90</td>
<td>50</td>
<td>59</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>2-1&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Base</td>
<td>230&lt;sup&gt;5&lt;/sup&gt;</td>
<td>57&lt;sup&gt;5&lt;/sup&gt;</td>
<td>50&lt;sup&gt;5&lt;/sup&gt;</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>2-2&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Base</td>
<td>195</td>
<td>46</td>
<td>40</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>2-3&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Base</td>
<td>45</td>
<td>55</td>
<td>64</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>3-1&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Base</td>
<td>60</td>
<td>53</td>
<td>61</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>3-2A&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Base/At-Grade</td>
<td>40</td>
<td>35</td>
<td>67</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>3-2B&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Base/Trench</td>
<td>40</td>
<td>35</td>
<td>67</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>3-2C&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Base/Tunnel</td>
<td>40</td>
<td>35</td>
<td>67</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>3-3&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Base</td>
<td>130</td>
<td>59</td>
<td>54</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>3-4A&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Base (North Alt.)</td>
<td>65</td>
<td>30</td>
<td>60</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>3-4B&lt;sup&gt;5&lt;/sup&gt;</td>
<td>South Alt.</td>
<td>60</td>
<td>40</td>
<td>49</td>
<td>72</td>
<td>0</td>
</tr>
<tr>
<td>3-5&lt;sup&gt;5&lt;/sup&gt;</td>
<td>Base</td>
<td>100</td>
<td>55</td>
<td>55</td>
<td>72</td>
<td>0</td>
</tr>
</tbody>
</table>

**Base Noise Impact Summary (with At-Grade Profile Option)** 5

**Base Noise Impact Summary (with Trench Profile Option)** 5

**Base Noise Impact Summary (with Tunnel Profile Option)** 5

**Cypress Waters Alternative Summary** 2

**South Alternative Summary** 0

<sup>1</sup> Ground-borne vibration levels are measured in VdB referenced to 1 μin/sec.

<sup>2</sup> All impacts are residential unless otherwise noted.

<sup>3</sup> There are no vibration-sensitive receptors in this section.

<sup>4</sup> There are no impacted receptors in this section. Data are for the receptor located closest to the alignment.

<sup>5</sup> Data are for closest Category 3 receptor, because there are no residential receptors in this section.

Source: Harris Miller Miller & Hanson Inc., June 2013

#### 3.2.1 Base Alternative

As indicated in **Table 3-3** above, for the Cotton Belt Project Base Alternative with the At-Grade Profile Option (Section 3-2A) and the Red Line Interface North Alternative (Section 3-4A) there are a total of five residential vibration impacts without mitigation. The vibration impacts are caused by the proximity of the receptors to train operations and to potential turnout locations. The potential turnout in this location is needed so that Cotton Belt Project trains can switch tracks to travel over the proposed bridge over Denton Tap Road.

#### 3.2.2 Cypress Waters Alternative

There are a total of two residential vibration impacts without mitigation identified for the Cypress Waters Alternative (Section 1-2B). The vibration impacts are caused by the proximity of the receptors to train operations on the proposed rail alignment approximately 40 feet away.
3.2.3 North Dallas Profile Options

**At-Grade Profile Option (Section 3-2A)**

For this analysis, the At-Grade Profile Option (Section 3-2A) is considered part of the Base Alternative as previously summarized. There are no vibration impacts predicted for the At-Grade Profile Option in this Section.

**Trench Profile Option (Section 3-2B)**

There are no vibration impacts predicted for the Trench Profile Option (Section 3-2B).

**Tunnel Alternative (Section 3-2C)**

There are no ground-borne vibration impacts predicted for the Tunnel Profile Option (Section 3-2C). It should be noted, however, that the vibration predictions for the tunnel section were based on surface vibration propagation tests. In later stages of analysis for this profile option, it is recommended that borehole vibration propagation tests be conducted at the depth of the tunnel and that the specific track design in this section be incorporated into the predictions.

