EXHIBIT I
TO 2020 EXTRAORDINARY PETITION OF KIC FOR AFFIRMATION OF 2019 VARIANCE
August 19, 2018

Ms. Megan Wood
Kiewit
160 Inverness Drive West, Suite 110
Englewood, CO 80112

Re: Central 70 Noise Mitigation
Wave #1776

Dear Megan,

Wave Engineering measured the construction noise reduction provided by the 12’ high sound barrier on the south side of Swansea Elementary School. Our findings were summarized in our report dated August 16, 2018. I understand that Kiewit is proposing to install additional sound barriers near residences north and south of I-70. The proposed locations are shown in Figure 1.

![Figure 1: Proposed Sound Barrier Locations](image-url)
We have not performed a detailed analysis to determine how much the sound levels will be reduced at each home, but we can offer these general comments on the potential effectiveness of the barriers.

The barrier construction will be identical or very similar to the existing barrier at Swansea Elementary. Our testing showed that that barrier provided about 16 dBA of noise reduction from the construction activity that was simulated. Based on past experience, this is at the high end of the expected performance. When estimating the expected performance of the proposed barriers, I suggest using a range of 10 to 15 dBA for noise reduction. Where the first row of homes are very close to the barrier, they may realize more noise reduction. Where the homes are further from barriers, or where the construction activity is further away, they may see less noise reduction. Where construction activity is visible through the openings in the barriers at the north-south running streets, then the barriers will not reduce noise from the visible construction.

With reference to the projected construction noise levels and the extent of the L_{eq} 75 dBA and the L_{MAX} 86 dBA noise levels shown in our August 18, 2018 report ("Central 70 Noise Variance Sound Level Projections"), the impacted areas would be much smaller and the number of affected homes would be significantly reduced if the 10 to 15 dBA noise reduction of the sound barriers were considered.

Please let me know if you have any questions or want to discuss this further.

Sincerely,

Jeff
Kwolkoski
Jeff Kwolkoski, P.E., INCE Bd. Cert.
President
August 18, 2018

Mr. Tom Ziolkowski
Kiewit
160 Inverness Drive West, Suite 110
Englewood, CO 80112

Re: Central 70 Nighttime Noise Variance Sound Level Projections
Wave #1776

Dear Mr. Ziolkowski,

Wave Engineering has reviewed the proposed nighttime construction operations related to the Central 70 project and the equipment associated with these operations. We calculated the projected sound levels from these operations at nearby locations.

The intent of this report is to compare the projected sound levels produced by the proposed Central 70 project's nighttime operations with the expected Denver nighttime noise variance sound level limits, and determine the number of residences and hotels impacted by sound levels above the variance limits. This report may then be used in your application for a nighttime noise variance.

Central 70 Project Background

The Central 70 project will reconstruct a 10-mile stretch of I-70 between I-25 and Chambers Road, add one new Express Lane in each direction, remove the aging 54-year old viaduct, lower the interstate between Brighton and Colorado Boulevards, and place a 4-acre park over a portion of the lowered interstate.

Denver Noise Ordinance

The Denver Noise Ordinance Chapter 36 limits noise levels to 55 dBA during the day and to 50 dBA at night at a residential property line. Construction noise is allowed to exceed the limits during the daytime. If construction noise levels will exceed the nighttime limits, then a variance is required. On previous projects for which a nighttime noise variance was granted by the City and County of Denver, construction noise levels have been limited to an LEQ of 75 dBA and an LMAX of 86 dBA.
Construction Noise Level Predictions

Wave Engineering used the Roadway Construction Noise Model (RCNM) developed by the Federal Highway Administration (FHA) to predict noise levels from nighttime construction activity.

There are many homes along the West work area. The nighttime construction noise levels at these homes will vary based on the type of work and the distance from the work.

**Corridor Wide**
Many of the construction operations will occur across the entire West work area. We will refer to these as "Corridor wide" operations. The noise levels for corridor wide work will be constantly shifting, consistent along the work route, and noise levels will be a function of distance from the edge of the lane of travel under construction.

