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4.7 NOISE

INTRODUCTION

The following section describes an analysis that was performed to assess potential impacts from traffic noise to properties neighboring the proposed transportation improvements. The purpose of the analysis was to conclude whether any receivers near the alternative alignments reach traffic noise impact thresholds according to CDOT and FHWA guidelines. Potential impacts from traffic noise were evaluated by examining the numbers and types of noise receivers near each of the alternatives and the predicted traffic noise levels at each. There are many properties in the study area that are traffic noise receivers and might be impacted by traffic noise from the various alternatives. Public concerns expressed through the public involvement process regarding noise include increased traffic noise in Golden and traffic noise echoing off canyon walls. These concerns are addressed in **Sections 4.7.2** and **Section 4.7.1.1**, respectively. More detailed information on the analysis is available (see **Northwest Corridor Supporting Document-Noise Impact Assessment**).

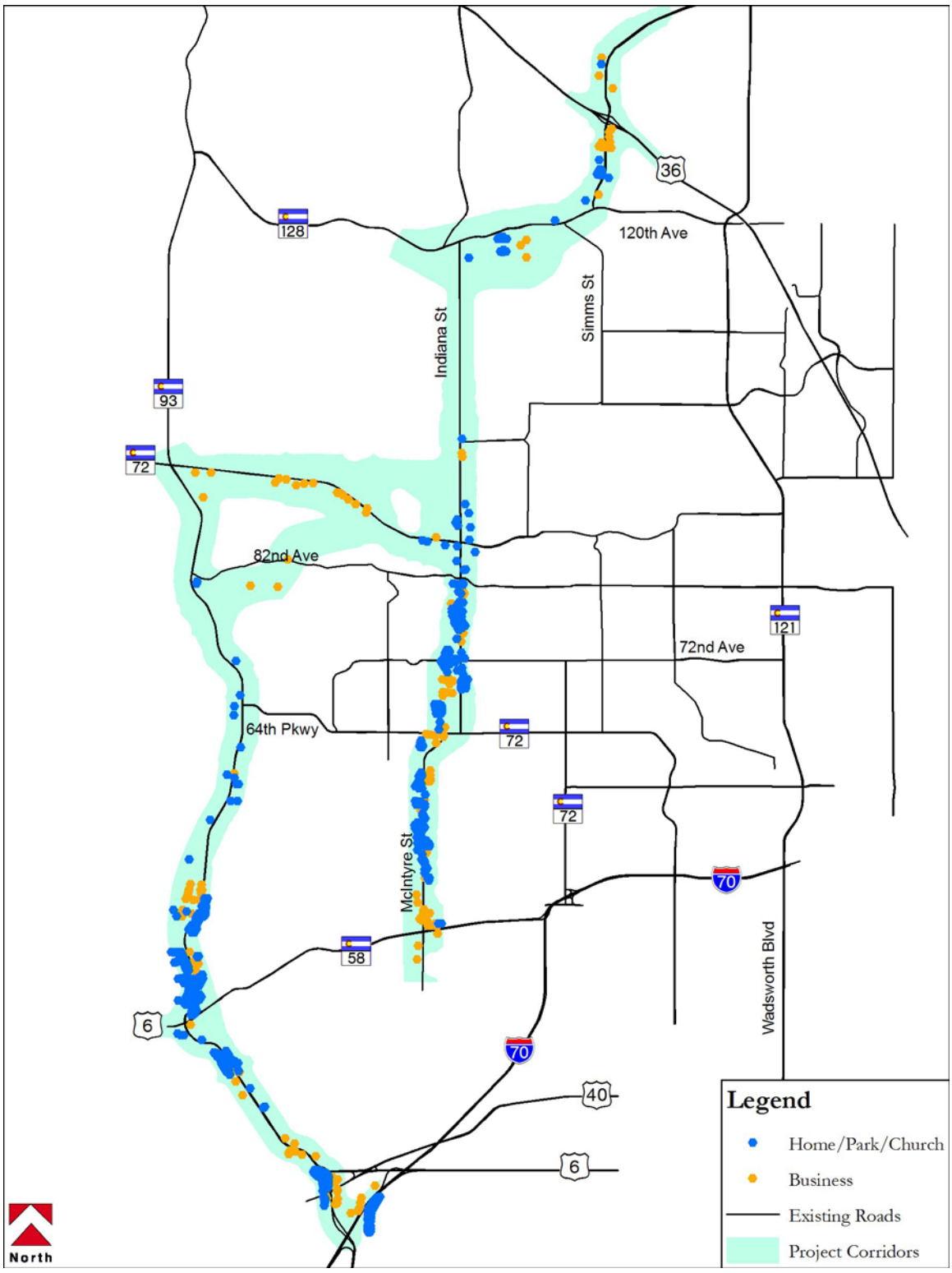
4.7.1 AFFECTED ENVIRONMENT

Increased traffic volumes and/or traffic speeds may lead to increased traffic noise. Depending on the alternative, roads may be constructed on new routes and thereby introduce traffic noise into new areas. To investigate these, a traffic noise analysis was performed for this study (see **Northwest Corridor Supporting Document-Noise Impact Assessment**).

Many noise sensitive areas exist in the study area (see **Figure 4.7-1**). At the north end of the study area near Interlocken, there are many residences and businesses close to all of the alternatives. Between 120th Avenue and SH 72, there are dispersed residences and businesses near the alternative alignments. Continuing south along Indiana Street and McIntyre Street to SH 58, there are numerous residences and businesses along the alignment of the Combined Alternative (Recommended Alternative). Along SH 72 and SH 93 from Indiana Street southwest to the City of Golden boundary, there are a small number of dispersed residences and businesses near the new alignment of the Freeway Alternative, Tollway Alternative, and Combined Alternative (Recommended Alternative) and also near the alignment of the Regional Arterial Alternative. Through Golden, along SH 93 and US 6, there are numerous residences and businesses near the alignment of the Freeway Alternative, Tollway Alternative, Regional Arterial Alternative, and Combined Alternative (Recommended Alternative). Change in proximity of residences and businesses to the alignments resulted from design modifications to avoid Section 4(f) designated lands identified by local agencies (see **Figure 4.7-1**).

A few barriers to reduce traffic noise have previously been built in the study area. There is a wall of varying height at the US 6/C-470 interchange shielding the Golden Terrace Mobile Home Park. This barrier protects many, but not all, of the homes in that neighborhood. This barrier is effective in reducing traffic noise from US 6 and the interchange ramps. There are a couple of berms/walls (approximately 6–10 feet tall) along the east side of SH 93 between approximately Washington Avenue and Virginia Street in Golden. These barriers protect the immediately adjacent homes in the neighborhoods. These barriers also appear to be effective in reducing traffic noise from SH 93. No other traffic noise barriers of consequence have been observed along the build alternative alignments.

Figure 4.7-1 Noise Sensitive Areas along Study Area Routes



Source: Compiled by FHU, 2006.

4.7.1.1 NOISE PRINCIPLES

Sound is created when an object vibrates and radiates part of that energy as acoustic pressure or waves through a medium such as air or water. Sound and noise are measured in units of decibels (dB). The dB scale is logarithmic. The human ear can accommodate a wide range of sound energy levels, including pressure fluctuations that increase by more than a million times. The human ear is not equally receptive to all frequencies of sound. "A-weighting" of sound levels (by frequency) is a method used to approximate scientifically how the human ear would perceive a sound, mostly by reducing the contribution from lower frequencies by specified amounts. A-weighted sound levels are reported in dBA. Commonly, sound loudness must change at least by 3 dBA, which is a two-fold change in the sound energy, before people will notice a difference. Generally speaking, a 3 dBA increase in sound levels could be achieved by doubling the number or strength of noise sources or by cutting the distance to the noise sources in half. Most people would relate a 10 dBA increase in sound levels to a doubling of the sound loudness.

Objects such as rock faces and canyon walls can reflect sound and thereby appear to be noise sources. However, the sound levels reflected off such objects will be considerably lower than sound levels near the source unless the reflector and listener are close together and close to the source due to the longer distance the reflected sound must travel. Sound levels diminish with distance from the source because of spreading, atmospheric absorption, interference from other objects, and ground effects. "Hard" ground (such as asphalt) and "soft" ground (such as grass) affect how sound is transmitted. "Hard" ground is more reflective and will produce louder sound levels farther from the source.