As discussed in the *Noise and Vibration Existing Conditions Technical Memorandum*, ground-borne noise impact criteria are particularly important for underground transit operations. Ground-borne noise is often described as the “rumble” that can be radiated from the motion of room surfaces in buildings due to ground-borne vibration. The FTA ground-borne noise impact criteria and methodology have been applied to receptors in the Tunnel Profile Option (Section 3-2C).

**Table 3-4** provides a summary of the projected ground-borne noise impacts at residential receptors. No ground-borne noise impacts are predicted at Category 3 receptors. The data provided in the table represent a range for the impacted receptors. The table includes the distance to the rail alignment, maximum speed, the impact criteria, and the projected future ground-borne noise levels. The locations of the impacted receptors are shown in **Appendix B**.

<table>
<thead>
<tr>
<th>Section</th>
<th>Alternative/Profile Option</th>
<th>Distance to Track (ft)</th>
<th>Train Speed, (mph)</th>
<th>Project Vibration Level¹</th>
<th>Ground-Borne Noise Impact Criterion¹</th>
<th>Number of Impacts²</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-2C</td>
<td>Base/Tunnel</td>
<td>40-70</td>
<td>32-50</td>
<td>38-44</td>
<td>38</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td><strong>Base Noise Impact Summary (with At-Grade Profile Option)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>Base Noise Impact Summary (with Trench Profile Option)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><strong>Base Noise Impact Summary (with Tunnel Profile Option)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>32</td>
</tr>
<tr>
<td></td>
<td><strong>Cypress Waters Alternative Summary</strong></td>
<td></td>
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<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><strong>Red Line Interface South Alternative Summary</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

¹ Ground-borne noise levels are measured in dBA referenced to 20 μPa.
² All impacts are residential unless otherwise noted.
Source: Harris Miller Miller & Hanson Inc., June 2013
3.2.4 Red Line Interface Alternatives

North Alternative (Section 3-4A)
For this analysis, the Red Line Interface North Alternative (Section 3-4A) is considered part of the Base Alternative as previously discussed. No vibration impacts are predicted in this Section.

South Alternative with Aerial Station and Depressed Freight (Section 3-4B)
There are no vibration impacts predicted for the Red Line Interface South Alternative with Aerial Station and Depressed Freight (Section 3-4B).

3.3 Construction Noise and Vibration Impacts

Temporary noise and vibration impacts could result from activities associated with the construction of new tracks and stations, utility relocation, grading, excavation, track work, demolition, and installation of systems components. Such impacts may occur in residential areas and at other noise-sensitive land uses located within several hundred feet of the rail alignment. The potential for noise impact would be greatest at locations near pavement breaking, and at locations close to any nighttime construction work. The potential for vibration impact would be greatest at locations close to vibratory compaction operations.
4.0 MITIGATION OF NOISE AND VIBRATION IMPACTS

4.1 Transit Noise Mitigation Measures

Potential mitigation measures for reducing noise impacts from the project are described below:

- **Establishment of Quiet Zones:** An effective option for mitigating noise impacts along the alignment would be to establish “quiet zones” near grade crossings in accordance with FRA regulations. In quiet zones, because of safety improvements at the at-grade crossings, train operators would sound horns only in emergency situations rather than as a standard operating procedure. Establishing quiet zones would require cooperative action among the municipalities along the corridor, FRA, the freight railroads and DART. The municipalities are key participants in the process as they must initiate the request to establish the zones through application to the FRA. To meet safety criteria, the municipalities may also be required to provide improvements at grade crossings such as modifications to the streets, raised medians, warning lights, and other devices. The FRA regulation also authorizes the use of automated wayside horns at crossings along with flashing lights and gates as a substitute for the train horn. While activated by the approach of trains, these devices are pole-mounted at the grade crossing, thereby limiting the horn noise exposure area to the immediate vicinity of the crossing.