**Bridge Work**
The nighttime construction for bridge work will occur in specific areas around each bridge. The work will be more stationary and noise levels will be a function of distance from the construction activity to the residences.

Predicting construction noise levels at each residence would be very difficult because the exact location of the construction activity will move around on a nightly basis, and the noise making equipment will move around each work area. Instead of predicting noise levels at every residence along the corridor or near each bridge, we determined the distances from each type of work where the LMAX and LEQ criteria may be exceeded and determined how many homes fall within this distance and may require additional mitigation or controls.

The following source levels for significant noise producing equipment were used in our analysis. The RCNM database of equipment noise levels and usage percentage were used.
The noise level at each individual residence will depend on which equipment is operating, the distance of the equipment from the residence, and whether or not the residence is shielded from the equipment by other buildings, sound walls, etc. Due to the close proximity of most of the first row receiver buildings to the construction, we have not included shielding of the equipment from the buildings. There will often be shielding of second, third, etc., row homes, but it will vary on a home-by-home basis. Additionally, as the road work descends below grade (in specific sections), the receivers will receive shielding from the ground that is above the road. We have not accounted for shielding in order to provide worst case estimates.

The $L_{EQ}$ values shown below were calculated with the RCNM program using the $L_{MAX}$ values at 50’ for equipment that is operating simultaneously and their associated usage. The $L_{EQ}$ is the equivalent noise level which is similar to an average noise level over a one hour period. We assumed that the equipment will be spread out around a typical work site. The $L_{MAX}$ noise levels are calculated from the loudest piece of equipment.

<table>
<thead>
<tr>
<th>Construction Equipment</th>
<th>$L_{MAX}$ at 50' (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auger Drill Rig</td>
<td>84</td>
</tr>
<tr>
<td>Concrete Mixer Truck</td>
<td>79</td>
</tr>
<tr>
<td>Concrete Pump Truck</td>
<td>81</td>
</tr>
<tr>
<td>Concrete Saw</td>
<td>90</td>
</tr>
<tr>
<td>Compressor</td>
<td>78</td>
</tr>
<tr>
<td>Crane</td>
<td>81</td>
</tr>
<tr>
<td>Dozer</td>
<td>82</td>
</tr>
<tr>
<td>Dump Truck</td>
<td>77</td>
</tr>
<tr>
<td>Excavator</td>
<td>81</td>
</tr>
<tr>
<td>Flat Bed Truck</td>
<td>74</td>
</tr>
<tr>
<td>Front End Loader/Skid Steer</td>
<td>79</td>
</tr>
<tr>
<td>Generator/Light Plant</td>
<td>81</td>
</tr>
<tr>
<td>Grader</td>
<td>85</td>
</tr>
<tr>
<td>Man Lift</td>
<td>75</td>
</tr>
<tr>
<td>Mounted Impact Hammer</td>
<td>90</td>
</tr>
<tr>
<td>Paver</td>
<td>77</td>
</tr>
<tr>
<td>Pickup Truck</td>
<td>75</td>
</tr>
<tr>
<td>Roller</td>
<td>80</td>
</tr>
<tr>
<td>Shears</td>
<td>96</td>
</tr>
<tr>
<td>Welder/Torch</td>
<td>74</td>
</tr>
</tbody>
</table>
The $L_{eq}$ calculations take into account the distance from the equipment and the usage factor of each piece of equipment. The usage factor is the percentage of time during a typical work hour when the equipment is operating at full power.

The $L_{max}$ values shown below were calculated using the $L_{max}$ values at 50'. The $L_{max}$ is the maximum noise level at each receiver location from the loudest piece of equipment. The $L_{max}$ calculations take into account the distance from the equipment to the receivers. The usage factor is not used in the $L_{max}$ calculation as it is assumed that the loudest piece of equipment is at full power.

