Noise Technical Report

I-70 / SH 58 Interchange Project

Jefferson County, Colorado

Project No.: NH0703-246

Draft Rev 2

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Prepared for:
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Prepared by:

Hankard Environmental, Inc.
Lafayette, Colorado

HANKARD ENVIRONMENTAL
ACOUSTICS AND VIBRATION CONSULTING

CH2M Hill
Englewood, Colorado

CH2MHILL

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1.0 Introduction

This report describes the results of a noise study conducted for the I-70 / SH 58 Interchange Project located in Jefferson County, Colorado (Project NH0703-246). Specifically, the project is located on I-70 between West 32nd Avenue and Kipling Street in Wheat Ridge, as shown in Figure 1 at the end of the report. The project is planned in three phases, which are shown in Figure 2. Phase 1 includes improvements to SH 58 and its connection to I-70 (except for eastbound SH 58 to eastbound I-70). Phase 2 includes the relocation of the eastbound ramps connecting to I-70. Phase 3 provides an improved connection from eastbound SH 58 to eastbound I-70, as well as changes to Youngfield (between 42nd and 44th Avenue). More specifically, the proposed project (all phases) consists of:

- Modification of the I-70/SH 58 interchange to provided full directional movements and to minimize its impact on traffic flow on I-70 from west of 38th Avenue to Tabor Street
- The modification to create full movements by adding an Eastbound SH58 to Westbound I-70 ramp and an Eastbound I-70 to Westbound SH 58 ramp
- Improvements to I-70 are limited to tie-ins at the above new ramps, plus relocated ramps at the Ward Road interchange

The purpose of the noise analysis was to determine if any of the existing residential or commercial receptors located within the project study area are considered impacted by noise per the Colorado Department of Transportation's (CDOT) noise guidelines, and if so, whether or not mitigation is feasible and reasonable to provide. Two separate analyses were conducted. One considering the implementation of Phases 1-2, and a second considering the implementation Phases 1, 2, and 3. This was done because there could be a significant amount of time between the implementation of Phases 1-2 and Phase 3.

This report is organized as follows. Section 2 describes the noise standards used to assess noise impacts and analyze mitigation on this project. Section 3 describes the methodology used to predict noise levels. Section 4 describes the predicted noise levels and the results of the noise impact assessment. Section 5 describes the results of the mitigation analysis. Construction noise is addressed in Section 6. Figures are provided at the end of the report. A discussion of relevant noise terminology is provided in Appendix A, and a completed CDOT Noise Abatement Determination form for this project is shown in Appendix B.

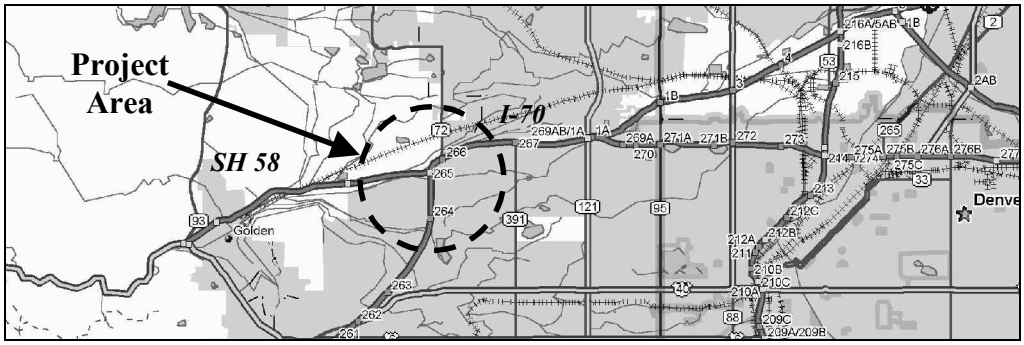

Figure 1: Project Location

2.0 Applicable Noise Standards

This project, as it involves state and federal funds, is subject to CDOT noise guidelines, which are set forth in the document entitled *CDOT Noise Analysis and Abatement Guidelines*, February 1, 1995. These guidelines establish noise abatement criteria, and design and cost requirements for noise mitigation. The guidelines state that noise mitigation must be considered for any receptor or group of receptors where predicted traffic noise levels, using future traffic volumes and roadway conditions, approach or exceed the Noise Abatement Criteria (NAC) shown in Table 1, below. Traffic noise is considered to "approach" a criterion at a level 1 dB(A) less than the criterion (e.g. 66 dB(A) for Category B receptors). The guidelines also state that noise mitigation must be considered for any receptors where predicted noise levels for future conditions are greater than existing noise levels by 10 dB(A) or more (Increase Criterion).

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CDOT guidelines also outline a method for determining the "feasibility and reasonableness" of proposed mitigation measures. Feasibility issues include:

- If a noise barrier is to be constructed, can it be constructed in a continuous manner (gaps in noise barriers, e.g. for driveways, significantly degrade their performance)?
- Can at least 5 dB(A) of noise reduction be achieved (minimum significant reduction)?
- Are there any "fatal flaw" maintenance or safety issues involved with the proposed mitigation measure?

Reasonableness issues include:

- Do existing and future noise levels exceed the aforementioned standards?
- What is the cost per affected receptor per decibel of noise reduction (must meet $3,500 limit)?
- What are the desires of area residents?
- What is the percentage of Category B development in the area?

