**Noise Study Technical Report**

# I-90/La Crosse Street Interchange

**Rapid City, South Dakota**

**HDR Project Number: 183454**

**March 2015**

# I-90/La Crosse Street Interchange

# NOISE STUDY TECHNICAL REPORT

## EXECUTIVE SUMMARY

The South Dakota Department of Transportation (SDDOT) initiated this study in order to address the current and future transportation needs noted in the South Dakota Decennial Interstate Corridor Study. The project would reconstruct the existing Interstate 90 (I-90) Exit 59 (La Crosse Street) interchange in Rapid City (the Project).

On behalf of SDDOT, and as part of the environmental documentation, HDR Engineering, Inc. (HDR), performed a traffic noise analysis on the proposed improvements. The analysis included traffic noise monitoring and modeling. HDR used the FHWA Traffic Noise Model (TNM), Version 2.5, to evaluate projected traffic noise levels under both the “Build” and “Existing” alternatives. Traffic noise impacts were identified in accordance with SDDOT Noise Analysis and Abatement Guidance (July 13, 2011). Noise levels were evaluated for the existing conditions and future Build Alternatives 1, 2, and 3 at 29 receptors in the Project area. No impacts were predicted as a result of the build alternatives.

Noise impacts are not predicted to occur as a result of the proposed project; therefore noise abatement measures will not be evaluated.

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# 1.Introduction

The South Dakota Department of Transportation (SDDOT) initiated this study in order to address the current and future transportation needs noted in the South Dakota Decennial Interstate Corridor Study. The project would reconstruct the existing Interstate 90 (I-90) Exit 59 (La Crosse Street) interchange in Rapid City (the Project). Figure 1 shows the project area.

The project needs include capacity issues at signalized ramp terminal intersections, which creates delay for the traveling public. Also noted is the need for additional turn lane storage lengths at the ramp terminal intersections to accommodate queues from exceeding the existing turn lane storage lengths. The purpose of the action is to increase safety for the traveling public, pedestrians and bicyclists. It will also improve traffic flow for current and future traffic levels along the proposed Project path.

HDR Engineering, Inc. (HDR), performed a highway traffic noise analysis for SDDOT in support of the Project, as part of the environmental documentation. The analysis is based on the SDDOT Noise Analysis and Abatement Guidance (July 13, 2011). Where projected traffic noise levels approach or exceed the SDDOT Noise Abatement Criteria (NAC), noise mitigation was evaluated. Results of the analysis are presented in this report.

# 2.Nature of Noise

Noise is defined as unwanted or excessive sound. Sound becomes unwanted when it interferes with normal activities, such as sleep, work, speech, or recreation. Vehicle noise is a combination of the noise produced by the engine, exhaust, and tires. Noise levels from highway traffic are affected by three factors: (1) the volume of the traffic, (2) the speed of the traffic, and (3) the number of trucks in the flow of traffic. Generally, traffic noise increases commensurate with these three factors.

Noise is measured in decibels (dB) – a logarithmic scale. Because human hearing is not equally sensitive to all frequencies of sound, certain frequencies are given more “weight.” The A-weighted scale corresponds to the sensitivity range for human hearing. Therefore, noise levels are measured in dBA, the A-weighted sound level in decibels. When noise levels change 3-dBA, the change is considered barely perceptible to human hearing. However, a 5-dBA change in noise level is clearly noticeable. A 10-dBA change in noise levels is perceived as a doubling or halving of noise loudness, while a 20-dBA change is considered a dramatic change in loudness. Table 1 shows noise levels associated with common, everyday sources and helps the reader more fully understand the magnitude of noise levels discussed in this report.