**Corridor Wide Construction**

The corridor wide construction will take place along on both sides of the roadway between Colorado Boulevard and I-25. We used the RCNM to determine the distances from each construction operation where the $L_{eq}$ noise level is equal to 75 dBA and where the $L_{max}$ is equal to 86 dBA. These distances began at the construction area, generally near the curb or edge of the road. The distances were determined for both the existing location of the road and the future placement of the road. Beyond these distances, the $L_{eq}$ and $L_{max}$ are less than 75 dBA and 86 dBA, respectively. Furthermore, the second, third, etc., row of homes will receive some screening from closer rows of homes or commercial buildings, so the actual noise levels should be lower (to be conservative, the change in the noise level from building screening was not used in the calculations).

Below is a description of the corridor wide nighttime operations, the equipment that will be used during the operations, the distances for the $L_{eq}$ and $L_{max}$ noise levels, and the number of homes that are within these distances. Keep in mind that all of the homes will not be affected on any given night, but the total number of homes that will be affected during the project from each type of nighttime construction operation is given. An example of the typical extent of construction noise is given in Figure 2. The shaded area in Figure 2 shows the extent of the area where the nighttime noise limits may be exceeded and mitigation measures would be implemented. Figure 2 shows the loudest corridor wide activity which is from the Excavation and Embankment work (as well as the Surface Removal work).
Figure 1: Construction Noise Extent for Excavation and Embankment Work
Maintenance of Traffic (MOT) Lane Closures - Corridor Wide

During this operation, pickup/flatbed trucks will operate along I-70 and associated frontage roads within the project limits to open/close specific lanes, which will be used to help control traffic during other phases of construction. This will take place and affect houses along the entire project area.

The equipment that will be used during this operation is listed in Table 2.

Table 2: Lane Closure Equipment

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup Truck</td>
<td>2</td>
</tr>
<tr>
<td>Flat Bed Truck</td>
<td>4</td>
</tr>
</tbody>
</table>

$L_{eq} = 75$ dBA at 60' from I-70
$L_{max} = 86$ dBA at 15' from I-70

Approximately 27 Denver homes along the corridor potentially fall within the 75 dBA $L_{eq}$ (within 60' distance)

Approximately 3 Denver homes along the corridor potentially fall within the 86 dBA $L_{max}$ (within 15' distance)

MOT Concrete Barrier Set/Remove - Corridor Wide

During this operation, pickup/flatbed trucks, an excavator, front end loaders, and generators will operate along I-70 and associated frontage roads within the project limits to set up and/or remove concrete barriers, which will be used to help control traffic during other phases of construction. This will take place and affect houses along the entire project area.

The equipment that will be used during this operation is listed in Table 3.

Table 3: Concrete Barrier Set/Remove equipment

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup Truck</td>
<td>2</td>
</tr>
<tr>
<td>Excavator</td>
<td>1</td>
</tr>
<tr>
<td>Front End Loader</td>
<td>2</td>
</tr>
<tr>
<td>Flat Bed Truck</td>
<td>6</td>
</tr>
<tr>
<td>Generator (Light Plant)</td>
<td>4</td>
</tr>
</tbody>
</table>

$L_{eq} = 75$ dBA at 160' from I-70
$L_{max} = 86$ dBA at 20' from I-70

Approximately 126 Denver homes along the corridor potentially fall within the 75 dBA $L_{eq}$ (within 160' distance)

Approximately 3 Denver homes along the corridor potentially fall within the 86 dBA $L_{max}$ (within 20' distance)
MOT Temp Paving Detours - Corridor Wide
During this operation, pickup/dump trucks, a paver, a front end loader, rollers, and generators will operate along I-70 and associated frontage roads within the project limits to set up detours, which will be used to help redirect traffic during other phases of construction. This will take place and affect houses along the entire project area.

The equipment that will be used during this operation is listed in Table 4.