TABLE 1
CDOT NOISE ABATEMENT CRITERIA (NAC)

Activity Category	L_{eq} (1) (2) (dB(A))	Description of Activity Category
A	57 (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	67 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries and hospitals.
C	72 (Exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	--	Undeveloped lands.
E	52 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums.

(1) Hourly A-weighted equivalent level for the noisiest hour of the day in the design year
(2) CDOT noise impact analysis uses the "approach criteria" which is 1 dB(A) less than shown in the table.

3.0 Noise Level Prediction Procedures

Noise levels were predicted using the STAMINA 2.0 highway noise level prediction software program developed by the Federal Highway Administration, which is approved for use on CDOT and Federal-aid projects. STAMINA calculates the hourly, A-weighted L_{eq} at a receptor location given the noise emission level of automobiles, medium, and heavy trucks, the volume and speed of each of these vehicle types on each roadway of interest, the relative location of all roadways, receptors, and terrain features (i.e. natural and man-made barriers), and the type of terrain between each receptor and each roadway. Sub-section 3.1 describes the STAMINA input data used to predict noise levels for both existing and design-year (2020) conditions on this project. Sub-section 3.2 describes the validation of the model, which was accomplished by comparing measured noise levels to predicted noise levels.

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3.1 STAMINA Input Data

The following paragraphs describe the STAMINA input data used to predict noise levels for both existing and design-year (2020) conditions on this project.

Vehicle Emission Levels

Vehicle emission levels refer to the noise level of vehicles measured at a reference distance and a reference speed. STAMINA requires separate emission levels for automobiles, medium trucks (trucks with two axles, six tires, and a gross vehicle weight greater than 4500 kg and less than 12,000 kg), and heavy trucks (trucks with three or more axles and a gross vehicle weight greater than 12,000 kg). The Colorado-specific Reference Energy Mean Emission Levels were used for all vehicle types in all of the predictions. These emission levels were developed by CDOT, and are published in the document entitled *Reference Energy Mean Emission Levels Used in STAMINA 2.0 for Highway Noise Prediction in the State of Colorado*, CDOT, February 1995.

Traffic Volumes

The traffic volumes used in the noise analysis were those developed for the project by CH2M Hill. Traffic flow is rated on a scale of 'A' through 'F', with 'A' being a free flowing condition and 'F' being congested. This noise analysis uses peak-hour traffic volumes that correspond to a Level-of-Service (LOS) of C, which is defined by the Highway Capacity Manual (1994) as "provides for flow with speeds still at or near the free-flow speed of the freeway". This level of service represents the loudest traffic condition, because there is a significant amount of traffic traveling at a relatively high speed. There may be more traffic volume under LOS D – F conditions, however speeds are lower, as are noise levels.

For the noise analysis it was determined that some traffic volumes on I-70 exceed those for LOS C conditions, which for a six-lane highway is defined as 1,450 vehicles per lane per hour (Highway Capacity Manual, 1994, Figure 3-2b). Thus, all traffic volumes used in the analysis were limited to 1,450 vehicles per lane per hour. Table 2 shows the existing (1999) peak-hour volume (P.M.) of automobiles, medium trucks, and heavy trucks used in the analysis. Table 3 shows the No Build (2020) peak-hour volumes (P.M.) used in the analysis. Tables 4 and 5 show the build (2020) peak-hour volumes (P.M.) used in the analysis for Phase 2 and Phase 3 conditions, respectively.

TABLE 2
PEAK-HOUR TRAFFIC VOLUMES AND SPEEDS – EXISTING CONDITIONS (1999)

Roadway	Automobiles	Medium Trucks	Heavy Trucks	Speeds (mph)
I-70 EB North of 58	4176	87	87	65
I-70 WB North of 58	4176	87	87	65
I-70 EB South of 58	4176	87	87	65
I-70 WB South of 58	4176	87	87	65
SH58 EB	960	20	20	65
SH58 WB	1056	22	22	65
44TH East of 1-70 ramps	1274	13	13	35
44TH Ward Road east to I-70 ramps	2597	27	27	35
44TH Ward to Youngfield	1960	20	20	35
44TH West to Youngfield	931	10	10	35
Ward South of WB I-70 Ramps	2695	28	28	30
Tabor St.	735	8	8	30
Youngfield South of 44th Ave.	1715	18	18	35
Youngfield South of 38th Ave.	1960	20	20	35
I-70 Service Road	490	5	5	30

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TABLE 3
PEAK-HOUR TRAFFIC VOLUMES AND SPEEDS – NO BUILD CONDITIONS (2020)

Roadway	Automobiles	Medium Trucks	Heavy Trucks	Speeds (mph)
I-70 EB North of 58	4176	87	87	65
I-70 WB North of 58	4176	87	87	65
I-70 EB South of 58	4176	87	87	65
I-70 WB South of 58	4176	87	87	65
SH58 EB	1300	25	25	65
SH58 WB	1470	30	30	65
44TH East of 1-70 ramps	1793	18	18	35
44TH Ward Road east to I-70 ramps	2891	30	30	35
44TH Ward to Youngfield	1705	17	17	35
44TH West to Youngfield	1323	14	14	35
Ward South of WB I-70 Ramps	2852	29	29	30
Tabor St.	1450	15	15	30
Youngfield South of 44th Ave.	1401	14	14	35
Youngfield South of 38th Ave.	2401	25	25	35
I-70 Service Road	421	4	4	30