- **Noise Barriers:** Installation of noise barriers beside the tracks is commonly used to reduce noise from surface transportation sources. Depending on the height and location relative to the tracks noise barriers can achieve between 5 and 15 dB of noise reduction. The primary requirements for an effective noise barrier are that (1) the barrier must be high enough and long enough to break the line-of-sight between the sound source and the receiver, (2) the barrier must be of an impervious material with a minimum surface density of 4 lb./sq. ft., and (3) the barrier must not have any gaps or holes between the panels or at the bottom. Because many materials meet these requirements, the selection of materials for noise barriers is usually dictated by aesthetics, durability, cost, and maintenance considerations. Noise barriers for transit projects typically range in height from eight to twelve feet. Noise barriers typically range in cost from $25 to $35 per square foot.

- **Building Sound Insulation:** Sound insulation of residences and institutional buildings to improve the outdoor-to-indoor noise reduction has been widely applied around airports and has seen limited application for rail and transit projects. Although this approach has no effect on noise in exterior areas, it may be the best choice for sites where noise barriers are not feasible or desirable and for buildings where indoor sensitivity is of most concern. Substantial improvements in building sound insulation (on the order of 5 to 10 dBA) can often be achieved by adding an extra layer of glazing to the windows, by sealing holes in exterior surfaces that act as sound leaks, and by providing forced ventilation and air-conditioning so that windows do not need to be opened. Sound insulation typically ranges in cost per home from $25,000 to $50,000.
• **Wheel/Rail Lubrication:** There are several options to mitigate potential wheel squeal from small-radius curves, including on-board solid-stick rail lubrication and wayside rail lubrication. Automated wayside top of rail friction modifier systems put a small amount of lubricant onto the top of the rail, which maintains a constant coefficient of friction. This type of lubricant has been shown to reduce or eliminate the potential for wheel squeal. The typical cost for this measure is $15,000 per track ($30,000 for both tracks).

• **Special Trackwork:** Because the impacts of rail vehicle wheels over rail gaps at track turnout locations increase airborne noise by about six dBA close to the track, turnouts are a major source of noise impact when they are located in sensitive areas. If turnouts cannot be relocated away from sensitive areas, other noise control measures can be used such as the use of spring-rail, flange-bearing, or moveable-point frogs in place of standard rigid frogs at turnouts. These devices allow the flangeway gap to remain closed in the main traffic direction for revenue service trains. Spring frogs typically cost $24,000 per frog while moveable point frogs cost approximately $140,000 per frog.

• **Property Acquisitions or Easements:** Additional options for avoiding noise impacts are for the agency to purchase residences likely to be impacted by train operations or to acquire easements for such residences by paying the homeowners to accept the future train noise conditions. These approaches are usually taken only in isolated cases where other mitigation options are infeasible, impractical, or too costly.

FTA states that, in determining the need for noise mitigation, severe impacts should be mitigated unless there are no practical means to do so. At the moderate impact level, more discretion should be used, and other project-specific factors should be included in the consideration of mitigation. These other factors can include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-to-indoor sound insulation and the cost-effectiveness of mitigating noise to more acceptable levels. Consistent with DART policy, noise mitigation for moderate noise impacts is considered at locations where a noise exposure increase of three decibels or more is projected. Other moderate impacts would be evaluated on a case-by-case basis depending, on proximity to other mitigation.

Most of the noise impacts from the Cotton Belt Project are due to the sounding of train horns at the numerous at-grade crossings along the alignment. Therefore, the most practical way to mitigate the noise impacts is with the establishment of quiet zones for at-grade crossings near impacted noise-sensitive receptors. Table 3-5 summarizes the number of noise impacts predicted from the Cotton Belt Project with train horns and with the implementation of quiet zones throughout the corridor. Appendix C identifies the location of potential noise impacts with the implementation of quiet zones.

Table 3-5 indicates that the majority of the noise impacts would be eliminated with the implementation of quiet zones. In the Baseline At-grade Profile Option, 100 percent of severe impacts and 98 percent of all noise impacts would be eliminated with the implementation of quiet zones throughout the corridor. Consistent with DART policy, severe noise impacts and moderate impacts with a noise increase of 3 dB or greater would need to be mitigated. Mitigation of other moderate impacts would be considered on a case-by-case basis. Mitigation
could include a combination of noise barriers and use of special trackwork designs or relocation of potential turnouts.