Table 4: MOT Temp Paving Detours equipment

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup Truck</td>
<td>2</td>
</tr>
<tr>
<td>Paver</td>
<td>1</td>
</tr>
<tr>
<td>Dump Truck</td>
<td>9</td>
</tr>
<tr>
<td>Front End Loader</td>
<td>1</td>
</tr>
<tr>
<td>Roller</td>
<td>3</td>
</tr>
<tr>
<td>Generator (Light Plant)</td>
<td>2</td>
</tr>
</tbody>
</table>

$L_{eq} = 75\text{ dBA at } 160' \text{ from I-70}$
$L_{max} = 86\text{ dBA at } 15' \text{ from I-70}$
Approximately 126 Denver homes along the corridor potentially fall within the 75 dBA $L_{eq}$ (within 160' distance)
Approximately 3 Denver homes along the corridor potentially fall within the 86 dBA $L_{max}$ (within 15' distance)

Asphalt Paving - Corridor Wide
During this operation, pickup/dump trucks, a paver, a front end loader, rollers, and generators will operate along I-70 and associated frontage roads within the project limits to lay asphalt for the new and existing roads. This will take place and affect houses along the entire project area.

The equipment that will be used during this operation is listed in Table 5.

Table 5: Asphalt Paving equipment

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup Truck</td>
<td>2</td>
</tr>
<tr>
<td>Paver</td>
<td>1</td>
</tr>
<tr>
<td>Dump Truck</td>
<td>9</td>
</tr>
<tr>
<td>Front End Loader</td>
<td>1</td>
</tr>
<tr>
<td>Roller</td>
<td>4</td>
</tr>
<tr>
<td>Generator (Light Plant)</td>
<td>2</td>
</tr>
</tbody>
</table>
Bridge Demolition

During this operation, pickup/dump/flatbed trucks, excavators, shears, mounted impact hammers, front end loaders, a compressor, generators, a welder/torch, and a concrete saw will operate at existing bridges to demolish them. The bridge locations are Brighton Boulevard bridge, UPRR Bridge, and the bridges at the I-70 viaduct.

The equipment that will be used during this operation is listed in Table 15.

Table 15: Bridge Demolition equipment

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup Truck</td>
<td>4</td>
</tr>
<tr>
<td>Excavator</td>
<td>8</td>
</tr>
<tr>
<td>Shears (on backhoe)</td>
<td>2</td>
</tr>
<tr>
<td>Mounted Impact Hammer</td>
<td>6</td>
</tr>
<tr>
<td>Front End Loader</td>
<td>3</td>
</tr>
<tr>
<td>Dump Truck</td>
<td>3</td>
</tr>
<tr>
<td>Compressor</td>
<td>1</td>
</tr>
<tr>
<td>Generator (Light Plant)</td>
<td>10</td>
</tr>
<tr>
<td>Welder/Torch</td>
<td>1</td>
</tr>
<tr>
<td>Flat Bed Truck</td>
<td>2</td>
</tr>
<tr>
<td>Concrete Saw</td>
<td>2</td>
</tr>
</tbody>
</table>

$\text{L}_{\text{EQ}} - 75 \text{ dBA at 700'}$ from edge of equipment (745' radius from center of equipment)

$\text{L}_{\text{MAX}} = 86 \text{ dBA at 180'}$ from edge of equipment (225' radius from center of equipment)

Approximately 264 Denver homes fall (total for all bridges combined) within the 75 dBA $\text{L}_{\text{EQ}}$ (within 700' distance).

Approximately 26 Denver homes (total for all bridges combined) fall within the 86 dBA $\text{L}_{\text{MAX}}$ (within 180' distance)

The $\text{L}_{\text{EQ}}$ distance/radius is shown in Figure 6.
Figure 5: Bridge Demolition Noise $L_{EQ}$ Distance/Radius

Areas Above $L_{EQ}$ and/or $L_{MAX}$ Limits

Brighton Blvd.

Fillmore St.
The home counts are based on construction in the closest lanes to the homes.