TABLE 4
PEAK-HOUR TRAFFIC VOLUMES AND SPEEDS – PHASE 2 BUILD CONDITIONS (2020)

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Roadway	Automobiles	Medium Trucks	Heavy Trucks	Speeds (mph)
I-70 EB North of 58	4176	87	87	65
I-70 WB North of 58	4176	87	87	65
I-70 EB South of 58	4176	87	87	65
I-70 WB South of 58	4176	87	87	65
SH58 EB	1920	40	40	65
SH58 WB	2237	47	47	65
44th, East of I-70 ramps	1784	18	18	35
44th, Ward Road east to I-70 ramps	2958	31	31	35
44th, Ward to Youngfield	1916	20	20	35
44th, West of Youngfield	1196	12	12	35
Tabor St.	1421	15	15	30
I-70 Service rd. West of Kipling St	412	4	4	30
Ward South of WB I-70 Ramps	2982	30	30	30
Youngfield South of 44th	1420	14	14	40
Youngfield South of 38th	1808	38	38	35
Ramp A	701	15	15	35
Ramp C	1536	32	32	35
Ramp D	576	12	12	35
Ramp F	816	17	17	35
Ramp G	1440	30	30	35
SH58 EB (ramp to I-70 EB)	1344	28	28	35

TABLE 5
PEAK-HOUR TRAFFIC VOLUMES AND SPEEDS – PHASE 3 BUILD CONDITIONS (2020)

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Roadway	Automobiles	Medium Trucks	Heavy Trucks	Speeds (mph)
I-70 EB North of 58	4176	87	87	65
I-70 WB North of 58	4176	87	87	65
I-70 EB South of 58	4176	87	87	65
I-70 WB South of 58	4176	87	87	65
SH58 EB	2246	47	47	65
SH58 WB	2304	48	48	65
44th, East of I-70 ramps	1798	18	18	35
44th, Ward Road east to I-70 ramps	2885	29	29	35
44th, Ward to Youngfield	1892	19	19	35
44th, West of Youngfield	1186	12	12	35
Tabor St.	1421	15	15	30
I-70 Service rd. West of Kipling St	740	5	5	30
Ward South of WB I-70 Ramps	2961	30	30	30
Youngfield South of 44th	1432	15	15	40
Youngfield South of 38th	1836	19	19	35
Ramp A	768	16	16	35
Ramp C	1536	32	32	35
Ramp D	557	12	12	35
Ramp F	864	18	18	35
Ramp G	1440	30	30	35
Ramp H	1690	35	35	35

Location of Roadways

Referring to Figures 3 through 5, the locations and elevations of the existing roadways were determined using the CAD topographical maps developed for the project. The locations of the proposed alignments of Youngfield and the I-70 ramps were taken directly from the CAD design files developed for the project and the elevations were taken from design cross-sections. The affect of roadway slope was taken into account for all conditions.

Location of Receptors

As shown in Figures 3 through 5, 48 Category B (refer to Table 1) receptors and 46 Category C receptors were identified within the project study area. Table 6 provides a description of the receptors. The exact locations and elevations of the receptors were determined using the CAD topographic files. In the STAMINA model, 5 feet was added to the elevation of each receiver to account for the height of a typical person's ear. Some of the residential and commercial structures in the area are two- and three-stories tall. However, consistent with CDOT policy, noise impact was analyzed at ground floor units only.

TABLE 6
DESCRIPTION OF NOISE RECEPTORS

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Receptor Number	Land Use Description	CDOT Receptor Category	Distance from I-70 Centerline (feet)
1	La Quinta Inn	B	325
2	3475 Youngfield Service Road	B	320
3	Table Mountain Animal Center	C	280
4	Strip Mall	C	285
5	World Savings	C	310
6	Blockbuster/Papa Johns	C	280
7	Ridgeview Baptist Church	B	290
8	12680 W. 38th Drive	B	535
9	12674 W. 38th Drive	B	535
10	12668 W. 38th Drive	B	525
11	12647 W. 38th Drive	B	460
12	Youngfield Plaza	C	335
13	Camping World	C	460
14	Casey's Recreational Sales	C	390
15	Pacso Labs	C	410
16	Modern Log Homes	C	335
17	12731 (behind Pasco Labs)	B	505
18	Prospect Recreation District	C	1010
19	American Dog Training/Residential	B	775
20	4220 Xenon	B	815
21	4221 Xenon	B	770
22	4235 Xenon	B	765
23	4315 Xenon	B	660
24	4365 Xenon	B	580
25	Flying Ranch	B	540
26	Single Family on Xenon	B	460
27	D. Deorio and Sons Memorials	C	350
28	Mount Olivet Cemetery	C	510
29	Casey's Recreational Service	C	350
30	CDOT	C	955
31	2 Buildings (office suites)	C	1540
32	Ted's Sheds	C	1785
33	13350 W. 43rd St (office buildings)	C	2020
34	13551 W. 43rd St offices	C	2330