Table 3-5
Summary of Noise Impacts With and Without Quiet Zones

<table>
<thead>
<tr>
<th>Section</th>
<th>Alternative/Profile Option</th>
<th>Moderate Impacts</th>
<th>Severe Impacts</th>
<th>Moderate Impacts With Less Than 3 dB Increase</th>
<th>Moderate Impacts With 3 dB or More Increase</th>
<th>Severe Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Base</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1-2A</td>
<td>Base</td>
<td>8</td>
<td>9</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1-2B</td>
<td>Cypress Waters</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1-3</td>
<td>Base</td>
<td>332</td>
<td>352</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2-1</td>
<td>Base</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2-2</td>
<td>Base</td>
<td>61</td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2-3</td>
<td>Base</td>
<td>296</td>
<td>642</td>
<td>0</td>
<td>8</td>
<td>0</td>
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<tr>
<td>3-1</td>
<td>Base</td>
<td>36</td>
<td>174</td>
<td>0</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>3-2A</td>
<td>Base/At-Grade</td>
<td>494</td>
<td>1449</td>
<td>0</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>3-2B</td>
<td>Base/Trench</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>3-2C</td>
<td>Base/Tunnel</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3-3</td>
<td>Base</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3-4A</td>
<td>Baseline (North Alt.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3-4B</td>
<td>South Alt.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3-5</td>
<td>Base</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Base Noise Impact Summary (with At-Grade Profile Option)</td>
<td>1228</td>
<td>2652</td>
<td>4</td>
<td>90</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Baseline Noise Impact Summary (with Trench Profile Option)</td>
<td>741</td>
<td>1203</td>
<td>4</td>
<td>51</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Baseline Noise Impact Summary (with Profile Option)</td>
<td>734</td>
<td>1203</td>
<td>4</td>
<td>44</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cypress Waters Alternative Summary</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>South Alternative Summary</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> The number of impacts includes both Category 2 (residential) and Category 3 (institutional) receptors.

<sup>2</sup> Noise levels are measured in dBA.

<sup>3</sup> There are no noise-sensitive receptors of this type in this section.

Source: Harris Miller Miller & Hanson Inc., June 2013
4.2 Transit Vibration Mitigation Measures

The vibration assessment assumes that the rail vehicle wheels and track are maintained in good condition with regular wheel truing and rail grinding. Beyond this, there are several approaches to reduce ground-borne vibration and ground-borne noise from train operation, as follows:

- **Ballast Mats:** A ballast mat consists of a pad made of rubber or rubber-like material placed on an asphalt or concrete base with the normal ballast, ties, and rail on top. The reduction in ground-borne vibration provided by a ballast mat is strongly dependent on the vibration frequency content and the design and support of the mat. The typical cost per track foot is $320.

- **Tire Derived Aggregate (TDA):** Also known as shredded tires, a typical TDA installation consists of an underlayment of 12 inches of nominally 3-inch size tire shreds or chips wrapped with filter fabric, covered with 12 inches of sub-ballast and 12 inches of ballast above that to the base of the ties. Tests suggest that the vibration attenuation properties of this treatment are midway between that of ballast mats and floating slab track. This low-cost option has been installed on two U.S. light rail transit systems (San Jose and Denver) for a number of years and test results have shown this treatment to be very effective at frequencies above about 25 Hz. The typical cost per track foot is $260.

- **Floating Slabs:** Floating slabs consist of thick concrete slabs supported by resilient pads on a concrete foundation; the tracks are mounted on top of the floating slab. Most successful floating slab installations are in subways, and their use for at-grade track is less common. Although floating slabs are designed to provide vibration reduction at lower frequencies than ballast mats, they are extremely expensive. The typical cost per track foot is $800.

