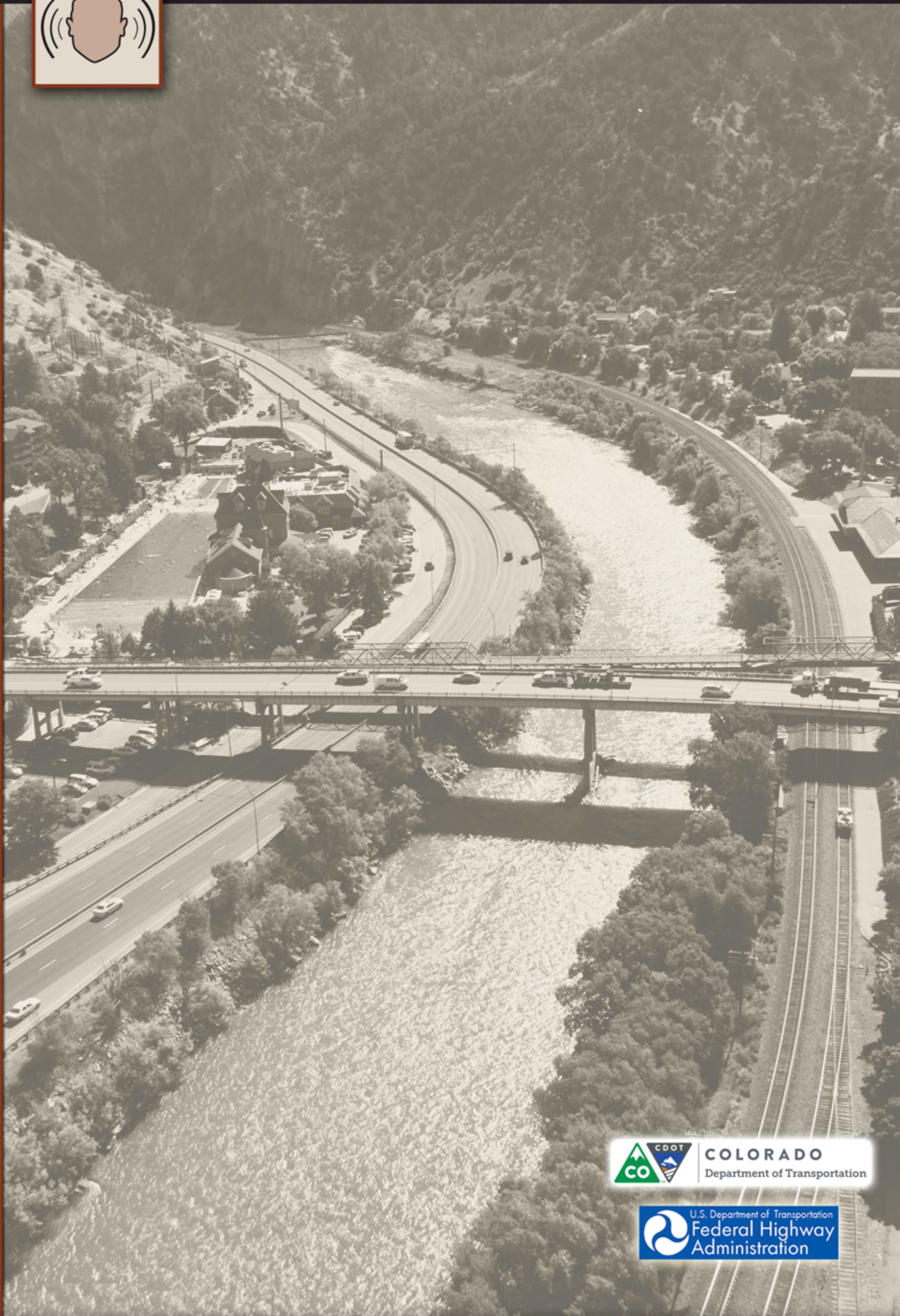
SH 82

GRAND AVENUE BRIDGE

Noise Technical Report



COLORADO Department of Transportation

U.S. Department of Transportation Federal Highway Administration

October 2014

SH 82 GRAND AVENUE BRIDGE

Noise Technical Report

for the

SH 82 Grand Avenue Bridge Environmental Assessment

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Prepared for:

Colorado Department of Transportation
Federal Highway Administration

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1.0 Introduction

The Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA) are conducting an Environmental Assessment (EA) process to address functional, structural, and safety deficiencies of the State Highway (SH) 82 Grand Avenue Bridge in Glenwood Springs, CO and to bring it up to current standards for a four-lane bridge. This bridge serves as a vital link of SH 82 across the Colorado River, Interstate 70 (I-70), and the Union Pacific Railroad, connecting downtown Glenwood Springs and the Roaring Fork Valley with the historic Hot Springs District.

2.0 Study Area

The study area is located in downtown Glenwood Springs, the Roaring Fork Valley, and the historic Hot Springs District, as depicted in Figure 1. The project corridors include 6th Street, Laurel Street, I-70 ramps, North River Street, and SH 82 from 6th Street to 8th Street.

3.0 Alternatives

3.1 No Action Alternative

The No Action Alternative assumes completion of those reasonably foreseeable projects that are already in progress, are programmed by CDOT or the City, or included in the fiscally constrained 2035 Intermountain Regional Transportation Plan (RTP). Currently, there are no such projects in the study area.

3.2 Build Alternative

The Build Alternative would consist of the elements described below and depicted in Figure 2. For greater detail on the Build Alternative, please refer to the *SH 82 Grand Avenue Environmental Assessment* (Jacobs, 2014).

3.2.1 Alignment

The existing four-lane SH 82/Grand Avenue highway bridge would be replaced with a new four-lane bridge on a modified alignment. The new bridge would start just north of the intersection of 8th Street and Grand Avenue, and continue on the existing SH 82/Grand Avenue alignment to 7th Street. At 7th Street, the alignment would begin a curve to the west as it crosses the Union Pacific Railroad (UPRR) and the Colorado River. It would touch down on the north side of the river on the west side of the Glenwood Hot Springs parking lot and southeast of the existing 6th and Laurel intersection. From the touchdown point, the alignment would curve southwest to the existing Exit 116 and access to I-70, and would connect to a new 6th and Laurel intersection just northeast of Exit 116 for local access.

3.2.2 Cross-sections

The new bridge would include four travel lanes with a striped median. Lanes would be widened to 11 to 12 feet to improve safety and mobility, and the southbound left turn lane to 8th Street would be lengthened. The majority of the bridge would be 12 feet wide, tapering to 11 feet wide between 7th and 8th Streets into downtown. No sidewalk would be included.

3.2.3 Intersections

6th and Laurel Intersection. A new five-leg roundabout at the 6th and Laurel intersection would help distribute traffic between I-70/ SH 82 and hotels west along W. 6th Street, the Hotel Colorado and Glenwood Hot Springs along 6th Street, and local businesses and residences along Laurel Street. The fifth leg would be one-way southbound lane to the Exit 116 interchange using the existing SH 82 alignment. Figure 2 shows the roundabout configuration.

8th and Grand Avenue Intersection. A traffic signal would provide for all movements at the 8th and Grand Avenue intersection.