**Figure 1: Project Location**

# Noise

**Interstate I-90/La Crosse Interchange**
**Rapid City, South Dakota**

**Table 1: Common Noise Sources and Levels**

| Sound Pressure Level (dB) | Typical Sources |
|---|---|
| 120 | Jet aircraft takeoff at 100 feet |
| 110 | Same aircraft at 400 feet |
| 90 | Motorcycle at 400 feet |
| 80 | Garbage disposal |
| 70 | City street corner |
| 60 | Conversational speech |
| 50 | Typical office |
| 40 | Living room (without TV) |
| 30 | Quiet bedroom at night |

*Source: Environmental Impact Assessment Handbook, ed. by Rau and Wooten, 1980*

# 3. SDDOT Noise Analysis and Abatement Guidance

The updated (July 13, 2011) SDDOT Noise Analysis and Abatement Guidance (Guidance), upon which this analysis is based, is intended to supplement FHWA traffic noise and abatement regulations and guidance. The Guidance provides procedures for noise studies and noise abatement measures to help protect the public health and welfare, to supply noise abatement criteria, and to establish requirements for traffic noise information to be given to those officials who have planning and zoning authority.

The Guidance contains noise abatement criteria that are based on the Leq(h), which is used to analyze traffic noise levels and identify noise impacts. The Leq is defined as the equivalent, steady-state sound level that, in a stated period of time, contains the same acoustic energy as the time-varying sound level during the same period. Therefore, for the purposes of this analysis, Leq can be considered the average sound level and Leq(h) can be considered the average sound level occurring over a one-hour time period. It is representative of the overall (average) traffic-generated noise level expressed on an hourly basis.

Land uses are assigned to an activity category based on the type of activities occurring in each area (i.e. picnic areas, churches, commercial land, and undeveloped land). Activity Categories are then ordered based on their sensitivity to traffic noise levels. NAC are assigned to each Activity Category. These NAC represent the maximum traffic noise levels that allow uninterrupted land use within each Activity Category. Table 2 summarizes noise abatement criteria corresponding to various land use activity categories. Activity categories and related traffic noise impacts are determined based on the actual land use in a given area.

**Table 2: Noise Abatement Criteria**

| 23 CFR 772 Noise Abatement Criteria [Hourly A-Weighted Sound Level, decibels (dBA)] | | | |
|---|---|---|---|
| **Activity Category** | **Leq(h)** | **Evaluation Location** | **Activity Description** |
| A | 57 | Exterior | Lands on which serenity and quiet are of extraordinary significance and serve as an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose. |
| B | 67 | Exterior | Residential |
| C | 67 | Exterior | Active sports areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public<br>meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools<br>television studios, trails and trail crossings |
| D | 52 | Interior | Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recordings studios, schools, and television studios. |
| E | 72 | Exterior | Hotels, motels, office, restaurant/bars, and other developed lands, properties or activities not included in A-D or F. |
| F | -- | -- | Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical) and warehousing |
| G | -- | -- | Undeveloped lands that are not permitted |

Highway traffic noise impacts occur when the predicted traffic noise levels for the design year approach (reach 1 decibel less than) or exceed the NAC contained in 23 CFR 772 (Table 2), or when the predicted traffic noise levels substantially exceed the existing noise levels by 15 dBA, even though the predicted levels may not exceed the NAC.

# 4.Noise Prediction Method

Existing and future “Build” traffic noise levels were determined by using the FHWA Traffic Noise Model (TNM), Version 2.5. Basic model inputs are:

- Existing and Preliminary project concept and geometry
- 2012 and 2035 traffic volumes for I-90/La Crosse Street in the Project Area (Table 3)
- The operational speed for I-90: 65 miles per hour (mph); La Crosse Street: 35 mph

The traffic volume used for this analysis is the PM Peak Hourly Volume (PHV) traffic. Traffic was provided in an October 2013 HDR report. Traffic volumes for the future “Build” condition were assumed to be the same as the future “No-Build” volumes because there will be an interchange at this location under any scenario.