TABLE 6 (CONTINUED)
DESCRIPTION OF NOISE RECEPTORS

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35	Construction site (offices)	C	2760
36	High Plateau Truss	C	3300
37	RV Sales 12505 44th Avenue	C	230
38	12500 44th	B	380
39	12430 W. 44th	B	450
40	Single Family House	B	490
41	The Cat Spa and Kennel	C	510
42	12400 44th	B	530
43	Single Family House	B	610
44	Total Gas Station	C	600
45	Classic Trailer Sales	C	240
46	Palacar Reef Bar	C	390
47	Public Storage	C	500
48	Abner's Market	C	770
49	Nursery	C	750
50	Mountain Vacation Homes	C	470
51	Single Family House	B	845
52	Falcon Books	C	850
53	Energy Transportation	C	900
54	TA Truck Stop	C	390
55	Quality Inn	C	1130
56	TDS (Tire Distributor)	C	1180
57	JWB Tire Company	C	1290
58	Public Storage	C	960
59	Single Family House on 44th Avenue	B	1140
60	RV America	C	1420
61	Heines Market	C	1220
62	Tabor Apartments (18 units)	B	1280
63	4430 Tabor St. Single Family	B	1100
64	4433 Tabor St. Single Family	B	920
65	4549 Tabor St (commercial bldg)	C	750
66	11790 46th St.	B	800
67	11781 46th St.	B	750
68	Single Family on Tabor St. (abandoned?)	B	670

TABLE 6 (CONTINUED)
DESCRIPTION OF NOISE RECEPTORS

69	Trailer Source	C	410
70	4625 Swadley St.	B	700
71	4635 Swadley St.	B	640
72	4645 Swadley St.	B	570
73	4655 Swadley St.	B	510
74	4665 Swadley St.	B	440
75	4675 Swadley St.	B	370
76	4683 Swadley St.	B	300
77	4787 - 4885 Swadley St. (duplex)	B	190
78	4794 Swadley St. (duplex)	B	200
79	4795 Simms St.	B	200
80	4768 Simms St. (2 ground level units)	B	210
81	4733 Routt St. (3 units)	B	200
82	Apartments on Routt St. (2 units)	B	210
83	4783 N. Robb St. (4 units)	B	180
84	1790 N. Robb St.	B	210
85	CB Stables	C	320
86	Mountain Vista	B	340
87	Wheat Ridge Industrial Park	C	210
88	Hank's Auto Body	C	210
89	Brass Armadillo Antique Mall	C	300
90	Medved auto sales	C	390
91	Park and Ride	C	460
92	Landscape supplies	C	450
93	Clear Creek bike path - west side	B	380
94	Clear Creek bike path - east side	B	390

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Location of Terrain Features and Structures

Existing terrain features such as embankments and structures can act as barriers. The following features were modeled as barriers on this project:

- existing noise walls adjacent to I-70
- edge of pavement from the Ridgeview Baptist Church parking lot
- Ridgeview Baptist Church building
- Modern Log Homes building
- Pasco Labs building
- I-70 and Youngfield Street edge of pavement
- Ramp A edge of pavement (2020 conditions only)
- Ramp H edge of pavement (2020 conditions only)
- Tabor St. edge of pavement

The locations and elevations of these features were determined from the project CAD files. The heights of the buildings were estimated based on field observations. Also, a shielding factor of 3 dB was used for second row receptors with respect to I-70 due to the partial shielding of I-70 noise by first row buildings.

Terrain Type

STAMINA allows the user to select one of two types of ground for each receiver-roadway pair: hard or soft. This selection is made using the alpha factor input variable which is an adjustment made to the sound propagation rate (e.g.: hard ground alpha of 0 relates to 3 dB reduction per doubling of distance and soft ground alpha of 0.5 relates to 4.5 dB per doubling of distance). An alpha factor of zero represents hard ground such as pavement and water, as well as the case where either the source or the receptor are significantly elevated above the ground. An alpha factor of 0.5 represents acoustically soft terrain, which is representative of vegetated ground with both source and receiver located close to the ground.

On this project, I-70 is elevated on fill or structure for much of its length, which results in minimal ground attenuation. Thus, a 0 alpha factor was used for defining the noise propagation from elevated portions of I-70 to applicable receptor locations. A 0.5 alpha was used where receptors and I-70 were relatively equal in elevation.

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3.2 Validation of Noise Prediction Procedures

The above-described modeling procedures were validated by measuring noise levels at four locations, using the STAMINA model to predict noise levels at these locations, and comparing the measured and predicted results. Noise levels were measured on August 22, 2001 at two sites. Three measurements were conducted at each site. The measurement locations for Site 1 were in and around Xenon Street and are shown as S1M1, S1M2 and S1M3 in Figure 3. The measurement locations for Site 2 were around the Ridgeview Baptist Church and nearby neighborhood and are S2M1, S2M2 and S2M3 in Figure 4. Noise levels were measured for about one hour at each site (Site 1 = 10:15 a.m. to 11:15 a.m., Site 2 = 1:30 p.m. to 2:30 p.m.). The measurements were conducted using a Larson Davis Model 820, a Metrosonics dB-604 and a Norsonics Type 114 analyzer, which all meet ANSI Type I specifications. Each meter was field-calibrated before and re-checked after the measurements. During the measurements, the number of automobiles, medium trucks, and heavy trucks which passed in each direction on I-70 and the nearby roadways were tabulated. Average traffic speeds were measured with a radar gun.