**Hotels Impacted by Nighttime Operations**

The following hotels will be affected by the MOT concrete barrier set/removal work, MOT temporary paving detours work, and asphalt paving work:

- Denver's Best Inn & Suites – 4590 Quebec St, Denver, CO
- Western Motor Inn – 4757 Vasquez Blvd. E, Denver, CO

The following hotels, as well as the hotels mentioned above, will be affected by the surface removal work:

- The Timbers Hotel – 4411 Peoria St, Denver, CO
- Courtyard by Marriot Denver Stapleton – 7415 E 41st Ave, Denver, CO

The following hotels, as well as the hotels mentioned above, will be affected by bridge demolition work:

- Comfort Inn Denver East – 4380 Peoria St, Denver, CO
- Rodeway Inn – 3975 Peoria Way, Denver, CO
- Motel 6 Denver - Airport – 12020 E 39th Ave, Denver, CO

**Fire Departments Impacted by Nighttime Operations**

The Denver Fire Department Fire Station 9 will be affected by noise from the bridge work conducted along Brighton Boulevard.

Please let me know if you have any questions on this report or would like to discuss it further.

Sincerely,

Jeff Kwolkoski
President/Senior Acoustical Engineer
August 16, 2018

Ms. Megan Wood
Kiewit
160 Inverness Drive West, Suite 110
Englewood, CO 80112

Re: Central 70 – Kiewit Equipment Sound Measurements
Wave #1776

Dear Megan,

On Monday, August 13, 2018, I measured sound levels of six pieces of Kiewit owned construction equipment at the equipment yard at 2401 Picadilly Road. This report summarizes our test procedures and result. The sound levels for similar equipment from the US FHA Roadway Construction Noise Model (RCNM) are shown for reference.

**Test Procedures**

Noise levels were measured for construction equipment between 4:00 p.m. and 5:00 p.m. on Monday, August 13, 2018.

Noise levels were measured at one location a distance of 50' from each piece of equipment. The measurement locations were generally chosen to be in the noisiest direction, closest to the engine exhaust, in direct view of noisy implements.

Each piece of equipment was measured at high idle. Where possible, the equipment was also measured while revving the engine and moving the implements. For example, the light plant was only measured at its steady idle. The equipment was not under actual load conditions during the testing, except for the light plant.

Sound levels were measured for periods of 30 to 45 seconds at a time, with the sound meter set to Slow response.
Sound Test Equipment

The following equipment was used.

Larson Davis Model 831 sound level meter S/N 0004081, Type 1 per ANSI S1.4
PCB preamp PRM831, S/N 036934
PCB ½" microphone Model 377B02, S/N 153301

Larson Davis CA200 acoustic calibrator, S/N 11780

The calibration of each sound meter was checked in the field before and after the measurements with the Larson Davis CAL200 acoustic calibrator. Laboratory calibration certificates for the equipment are available upon request.

The temperature was approximately 88°F with Relative Humidity of 35 to 40% during the testing. There was a slight wind of 0 to 5 mph from the NNE during the tests, but it did not affect the test results.

Measurement Results

The measured sound levels are shown in Table 1 below. The $L_{EQ}$ (average) and $L_{MAX}$ (maximum) are shown. The sound levels taken from the United States Federal Highway Administration Roadway Construction Model (RCNM) database (measured at 50') are also shown in the table for reference. The RCNM values were used in the noise assessment for the Denver nighttime noise variance.
Table 1: Measured Sound Levels & RCNM Sound Levels

<table>
<thead>
<tr>
<th>Construction Equipment</th>
<th>Sound Pressure Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Measured L_Eq (dBA)</td>
</tr>
<tr>
<td>Caterpillar 289D Compact Track Loader</td>
<td></td>
</tr>
<tr>
<td>at high idle</td>
<td>65</td>
</tr>
<tr>
<td>moving implement</td>
<td>72</td>
</tr>
<tr>
<td>Caterpillar 335F Excavator</td>
<td></td>
</tr>
<tr>
<td>at high idle</td>
<td>62</td>
</tr>
<tr>
<td>moving implement</td>
<td>76</td>
</tr>
<tr>
<td>Caterpillar 950M Wheel Loader</td>
<td></td>
</tr>
<tr>
<td>at high idle</td>
<td>65</td>
</tr>
<tr>
<td>moving implement*</td>
<td>--</td>
</tr>
<tr>
<td>Vector HXX Vacuum Excavator Truck</td>
<td></td>
</tr>
<tr>
<td>at high idle, no suction</td>
<td>85</td>
</tr>
<tr>
<td>Allmand 8KW MaxiLite II 4-light plant</td>
<td></td>
</tr>
<tr>
<td>at high idle</td>
<td>63</td>
</tr>
<tr>
<td>Caterpillar 304.5E XTC Mini Excavator</td>
<td></td>
</tr>
<tr>
<td>at high idle</td>
<td>53</td>
</tr>
<tr>
<td>moving implement</td>
<td>65</td>
</tr>
</tbody>
</table>