**Table 3: Traffic Volumes**

| Roadway Section | Existing Peak Hour Speed (mph) | Existing Peak Hour PM | Build Peak Hour Speed (mph) | Build Peak Hour PM |
|---|---|---|---|---|
| EB I-90 (west of off-ramp) | 65 | 1635 | 65 | 2280 |
| EB I-90 (between ramps) | 65 | 995 | 65 | 1530 |
| EB I-90 (east of on-ramp) | 65 | 1310 | 65 | 1940 |
| WB I-90 (east of off-ramp) | 65 | 1470 | 65 | 2300 |
| WB I-90 (between ramps) | 65 | 1120 | 65 | 1880 |
| WB I-90 (west of on-ramp) | 65 | 1700 | 65 | 2650 |
| NB La Crosse Street (south of on-ramp) | 35 | 1025 | 35 | 1500 |
| NB La Crosse Street (between ramps) | 35 | 1050 | 35 | 1540 |
| NB La Crosse Street (north of on-ramp) | 35 | 790 | 35 | 1210 |
| SB La Crosse Street (north of on-ramp) | 35 | 660 | 35 | 1150 |
| SB La Crosse Street (between ramps) | 35 | 690 | 35 | 1130 |
| SB La Crosse Street (south of off-ramp) | 35 | 990 | 35 | 1430 |
| EB I-90 off-ramp (to La Crosse Street) | 45 | 640 | 45 | 750 |
| EB I-90 on-ramp (from La Crosse Street) | 45 | 315 | 45 | 410 |
| WB I-90 off-ramp (to La Crosse Street) | 45 | 350 | 45 | 420 |
| WB I-90 on-ramp (from La Crosse Street) | 45 | 580 | 45 | 770 |

Table 4 presents the vehicle classifications and vehicle mix used in these analyses.

**Table 4: Vehicle Classification**

| Vehicle | EB I-90 | WB I-90 | La Crosse Street |
|---|---|---|---|
| | Percent | | |
| Auto | 95% | 97% | 99% |
| Medium truck | 2.75% | 1.65% | 0.55% |
| Heavy truck | 2.25% | 1.35% | 0.45% |
| Bus | 0% | 0% | 0% |
| Motorcycle | 0% | 0% | 0% |

# 5.Adjacent Land Use

Twenty-nine (29) receptors were identified in the project area. Land use immediately adjacent to this Project is primarily commercial/retail. If no exterior areas of frequent human use are present at these locations, no further noise analysis is required. Residential areas (apartments/single family homes) are located mainly behind the commercial/retail receptors and were modeled to insure no impacts are occurring. Figure 1 (shown previously in this report) provides an aerial view of the project area.

# 6.Model Validation

Existing traffic noise levels were measured in the field and then compared against computer modeling results to verify the accuracy of the computer model. When modeled and measured levels are within + or – 3 dBA of one another, this indicates that the model is within the accepted level of accuracy.

## 6.1. Field Testing Procedure

On July 12, 2013, HDR staff measured traffic noise levels at representative sites along I-90 and La Crosse Street. Traffic noise measurements were conducted in accordance with the FHWA-PD-96-046 Measurement of Highway Related Noise (May 1996). The average meteorological conditions were reported as shown in Table 5 below.

**Table 5: Meteorological Conditions**

| | |
|---|---|
| **Temperature** | ≅ 80-89 °F |
| **Humidity** | ≅ 26-42% |
| **Wind** | < 12 mph |
| **Conditions** | Clear |
| **Barometric Pressure** | ≅ 29.85 inches |

## 6.2. Instrumentation

Traffic noise monitoring was conducted using a Larson Davis 824 Sound Level Meter (SLM). The meter was set at a height of approximately 5 feet for all measurements. The microphone was covered with a windscreen. Table 6 summarizes the instruments used to collect the data for this noise analysis report.

**Table 6: Noise Analysis Instrumentation Summary**

| Instrument | Make | Model | Serial Number |
|---|---|---|---|
| Sound Analyzer 1 | Larson Davis | 824 | 824A2636 |
| Calibrator | Larson Davis | CAL200 | 3722 |

## 6.3. Field Measurement Methods

The SLM was programmed to compute the Leq(h). The following procedures were used for noise monitoring:

- The durations of the Leq(h) measurements were three repetitions of 15 minutes.
- The SLM was calibrated before and after monitoring. No significant calibration drifts were detected.
- The microphone was mounted on a tripod 5 feet above the ground.
- The microphone was covered with a windscreen.