Using the measured traffic volumes and speeds, along with the roadway and other input data described above for existing conditions, noise levels were predicted at each measurement location. The measured and predicted noise levels are compared in Table 7, below. STAMINA is generally expected to predict noise levels with an accuracy of $\pm$3.0 dB(A). The results are within this range for all but one of the measurements (S1M3). As shown in Table 7, this location is predicted to be 6.2 dB louder than what was measured. S1M3 is approximately 100 feet further from I-70 and Youngfield than S1M2, and was measured to be 6.3 dB quieter than S1M2. One would expect to see only a 1 to 2 dB difference in measured noise levels for a 100 ft difference in distance at these sites. This would suggest that the measurement at S1M3 is in error.

TABLE 7
STAMINA NOISE MODEL VALIDATION
(L_{eq}, dB(A))

Location	Time	Measured Level	Predicted Level	Difference (pred. – meas.)
S1M1	10:15-11:15 p.m.	64.0	65.2	1.2
S1M2	10:15-11:15 p.m.	57.9	58.8	0.9
S1M3	10:15-11:15 p.m.	51.6	57.8	6.2
S2M1	1:30 - 2:30 p.m.	66.3	65.7	-0.6
S2M2	1:30 - 2:30 p.m.	56.0	57.5	1.5
S2M3	1:30 - 2:30 p.m.	53.7	55.7	2.0

4.0 Predicted Noise Levels

Using the above described prediction methodology, noise levels were predicted at each of the 94 receptor locations shown in Figures 3 through 5. Noise levels were predicted for both existing and design-year conditions. For this project, design year predictions were made separately for a) the completion of Phases 1 and 2 (referred to hereafter as Phase 2), and b) the completion of Phases 1, 2, and 3 (referred to hereafter as Phase 3). The following sections describe the results for Phase 2 and Phase 3, followed by a summary of the impacts for both phases.

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Phase 2

Table 8, lists the Phase 2 noise levels predicted at each Category C (i.e. commercial) receptor location for both existing and design-year conditions, the increase in noise levels between existing and design-year conditions, and whether or not the predicted levels equal or exceed the NAC or the Increase Criterion (+10 dB(A) over existing). Noise levels at two Category C Receptors locations (27 and 37) are predicted to have design-year noise levels that equal or exceed the applicable NAC of 71 dB(A). Table 9 shows the Phase 2 noise levels predicted at each Category B (i.e. residential) receptor location. A total of ten Category B Receptor locations (1, 2, 7, 11, 26, 38, 39, 40, 42 and 59) are predicted to have design-year noise levels that equal or exceed the applicable NAC of 66 dB(A). None of the predicted noise level increases exceed the Increase Criterion. Mitigation alternatives for these receptors are discussed in Section 6.

TABLE 8
RESULTS OF PHASE 2 IMPACT ASSESSMENT – CATEGORY C RECEPTORS

Receptor	Existing (1999) Conditions (dB(A))	No Build (2020) Conditions (dB(A))	Phase 2 - Design-Year (2020) Conditions (dB(A))	Phase 2- Design-Year Exceed NAC? (yes/no)	Distance from I-70 Centerline (feet)
3	68	68	68	---	280
4	68	68	68	---	285
5	68	68	68	---	310
6	68	69	68	---	280
12	66	66	68	---	335
13	65	65	67	---	460
14	66	66	67	---	390
15	65	65	67	---	410
16	66	66	69	---	335
18	57	57	58	---	1010
27	68	67	72	YES	350
28	64	64	65	---	510
29	66	67	69	---	350
30	65	66	67	---	955
31	67	69	68	---	1540

TABLE 8 (CONTINUED)
RESULTS OF PHASE 2 IMPACT ASSESSMENT – CATEGORY C RECEPTORS

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Receptor	Existing (1999) Conditions (dB(A))	No Build (2020) Conditions (dB(A))	Phase 2 - Design-Year (2020) Conditions (dB(A))	Phase 2- Design-Year Equal or Exceed NAC? (yes/no)	Distance from I-70 Centerline (feet)
32	65	67	67	---	1785
33	67	68	68	---	2020
34	64	65	66	---	2330
35	62	63	64	---	2760
36	65	67	66	---	3300
37	69	69	71	YES	230
41	67	67	67	---	510
44	68	68	67	---	600
45	68	68	70	---	240
46	68	68	68	---	390
47	67	68	67	---	500
48	65	65	64	---	770
49	66	66	65	---	750
50	66	66	66	---	470
52	65	65	64	---	850
53	62	63	63	---	900
54	65	65	66	---	390
56	59	60	61	---	1180
57	59	60	61	---	1290
58	61	62	67	---	960
60	59	61	61	---	1420
61	62	64	64	---	1220
65	61	63	64	---	750
69	65	65	68	---	410
85	65	65	61	---	320
87	68	68	61	---	210
88	70	70	62	---	210
89	67	67	62	---	300
90	65	65	63	---	390
91	64	64	64	---	460
92	65	65	65	---	450