- **Resiliently Supported Concrete Ties (Under-Tie Pads):** This treatment involves a special soft rubber pad embedded in the base of a concrete tie. The pad serves two purposes: (1) it provides a pliable surface to help anchor the ties on ballast; and (2) it provides vibration isolation between the tie and the ballast. This relatively simple treatment has been used extensively in Europe. Test results have shown this treatment to be very effective at frequencies above about 25 Hz and its cost is about 1.2 times the cost of a standard concrete tie. The typical cost per track foot is $260.

- **Resilient Rail Fasteners:** Resilient fasteners can be used to provide vibration isolation between rails and ties, as well as on concrete slabs for direct fixation track on aerial structures or in tunnels. These fasteners include a soft, resilient element to provide greater vibration isolation than standard rail fasteners in the vertical direction. Resilient rail fasteners are effective at frequencies above about 40 Hz. The typical cost per track foot is $360.

- **Special Trackwork:** Because the impacts of vehicle wheels over rail gaps at track turnout locations increases ground-borne vibration by about 10 VdB close to the track, turnouts are a major source of vibration impact when they are located in sensitive areas. If turnouts cannot be relocated away from sensitive areas, another approach is to use spring-rail, flange-bearing or moveable-point frogs in place of standard rigid frogs at
turnouts. These devices allow the flangeway gap to remain closed in the main traffic direction for revenue service trains. Spring frogs typically cost $24,000 per frog while moveable-point frogs cost approximately $140,000 per frog.

Vibration impacts that exceed FTA criteria are considered to be significant and to warrant mitigation, if reasonable and feasible. Therefore, the predicted ground-borne vibration and ground-borne noise impacts that have been identified above would need to be considered for mitigation. The vibration analysis will be updated during later stages of the project to account for more detailed information, and mitigation measures will be considered at that time if warranted.

4.3 Construction Noise and Vibration Mitigation Measures

Construction activities will be carried out in compliance with all applicable local noise regulations. In addition, the following mitigation measures will be applied as needed to minimize temporary construction noise and vibration impacts:

- Avoiding nighttime construction in residential neighborhoods;
- Locating stationary construction equipment as far as possible from noise-sensitive sites;
- Constructing noise barriers, such as temporary walls or piles of excavated material, between noisy activities and noise-sensitive receivers;
- Routing construction-related truck traffic to roadways that will cause the least disturbance to residents; and
- Using alternative construction methods to minimize the use of impact and vibratory equipment (e.g., pile-drivers and compactors).
5.0 LITERATURE/SOURCES CITED


Dallas Area Rapid Transit, “Cotton Belt Corridor Regional Rail Noise and Vibration Existing Conditions Technical Memorandum” (June 14, 2013).

APPENDIX A: NOISE IMPACT LOCATIONS
Figure A-1
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-2
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-3
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-4
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence, as, for example, in the case of multi-family buildings.
Figure A-5
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence, as, for example, in the case of multi-family buildings.
Figure A-6
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-7
Baseline Alternative Noise Impact Locations

Cotton Belt Corridor Regional Rail

Cotton Belt Project
- Cotton Belt Baseline Alternative
- South Alignment Alternative
- Cypress Waters Alternative
- Forestal Terminal Location
- At-Grade Crossing

Existing Quiet Zone

DART Rail
- Red Line
- Blue Line
- Green Line
- Orange Line

Other Rail
- "SCTA" Trains
- "Proposed TEXRail"

Impact Locations
- Moderate Noise Impact
- Severe Noise Impact

Note: In some instances, a single dot on the map may represent noise impact at more than one residence, as, for example, in the case of multi-family buildings.

June, 2013
Figure A-8
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-9
Baseline Alternative Noise Impact Locations

Cotton Belt Corridor Regional Rail

Cotton Belt Project
- Cotton Belt Baseline Alternative
- South Alignment Alternative
- Cypress Waters Alternative
- Possible Turnout Location
- 44th Grade Crossing
- Existing Quiet Zone

DART Rail
- Red Line
- Blue Line
- Green Line
- Orange Line

Other Rail
- Proposed TEX Rail

Impact Locations
- Moderate Noise Impact
- Severe Noise Impact

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.