## 6.4. Field Measurement Locations

Table 7 describes the locations of each of the validation sites along I-90 and La Crosse Street.

**Table 7: Noise Validation Location Summary**

| Measurement Location | Description |
|---|---|
| A | ≈ 100 feet south of outside edge of I-90 nearest lane |
| B | ≈ 140 feet north of outside edge of I-90 nearest lane |
| C | ≈ 50 feet east of outside edge of La Crosse Street nearest lane |
| D | ≈ 100 feet south of outside edge of I-90 nearest lane |

Validation locations are shown in Figure 1, and are within 50 to 140 feet of the nearest I-90/La Crosse Street outside lane.

## 6.5. Model Validation Results

The measured and modeled noise levels for each of the monitoring sites selected along the project corridor are presented in Table 8. Each set of predicted and measured data was found to be within the acceptable + or – 3 dBA tolerance; therefore, the model is considered to be validated.

**Table 8: Model Validation Results**

| Measurement Location | Measurement | Leq(h)(dBA) | | |
|---|---|---|---|---|
| | | Measured | Modeled | Difference |
| A | A.1 | 75.8 | 72.8 | -3.0 |
| | A.2 | 74.6 | 72.7 | -1.9 |
| | A.3 | 74.7 | 72.6 | -2.1 |
| | *Average* | 75.0 | 72.7 | -2.3 |
| B | B.1 | 71.7 | 69.9 | -1.8 |
| | B.2 | 72.6 | 70.7 | -1.9 |
| | B.3 | 73.7 | 70.7 | -3.0 |
| | *Average* | 72.7 | 70.4 | -2.3 |
| C | C.1 | 67.1 | 65.3 | -1.8 |
| | C.2 | 67.4 | 65.0 | -2.4 |
| | C.3 | 68.0 | 65.0 | -3.0 |
| | *Average* | 67.5 | 65.1 | -2.4 |
| D | D.1 | 72.2 | 72.3 | +0.1 |
| | D.2 | 73.0 | 72.5 | -0.5 |
| | D.3 | 73.1 | 72.4 | -0.7 |
| | *Average* | 72.8 | 72.4 | -0.4 |

## 6.6. Traffic Noise Prediction

HDR used the FHWA TNM, Version 2.5, to evaluate future traffic noise levels at noise sensitive receptors within the limits of the Project. The predicted traffic noise levels reflect the elevation differences and the proposed roadway alignment in relation to the noise-sensitive sites. Table 9 lists the NAC, existing Leq(h), and the future (2035) predicted Leq(h) for both the “Existing” and “Build” alternatives.