Traffic noise tends to fluctuate over time according to traffic volumes, vehicle types, and speeds. This fluctuation makes it difficult to describe adequately noise and noise impacts through a single value. The one-hour equivalent sound level (L_{eq}) was the metric chosen for assessing traffic noise impacts in this study. The L_{eq} is essentially the "average" of the fluctuating noise levels over a time period, or the constant noise level that would produce the same total sound energy over the time period as the fluctuating noise level.

On busy roads and highways, the loudest traffic noise generally occurs when the largest traffic volume can travel at the highest speed, which is usually not when traffic becomes overly congested and slows. Traffic noise can actually decrease during rush hour due to lower vehicle speeds from overloaded and congested roads. The loudest traffic condition generally is during Level of Service (LOS) C conditions for a highway (see **Section 3.1.3.1**). When considering noise impacts, the "peak hour" refers to the loudest traffic noise hour, which may or may not correspond to the hour of most traffic.

4.7.1.2 NOISE ANALYSIS METHODS

The purpose of the traffic noise analysis was to assess traffic noise at properties near the project alternatives' alignments and conclude whether traffic noise impacts may occur and whether noise mitigation actions may be appropriate in the project design. The noise analysis included roads that would be changed or newly built by the project alternatives in an area roughly bounded by SH 93, I-70, US 36, and Wadsworth Boulevard.

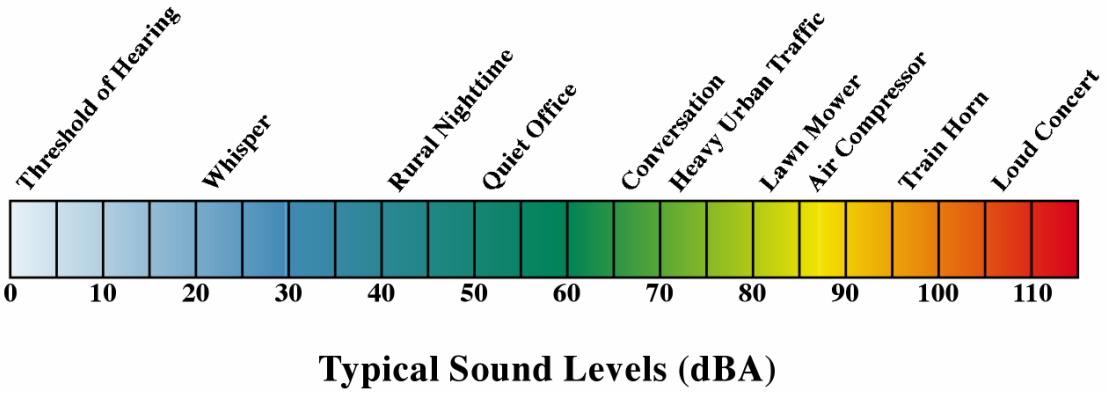
Normal sounds can span a broad range of loudness levels (see **Figure 4.7-2**). Impacts from traffic noise were assessed on the basis of the noise levels' relationship to CDOT's Noise Abatement Criteria (NAC) (see **Table 4.7-1**). Since many of the roads of interest in the study area are state or federal highways, the appropriate noise impact criteria are state and federal guidelines, not local nuisance noise ordinances. The CDOT NAC for residences and other Category B receivers is an exterior one-hour L_{eq} of 66 dBA, and for commercial areas (Category C) is an L_{eq} of 71 dBA. Land Use Categories A, D, and E are not relevant to the build alternatives being analyzed and are not considered further (see **Table 4.7-1**). Areas that are especially noise sensitive, such as outdoor concert venues (Category A), were not present in the study area. Undeveloped areas (Category D) do not have a NAC. Therefore, Category A and Category D land uses are not relevant for this analysis. Indoor noise levels (Category E) are used only when there are no exterior activity areas to evaluate. Under CDOT guidelines, equaling or exceeding the NAC is viewed as a noise impact and triggers an

evaluation of traffic noise mitigation measures. A "substantial" traffic noise increase (when the noise level is expected to increase by 10 dBA or more over existing levels at any location modeled) would also be considered a noise impact and also lead to evaluation of mitigation actions.

The noise analysis for the study area was based on measurements of existing noise conditions and computer modeling of traffic noise for both existing (2004) and expected (2030) traffic conditions. Measurements of existing traffic noise were performed at 37 locations in the study area in 2004 and 2005. Modeling is used because day-to-day variations in traffic or weather conditions that affect noise levels cannot be captured or quantified by brief noise measurements alone. Computer modeling was used to predict the existing and the expected average traffic noise, focusing on potential impacts to the most sensitive receivers. Current roads and each build alternative being considered were modeled. Residential areas are typically the existing land uses most sensitive to traffic noise impacts and there are many such areas close to the various alternatives (see **Figure 4.7-1**). Other sensitive land uses include parks, schools, and churches. The measured and calculated noise levels were compared to the noise impact criteria to assess for and identify impacted areas.

The FHWA STAMINA model in SoundPlan® software was used to calculate noise levels at approximately 980 receiver locations that represent each property or park within about 500 feet of a major road within the study area. The same receiver locations were used in each model for consistency. The modeled roads included those roads that will be built or changed by the build alternatives and any major intersecting roads. The computer noise models require a considerable amount of input data regarding the geometry of the roadways as well as traffic volumes, vehicle mix, speeds, and topography (see **Northwest Corridor Supporting Document-Noise Impact Assessment**).

Figure 4.7-2 Typical Noise Levels



Source: Department of Housing and Urban Development, 1991.

Table 4.7-1 Noise Abatement Criteria

Land Use Category	CDOT NAC (L_{eq})	Description
A	56 dBA (Exterior)	Tracts of land in which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is to continue to serve its intended purpose. Such areas could include amphitheaters, particular parks, or open spaces that are recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B	66 dBA (Exterior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, picnic areas, playgrounds, active sports areas, and parks.
C	71 dBA (Exterior)	Developed lands, properties, or activities not included in categories A and B above.
D	None	Undeveloped lands.
E	51 dBA (Interior)	Residences, motels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Source: CDOT, 2002.

4.7.1.3 NOISE MEASUREMENTS

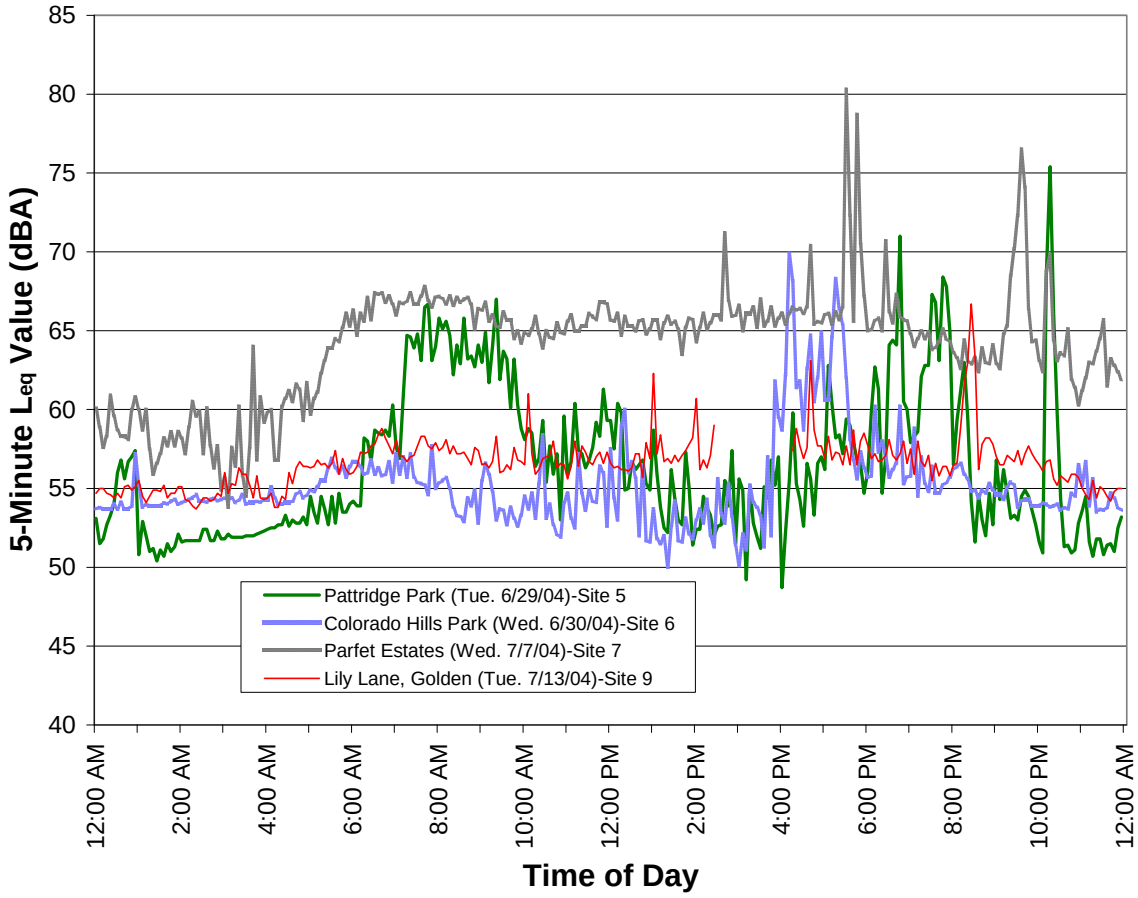
Noise measurements can serve several purposes. They can provide actual noise level data for strategic locations within the study area. But equally important, noise measurements can be used to check the performance of the project noise models (see **Section 4.7.1.4**). A traffic noise verification model was assembled using data gathered from the measurements described below, and the model results were compared to the actual measured noise levels. The measured and modeled results for 27 of 28 verification locations were within the 3 dBA required for the noise model to be valid (see **Northwest Corridor Supporting Document-Noise Impact Assessment**). Thus the model was considered to be valid for this project. The measurement at the location that did not meet the requirement was approximately 700 feet from the nearest road and may have been affected by light wind.