* the loader implement could not be moved during testing.

Conclusions

Sound levels were measured 50' from each piece of equipment. This data may be useful for future reference. The Compact Trak Loader and the Excavator were slightly louder than the RCNM database. The light plant and the mini excavator were significantly quieter. We only measured one sample from each category of equipment. It is normal for individual pieces of equipment to vary within categories of equipment.

The RCNM database is useful as a reference but includes a broader range of equipment under single categories and in many cases includes samples of many pieces of equipment. Please let me know if you have any questions or want to discuss this further.

Sincerely,

Jeff Kwolkoski

Jeff Kwolkoski, P.E., INCE Bd. Cert.
President

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www.WaveEngineering.com
August 16, 2018

Ms. Megan Wood
Kiewit
160 Inverness Drive West, Suite 110
Englewood, CO 80112

Re: Central 70 Swansea Sound Wall Test Report
Wave #1776

Dear Megan,

On Monday, August 13, 2018, I measured sound levels to determine the effectiveness of the sound wall that is being installed on the south side of Swansea Elementary School. This report summarizes the test procedures and results.

Summary

Sound levels from construction equipment were measured on the near and far side of the 12' high sound wall near Swansea Elementary School. The difference between the shielded and unshielded sound levels provides a good indication of the noise reduction provided by the wall. The actual performance will vary depending on the exact location of the sound source and sound receiver, but we found that the wall is providing about 16 dBA of noise reduction.

Background

A sound wall reduces sound levels outdoors by blocking the line-of-sight between a sound source and a sound receiver, and in turn blocking the direct path of sound. Some sound will still refract over the top of the wall. The taller the wall, the better it works. A sound wall also works better when the sound source and/or receiver are closer to the wall, and are not near one end of the wall. The height of the source and receiver also affect the wall’s effectiveness. Sound from a source higher above the ground will transmit over the wall better than a source close to the ground.

A sound wall is currently under construction near Swansea Elementary School as part of the Central 70 project. It runs east-west on the south side of the school. The wall consists of plywood
sheets on each side of 2x12 wood framing. The plywood wall is 12' high. The east end of the wall was substantially complete at the time of the sound tests with the exception of some painting.

Test Procedures

Construction activity was simulated with heavy equipment to evaluate the wall’s effectiveness. For the tests, two wheel loaders and one compact track skid-steer loader were operated. The equipment is listed below.

- Caterpillar 950K wheel loader
- Caterpillar 930K wheel loader
- Caterpillar 289D Compact Track Loader

The two wheel loaders dumped rocks from one to the other and moved forward and backward. The compact track loader idled and moved around to activate its backup alarm.

The heavy equipment included traditional backup beeper alarms and also broadband backup alarms.

Two sound level meters were set up on tripods to measure noise levels continuously at two locations. They were set to continuously measure a series of one-minute duration sound levels. The data include the average sound level as well as the minimum, the maximum, and a series of statistical sound levels at each measurement location.

We used the L10 statistical level for analysis of the wall performance. The L10 is the sound level that is exceeded 10% of the time over a given time period. The L10 approaches the maximum sound level but is not as high as the maximum. I used the L10 instead of the average sound level to avoid interference from the background sound of traffic on I70 and 46th Avenue. Traffic noise is significant at the site and interferes with the measurement of the average sound level from the equipment operation, but not the L10. By using the L10, we evaluated the wall performance during louder periods when the construction noise clearly exceeded the traffic noise. This gives a better indication of the wall performance.