Figure 1. Study Area Map

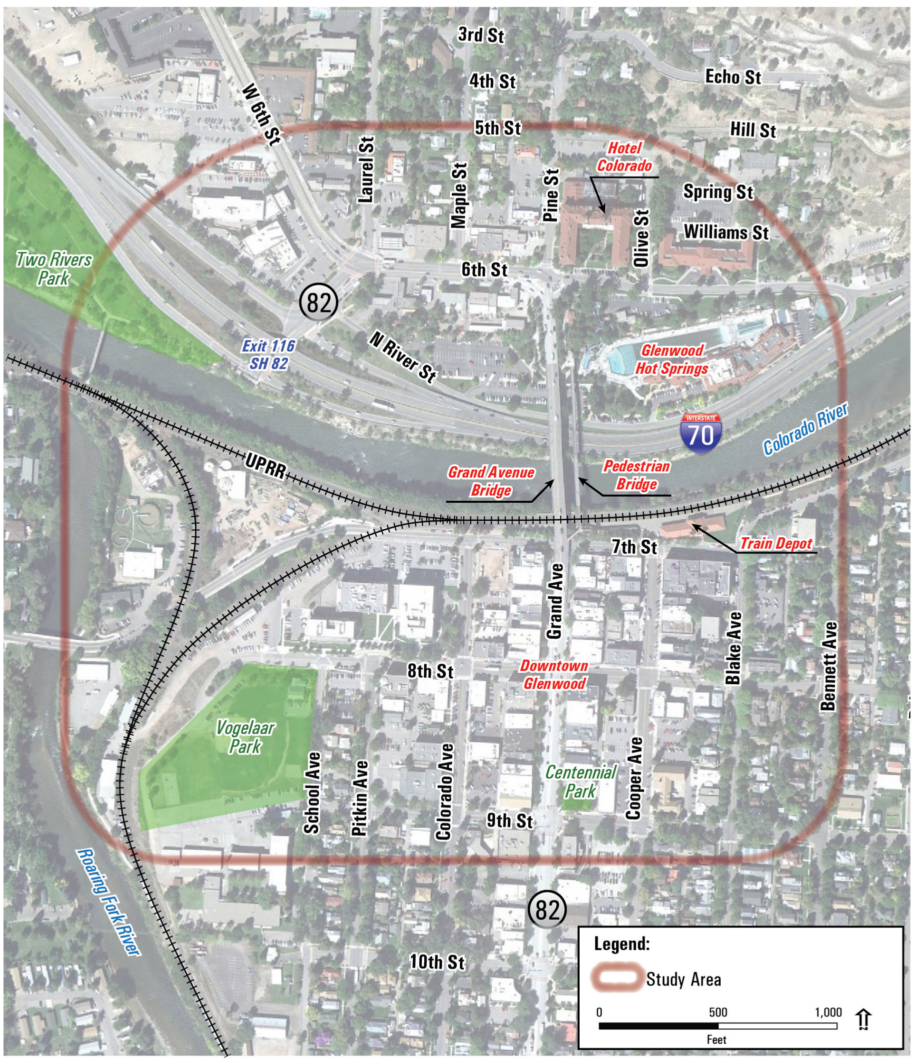
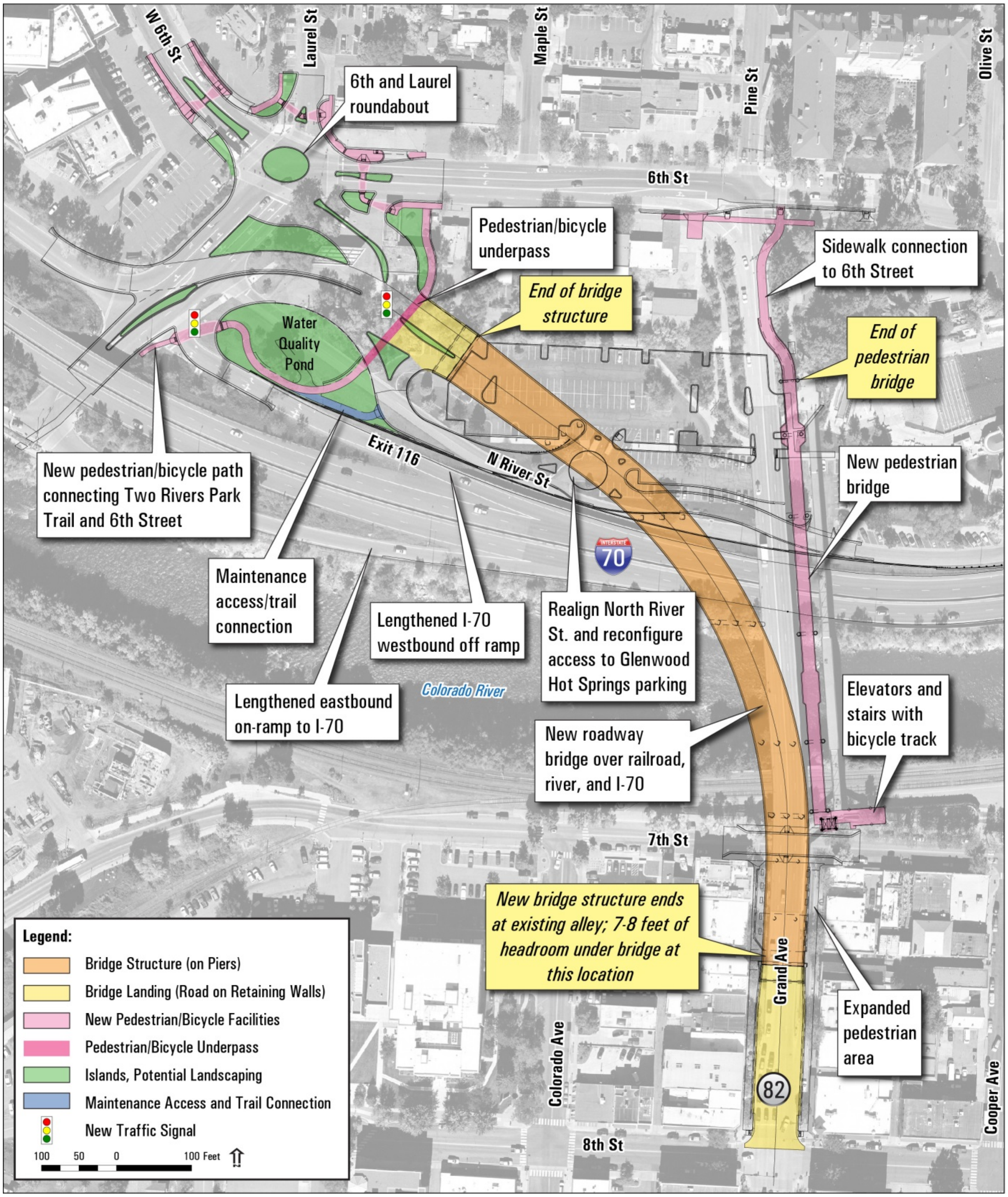


Figure 2. Build Alternative



3.2.4 Pedestrian/Bicycle Facilities

New Pedestrian Bridge. The Build Alternative would replace the existing pedestrian bridge immediately east of the highway bridge. The following facilities would be built in conjunction with this bridge and other elements of the Build Alternative described above.

- Connection to 7th Street. A wider staircase with a bicycle track would take pedestrians to and from the south end of the new pedestrian bridge to 7th Street and downtown Glenwood Springs. In addition, to meet ADA requirements, the Build Alternative would include two elevators.
- Expanded Pedestrian Plaza Under Bridge near 7th Street. The bridge design would allow for an expanded open area under the new Grand Avenue Bridge south of 7th Street.
- Connection to 6th Street. The north end of the new pedestrian bridge would land at approximately where the existing SH 82 bridge lands; a sidewalk connection would continue north to the intersection of 6th Street and Pine Street; and the existing stairway would provide a direct connection to the Glenwood Hot Springs.

6th and Laurel Intersection. New sidewalks and crossings would be installed.

Pedestrian/bicycle path connecting the existing Two Rivers Park Trail and 6th Street. This new grade-separated path would start at the existing Two Rivers Park Trail just north of the I-70 underpass at Exit 116, cross the improved westbound I-70 off ramp, and continue north using an underpass/tunnel of the new SH 82/Grand Avenue Bridge alignment just west of the new bridge.

A new maintenance access and trail connection would link the new trail north of the I-70 off-ramp to the on-road bicycle route on North River Street. This trail would be open to the public.

3.2.5 Additional Roadway Improvements

The Build Alternative would make improvements to existing facilities that would stay in place for the long term.

North River Street. The west end of North River Street would be raised to match the new SH 82 elevation and realigned slightly to avoid the new piers. The intersection with SH 82/Grand Avenue would be moved to the east and become a right-in/right-out intersection.

A small roundabout would be built on North River Street at the entrance to the Glenwood Hot Springs parking lot. This roundabout would enable motorists heading west on North River Street to make a U-turn to access 6th Street, which would be required to access I-70. This would be particularly beneficial for larger vehicles, such as recreational vehicles. It would also provide good traffic control at the Glenwood Hot

Springs parking lot entrance. Drivers continuing west past this roundabout would turn right at SH 82 and go south over the Grand Avenue Bridge.

Exit 116 On and Off Ramps. Improvements to the I-70 on and off ramps at Exit 116 would be made after the existing Grand Avenue Bridge piers adjacent to them are removed. The Intermountain Transportation Planning Region has identified funding for these improvements in its list of improvements for the Statewide Transportation Improvement Program. They are planned to be constructed concurrently with the bridge project for cost and construction efficiency.