Existing noise level data from 24-hour logging measurements at four locations were used to guide the rest of the noise measurement program (see **Figure 4.7-3**). The program spread measurements over a variety of locations in the study area and adjacent to a range of road types. The 24-hour data showed daily AM and PM traffic noise peaks and that representative peak noise measurements could be taken during the afternoon hours. This approach was used for the rest of the noise measurement program.

Measurements were taken at a number of locations in the study area to document existing ambient conditions across the study area (see **Figure 4.7-4**). These locations included residential, park, commercial, and undeveloped areas along the alternative alignments that were under consideration during the screening of alternatives. Some of these locations were along alignments that were screened out during earlier stages of the study and were not included in the noise models. Actual traffic counts, including the number of large trucks, were collected when traffic was visible during the noise measurement periods (see **Northwest Corridor Supporting Document-Noise Impact Assessment**).

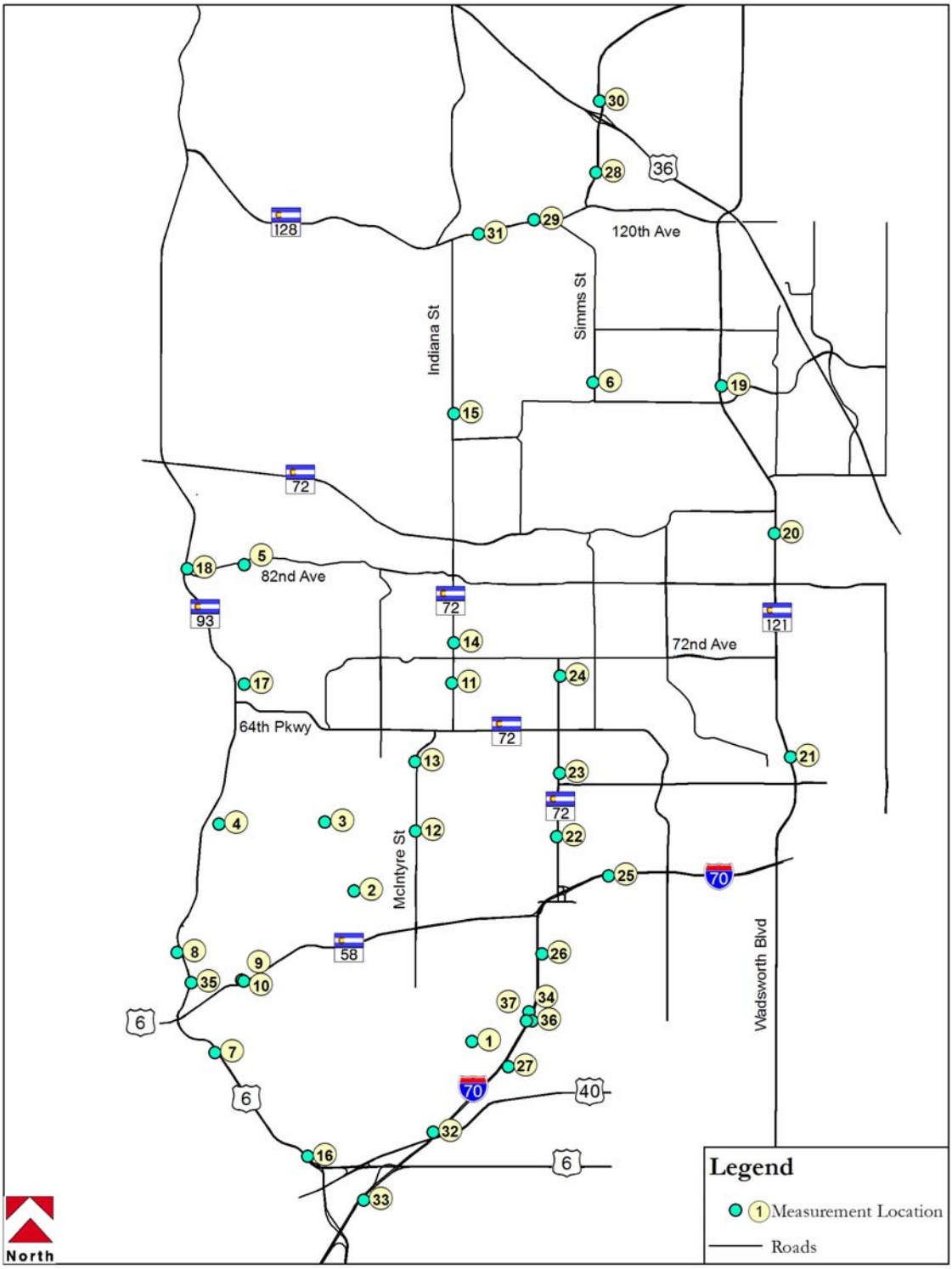
The measurements indicated that the existing traffic noise environment exceeded the applicable CDOT NAC at some locations in the study area. These included residences near US 6 in Golden and residences along I-70 in Lakewood (see **Table 4.7-2**).

Figure 4.7-3 24-Hour Noise Measurement Data



Source: FHU field data, 2004.

Figure 4.7-4 Noise Measurement Locations



Source: Compiled by FHU, 2006.

Table 4.7-2 Noise Measurement Results

Location Number	Location	L_{eq} (dBA)	Land Use Category	CDOT NAC (dBA)
1	South Table Mountain Open Space near Old Quarry Road	51	D	—
2	Near 4700 block Easly Road	44	D	—
3	South Table Mountain Open Space near 53rd Avenue	44	D	—
4	North Table Mountain Open Space	52	D	—
5	Pattridge Park Open Space	60	D	—
6	Colorado Hills Open Space at 103rd Avenue	57	D	—
7	1800 block Parfet Estates	66[a]	B	66
8	400 block Snowberry Court	59	D	—
9	300 block Lily Lane	57	B	66
10	Lily Lane at SH 58	62	B	66
11	69th Avenue and Indiana Street	63	D	—
12	52nd Avenue and McIntyre Street	62	D	—
13	60th Avenue and McIntyre Street	62	B	66
14	74th Drive and Indiana Street	66	D	—
15	Indiana Street at Woman Creek	68	D	—
16	100 Jefferson County Parkway	70	C	71
17	Arvada Reservoir Open Space	46	D	—
18	State Highway 93 and 82nd Avenue	64	D	—
19	Wadsworth Boulevard and 102nd Avenue	60	C	71
20	Wadsworth Boulevard and 87th Drive	70[a]	B	66
21	Wadsworth Boulevard and 61st Avenue	74[a]	B	66
22	Ward Road and 52nd Avenue	66	D	—
23	5800 block Ward Road (church)	68[a]	B	66
24	Ward Road and 70th Avenue	63	B	66
25	4700 block Robb Street	71	D	—
26	3800 block Youngfield Street (church)	67	B	66
27	Applewood Park	64	B	66
28	Near Camden Apartments	64	B	66
29	Omni Interlocken golf course	65	B	66
30	StorageTek Drive	61	D	—
31	120th Avenue	70	D	—
32	900 block Kendrick Street	60	B	66
33	Near 16700 block W. 1st Avenue	76	D	—
34	Near 13000 block W. 27th Lane	60	B	66
35	Mitchell Elementary School, 201 Rubey Drive	63	B	66
36	26th Avenue and I-70 (east side)	64	B	66
37	26th Avenue and I-70 (west side)	65	B	66

Note: [a] Value meets or exceeds applicable NAC.