**Table 9: Predicted Noise Levels at Receptors**

| Receptor ID | Land Use | NAC (dBA) | Hourly Leq(h) dBA | | | | | | Approaches or Exceeds Standards in 2035 Build | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2012 Existing | 2035 Build | | | Difference Between Existing/Build | | | | |
| | | | | Alt 1 | Alt 2 | Alt 3 | Alt 1 | Alt 2 | Alt 3 | Alt 1 | Alt 2 | Alt 3 |
| 1 | E | 72 | 63 | 64 | 65 | 65 | 1 | 2 | 2 | N | N | N |
| 2 | B | 67 | 58 | 59 | 59 | 59 | 1 | 1 | 1 | N | N | N |
| 3 | B | 67 | 57 | 59 | 59 | 59 | 2 | 2 | 2 | N | N | N |
| 4 | B | 67 | 58 | 60 | 60 | 60 | 2 | 2 | 2 | N | N | N |
| 5 | B | 67 | 59 | 61 | 61 | 61 | 2 | 2 | 2 | N | N | N |
| 6 | E | 72 | 64 | 66 | 66 | 66 | 2 | 2 | 2 | N | N | N |
| 7 | B | 67 | 59 | 60 | 60 | 61 | 1 | 1 | 2 | N | N | N |
| 8 | B | 67 | 60 | 61 | 61 | 62 | 1 | 1 | 2 | N | N | N |
| 9 | B | 67 | 60 | 61 | 61 | 61 | 1 | 1 | 1 | N | N | N |
| 10 | B | 67 | 59 | 61 | 61 | 61 | 2 | 2 | 2 | N | N | N |
| 11 | B | 67 | 59 | 61 | 60 | 61 | 2 | 1 | 2 | N | N | N |
| 12 | B | 67 | 59 | 61 | 60 | 61 | 2 | 1 | 2 | N | N | N |
| 13 | B | 67 | 58 | 59 | 58 | 59 | 1 | 0 | 1 | N | N | N |
| 14 | B | 67 | 58 | 58 | 58 | 59 | 0 | 0 | 1 | N | N | N |
| 15 | B | 67 | 57 | 58 | 57 | 58 | 1 | 0 | 1 | N | N | N |
| 16 | B | 67 | 57 | 58 | 58 | 58 | 1 | 1 | 1 | N | N | N |
| 17 | B | 67 | 57 | 57 | 57 | 58 | 0 | 0 | 1 | N | N | N |
| 18 | E | 72 | 61 | 62 | 62 | 62 | 1 | 1 | 1 | N | N | N |
| 19 | B | 67 | 50 | 51 | 51 | 51 | 1 | 1 | 1 | N | N | N |
| 20 | B | 67 | 49 | 51 | 51 | 51 | 2 | 2 | 2 | N | N | N |
| 21 | B | 67 | 49 | 51 | 51 | 51 | 2 | 2 | 2 | N | N | N |
| 22 | B | 67 | 49 | 51 | 51 | 51 | 2 | 2 | 2 | N | N | N |
| 23 | B | 67 | 49 | 51 | 51 | 51 | 2 | 2 | 2 | N | N | N |
| 24 | B | 67 | 49 | 51 | 51 | 51 | 2 | 2 | 2 | N | N | N |
| 25 | B | 67 | 49 | 51 | 51 | 51 | 2 | 2 | 2 | N | N | N |

| Receptor ID | Land Use | NAC (dBA) | Hourly Leq(h) dBA | | | | | | | | | Approaches or Exceeds Standards in 2035 Build | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2012 Existing | 2035 Build | | | Difference Between Existing/Build | | | | | | | |
| | | | | Alt 1 | Alt 2 | Alt 3 | Alt 1 | Alt 2 | Alt 3 | Alt 1 | Alt 2 | Alt 3 |
| 26 | B | 67 | 49 | 50 | 50 | 50 | 1 | 1 | 1 | N | N | N |
| 27 | B | 67 | 48 | 50 | 50 | 50 | 2 | 2 | 2 | N | N | N |
| 28 | B | 67 | 48 | 49 | 49 | 49 | 1 | 1 | 1 | N | N | N |
| 29 | C | 67 | 63 | 65 | 65 | 65 | 2 | 2 | 2 | N | N | N |

# 7.Noise Abatement Measures

Noise abatement measures are considered when predicted traffic noise levels approach or exceed the NAC, or when the predicted traffic noise levels substantially exceed existing noise levels. As shown in Table 10, there are no impacts predicted under the Existing Alternative, Future Build Alternative 1, Future Build Alternative 2, or Future Build Alternative 3.

**Table 10: Impact Summary**

| Alternative | Approach NAC | Exceed NAC | Substantially Exceed | Total Receptors Affected |
|---|---|---|---|---|
| Existing | 0 | 0 | 0 | 0 |
| Alternative 1 | 0 | 0 | 0 | 0 |
| Alternative 2 | 0 | 0 | 0 | 0 |
| Alternative 3 | 0 | 0 | 0 | 0 |

## 7.1. Impacts

### 7.1.1. Alternative 1

The difference between the existing 2012 and the predicted 2035 Build noise levels range from 0 to +2 dBA. Results of this analysis indicate that traffic noise impacts are not predicted to occur as a result of this alternative. The difference in noise levels can be accounted for by the increase in traffic between the existing and build alternatives.