4.0 Noise Basics

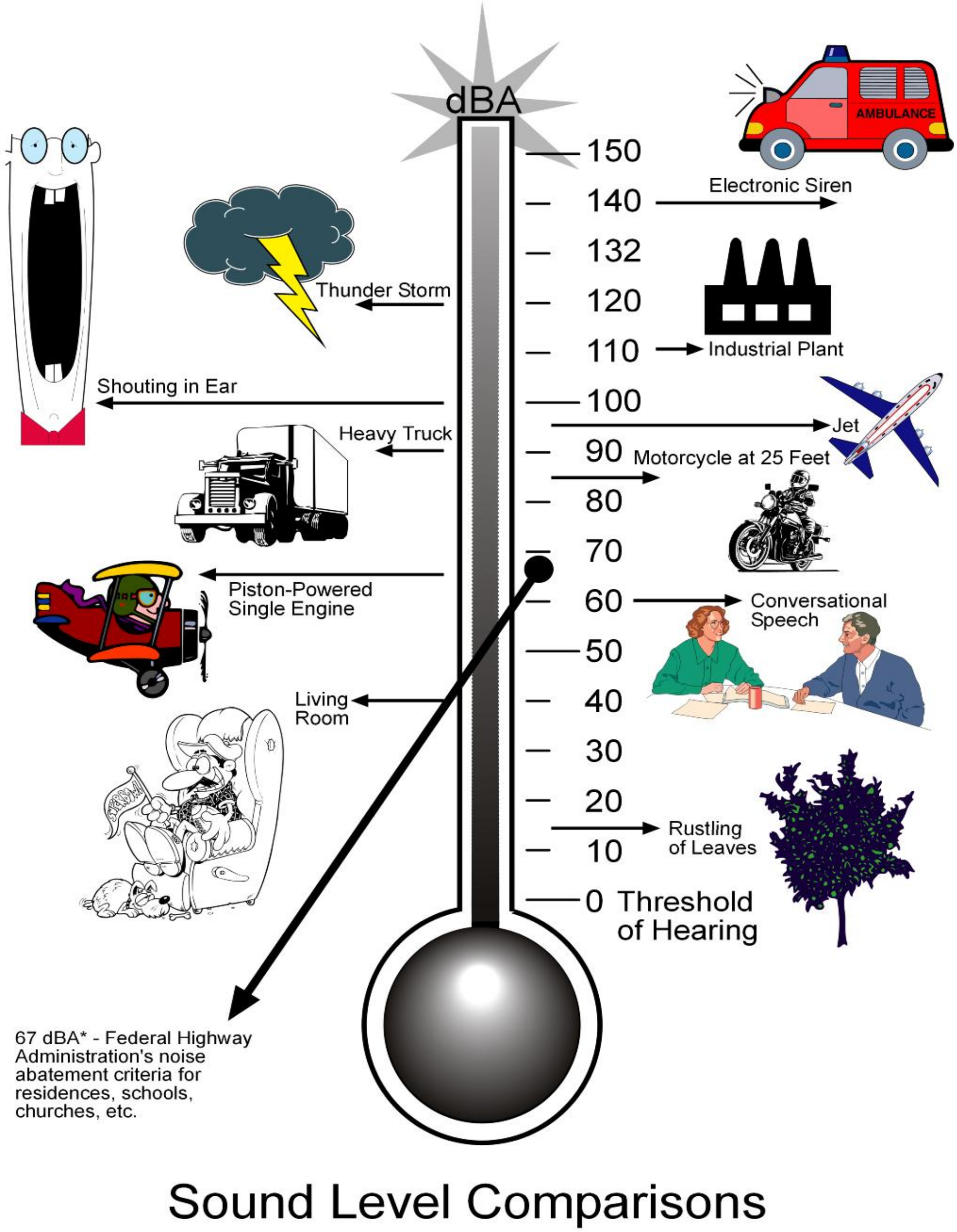
Noise is generally referred to as unwanted sound. Sound is defined as a form of energy transmitted by vibrations through the air that are received by the ear through sense of hearing. The terms noise and sound are used synonymously.

Noise consists of three inter-related elements: the source, the transmission path, and the receptor. In order for there to be noise, all three elements must be present. Without a source to produce sound, there is no noise. Likewise, there is no noise if the sound is not received. Noise may be continuous or intermittent and of high frequency or low frequency. Traffic noise is typically measured over a one-hour time period which is defined as the level equivalent (Leq(h)).

Sound is described as the average sound pressure levels (SPL). The most common unit of measurement is decibel, (dB). To approximate the response of the human ear, sound levels of individual frequency bands are weighted, depending on the human sensitivity to those frequencies. The A-weighting network approximates the frequency response of the average young ear when listening to most ordinary sounds. For the purposes of environmental studies, the A-weighted scale on a common sound level instrument is used since this scale closely approximates the range of frequencies an average human ear can detect. The A-weighted noise levels are defined as dB(A). Figure 3 shows common A-weighted noise levels (dB[A]).

In typical noisy environments, changes in noise of 1 dB to 2 dB are generally not perceptible. However, it is widely accepted that people are able to begin to detect sound level increases of 3 dB in typically noisy environments. Further, a 5 dB increase is generally perceived as a distinctly noticeable increase, and a 10 dB increase is generally perceived as a doubling of loudness. Therefore, a doubling of sound energy (e.g., doubling the volume of traffic on a highway) that would result in a 3 dB increase in sound would generally be perceived as barely detectable.

Figure 3. Examples of Common Noise and dB(A) Levels



* The Federal Highway Administration's noise abatement criteria are listed as dBA. dBA is a time weighted value for noise. dB represents an individual noise event. dBA for a noise source is generally less than dB.

Source: FHWA.

5.0 Noise Standards and Fundamentals

There are three primary sources that assist in the determination of noise impacts and when it is applicable to provide mitigation for impacted receptors:

- Federal Highway Administration, Procedures for Abatement of Highway Traffic Noise and Construction Noise (23 CFR Part 772).
- Federal Highway Administration, *Highway Traffic Noise Analysis and Abatement, Policy and Guidance,* December 2010.
- Colorado Department of Transportation, *Noise Analysis and Abatement Guidelines*, February 2013.

This project would construct a roadway on a new location that is considered an activity of a Type I project, and therefore a noise analysis is required (CDOT, 2013).

The FHWA Noise Abatement Criteria (NAC) defines noise levels for land activity categories. CDOT has adopted these NAC and defines noise levels that if approached (1 dB(A) less than the FHWA NAC) or exceeded, require noise abatement consideration. Table 1 summarizes the various land activity categories with the corresponding noise abatement criteria. FHWA guidelines also state that noise abatement should be considered when the noise levels substantially exceed the existing noise levels (23 CFR 772.11(f)). CDOT defines this criterion as increases in the L_{eq} of 10 dB(A) or more above existing noise levels.

Table 1. CDOT Noise Abatement Criteria, Hourly A-Weighted Sound Level Decibels

Land Activity Category	Activity Leq(h)*	Evaluation Location	Description of Activities
A	56	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve 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[1]	66	Exterior	Residential
C[1]	66	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	51	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E[1]	71	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A – D or F.

Table 1. CDOT Noise Abatement Criteria, Hourly A-Weighted Sound Level Decibels

Land Activity Category	Activity Leq(h)*	Evaluation Location	Description of Activities
F	NA	NA	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	NA	NA	Undeveloped lands that are not permitted for development.

Source: Colorado Department of Transportation, *Noise Analysis and Abatement Guidelines*, February 2013.

[1] – Includes undeveloped lands permitted for this activity category.

* - Hourly A-weighted sound level in dB(A), reflecting a 1-dB(A) approach value below 23CFR772 values.
N/A = Not applicable.

The following is a brief summary of key terminology:

- **Decibel**—A decibel is a unit of measure for sound. Decibels are presented with the units dB(A).
- **dB(A)**—dB(A) represents the noise levels in decibels measured with an A-weighted frequency. The A-weighting corresponds to the A-scale on a standard sound level instrument that closely approximates frequencies that the human ear can detect.
- **Leq(h)**—Leq(h) is defined as the equivalent sound level for a one-hour time period. For normal human hearing, the actual sound level measurement is modified by applying A-weighting. The A-weighted sound level is the most widely used measure of environmental noise.