Source: FHU field data, 2004–2006.

4.7.1.4 NOISE MODEL RESULTS

A noise model was constructed, as described above, to evaluate existing conditions on a broader basis than allowed by the measurements alone. The traffic model used the major existing roads that could be affected by the build alternatives, with existing (2004) traffic volumes and road layouts. About 980 noise receivers were modeled (see **Appendix A**). Thirty-nine of the model receivers were calculated to have existing traffic noise above the respective NAC during either the AM or PM peak hours (see **Figure 4.7-5**). All of these were Category B properties (homes and parks). The residential areas impacted were:

- Twenty homes in 6th Avenue West Estates
- Five homes in the Golden Terrace Mobile Home Park
- One home in Parfet Estates
- Five homes and two apartment buildings in Golden/Mesa Meadows
- Seven homes in Cameo Estates

The ball field at the Colorado School of Mines was also estimated to have traffic noise levels above the CDOT NAC for Category B. No commercial receivers were estimated to exceed the CDOT Category C NAC.

The farthest distance from a model road to a receiver impacted by traffic noise was approximately 400 feet from I-70 and approximately 150 feet from the other study area roads.

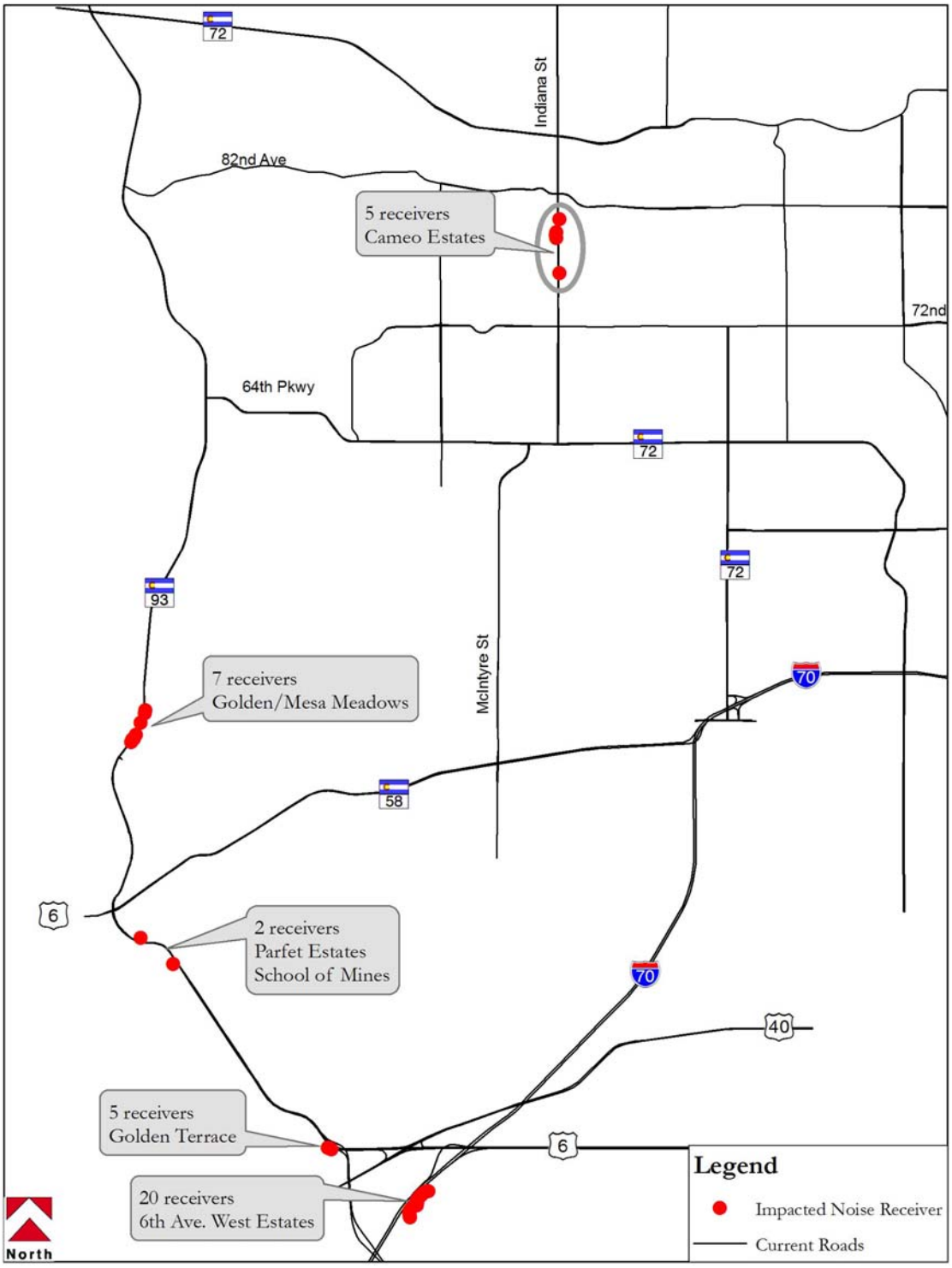
The existing conditions model results agree with the measurement results in that several Category B areas currently meet or exceed the CDOT NAC and were therefore impacted. The impacted areas are summarized (see **Figure 4.7-5**).

4.7.1.5 VIBRATION

Studies assessing the impact of operational traffic-induced vibrations have shown that both measured and predicted vibration levels are less than any known criteria for structural damage to buildings (FHWA, 1995). Often, normal indoor activities like closing doors have been shown to create greater levels of vibration than highway traffic. As such, vibration from highway traffic was not a concern in this study and will not be examined further in this analysis.

Vibration from road construction could be a concern if specific construction techniques such as pile driving or blasting are used. Concerns about construction-generated vibrations would depend on the types of activities occurring close to vibration-sensitive locations. At present, it is not expected that these types of construction techniques will be necessary for the build alternatives, let alone occur near occupied properties. If such techniques are necessary at a specific location, the vibration concerns can be addressed on a case-by-case basis and appropriate mitigation action taken.

Figure 4.7-5 Noise Impacted Areas from Existing Conditions Model



Source: Compiled by FHU, 2006.

4.7.2 Environmental Consequences

The traffic noise modeling effort for the alternatives was conducted to assess whether future noise levels near the alternative alignments would exceed the relevant CDOT NAC or cause a substantial noise increase. Either of these conditions would represent a traffic noise impact. When impacts were predicted, potential noise mitigation measures were considered and evaluated following CDOT guidelines.

Noise models were constructed and traffic model runs were made for the major project roads in the study area, using predicted (2030) traffic volumes and road layouts. The model noise results are presented below and the impacts are summarized (see **Section 4.7.4** and **Appendix A**).