TABLE 9
RESULTS OF PHASE 2 IMPACT ASSESSMENT – CATEGORY B RECEPTORS

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Receptor	Existing (1999) Conditions (dB(A))	No Build (2020) Conditions (dB(A))	Phase 2 - Design-Year (2020) Conditions (dB(A))	Phase 2- Design-Year Equal or Exceed NAC? (yes/no)	Distance from I-70 Centerline (feet)
1	67	67	67	YES	325
2	67	67	67	YES	320
7	69	69	69	YES	290
8	62	62	64	---	535
9	61	61	64	---	535
10	61	61	63	---	525
11	64	64	66	YES	460
17	63	63	64	---	505
19	61	61	63	---	775
20	61	61	63	---	815
21	62	62	63	---	770
22	62	62	63	---	765
23	63	63	64	---	660
24	64	64	64	---	580
25	64	64	65	---	540
26	65	65	66	YES	460
38	67	67	71	YES	380
39	67	66	67	YES	450
40	67	67	67	YES	490
42	67	68	67	YES	530
43	66	66	65	---	610
51	64	64	63	---	845
55	58	59	59	---	1130
59	63	65	67	YES	1140
62	61	63	63	---	1280
63	60	62	63	---	1100
64	61	63	64	---	920
66	60	62	62	---	800
67	62	63	63	---	750
68	63	65	65	---	670
70	60	60	61	---	700
71	60	61	61	---	640
72	61	61	61	---	570
73	61	61	62	---	510
74	62	62	62	---	440
75	63	63	63	---	370

TABLE 9 (CONTINUED)
RESULTS OF PHASE 2 IMPACT ASSESSMENT – CATEGORY B RECEPTORS

Receptor	Existing (1999) Conditions (dB(A))	No Build (2020) Conditions (dB(A))	Phase 2 - Design-Year (2020) Conditions (dB(A))	Phase 2- Design-Year Equal or Exceed NAC? (yes/no)	Distance from I-70 Centerline (feet)
76	64	64	64	---	300
77	65	65	65	---	190
78	64	64	64	---	200
79	64	64	65	---	200
80	64	64	65	---	210
81	65	65	63	---	200
82	65	65	63	---	210
83	66	65	65	---	180
84	65	65	65	---	210
86	65	65	61	---	340
93	66	66	64	---	380
94	66	66	65	---	380

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Phase 3

Table 10, lists the Phase 3 noise levels predicted at each Category C (i.e. commercial) receptor location for both existing and design-year conditions, the increase in noise levels between existing and design-year conditions, and whether or not the predicted levels equal or exceed the NAC or the Increase Criterion (+10 dB(A) over existing). Noise levels at two Category C Receptors locations (27 and 37) are predicted to have design-year noise levels that equal or exceed 71 dB(A). Table 11 shows the Phase 3 noise levels predicted at each Category B (i.e. residential) receptor location. A total of thirteen Category B Receptor locations (1, 2, 7, 11, 26, 38, 39, 40, 42, 59, 83, 84 and 93) are predicted to have design-year noise levels that equal or exceed 66 dB(A). None of the predicted noise level increases exceed the Increase Criterion. Mitigation alternatives for these receptors are discussed in Section 6.

TABLE 10
RESULTS OF PHASE 3 IMPACT ASSESSMENT – CATEGORY C RECEPTORS

Receptor	Existing (1999) Conditions (dB(A))	No Build (2020) Conditions (dB(A))	Phase 3 - Design-Year (2020) Conditions (dB(A))	Phase 3- Design-Year Exceed NAC? (yes/no)	Distance from I-70 Centerline (feet)
3	68	68	68	---	280
4	68	68	68	---	285
5	68	68	68	---	310
6	68	69	68	---	280
12	66	66	68	---	335
13	65	65	67	---	460
14	66	66	67	---	390
15	65	65	66	---	410
16	66	66	69	---	335
18	57	57	58	---	1010
27	68	67	72	YES	350
28	64	64	65	---	510
29	66	67	69	---	350
30	65	66	67	---	955
31	67	69	68	---	1540
32	65	67	66	---	1785
33	67	68	67	---	2020
34	64	65	64	---	2330
35	62	63	61	---	2760
36	65	67	63	---	3300
37	69	69	71	YES	230
41	67	67	67	---	510
44	68	68	67	---	600
45	68	68	70	---	240

TABLE 10 (CONTINUED)
RESULTS OF PHASE 3 IMPACT ASSESSMENT – CATEGORY C RECEPTORS

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Receptor	Existing (1999) Conditions (dB(A))	No Build (2020) Conditions (dB(A))	Phase 3 - Design-Year (2020) Conditions (dB(A))	Phase 3- Design-Year Exceed NAC? (yes/no)	Distance from I-70 Centerline (feet)
46	68	68	68	---	390
47	67	68	67	---	500
48	65	65	64	---	770
49	66	66	65	---	750
50	66	66	66	---	470
52	65	65	64	---	850
53	62	63	63	---	900
54	65	65	66	---	390
56	59	60	61	---	1180
57	59	60	61	---	1290
58	61	62	67	---	960
60	59	61	61	---	1420
61	62	64	64	---	1220
65	61	63	64	---	750
69	65	65	68	---	410
85	65	65	63	---	320
87	68	68	69	---	210
88	70	70	70	---	210
89	67	67	67	---	300
90	65	65	65	---	390
91	64	64	65	---	460
92	65	65	65	---	450