6.0 Methodology

The methodology for analyzing traffic noise impacts for this project is consistent with CDOT guidelines. FHWAs approved Traffic Noise Model (TNM 2.5) was used for this analysis. The basic inputs to noise modeling include roadway network layout, site characteristics, traffic volume projections, fleet mix, and vehicular operating speeds. Roadway and receptor geometry were included based on a civil design CAD file and aerial photography. The files used for this analysis were based on a modified State Plane system; and x, y, and z coordinates were input into the TNM 2.5. All input and output files for TNM 2.5 are included in Appendix A.

7.0 Traffic Data

Based on the *Highway Capacity Manual* (Transportation Research Board, 2000), CDOT has estimated the highest traffic volumes per lane at various speed limits along different types of roadways that were found to produce the loudest noise conditions. In accordance with the CDOT noise policy, the projected traffic volumes for the project are to be used if they are less than the estimated traffic volumes in the CDOT noise policy. Traffic volumes from existing and the future design year 2035 for this project were used in this study's TNM 2.5 since these volumes are lower than the estimated volumes presented in CDOTs noise policy (CDOT, 2012). Traffic data is provided in Appendix B.

The vehicle mix assumed was 96 percent automobiles 2.4 percent medium trucks, and 1.6 percent heavy trucks along SH 82 and 6th Street. For the other local roadways such as 7th Street, 8th Street, Colorado Avenue, Copper Avenue, and North River Street, a vehicle mix of 99 percent automobiles and 1 percent trucks (0.5 medium and 0.5 heavy) was assumed. Traffic volumes for I-70 were obtained from CDOTs website, and are provided in Appendix B. The vehicle mix assumed was 85.4 percent automobiles and 14.6 percent trucks east of the Grand Avenue Bridge and 90.8 percent automobiles and 9.2 percent trucks west of the Grand Avenue Bridge. The existing posted speed limit is 25 miles per hour (mph) on all roadways within the study area except for I-70.The existing posted speed limit along I-70 is 50 mph east of the SH 82 Grand Avenue Bridge and 65 mph west of the SH 82 Grand Avenue Bridge. The existing posted speed limits were assumed for all conditions. The future posted speed limit on the new alignment will also be 25 mph. Table 2 summarizes the existing and future traffic volumes for the project.

Table 2. Existing and Future PM Peak Hour Traffic Volumes

Roadway/Intersection	Existing (Total Vehicles per Hour)	No Action (Total Vehicles per Hour)	Build (Total Vehicles per Hour)
6th Street & Laurel Street	2,113	3470	N/A
Proposed Roundabout at 6th & Laurel	N/A	N/A	1,710
6th Street & SH 82	2,205	3,600	N/A
SH 82 & 8th Street	2,238	3,680	3,680
SH 82 & 9th Street	2,246	3,720	3,720
Laurel Street and I-70 on ramp	225	740	370
Laurel Street/I-70 on ramp/proposed SH 82	N/A	N/A	2,470
Laurel Street & I-70 off ramp	1,352	2,350	N/A
Laurel Street/I-70 off ramp/proposed SH 82	N/A	N/A	2,470
Proposed SH 82/W. 6th Street/North River Street	N/A	N/A	5,430
I-70 east of SH 82	1,950	3,097	3,097
I-70 west of SH 82	2,420	3,672	3,672

Sources: Tsiouvaras Simmons Holderness, CDOT.
N/A = not available.

8.0 Noise Analysis

8.1 Noise-Sensitive Receptors

Noise-sensitive receptors are those areas where frequent outdoor human use would occur that may be impacted by existing and/or future transportation conditions. CDOT noise policy requires a noise analysis to include all receptors within a study area that are likely to be impacted by noise, typically defined within 500 feet from the proposed project's extent of work or areas likely to experience NAC levels of noise.

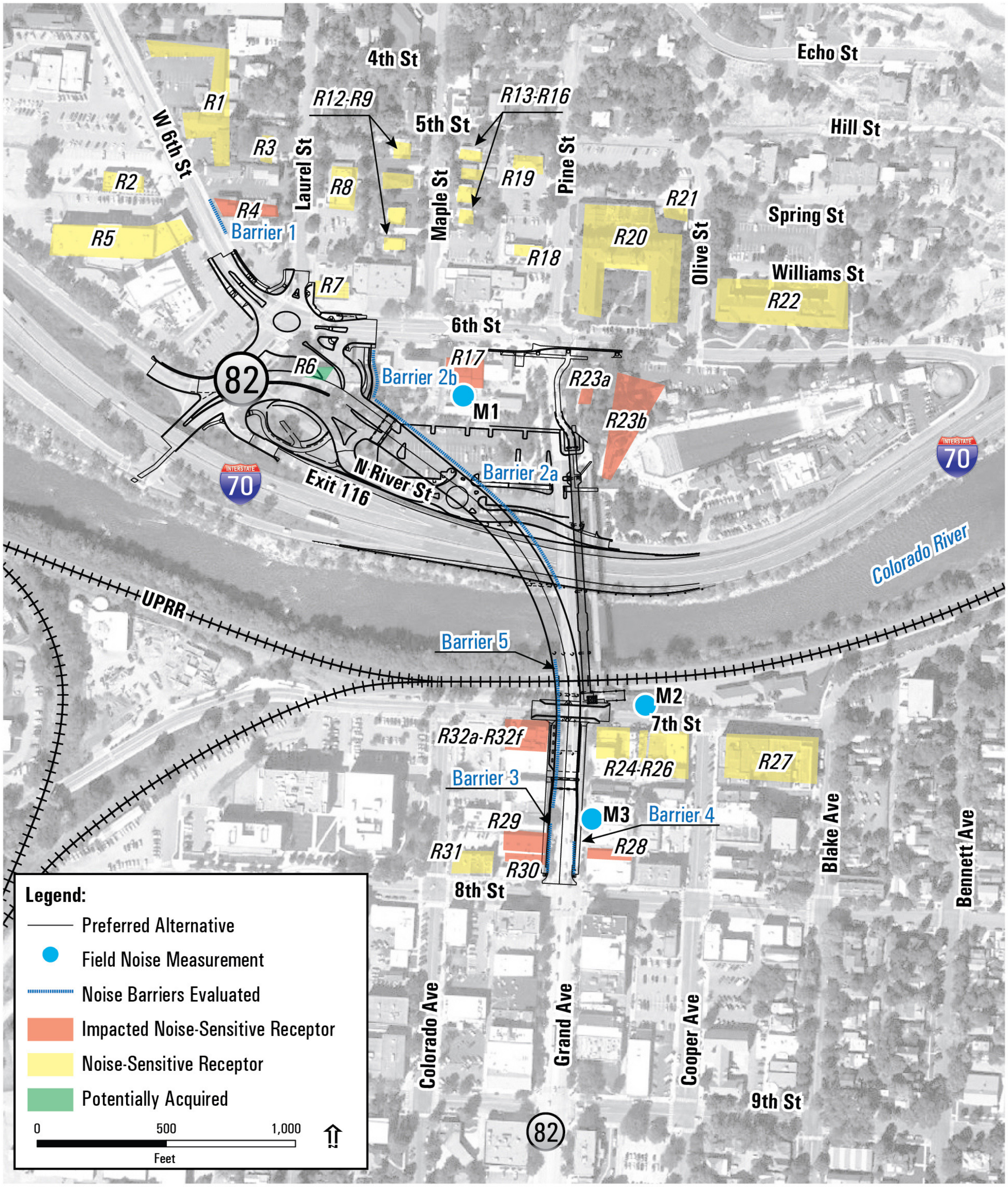
The noise-sensitive receptors within the study area listed below include hotels, recreation areas, residences, restaurants, service stations, and businesses. Figure 4 shows the locations of the noise-sensitive receptors. They fall into the land activity categories described in Table 1—Activity Category B (residential) and Activity Categories C, D, and E. There is one site listed as historic on the National Register of Historic Places (NRHP) and three sites that are eligible for listing on the NRHP.

- Glenwood Motor Inn (R1)
- Tequila's Mexican Restaurant (R2)
- Single Family Resident (R3)
- Starlight Lodge (R4)
- Ramada Inn and Suites (R5)
- Glenwood Shell Station (R6)
- Kum & Go Station (R7)
- Qdoba Restaurant (R8)
- Single Family Residences (R9 – R17)
- KFC Restaurant (R18)
- Fiesta Guadalajara (R19)
- Hotel Colorado – historic (listed) (R20)
- Single Family Resident (R21)
- Glenwood Springs Hot Springs Hotel (R22) – historic (eligible)
- Glenwood Springs Hot Springs Recreation Area – historic (eligible) R23)
- Peppo Nino Courtyard Restaurant (R24)
- Juicy Lucy Steakhouse (roof top seating) (R25)
- The Pullman Restaurant (R26)
- Hotel Denver (R27)
- Bluebird Cafe (R28)
- Sacred Grounds Bakery (R29)
- Daily Bread Bakery – historic (eligible) (R30)
- Noonan Building/HP Restaurant (R31)
- Single Family Residences (R32a – 32f)

Category D activities (indoor noise levels) were not considered since exterior outdoor uses were identified at these receptors. Category F activities, such as retail facilities, were identified within the study area. However, these facilities are not sensitive to noise and, therefore, not included in the noise analysis.