4.7.2.1 No Action Alternative–2030 Noise Model Results

Model results for the 2030 No Action Alternative were similar to the existing conditions results (see **Figure 4.7-6**). The traffic noise patterns were similar to existing conditions with the noise levels pushed out a bit farther from the roads due to increased traffic volumes, so that the impacted areas were slightly larger overall. The areas impacted under existing conditions were also impacted under this alternative. For the No Action Alternative, it was calculated that 56 Category B receivers and no Category C receivers in the study area would be impacted by traffic noise. The residential areas predicted to be impacted were:

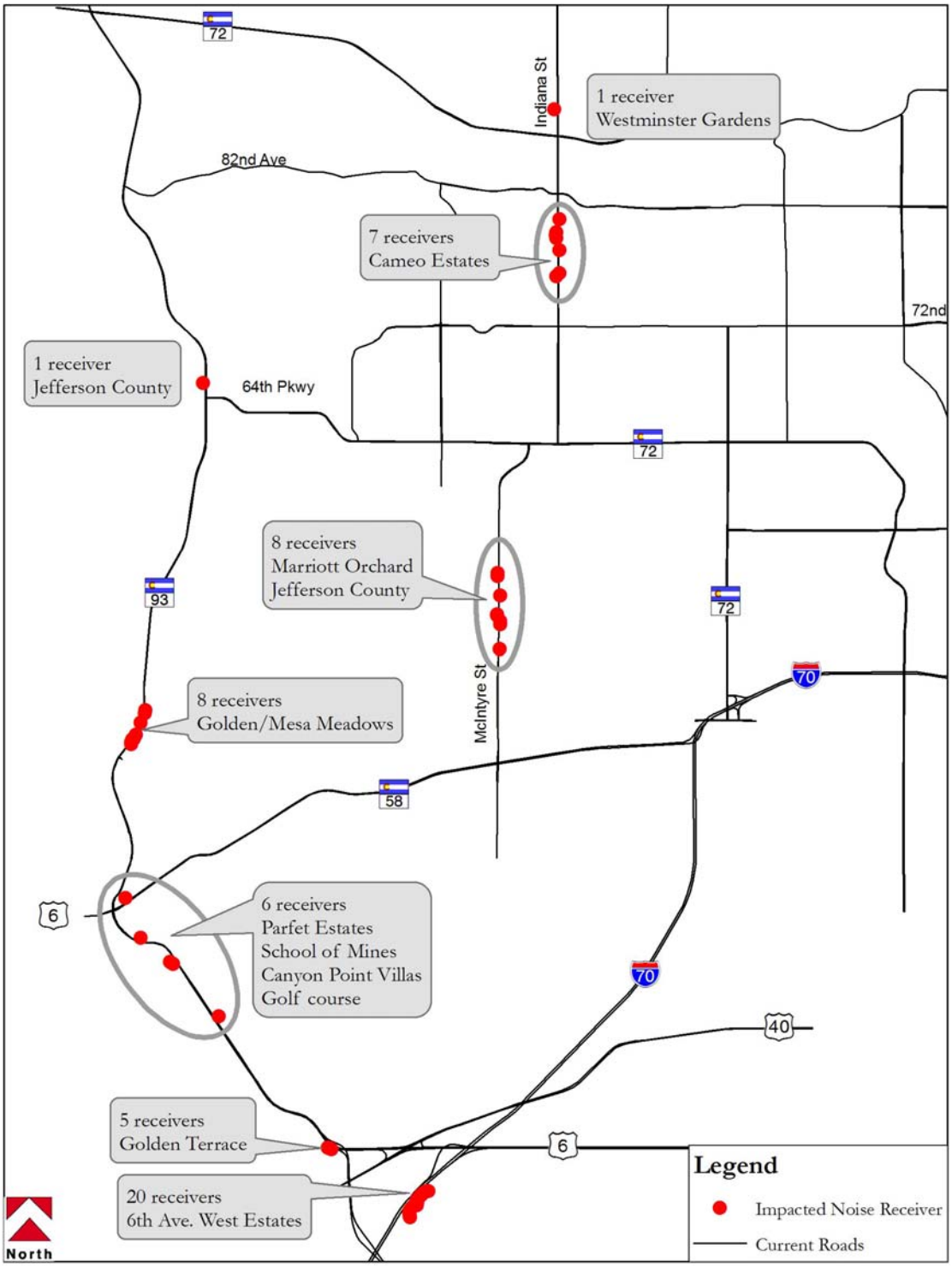
- One home in Jefferson County
- One home in Westminster Gardens
- Seven homes in Cameo Estates
- Eight homes in Marriott Orchard/Jefferson County
- Six homes and two apartment buildings in Golden/Mesa Meadows
- One home in Canyon Point Villas
- Three homes in Parfet Estates
- Five homes in the Golden Terrace Mobile Home Park
- Twenty homes in 6th Avenue West Estates

In addition, a ball field at the Colorado School of Mines and part of a golf course were predicted to have traffic noise levels above the CDOT NAC for Category B. No receivers were expected to experience a 10-dBA increase; the largest increase was predicted to be 5 dBA.

The No Action Alternative was predicted to impact the fewest receivers of the alternatives, primarily due to fewer vehicles traveling at lower speeds and producing less traffic noise.

The farthest distance from a model road to a receiver impacted by traffic noise was approximately 400 feet from I-70 and approximately 150 feet from the other study area roads.

Figure 4.7-6 Noise Impacted Areas from the 2030 No Action Alternative Model



Source: Compiled by FHU, 2006.

4.7.2.2 FREEWAY ALTERNATIVE–2030 NOISE MODEL RESULTS

For the Freeway Alternative, it was estimated that 276 Category B receivers and 19 Category C receivers in the study area would be impacted by traffic noise (see **Figure 4.7-7**). Of these, 236 were predicted to exceed the NAC and 59 others were predicted to increase by 10 dBA or more over existing conditions without reaching the relevant NAC.

Model results for the 2030 Freeway Alternative share some similarities to the 2030 No Action model results, even with the proposed roadway changes, in that many of the same receivers were predicted to be impacted. However, the Freeway Alternative was predicted to impact more and different receivers due to new roads, higher traffic speeds, and greater traffic volumes. More receivers mainly along US 6 and SH 93 were predicted to be impacted primarily because of alignment adjustments to avoid Section 4(f) lands. The addition of overpasses at Iowa Street and Washington Avenue largely contributed to the change in receivers that are impacted. Changes in the alternatives as a result of Section 4(f) avoidance are described (see **Section 2.3.4.2**). The residential areas predicted to be impacted with the Freeway Alternative were:

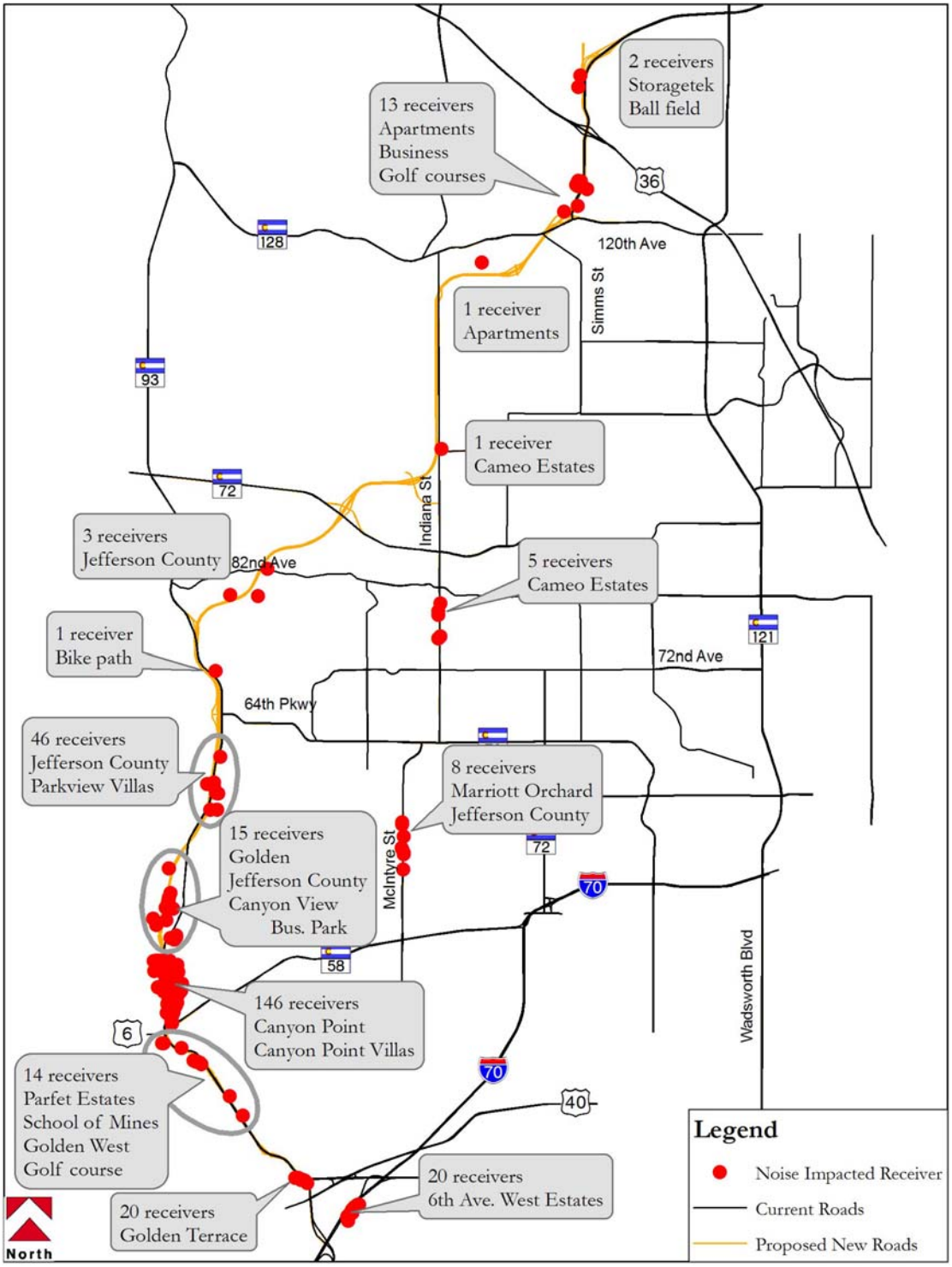
- Ten apartment buildings in Broomfield
- One apartment building in Jefferson County near SH 128
- Six homes in Cameo Estates
- Eight homes in Marriott Orchard/Jefferson County
- Nine homes in Jefferson County along SH 93
- Approximately 40 future homes in Parkview Villas along SH 93 (under construction)
- Five homes in North Golden
- One hundred thirty-nine receivers in Canyon Point and Canyon Point Villas
- Two receivers in Golden West Condos
- Nine homes in Parfet Estates
- One home along US 6
- Twenty homes in the Golden Terrace Mobile Home Park
- Twenty homes in 6th Avenue West Estates