TABLE 11
RESULTS OF PHASE 3 IMPACT ASSESSMENT – CATEGORY B RECEPTORS

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Receptor	Existing (1999) Conditions (dB(A))	No Build (2020) Conditions (dB(A))	Phase 3 - Design-Year (2020) Conditions (dB(A))	Phase 3- Design-Year Exceed NAC? (yes/no)	Distance from I-70 Centerline (feet)
1	67	67	67	YES	325
2	67	67	67	YES	320
7	69	69	69	YES	290
8	62	62	64	---	535
9	61	61	64	---	535
10	61	61	63	---	525
11	64	64	66	YES	460
17	63	63	65	---	505
19	61	61	62	---	775
20	61	61	62	---	815
21	62	62	63	---	770
22	62	62	63	---	765
23	63	63	63	---	660
24	64	64	64	---	580
25	64	64	65	---	540
26	65	65	66	YES	460
38	67	67	71	YES	380
39	67	66	67	YES	450
40	67	67	67	YES	490
42	67	68	67	YES	530
43	66	66	65	---	610
51	64	64	63	---	845
55	58	59	59	---	1130
59	63	65	67	YES	1140
62	61	63	63	---	1280
63	60	62	63	---	1100
64	61	63	64	---	920

TABLE 11 (CONTINUED)
RESULTS OF PHASE 3 IMPACT ASSESSMENT – CATEGORY B RECEPTORS

Receptor	Existing (1999) Conditions (dB(A))	No Build (2020) Conditions (dB(A))	Phase 3 - Design-Year (2020) Conditions (dB(A))	Phase 3- Design-Year Exceed NAC? (yes/no)	Distance from I-70 Centerline (feet)
66	60	62	62	---	800
67	62	63	63	---	750
68	63	65	65	---	670
70	60	60	61	---	700
71	60	61	61	---	640
72	61	61	61	---	570
73	61	61	62	---	510
74	62	62	62	---	440
75	63	63	63	---	370
76	64	64	64	---	300
77	65	65	65	---	190
78	64	64	64	---	200
79	64	64	65	---	200
80	64	64	65	---	210
81	65	65	65	---	200
82	65	65	65	---	210
83	66	65	66	YES	180
84	65	65	66	YES	210
86	65	65	65	---	340
93	66	66	69	YES	380
94	66	66	65	---	380

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Summary of Impacted Noise Receptors (Phase 2 and 3)

Figures 3 – 5 show the locations where predicted noise levels exceed the NAC. Table 12 provides a summary of the impacted receptor locations, including the average predicted build noise level for Phases 2 and 3. The impacted receptor locations for Phases 2 and 3 are similar except that Phase 3 has three additional NAC Category B locations that are considered impacted. As some of the impacted receptor locations are within a close proximity to one another, these locations are grouped together (Impacted Area). Mitigation alternatives for these receptor areas are discussed in Section 5.

TABLE 12
SUMMARY OF IMPACT ASSESSMENT

Impacted Area	**NAC Category**	**Receptor Locations**	**Phase 2 - Avg. Design-Year (2020) Noise Level *(dB(A))***	**Phase 3 - Avg. Design-Year (2020) Noise Level *(dB(A))***
La Quinta Inn	B	1	67	67
Residences behind existing I-70 Noise Wall	B	83, 84	not impacted	66
Residence on 44th Avenue	B	59	67	67
Residences near 44th Avenue and Ward Rd.	B	26, 38, 39, 40, 42	68	68
Businesses near 44th Avenue and Ward Rd.	C	27, 37	72	72
Clear Creek bike path	B	93	not impacted	69
Ridgeview Church & Adjacent Residences	B	7, 11	68	68
Residence at 3475 Youngfield Service Rd	B	2	67	67

5.0 Noise Mitigation Analysis

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As discussed in the previous section, predicted design-year noise levels equal or exceed CDOT's NAC at 11 Category B and 2 Category C locations for Phase 2, and 13 Category B and 2 Category C locations for Phase 3. Subsequently, per CDOT policy, the feasibility and reasonableness of constructing noise mitigation measures was analyzed for these receptors. As discussed in Section 2.0, the mitigation analysis must address the following:

- Does the proposed mitigation measure create any significant safety or maintenance issues?
- Does the proposed mitigation measure provide at least 5 dB(A) of noise reduction, on average, at the front row of receivers?
- Does the proposed mitigation measure meet the $3,500 per affected receptor per dB(A) of noise reduction limit?

The feasibility and reasonableness of constructing noise walls for the subject residences was analyzed and the results of these analyses are discussed in the following sub-sections. The following highway noise mitigation measures were deemed infeasible on this project and were not analyzed:

- Traffic Management Measures (i.e. the prohibition or time-use restriction of certain vehicle types (i.e. trucks), and reduced speed limits)
- Alteration of Horizontal and Vertical Alignments
- Acquisition of Property To Form Buffer Zone
- Noise Insulation of Buildings (reserved for public buildings, or severe traffic noise impacts)

Mitigation alternatives were analyzed for each of the eight impacted areas described in Table 11. Note that the mitigation analysis for the residences and businesses near 44th and Ward were combined into one analysis as the mitigation design is identical. In some cases the mitigation analysis is the same for Phases 2 and 3, but in other instances they are different due to differing alignments and/or traffic volumes. The results of the mitigation analyses conducted for each area are described below. Note that a unit noise wall cost of $25 per ft^2 was used in all of the calculations.