There are several historic structures and sites identified within the study area, including businesses and the Union Pacific Railroad. However, only three sites (Hotel Colorado [R20], Glenwood Hot Springs [R23], and Sacred Grounds Bakery [R29]) are considered to have noise-sensitive activities (courtyard, outdoor eating areas, and recreational uses such as mini-golf and pool). There are several noise-sensitive activities on the Glenwood Hot Springs site. However, only the closest outdoor activities were modeled and assessed for the noise analysis. The railroad corridor does not have frequent human outdoor use and, therefore, was not considered a noise-sensitive site and was not included in the noise analysis.

Figure 4. Noise-Sensitive Receptors



Source: Jacobs, 2014.

Noise Measurements and Model Validation

In March and May 2013, three noise measurements were taken within the study area to determine ambient noise levels. Weather conditions were clear with 0-5 mph winds. Temperatures ranged from approximately 60 to 65 degrees Fahrenheit throughout the day. Meters were calibrated and placed five feet above ground surface as this is the average height of the human ear. Noise readings were collected for 10 minutes for each measurement. Traffic counts, by vehicle type, were collected simultaneously with the noise measurements. Operating speeds and existing geometry were also collected. Traffic counts and operating speed data were input into the FHWA approved TNM 2.5 software for validation analysis. Table 3 summarizes the field recorded and TNM 2.5 predicted noise levels. Figure 4 depicts the locations of the field measurements. The difference between the field recordings and the model predicted noise levels was less than 3 A-weighted decibels (dB[A]), which is considered validated. Therefore, the model was considered an accurate representation of the existing conditions.

Table 3. Field Recorded and TNM 2.5 Predicted Noise Levels

Meter No.	Location	Field Recorded Noise Levels L(eq)	TNM Predicted Noise Levels L(eq)	Difference L(eq)
M1	Single Family Resident	58.1	59.9	1.8
M2	Recreation area near pedestrian bridge	60.7	62.6	1.9
M3	Businesses along Grand Avenue wing street (between 7th and 8th Street on the east side of Grand Avenue) and Grand Avenue	71.0	70.3	-0.7

8.2 Prediction of Existing and Future Noise Levels

Noise models were developed for all noise-sensitive receptors within the study area likely to be impacted, as well as receptors within 500 feet of the proposed project roadway improvements. The noise-sensitive receptors in the study area are identified in Section 8.1.

Noise receptors were grouped according to their activity category and location. All receptors were modeled at the standard five feet above ground surface as this is the average height of the human ear, except at two locations (R17 and R25). Outdoor uses at R17 (2nd story residences) are located on the 2nd floor (approximately 15 feet above ground surface). Outdoor uses at R25 (restaurant roof top seating) are also located on the 2nd floor (approximately 15 feet above ground surface). The purpose of the models is to show whether traffic noise levels satisfy defined noise abatement criteria and subsequently whether traffic noise mitigation should be considered.

Under existing conditions, twelve noise-sensitive receptors (R6, R17, R23a and b, R28, R30, and R32a – 32f) are impacted by traffic noise. Table 4 summarizes the modeled noise levels for existing, no action, and build conditions. Bold numbers indicate traffic noise levels that approach or exceed the NAC. A discussion of future impacts is found in Section 8.4.

Table 4. Modeled Noise Levels

Receptor #	# of Receptors by Activity	NAC	Existing (dB[A])	No Action Alternative (dB[A])	Build Alternative (dB[A])	Difference Between Future and Existing Noise Level (+ or -) (dB[A])	Build Impact*
R1	1 - H	71	65.0	67.0	67.9	+2.9	No
R2	1 - R	71	63.1	65.0	66.0	+2.9	No
R3	1 - SFR	66	60.6	62.5	63.3	+2.7	No
R4	1 - H	71	66.4	68.4	**70.8**	+4.4	**Yes**
R5	1 - H	71	65.6	67.5	68.8	+3.2	No
R6	1 - Station	71	**70.7**	**72.7**	N/A	N/A	No
R7	1 - Station	71	69.7	**71.8**	69.7	0	No
R8	1 - R	71	62.0	64.0	64.0	+2	No
R9	8 - SFR	66	61.1	63.1	62.1	+1	No
R17 (2nd story)	1 - SFR	66	**67.8**	**69.7**	**70.0**	+2.2	**Yes**
R18	2 - R	71	64.6	66.7	64.6	0	No
R20 - historic (listed)	1 - H	71	65.0	67.1	63.0	-2	No
R21	1 - SFR	66	58.6	60.5	60.0	+1.4	No
R22 - historic (eligible)	1 - H	71	60.2	62.1	61.1	+0.9	No
R23a – historic (eligible)	1 - RA	66	**68.3**	**70.4**	**66.2**	-2.1	**Yes**
R23b– historic (eligible)	1 - RA	66	**67.4**	**69.3**	**68.9**	+1.5	**Yes**
R24	1 - R	71	65.2	67.1	66.9	+1.7	No
R25 (2nd story)	1 - R	71	66.5	68.3	68.1	+1.6	No
R26	1 - R	71	66.2	67.3	67.3	+1.1	No
R27	1 - H	71	64.2	65.6	65.7	+1.5	No
R28	1 - R	71	**71.6**	**73.8**	**73.9**	+2.3	**Yes**
R29– historic (eligible)	1 - R	71	70.2	**72.3**	**72.8**	+2.6	**Yes**
R30	1 - R	71	**71.7**	**73.9**	**74.2**	+2.5	**Yes**
R31	1 - R	71	67.1	68.8	68.9	+1.8	No
R32a – R32f	6 – SFR	66	**69.2**	**71.2**	**71.6**	+2.4	**Yes**

Source: Jacobs, 2013.
*This column only includes noise impacts that would occur as a result of the Build Alternative and that would require assessment of noise abatement.
H = Hotel
R = Restaurant
SFR = Single Family Residence
Station = Service Station
RA = Recreational Area
N/A = acquisition; therefore, not applicable

8.3 Impact Assessment

Traffic noise models were developed for No Action and Build conditions. The purpose of the models is to show whether traffic noise levels satisfy defined noise abatement criteria and subsequently whether traffic noise mitigation should be considered.

8.3.1 No Action Alternative

There would be no improvements under the No Action Alternative. However, as shown in Table 4, fourteen receptors (R6, R7, R17, R23a and b, R28, R29, R30, and R32a – R32f) would meet or exceed the NAC under the No Action Alternative. These receptors are located near the new SH 82 alignment where it connects to 6th Street and near the intersections of SH 82 and 8th Street and SH 82 and 9th Street.

Although noise impacts would occur under the No Action Alternative, noise abatement was not considered because no improvements are proposed.

8.3.2 Build Alternative

Thirteen noise-sensitive receptors (R4, R17, R23a and b, R28, R29, R30, and R32a – R32f) would meet or exceed the NAC as a result of the Build Alternative. All of these receptors are already impacted under existing (except R4 and R29) and No Action (except R4) Alternative conditions. No sensitive receptors would experience a substantial noise increase over existing conditions (10 dB[A] or more). These six impacts are a result of traffic increases along Grand Avenue and realignment of the Grand Avenue Bridge as a result of the Build Alternative. Therefore, noise abatement was considered for all impacted receptors.

8.4 Noise Abatement Measures and Analysis

Impacted areas were evaluated for abatement according to CDOT *Noise Analyses and Abatement Guidelines* (CDOT, 2013). Noise Abatement Determination worksheets (Form 1209) are required to be completed for all impacted noise-sensitive receptors within the study area and are included in Appendix C. Abatement mitigation is addressed for feasibility and reasonableness for each receptor location. Noise abatement is considered feasible if a reduction (insertion loss) of at least 5 dB(A) can be achieved by a noise barrier and the mitigation does not cause unsafe roadway conditions. If feasibility conditions are met, CDOT considers three factors to determine how reasonable noise abatement would be for the evaluated locations. Section 8.6 provides further discussion of the feasible and reasonable criteria and the results of the mitigation analysis.