In addition, a ball field at the Colorado School of Mines, parts of three golf courses, part of a bike path, and a ball field at Sun Microsystems were predicted to be impacted by traffic noise. Seven businesses in Canyon Point, seven in the Canyon View Business Park, three in Jefferson County, and two in Broomfield were predicted to be impacted by traffic noise.

The farthest distance from a model road to an impacted receiver was approximately 700 feet, due to a calculated 10 dBA increase in noise. It should be noted that the receivers in the Mesa Meadows and Westminster Meadows areas were not impacted by the Freeway Alternative, though they were under the No Action Alternative.

The Freeway Alternative was predicted to impact the most receivers of all the alternatives. This was primarily because it results in the most vehicles traveling at the highest speeds, thus producing more traffic noise.

Figure 4.7-7 Noise Impacted Areas from the 2030 Freeway Alternative Model



Source: Compiled by FHU, 2006.

4.7.2.3 TOLLWAY ALTERNATIVE–2030 NOISE MODEL RESULTS

For the Tollway Alternative, it was estimated that 118 Category B receivers and 10 Category C receivers in the study area would be impacted by traffic noise (see **Figure 4.7-8**). Of these, 106 were predicted to exceed the NAC and 22 others were predicted to increase by 10 dBA or more over existing conditions without reaching the relevant NAC.

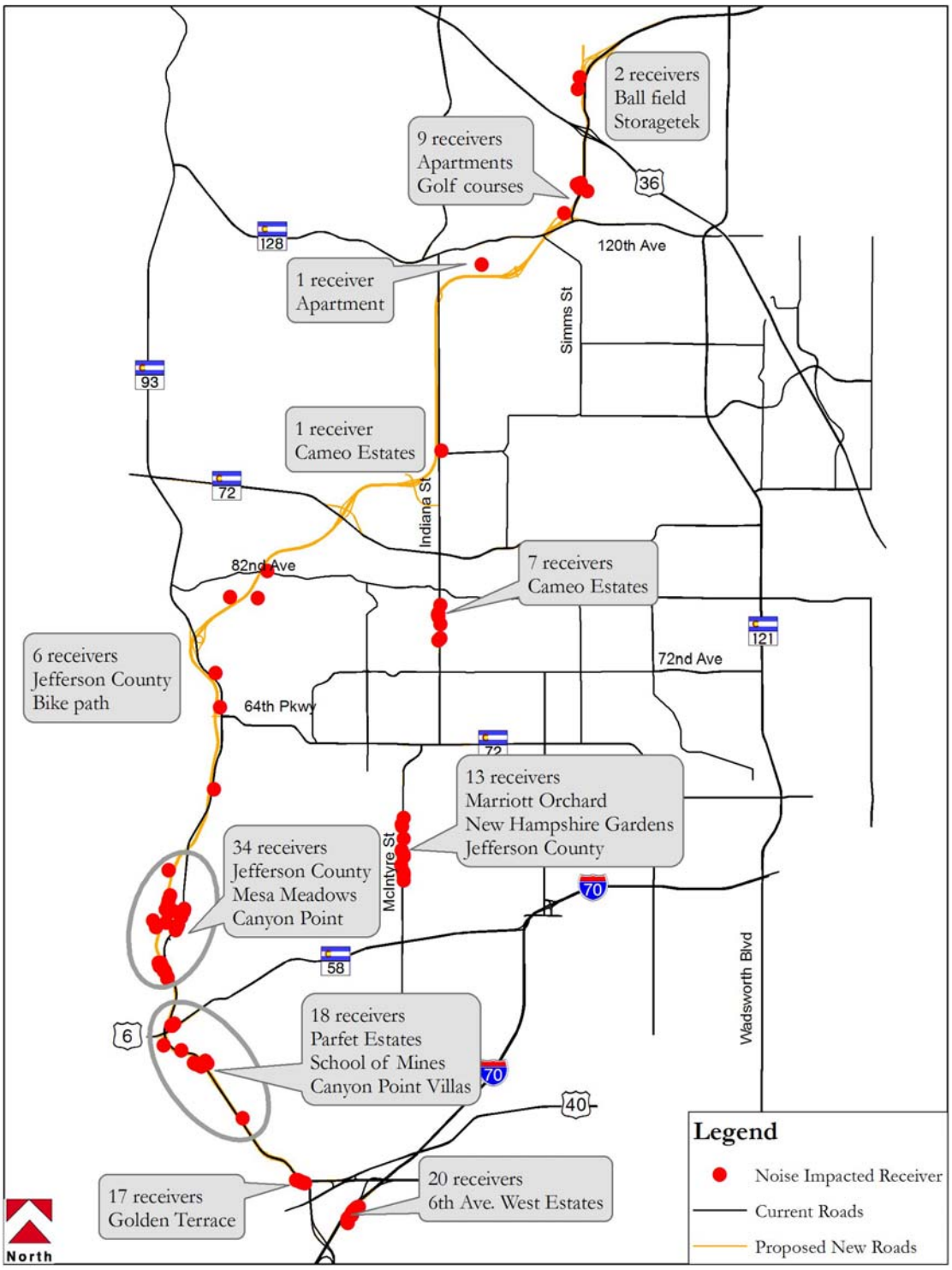
Model results for the 2030 Tollway Alternative were similar to the 2030 No Action model results, even with the proposed roadway changes. However, the Tollway Alternative was predicted to impact more and different receivers due to new roads, higher traffic speeds, and greater traffic volumes. More receivers mainly along US 6 and SH 93 were predicted to be impacted due to minor alignment shifts in an effort to avoid Section 4(f) lands. Section 4(f) avoidance was not achieved with the Tollway Alternative. Changes in the alternatives as a result of Section 4(f) avoidance are described (see **Section 2.3.4.2**). The areas predicted to be impacted were:

- Seven apartment buildings in Broomfield
- One apartment building along SH 128
- Eight homes in Cameo Estates
- Thirteen homes in Marriott Orchard/Jefferson County
- Six homes in Jefferson County along SH 93
- Six homes and two apartment buildings in Golden/Mesa Meadows
- Sixteen homes in Canyon Point
- Three homes in Canyon Point Villas
- One building in Golden West Condos
- Three Colorado School of Mines residences
- Nine homes in Parfet Estates
- One home along US 6
- Seventeen homes in the Golden Terrace Mobile Home Park
- Twenty homes in 6th Avenue West Estates

In addition, a ball field at the Colorado School of Mines, parts of two golf courses, part of a bike path, and a ball field at Sun Microsystems were predicted to be impacted by traffic noise. Ten businesses in Jefferson County and Broomfield were predicted to be impacted by traffic noise.