### 7.1.2. Alternative 2

The difference between the existing 2012 and the predicted 2035 Build noise levels range from 0 to +2 dBA. Results of this analysis indicate that traffic noise impacts are not predicted to occur as a result of this alternative. The difference in noise levels can be accounted for by the increase in traffic between the existing and build alternatives.

### 7.1.3. Alternative 3

The difference between the existing 2012 and the predicted 2035 Build noise levels range from 1 to +2 dBA. Results of this analysis indicate that traffic noise impacts are not predicted to occur as a result of this alternative. The difference in noise levels can be accounted for by the increase in traffic between the existing and build alternatives.

## 7.2. Abatement Measures

In accordance with 23 CFR, Part 772, noise abatement measures must be evaluated for noise sensitive sites predicted to approach or exceed the FHWA NAC as a result of the Build Alternative, or which are predicted to experience a substantial (15 dB(A)) noise level increase over existing noise levels. Noise impacts are not predicted to occur as a result of the proposed project; therefore noise abatement measures will not be evaluated.

# 8. Construction Noise and Vibration

Construction of the Project would result in temporary noise and vibration increases within the Project area. The evaluation and control of construction noise and vibration must be considered along with traffic noise. This Project is bordered by commercial and scattered residential receptors for which impacts from construction noise and vibration are a concern.

The following are basic categories for mitigation measures for construction noise. Due to the interrelatedness of construction noise and vibration, some of these measures will also apply for vibration resulting from construction activities.

*Design Considerations:* Design considerations include measures in the plans and specifications to minimize or eliminate adverse impacts. The design for this Project includes reconstructing the La Crosse Street interchange on I-90. The proposed changes and their proximity to noise sensitive receptors were considered during design.

*Community Awareness*: It is important for people to be made aware of the possible inconvenience construction can cause, and to know its approximate duration so they can plan their activities accordingly. It is SDDOT's policy to submit such Project information to all local news media.

*Source Control:* Source control involves reducing noise impacts from construction by controlling the noise emissions at their source. This can be accomplished by specifying proper muffler systems, either as a requirement in the plans and specifications on this Project or through an established local noise ordinance requiring mufflers. Contractors generally maintain proper muffler systems on their equipment to ensure efficient operation and to minimize noise for the benefit of their own personnel as well as the adjacent receptors.

*Site Control*: Site control involves the specification of certain areas where extra precautions should be taken to minimize construction noise. One way to reduce construction noise impacts at sensitive receptors is to operate stationary equipment, such as air compressors or generators, as far away from the sensitive receptors as possible. Another method might be placing a temporary noise barrier in front of the equipment. As a general rule, good coordination between the project engineer, the contractor and the affected receptors is less confusing, less likely to increase the cost of the project ,and provides a more personal approach to work out ways to minimize construction noise impacts in the more noise-sensitive areas. No specific construction-noise, site-control specifications will be included in the plans.

*Time and Activity Constraints*: Limiting working hours on a construction site can be very beneficial during the hours of sleep or on Sundays and holidays. However, most construction activities do not occur at night and usually not on Sundays. Exceptions due to weather, schedule, and time-related phases of construction could occur. No specific constraints will be incorporated in the plans of this improvement. Enforcement of such constraints could be handled through a general city or county ordinance, either listing the exceptions or granting them on a case-by-case basis.

# 9.Conclusion

Noise levels were evaluated for the existing conditions and future Build Alternatives 1, 2, and 3 at 29 receptors in the Project area. No impacts were predicted as a result of the build alternatives.

Noise impacts are not predicted to occur as a result of the proposed project; therefore noise abatement measures will not be evaluated.

# 10. References

South Dakota Department of Transportation, “Noise Analysis and Abatement Guidance,” July 13, 2011.

Federal Highway Administration (FHWA), “Procedures for Abatement of Highway Traffic Noise and Construction Noise,” July 13, 2011.

Methods for evaluation and control of construction noise were taken from the FHWA Special Report – “Highway Construction Noise: Measurement, Prediction and Mitigation.”