Four noise abatement measures were considered for this project:

- Alteration of the vertical or horizontal roadway alignment.
- Noise buffers by acquisition of undeveloped land.
- Traffic management.
- Noise barriers.

Results of the noise abatement evaluation are presented below:

- **Alteration of the vertical or horizontal roadway alignment.** Businesses and residences would lose direct access by alteration of the vertical roadway alignment. Further alteration of the horizontal alignment would result in additional right-of-way, business, and noise impacts.

- **Buffer zones**. The study area is in an urban setting with little undeveloped land. Further, the existing noise-sensitive receptors are currently adjacent to the project corridors. Therefore, acquiring undeveloped land for buffer zones would not be feasible since they would have to be placed in between the roadway and the noise-sensitive receptor in order to achieve a substantial traffic noise reduction.

- **Traffic management.** SH 82 is classified as a regional highway. The percentage of heavy trucks that use this roadway is minimal (approximately 4 percent). Therefore, since heavy truck traffic is minimal, it would not be feasible to restrict heavy trucks along SH 82. This is the primary transportation corridor in the region and, therefore, alternate routing of truck traffic is not feasible. In addition, truck traffic is already restricted along Midland Avenue, the other main route south to the Roaring Fork Valley. The other project corridors (7th Street, 8th Street, 9th Street, Colorado Avenue, and Cooper Avenue) are classified as arterial roadways with low percentages of heavy trucks (approximately one percent). These roads are not suited for heavy traffic volumes. Further, signalized intersections along SH 82 already work to reduce the traffic speeds, and the posted speed limit is 25 mph. Therefore, traffic management would not be a reasonable abatement measure.

- **Noise barriers.** Noise barriers are the most common form of traffic noise abatement since they usually provide a greater insertion loss (traffic noise reduction) and are generally more feasible to engineer compared to other measures. Therefore, traffic noise barriers were considered for all impacted receptors in the study area. Only concrete traffic noise barriers were considered for this analysis.

8.5 Mitigation Analysis

According to CDOT guidelines, all locations that are projected to experience noise impacts must consider the "feasibility and reasonableness" of mitigation. The analysis of acoustical feasibility of mitigation considers such factors as the effectiveness of a barrier to achieve at least a 5 dB(A) noise reduction in predicted future noise levels. The analysis of engineering feasibility considers construction, engineering, maintenance, and other design issues. The barrier cannot create a safety or unacceptable maintenance problem or engineering fatal flaw, such as reduction of line-of-sight, accessibility deficiencies, icing, or other notable roadway maintenance concerns.

Noise mitigation is considered reasonable if it meets these three required criteria: the noise reduction design goal, the cost per receptor per decibel of noise reduction, and the benefited receptor's desires. Mitigation measures are considered reasonable if they can achieve a minimum 7 dB(A) noise reduction for at least one receptor. If any receptor receives a 5 dB(A) or more noise reduction from a noise abatement measure, it is considered a benefited receptor (impacted or not).

The cost per benefited receptor per decibel of reduction threshold is $6,800. The cost of materials is based on $45 per exposed square foot for a noise barrier.

The desires of the benefited receptors are considered in the evaluation of reasonableness of a noise barrier. The decision to build or not build noise abatement results from a simple majority of received responses from the benefited receptors. CDOT takes into account opinions of both the property owner and the resident of the property. Therefore, in some cases, there may be two votes per benefited property. Feasible and reasonable noise abatement measures will be presented during the public involvement process. Benefited receptors will have the opportunity to vote on the abatement measure at that time. The results of the survey will be documented and attached to the CDOT Form 1209 for that noise abatement measure.

The Noise Abatement Determination worksheets (CDOT Form 1209 in Appendix C), summarize the mitigation recommendations and identify additional decision criteria used to evaluate the feasibility and reasonableness of the noise barriers.

The mitigation analysis identified five areas within the study area where noise barriers may meet these criteria for the impacted receptors.

8.5.1 Starlight Lodge (Barrier 1)

A noise barrier was considered for the Starlight Lodge (receptor R4). The noise abatement measure was modeled within the CDOT right-of-way (adjacent to the roadway shoulder). Figure 4 shows the location of modeled noise barrier.

Barrier 1 was modeled at heights up to 12 feet tall for the impacted receptor east of 6th Avenue and north of the proposed 6th Avenue/Grand Avenue roundabout. Table 5 summarizes the noise levels with and without mitigation, as well as the noise reduction provided by the mitigation measure.

Table 5. Noise Mitigation Analysis for Starlight Lodge East of 6th Avenue

Benefited Receptor	2035 Predicted Noise Level Without Mitigation (dB[A])	2035 Predicted Noise Level w/ 12 Foot Tall Barrier (dB[A])	Noise Reduction (Decibel)
R4	**70.9**	63.8	-7.1

Table 6. Noise Barrier Cost Analysis for Starlight Lodge East of 6th Avenue

Barrier	Total Length of Barrier (feet)	Height of Barrier (Feet)	Total Cost of Barrier*	Total Decibel Reduction (dB[A])	# of Benefited Receptors	Cost/ Receptor/ dB[A]
1	96	12	$51,840	7.1	1	$7,301

*The cost of materials is based on $45/square foot.

As shown in Table 5, the modeled noise barrier would meet the 5 dB(A) feasible noise reduction criteria and the reasonable noise reduction criteria of at least 7 dB(A) for at least one receptor. However, as shown in Table 6, the cost per benefited receptor would exceed CDOT's cost reasonable criteria threshold of $6,800. Therefore, a noise barrier would not be reasonable for the noise receptor in this area.

8.5.2 Individual Residences and Glenwood Hot Springs Recreation Area (Barriers 2a and 2b)

Noise barriers were considered for the individual second story residences and Glenwood Hot Springs recreation area. The noise abatement measure was modeled within the CDOT right-of-way (adjacent to the roadway shoulder). Figure 4 shows the location of modeled noise barriers.

Barriers 2a and 2b were modeled at heights up to 20 feet tall for the impacted receptors adjacent to the new Grand Avenue Bridge alignment. Table 7 summarizes the noise levels with and without mitigation, as well as the noise reduction provided by the mitigation measure. Table 8 summarizes the noise barrier cost analysis.

Table 7. Noise Mitigation Analysis for Individual Resident and Glenwood Hot Springs Recreation Area Adjacent to New Grand Avenue Bridge Alignment

Benefited Receptor	2035 Predicted Noise Level Without Mitigation (dB[A])	2035 Predicted Noise Level w/ 20 Foot Tall Barrier (dB[A])	Noise Reduction (Decibel)
R17	**70.0**	**68.3**	-1.7
R23	**66.2**	**65.7**	-0.5

Table 8. Noise Barrier Cost Analysis for Individual Resident and Glenwood Hot Springs Recreation Area Adjacent to new Grand Avenue Bridge Alignment

Barrier	Total Length of Barrier (feet)	Height of Barrier (Feet)	Total Cost of Barrier*	Total Decibel Reduction (dB[A])	# of Benefited Receptors	Cost/ Receptor/ dB(A)
2a	401	20	$360,900	0	0	$360,900
2b	111	20	$99,900	0	0	$99,900
Total	**660**	**20**	**$4590,900**	**0**	**0**	**$459,900**

*The cost of materials is based on $45/square foot.

As shown in Table 7, none of the modeled noise barriers would meet the 5 dB(A) feasible noise reduction criteria or the reasonable noise reduction criteria of at least 7 dB(A) for at least one receptor. In addition, as shown in Table 8, the cost per benefited receptor would exceed CDOT's cost reasonable criteria threshold of $6,800. Therefore, noise barriers would not be feasible or reasonable for the noise receptors in this area.

8.5.3 Restaurants (Barrier 3)

A noise barrier was considered for the restaurants west of Grand Avenue and north of 8th Street. The noise abatement measure was modeled within the CDOT right-of-way (adjacent to the roadway shoulder). Figure 4 shows the location of modeled noise barrier.

Barrier 3 was modeled at heights up to 20 feet tall for the impacted receptors west of Grand Avenue and north of 8th Street. Table 9 summarizes the noise levels with and without mitigation, as well as the noise reduction provided by the mitigation measure. Table 10 summarizes the noise barrier cost analysis.