The farthest distance from a model road to an impacted receiver was approximately 700 feet, due to a calculated 10 dBA increase in noise. It should be noted that the receivers in the Mesa Meadows area were impacted by the Tollway Alternative, as they were under the No Action Alternative.

Figure 4.7-8 Noise Impacted Areas from the 2030 Tollway Alternative Model



Source: Compiled by FHU, 2006.

4.7.2.4 REGIONAL ARTERIAL ALTERNATIVE–2030 NOISE MODEL RESULTS

For the Regional Arterial Alternative, it was estimated that 104 Category B receivers and 20 Category C receivers in the study area would be impacted by traffic noise (see **Figure 4.7-9**). Of these, 81 were predicted to exceed the NAC and 43 others were predicted to increase by 10 dBA or more over existing conditions without reaching the relevant NAC.

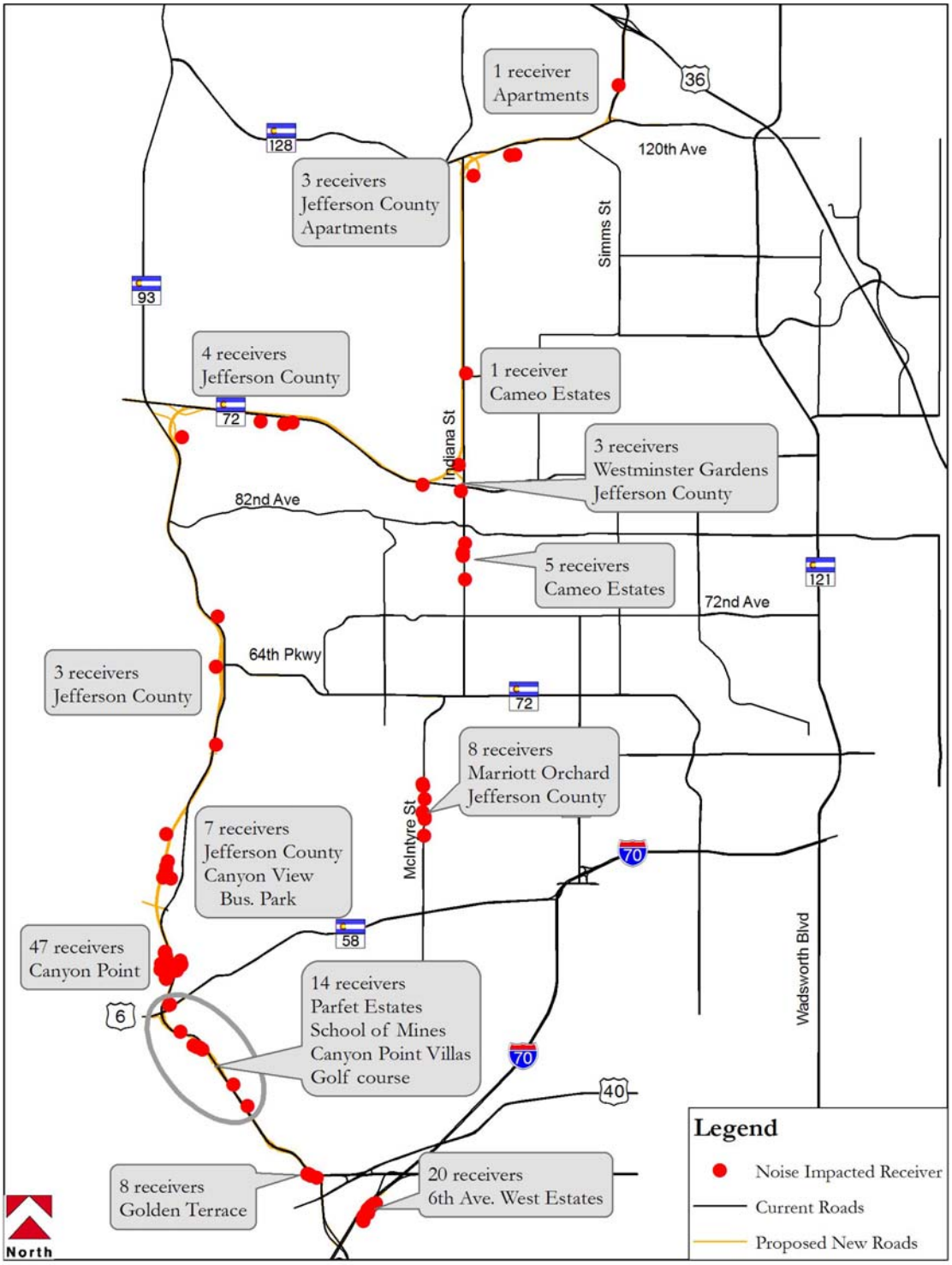
Model results for the 2030 Regional Arterial Alternative share some similarities with the 2030 No Action model results, even with the proposed roadway changes, in that many of the same receivers were predicted to be impacted. However, the Regional Arterial Alternative was predicted to impact more and different receivers due to higher traffic speeds, new roads, and greater traffic volumes. More receivers mainly along US 6 and SH 93 were predicted to be impacted primarily because of alignment adjustments to avoid Section 4(f) lands. The addition of an overpass at Iowa Street largely contributes to the change in receivers that are impacted. Changes in the alternatives as a result of Section 4(f) avoidance are described (see **Section 2.3.4.2**). The residential areas predicted to be impacted were:

- Three apartment buildings in Broomfield
- One home in Jefferson County along SH 128
- One home in Jefferson County along SH 72
- Two homes in Westminster Gardens
- Six homes in Cameo Estates
- Eight homes in Marriott Orchard/Jefferson County
- Three homes in Jefferson County along SH 93
- Forty-seven homes in Canyon Point
- Two homes in Canyon Point Villas
- Nine homes in Parfet Estates
- One home along US 6
- Eight homes in the Golden Terrace Mobile Home Park
- Twenty homes in 6th Avenue West Estates

In addition, a ball field at the Colorado School of Mines, part of a bike path, and part of a golf course were predicted to be impacted by traffic noise. Ten businesses in Jefferson County were predicted to be impacted by traffic noise.

The farthest distance from a model road to an impacted receiver was approximately 600 feet, due to a calculated 10 dBA increase in noise. It should be noted that the receivers in the Mesa Meadows area were not impacted under the Regional Arterial Alternative, though they were under the No Action Alternative.

Figure 4.7-9 Noise Impacted Areas from the 2030 Regional Arterial Alternative Model



Source: Compiled by FHU, 2006.

4.7.2.5 COMBINED ALTERNATIVE (RECOMMENDED ALTERNATIVE)–2030 NOISE MODEL RESULTS

For the Combined Alternative (Recommended Alternative), it was estimated that 133 Category B receivers and 14 Category C receivers in the study area would be impacted by traffic noise (see **Figure 4.7-10**). Of these, 108 were predicted to exceed the NAC and 39 others were predicted to increase by 10 dBA or more over existing conditions without reaching the relevant NAC.