June, 2013
Figure A-10
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-11
Baseline Alternative Noise Impact Locations

Cotton Belt Corridor
Regional Rail

Cotton Belt Project
- Cotton Belt Baseline Alternative
- South Alignment Alternative
- Cypress Waters Alternative
- Fort Worth Traction Location
- 48 Grade Crossing
- Existing Quiet Zone

DART Rail
- Red Line
- Blue Line
- Green Line
- Orange Line

Other Rail
- 48' Traction
- Proposed DTV Rail

Impact Locations
- Moderate Noise Impact
- Severe Noise Impact

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-12
Baseline Alternative Noise Impact Locations

Cotton Belt Corridor Regional Rail

Cotton Belt Project
- Cotton Belt Baseline Alternative
- South Alignment Alternative
- Cypress Waters Alternative
- Potential Tunnel Location
- 41 Grade Crossing
- Existing Quiet Zone

DART Rail
- Red Line
- Blue Line
- Green Line
- Orange Line

Other Rail
- **** DART Tram
- •••• Proposed TEXRail

Impact Locations
- Moderate Noise Impact
- Severe Noise Impact

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.

June, 2013
Figure A-13
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-14
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-15
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence, as, for example, in the case of multi-family buildings.
Figure A-16
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence, as, for example, in the case of multi-family buildings.

June, 2013
Figure A-17
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.

June, 2013
Figure A-18
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence; for example, in the case of multi-family buildings.
Figure A-19  
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-20
Baseline Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence, as, for example, in the case of multi-family buildings.
Figure A-21
Baseline Alternative Noise Impact Locations
Figure A-22
Cypress Waters Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure A-23
North Dallas Trench Alternative Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence; for example, in the case of multi-family buildings.
Figure A-24
North Dallas Trench Alternative Noise Impact Locations
APPENDIX B: VIBRATION IMPACT LOCATIONS
Figure B-1
Baseline Alternative Ground-Borne Vibration Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence; for example, in the case of multi-family buildings.
Figure B-2
Cypress Waters Alternative Ground-Borne Vibration Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence, as, for example, in the case of multi-family buildings.

June, 2013
Figure B-3
North Dallas Tunnel Alternative Ground-Borne Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence, for example, in the case of multi-family buildings.
Figure B-4
North Dallas Tunnel Alternative Ground-Borne Noise Impact Locations

Note: In some instances, a single dot on the map may represent noise impact at more than one residence, as, for example, in the case of multi-family buildings.
APPENDIX C: NOISE IMPACT LOCATIONS WITH IMPLEMENTATION OF QUIET ZONES
Figure C-1
Baseline Alternative Noise Impact Locations with Implementation of Quiet Zones

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure C-2
Baseline Alternative Noise Impact Locations with Implementation of Quiet Zones

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure C-3
Baseline Alternative Noise Impact Locations with Implementation of Quiet Zones

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure C-4
Baseline Alternative Noise Impact Locations with Implementation of Quiet Zones

Note: In some instances, a single dot on the map may represent noise impact at more than one residence as, for example, in the case of multi-family buildings.
Figure C-5
Baseline Alternative Noise Impact Locations with Implementation of Quiet Zones
Figure C-6
Baseline Alternative Noise Impact Locations with Implementation of Quiet Zones
Alliance Transportation Group
Arredondo, Zepeda & Brunz
Bowman Engineering
Connetics Transportation Group
Cox|McLain Environmental Consulting
CP&Y
Criado & Associates
Dunbar Transportation Consulting
HMMH
KAI Texas
K Strategies Group
Legacy Resource Group
Mas-Tek Engineering & Associates
Nathan D. Maier Consulting Engineers
Pacheco Koch Consulting Engineers
Parsons
Schrader & Cline
Spartan Solutions
Stantec Consulting Services Inc.