Table 9. Noise Mitigation Analysis for the Restaurants West of Grand Avenue and North of 8th Street

Benefited Receptor	2035 Predicted Noise Level Without Mitigation (dB[A])	2035 Predicted Noise Level w/ 20 Foot Tall Barrier (dB[A])	Noise Reduction (Decibel)
R29	**72.8**	**66.7**	-6.1
R30	**74.3**	**72.1**	-2.2

Table 10. Noise Barrier Cost Analysis for the Restaurants West of Grand Avenue and North of 8th Street

Barrier	Total Length of Barrier (feet)	Height of Barrier (Feet)	Total Cost of Barrier*	Total Decibel Reduction (dB[A])	# of Benefited Receptors	Cost/ Receptor/ dB[A]
3	92	20	$82,800	0	0	$82,800

*The cost of materials is based on $45/square foot.

As shown in Table 9, a 20-foot tall noise barrier would meet the 5 dB(A) feasible noise reduction criteria for one receptor, but not the reasonable noise reduction criteria of at least 7 dB(A) for at least one receptor. In addition, as shown in Table 10, the cost per benefited receptor would exceed CDOT's cost reasonable criteria threshold of $6,800. Therefore, a noise barrier would not be feasible or reasonable for the noise receptors in this area.

8.5.4 Bluebird Cafe (Barrier 4)

A noise barrier was considered for the Bluebird Cafe east of Grand Avenue and north of 8th Street. The noise abatement measure was modeled within the CDOT right-of-way (adjacent to the roadway shoulder). Figure 4 shows the location of modeled noise barrier.

Barrier 4 was modeled at heights up to 16 feet tall for the impacted receptor east of Grand Avenue and north of 8th Street. Table 11 summarizes the noise levels with and without mitigation, as well as the noise reduction provided by the mitigation measure. Table 12 summarizes the noise barrier cost analysis.

Table 11. Noise Mitigation Analysis for Bluebird Cafe East of Grand Avenue and North of 8th Street

Benefited Receptor	2035 Predicted Noise Level Without Mitigation (dB[A])	2035 Predicted Noise Level w/ 20 Foot Tall Barrier (dB[A])	Noise Reduction (Decibel)
R28	**73.9**	**66.8**	**-7.1**

Table 12. Noise Barrier Cost Analysis for Bluebird Cafe East of Grand Avenue and North of 8th Street

Barrier	Total Length of Barrier (feet)	Height of Barrier (Feet)	Total Cost of Barrier*	Total Decibel Reduction (dB[A])	# of Benefited Receptors	Cost/ Receptor/ dB[A]
4	111	16	$79,920	7.1	1	$11,256

*The cost of materials is based on $45/square foot.

As shown in Table 11, the modeled noise barrier would meet the 5 dB(A) feasible noise reduction criteria and the reasonable noise reduction criteria of at least 7 dB(A) for at least one receptor. However, as shown in Table 12, the cost per benefited receptor would exceed CDOT's cost reasonable criteria threshold of $6,800. Therefore, a noise barrier would not be reasonable for the noise receptor in this area.

8.5.5 Single Family Residences (Barrier 5)

A noise barrier was considered for the single family residences south of 7th Street and west of Grand Avenue. The noise abatement measures were modeled within the CDOT right-of-way (adjacent to the roadway shoulder). Figure 4 shows the location of modeled noise barriers.

Barrier 5 was modeled at heights up to 20 feet tall for the impacted receptors south of 7th Street and west of Grand Avenue. Table 13 summarizes the noise levels with and without mitigation, as well as the noise reduction provided by the mitigation measure. Table 14 summarizes the noise barrier cost analysis.

Table 13. Noise Mitigation Analysis for Single Family Residences South of 7th Street and West of Grand Avenue

Benefited Receptor	2035 Predicted Noise Level Without Mitigation (dB[A])	2035 Predicted Noise Level w/ 20 Foot Tall Barrier (dB[A])	Noise Reduction (Decibel)
R32a	**71.6**	**68.6**	-3.0
R32b	**70.6**	**68.9**	-1.7
R32c	**70.2**	**68.8**	-1.4
R32d	**69.4**	**68.3**	-1.1
R32e	**69.5**	**68.1**	-1.4
R32f	**69.8**	**68.1**	-1.7

Table 14. Noise Barrier Cost Analysis for Single Family Residences South of 7th Street and West of Grand Avenue

Barrier	Total Length of Barrier (feet)	Height of Barrier (Feet)	Total Cost of Barrier*	Total Decibel Reduction (dB[A])	# of Benefited Receptors	Cost/ Receptor/ dB[A]
5	243	20	$218,700	0	0	$218,700

*The cost of materials is based on $45/square foot.

As shown in Table 13, none of the modeled noise barriers would meet the 5 dB(A) feasible noise reduction criteria or the reasonable noise reduction criteria of at least 7 dB(A) for at least one receptor. In addition, as shown in Table 14, the cost per benefited receptor would exceed CDOT's cost reasonable criteria threshold of $6,800. Therefore, a noise barrier would not be feasible or reasonable for the noise receptors in this area.

9.0 Construction Noise

The study team developed a construction phasing approach to accommodate accelerated bridge construction (ABC) that would minimize the duration of detours and total closures of the Grand Avenue Bridge, SH 82, and I-70. The approach involves building most bridge elements outside the existing SH 82 route during much of the construction phase, thereby allowing SH 82 to remain open as long as possible.

The construction phasing plan calls for removing the existing Grand Avenue Bridge and installing the new bridge within an approximate 90-day period, during which the Grand Avenue Bridge would be fully closed to traffic. Based on current traffic volumes and concerns voiced by the public, full closure would be scheduled to occur during the Spring or Fall seasons, when traffic volumes and tourism are typically lower. In addition a pedestrian connection would be maintained for access across the Colorado River, I-70, and the railroad at all times.

Project construction would involve construction of a highway and a pedestrian bridge with piers, retaining walls, road pavement, storm sewers, curb and gutter, sidewalks, and paths; and installation of traffic signals and other overhead traffic control, wayfinding and traffic signs, and landscaping. Activities would include demolition, excavation, and grading.

Noise levels from demolition and construction activities would vary depending on the activity periods, location of activities, and the number and types of equipment used. Construction activities would generate noise from diesel-powered earth-moving equipment, such as dump trucks and bulldozers, back-up alarms on certain equipment, compressors, and pile drivers. Pile driving could be the loudest construction noise source, but is unlikely for the bridge piers. Construction noise at off-site receptor locations would be dependent on the loudest piece of equipment operating at the moment. According to the FHWA *Construction Noise Handbook* (FHWA, 2006), noise levels from diesel-powered equipment range from 80 to 95 dB(A) at a distance of 50 feet. Impact equipment, such as pile drivers, can generate louder noise levels in the range of

95 to 101 dB(A). Table 15 below summarizes pieces of construction equipment that would operate during each construction phase and the maximum noise levels at 50 feet.

Table 15. Construction Equipment Maximum Noise Levels at 50 Feet

Equipment	Acoustical Usage Factor (%)	Specified Lmax at 50 feet (DB[A])	Actual Measured Lmax at 50 feet (dB[A])	Construction Phase
Auger Drill Rig	20	85	84	All
Backhoe	40	80	78	All
Bar Bender	20	80	n/a	All
Boring Jack Power Unit	50	80	83	1 and 3
Chain Saw	20	85	84	1 and 3
Clam Shovel (dropping)	20	93	87	2
Compactor (ground)	20	80	83	All
Compressor (Air)	40	80	78	All
Concrete Mixer Truck	40	85	79	All
Concrete Pump Truck	20	82	81	All
Concrete Saw	20	90	90	All
Crane	16	85	81	All
Dozer	40	85	82	All
Drill Rig Truck	20	84	79	All
Drum Mixer	50	80	80	All
Dump Truck	40	84	76	All
Excavator	40	85	81	All
Flat Bed Truck	40	84	74	All
Front End Loader	40	80	79	All
Generator	50	82	81	All
Gradall	40	85	83	1 and 3
Grader	40	85	n/a	1 and 3
Horizontal Hydraulic Jack	25	80	82	All
Hydra Break Ram	10	90	n/a	All
Jackhammer	20	85	89	All

Table 15. Construction Equipment Maximum Noise Levels at 50 Feet

Equipment	Acoustical Usage Factor (%)	Specified Lmax at 50 feet (DB[A])	Actual Measured Lmax at 50 feet (dB[A])	Construction Phase
Man Lift	20	85	75	All
Mounted Impact Hammer (hoe ram)	20	90	90	All
Pavement Scarifier	20	85	90	1 and 3
Paver	50	85	77	1 and 3
Pickup Truck	40	55	75	All
Pneumatic Tools	50	85	85	All
Pumps	50	77	81	All
Rivit Buster/Chipping Gun	20	85	79	All
Roller	20	85	80	All
Sand Blasting (single nozzle)	20	85	96	All
Sheers (on backhoe)	40	85	96	All
Slurry Plant	100	78	78	All
Tractor	40	84	n/a	All
Vacuum Excavator (Vac-Truck)	40	85	85	All
Vacuum Street Sweeper	10	80	82	All
Ventilation Fan	100	85	79	1 and 3
Vibratory Concrete Mixer	20	80	80	All
Vibratory Pile Driver	20	95	101	All
Welder/Torch	40	73	74	All

*noise emission levels based on extensive measurements taken in conjunction with the Central Artery/Tunnel Project.
Source: FHWA, Construction Noise Handbook, 2006.