The wall performance was evaluated by measuring sound levels at a location behind the wall (shielded) and comparing them to sound levels measured in front of the wall (unshielded).

Two tests were run. For Test 1, the sound source (construction equipment) was 40’ south of the sound wall and Sound Meter M2 was 40’ north of the wall (total of 80’ from the source). Sound Meter M3 was placed 80’ south of the source (see M3a on Figure 1). The sound levels were
measured at each location and directly compared to determine the effectiveness of the wall. Test 1 ran for approximately 8 minutes.

For Test 2, the sound source was moved 30' south so that it was now 70' from the wall and 110' from Sound Meter M2. Sound Meter M3 was moved 30' south (see M3b on Figure 1). Ideally it would be moved 60' south to a point 110' from the source, but that point was too close to 46th Street and I was concerned that traffic noise would interfere too much. Instead, sound levels were measured 80' from the source with Meter M3 and the equivalent sound level at 110' was calculated to account for difference in distance. The calculation shows that sound levels at M3 should be reduced by 2.8 dBA to determine the equivalent level at 110'. Therefore, the measured sound levels for Meter M3 (unshielded) were reduced by 2.8 dBA and then compared to the sound levels measured by Meter M2 (shielded by wall). Test 2 ran for about 5 minutes.

**Sound Test Equipment**

The following equipment was used.

**Meter M2 (Shielded measurements north of wall)**
Larson Davis Model 831 sound level meter S/N 0001119, Type 1 per ANSI S1.4
PCB preamp PRM831, S/N 026106
PCB 1/2" microphone Model 377B02, S/N 138652

**Meter M3 (Unshielded measurements south of wall)**
Larson Davis Model 831 sound level meter S/N 0004081, Type 1 per ANSI S1.4
PCB preamp PRM831, S/N 036934
PCB 1/2" microphone Model 377B02, S/N 153301

Larson Davis CA200 acoustic calibrator, S/N 11780

Each sound meter was placed on a tripod so that it was 5' above the ground with a windscreen on the microphone.

The calibration of each sound meter was checked in the field before and after the series of measurements with the Larson Davis CAL200 acoustic calibrator. Laboratory calibration certificates for the equipment are available upon request.

The temperature was approximately 86°F with Relative Humidity of 35 to 40% during the testing. There was a slight wind of 0 to 2 mph from the NNE during the tests.

Please note that M2 and M3 are Wave Engineering's designations for these sound meters. Meter M1 was not used in this testing.

The construction equipment and sound meter locations are shown in Figure 1.
The aerial image in Figure 1 is from Google Maps and still shows the red roof of the Colonial Manor Motel. The motel has been demolished and was no longer there at the time of testing.

Construction is also being done on the Swansea Elementary School parking lot and Elizabeth Street has been demolished west of our test site (east of the school). We appreciate the cooperation of the school construction crew as they ceased operation of their heavy equipment during our sound testing.
Measurement Results

The sound levels measured by Meter M2 and M3 are plotted in Figure 2 below. These are a series of one-minute duration measurements and the L10 for each minute are plotted. The difference between the Shield and Unshielded sound levels is also plotted. The difference is the noise reduction provided by sound wall. Again, the data for M3 in Test 2 was adjusted because Meter M2 was 110' from the source and M3 was 80' from the source.

Figure 2: Sound Wall Test Data
Conclusions

Figure 2 shows that the average noise reduction provided by the wall in Test 1 was 16.6 dBA. Test 2 shows 15.8 dBA of noise reduction. Less reduction was expected for Test 2 since the source was further from the sound wall.

The performance of the wall will vary according to source and receiver height, distance from the wall, and other factors in the field. However, I believe that this test shows that the wall reduces noise by about 16 dBA in conditions that were comparable to much of the construction that will take place near the homes on the north side of I-70.

Please let me know if you have any questions or want to discuss this further.

Sincerely,

Jeff Kwolkoski
Jeff Kwolkoski, P.E., INCE Bd. Cert.
President