<u>La Quinta Inn</u>
CDOT noise policy states that noise mitigation will only be applied for active outdoor use areas. The only active outdoor use area at the La Quinta Inn is the swimming pool, which is located inside the "quad" formed by the hotel (See Figure 3). Mitigation of highway noise, particularly in the form of a noise wall, would not benefit the pool area, and therefore is not recommended for either Phase 2 or 3.

<u>Residences Behind Existing I-70 Noise Wall</u>
For Phase 3, the predicted noise levels at the residents behind the existing noise wall along I-70 (See Figure 5) equal 66 dB(A). Thus, consideration for additional mitigation under this project is required. It is possible that this wall would need to be re-set as a result of the new ramp on I-70. If so, that opportunity should be taken to re-analyze the appropriate height for this wall.

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Residence on 44th Avenue

A noise wall (See NW1 in Figure 5) was modeled along the proposed I-70 on-ramp adjacent to this residence. A 150-foot long 16-foot tall wall was modeled. This wall was predicted to reduce noise levels at the residence by only 1 dB(A), which does not meet CDOT's 5 dB(A) minimum requirement. Also, the wall was predicted to cost approximately $60,000 per receptor per dB or reduction, which greatly exceeds CDOT's $3,500 cost per receptor per dB limit. Therefore, a wall is not recommended for either Phase 2 or 3.

Residences and Businesses Near 44th and Ward

For Phase 2, a noise wall (See NW2 in Figure 4) was modeled along I-70 near these residences and businesses. A 1,300 foot long 20 foot tall wall was modeled. Three properties were predicted to receive at least 5 dB(A) of noise reduction, which meets CDOT's 5 dB(A) minimum requirement. However, the wall was predicted to cost approximately $26,000 per receptor per dB of reduction, which exceeds CDOT's $3,500 cost per receptor per dB limit. The main reasons why this wall does not provide more reduction to more homes is that many of the residences in this area are a large distance from I-70, and much of the noise at the closer receptors is due to traffic on 44th Avenue. A wall could not be constructed along 44th Avenue because the properties there have driveways (direct access) onto 44th, which would require a number of breaks in the wall creating both a safety issue and an ineffective noise wall. Therefore, a noise wall is not recommended for Phase 2.

For Phase 3, a noise wall (See NW6 in Figure 4) was modeled along the new alignment of I-70 near these residences and businesses. A 1,300 foot long 20 foot tall wall was modeled. No properties were predicted to receive at least 5 dB(A) of noise reduction, which does not meet CDOT's 5 dB(A) minimum requirement. Therefore, a noise wall is not recommend for Phase 3.

Clear Creek Bike Path

Noise levels on the bike path exceed 66 dB(A) within approximately 200 feet of I-70. A 180-foot long 10 foot tall wall was modeled along the structure over Clear Creek was modeled (See NW3 in Figure 4). Only 3 dB(A) of reduction was predicted, which does not meet CDOT's 5 dB(A) minimum requirement. While this wall could be considered on the basis of aesthetics, it is not recommended from a noise reduction standpoint. In fact, even a 500 foot long, 12-foot tall wall only provides 3 dB(A) of noise reduction.

Ridgeview Church and Adjacent Residences

A noise wall (See NW4 in Figure 3) was modeled along I-70 in front of the church and the residences. A 500 foot long 12 foot tall wall was modeled. This wall was predicted to reduce noise levels at the church by 5 dB(A), but only 1 dB(A) at the surrounding residences. This wall is estimated to cost $150,000. This results in a cost per dB per receptor of $30,000, which greatly exceeds CDOT's $3,500 cost per receptor per dB limit. Therefore, a wall is not recommended for either Phase 2 or 3.

Residence at 3475 Youngfield Service Road

A noise wall (See NW5 in Figure 3) was modeled along I-70 in front of this residence. A 335-foot long 20-foot tall wall was modeled. This completely encompasses this residence's frontage to I-70. This wall was predicted to reduce noise levels at the residence by 3 dB(A), which does not meet CDOT's 5 dB(A) minimum requirement. Also, the wall was predicted to cost approximately $55,000 per receptor per dB or reduction, which greatly exceeds CDOT's $3,500 cost per receptor per dB limit. Therefore, a wall is not recommended for either Phase 2 or 3.

6.0 Construction Noise

Construction of the project will generate noise from diesel-powered earth moving equipment such as dump trucks and bulldozers, back-up alarms on certain equipment, compressors, and pile drivers (near bridge abutments and retaining walls, if necessary). Construction noise at off-site receptor locations will usually be dependent on the loudest one or two pieces of equipment operating at the moment. Noise levels from diesel-powered equipment range from 80 to 95 dB(A) at a distance of 50 feet. Impact equipment such as rock drills and pile drivers can generate louder noise levels.

Construction noise, while temporary, can be mitigated by limiting work to daylight hours, requiring the contractor to use well-maintained equipment (particularly with respect to mufflers), and through the use of mitigation measures such as temporary noise barriers where applicable.