The noise levels presented in Table 15 represent maximum noise levels adjusted for time-usage factors and would not be continuous noise emissions. Construction equipment use would be intermittent throughout the course of a normal workday. Therefore, noise levels generated from construction equipment would not be cumulative.

Detour Routes

During construction, noise would be generated from the various types of vehicles traveling these roads. Construction traffic would consist of heavy duty trucks, light trucks, and the private vehicles of the construction workers throughout the duration of activities. In addition, local traffic would still travel these roads. Therefore, traffic noise would increase near the sensitive receptors along these detour routes. However, some of the traffic noise could be reduced by directing work trips to transit or bicycle/pedestrian and alternative work schedules. In addition, other trips for shopping, recreation, or other could be directed to non-peak times and days, such as weekends.

- ***SH 82 Detour.*** During the approximate 90-day full closure of the Grand Avenue Bridge between 8th Street south of the river and 6th Street north of the river, SH 82 traffic would be rerouted onto the designated SH 82 Detour. The temporary route for regional traffic would begin at Exit 114 on I-70 and proceed south on Midland Avenue to 8th Street across the Roaring Fork River then along a new 8th Street connection into downtown. In the downtown grid, the traffic would be routed through a temporary "square about" for continuation south on SH 82/Grand Avenue to Aspen. This detour route would extend 8th Street to the existing 8th Street bridge. This would require temporary removal of portions of four existing railroad tracks; two 12-foot lanes on 8th Street with curb and gutter on both sides; drainage and water quality infrastructure; grade modifications and retaining walls, as needed, on 7th Street, Defiance Avenue, and the park access road; modifications at 7th Street/8th Street to maintain bicycle access from the Rio Grande Trail along the river to downtown and sidewalk on 7th Street; and increased turn radius at the northeast corner of the 8th Street and Midland Avenue intersection to accommodate larger vehicles.

A traffic noise model was developed to determine potential temporary impacts from the SH 82 Detour route. Noise-sensitive receptors within the vicinity of the detour route include businesses, single family residences, places of worship, and recreational areas. Approximately 41 receptors (29 additional from existing model) were modeled. Noise levels during construction are predicted to range from 59 dB(A) to 75 dB(A). Since the City of Glenwood Springs Code has not established any noise level restrictions, the predicted noise levels were compared to the CDOT NAC. Approximately 11 receptors would exceed the NAC of 66 dB(A) and 71 dB(A) for Category B and C activity categories, respectively. In addition, approximately 21 receptors would experience an increase in at least 3 dB(A) or more, which is perceivable by the human ear. Appendix D details the existing and construction noise levels at receptor locations in the vicinity of the SH 82 Detour route. Since noise levels are anticipated to increase during construction, temporary mitigation measures are recommended below to mitigate temporary noise impacts during construction.

I-70 Closure Detour. Construction of the Grand Avenue Bridge and the pedestrian bridge would require full nighttime closures of I-70 approximately ten times for safety-critical overhead work, such as bridge demolition, construction of bridge components, and concrete installation. This would be planned to occur between the hours of 8:30 p.m. and 5:30 a.m., when current traffic volumes are generally between 50 and 150 vehicles per hour per direction on I-70, according to CDOT data. Detouring I-70 traffic to local streets is proposed to maintain emergency access to and from Glenwood Canyon and because a detour route along state highways would be very long.

A traffic noise model was not developed for the I-70 closure detour since this detour would be limited to overnight periods and only expected for approximately ten nights. Noise-sensitive receptors within the vicinity of the I-70 closure detour include hotels (e.g., Hotel Colorado and Glenwood Hot Springs), businesses, and a single-family residence. Potential temporary impacts would be greatest at the hotels due to noise sensitivity during the nighttime hours. However, coordination with the hotels would be conducted to minimize temporary noise impacts (see mitigation section below). Although residences are also sensitive to noise during nighttime hours, the outdoor use at this residence is located behind the building away from traffic on 6th Street, lessening the degree of any temporary noise impacts. Businesses are generally closed during nighttime hours and, therefore, are not anticipated to be affected by construction traffic noise.

Construction-related activities would adhere to the City of Glenwood Springs Code (Article 100.070, Regulation of Noise). Either a construction noise work permit or waiver to the ordinance would be obtained if construction activities occur outside of the hours allowed by the Code. The Code allows construction activities to commence between the hours of 7:00 a.m. – 8:00 p.m. Monday to Friday and 8:00 a.m. – 6:00 p.m. Saturday and Sunday. Section 9.1 lists temporary mitigation measures for construction-related noise impacts.

Upon construction completion, the access roads and railroad grade crossing would be removed and the areas returned to their pre-construction condition and appearance.

9.1 Temporary Mitigation Measures

During construction, CDOT will employ the following measures to aid in mitigating temporary noise impacts:

- Obtain a construction noise work permit or waiver for construction activities occurring outside of the hours allowed by the Code. Adhere to the City of Glenwood Springs Code (Article 100.070, Regulation of Noise). The Code allows construction activities to commence between the hours of 7:00 a.m. and 8:00 p.m. Monday to Friday, and 8:00 a.m. to 6:00 p.m. Saturday and Sunday.

- Offer hotel vouchers to downtown residents most impacted by construction activities during nighttime hours. These are anticipated to be R17 and R32a – R32f. Per Jill Schlaefer at CDOT EPB, CDOT typically uses 66 dBA as a threshold for nighttime noise levels during construction.

- Limit construction activities adjacent to noise-sensitive receptors when they are most sensitive, as practical and feasible.

- Use noise blankets or other muffling devices on equipment and quiet-use generators at noise-sensitive receptors, as needed.

- Use well-maintained equipment and have equipment inspected regularly.

- Locate stationary equipment and haul roads away from noise-sensitive receptors, as practical and feasible.
- Minimize pile driving through use of drill shafts. Limit pile driving activities, if needed, to daytime hours.
- Minimize back-up alarm noises on construction vehicles in construction areas where practical and feasible.
- Turn off idling equipment and vehicles when not in use.
- Use only equipment that, operating under full load, meets manufacturer specifications. If the equipment falls out of compliance, the contractor will take remedial action to comply with the specifications.
- For the I-70 closure detour, coordinate detour nights and times with local hotels (e.g., Hotel Colorado and Glenwood Hot Springs). This will help hoteliers to move patrons to rooms further from detour noise.

10.0 Recommendations

At this time, none of the modeled noise barriers would meet both the feasible and reasonable criteria. Therefore, noise barriers are not recommended at this time.

If future substantial changes are made to design elements of the project from what has been analyzed for this project, the noise analysis will need to be re-assessed in order to evaluate the impact of those changes.

Shielding would be constructed on the Grand Avenue Bridge to provide splash back protection to pedestrians and business patrons along Grand Avenue A preliminary noise analysis was conducted to determine if the shielding would provide a noise reduction benefit. The panels were modeled at different heights ranging from 3.5 feet to 10 feet tall. A minimum four-foot-tall panel would provide a minimum 3 dBA noise reduction along portions of the bridge. The human ear can detect sound changes of 3 dBA or more. Therefore, the shielding would provide a noticeable noise reduction to the pedestrian sidewalk users along portions of the bridge and will be implemented as part of the project.

11.0 References

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Appendix A:
Noise Model Inputs and Outputs

Appendix B:
Traffic Data

Appendix C:
Noise Abatement Worksheets

Appendix D:
Construction Noise Analysis Data