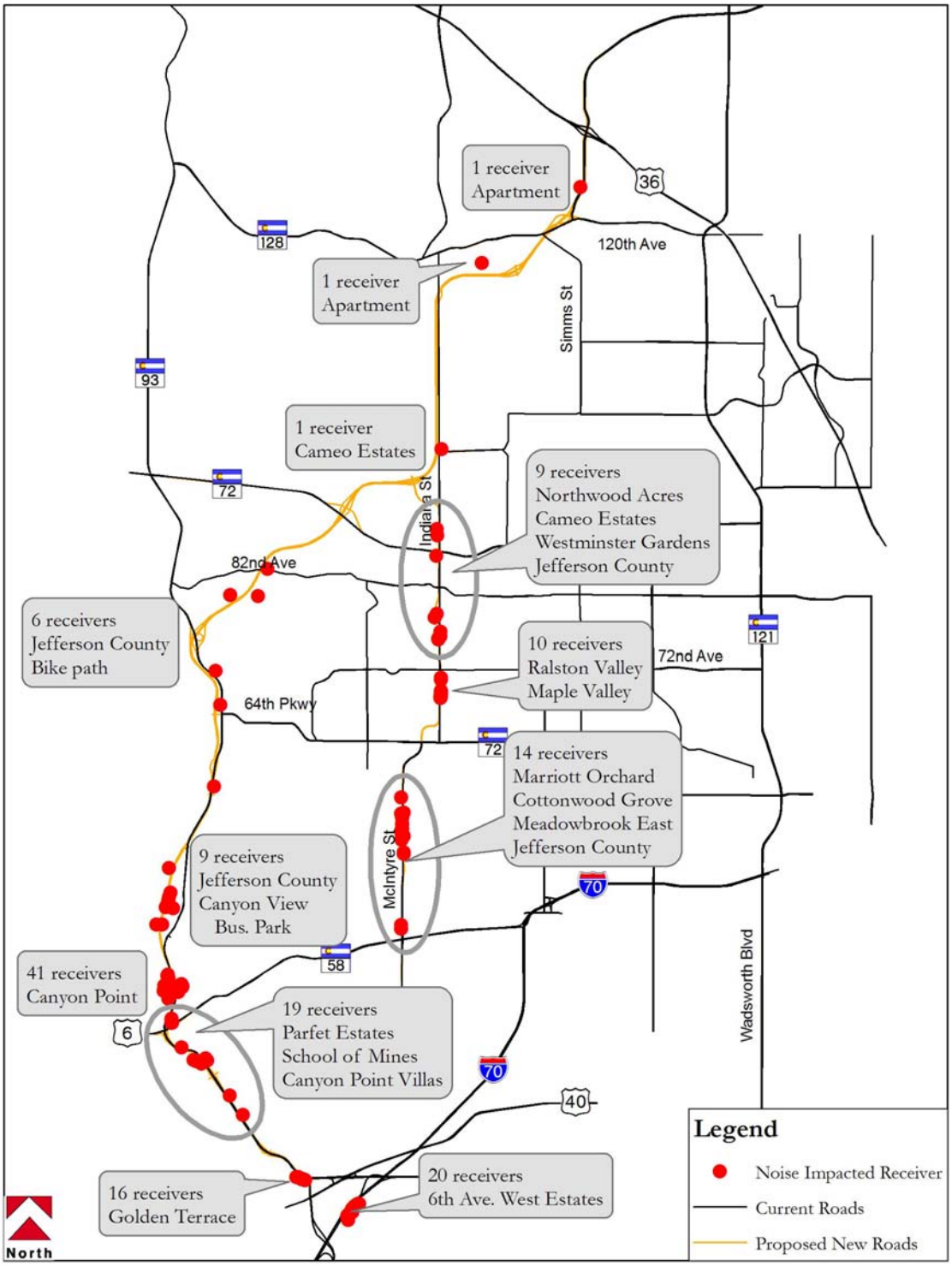
Model results for the 2030 Combined Alternative (Recommended Alternative) were similar to the 2030 No Action model results, even with the proposed roadway changes. In both cases, the same receivers in 6th Avenue West Estates were predicted to be impacted. However, the Combined Alternative (Recommended Alternative) was predicted to impact more and different receivers due to new roads, higher traffic speeds, and greater traffic volumes. More receivers mainly along US 6 and SH 93 were predicted to be impacted primarily because of alignment adjustments to avoid Section 4(f) lands. The addition of an overpass at Iowa Street largely contributes to the change in receivers that are impacted. Changes in the alternatives as a result of Section 4(f) avoidance are described (see **Section 2.3.4.2**). The residential areas impacted were:

- One apartment building in Broomfield
- One apartment building along SH 128
- Ten homes in Northwood Acres/Cameo Estates/Westminster Gardens/Jefferson County
- Ten homes in Ralston Valley/Maple Valley
- Ten homes in Marriott Orchard/Cottonwood Grove/Meadowbrook East/Jefferson County
- Four homes in Jefferson County along SH 93
- Forty-one homes in Canyon Point.
- Four homes in Canyon Point Villas
- Three Colorado School of Mines residences
- Nine homes in Parfet Estates
- One home along US 6
- Sixteen homes in the Golden Terrace Mobile Home Park
- Twenty homes in 6th Avenue West Estates

In addition, a ball field at the Colorado School of Mines, part of a golf course, and part of a bike path, were predicted to be impacted by traffic noise. Four businesses along McIntyre Street and 10 in Jefferson County were predicted to be impacted by traffic noise.

The farthest distance from a model road to an impacted receiver was approximately 600 feet, due to a calculated 10 dBA increase in noise. It should be noted that the receivers in the Mesa Meadows area were not impacted by the Combined Alternative (Recommended Alternative), though they were under the No Action Alternative.

Figure 4.7-10 Noise Impacted Areas from the 2030 Combined Alternative (Recommended Alternative) Model



Source: Compiled by FHU, 2006.

4.7.2.6 CONSTRUCTION NOISE

Adjoining properties in the project area could be exposed to noise from road construction activities associated with the build alternatives. Construction noise differs from traffic noise in several ways:

- Construction noise lasts only for the duration of the construction event, with most construction activities in noise-sensitive areas being conducted during hours that are least disturbing to adjacent and nearby residents.
- Construction activities generally are of a short-term nature and, depending on the nature of the construction operations, could last from seconds (e.g., a truck passing a receiver) to months (e.g., constructing a bridge).
- Construction noise is intermittent and depends on the type of operation, location, and function of the equipment, and the equipment usage cycle.

Construction noise is not assessed like operational traffic noise; there are no CDOT NACs for construction noise. Construction noise would be subject to relevant local regulations and ordinances, and any construction activities would be expected to comply with them.

4.7.3 SUGGESTED MITIGATION

The results from noise measurements and modeling indicate that several receivers will be impacted by traffic noise from each of the build alternatives. Therefore, traffic noise reduction actions for the impacted areas were investigated. It is important to note that impacted areas are not guaranteed mitigation measures, but mitigation measures for them were evaluated and suggested.

Traffic noise impacts from the alternatives affected multiple geographic areas and multiple land uses. Several types of mitigation were considered. Noise barriers are a common mitigation action and were evaluated, but other kinds of mitigation were also considered. The overall feasibility and reasonableness of noise reduction actions that provide a minimum acceptable mitigation benefit for the impacted receivers were evaluated and these actions were then either recommended or not.

For reasons described below, barriers appeared to be the only viable mitigation action and were the only mitigation evaluated through modeling. In general, CDOT's goal for noise barriers is a reduction of 10 dBA with a minimum reduction of 5 dBA.

4.7.3.1 NON-BARRIER MITIGATION EVALUATION

Traffic management measures such as lane closures or reduced speeds could reduce noise but do not appear to be reasonable for the roads of primary interest to the project. One of the reasons for the road improvements in the study area is to enhance intra-regional and inter-regional traffic flow. Closing lanes would be counterproductive. The improvements would also elevate the classification of some roads in the project area. While reducing vehicle speeds could reduce traffic noise, it would not be consistent with the function of these kinds of roads.

Changes in horizontal alignments of the roads near the impacted receivers could reduce noise but have limited possibilities in the alternative alignments. Many of the impacted Category B receivers are in areas that are fully developed. Therefore, possible horizontal realignments are limited by the developed land adjacent to the alternative alignments. Some road realignments were incorporated into the alternatives. For example, the SH 93 corridor north of Golden Gate Canyon Road is proposed to be realigned to the west of its current location. This realignment would have the benefit of reducing traffic noise for several currently impacted receivers in the Mesa Meadows area. However, this realignment would displace several buildings and would cause several receivers in Jefferson County not currently impacted by traffic noise to become impacted, so there is not a simple realignment solution to most of the traffic noise impacts. Moving the roads horizontally away from some impacted receivers could reduce traffic noise in those areas but could transfer the impacts to

other neighboring areas or require disruptions of adjoining property uses. The proposed horizontal alignments were already carefully considered in the design process to minimize overall impacts and meet operational needs. In the less developed areas in the northwest portion of the study area where realignment would be easier, there are few receivers nearby to warrant realignment.

Changes in vertical alignments could reduce noise. Some changes in vertical alignments were included for some parts of some alternatives in the study area. For example, it would be necessary in the Tollway Alternative and the Combined Alternative (Recommended Alternative), to grade-separate the toll lanes from local roads in many locations. In other cases, it would be necessary to grade-separate existing intersections to accommodate a higher road classification, such as the US 6/SH 93/SH 58 intersection. In many cases, the planned grade-separation is below ground, which generally serves to reduce traffic noise impacts. In other cases, the grade-separation involves elevated structures. However, elevated structures alone do not necessarily mean greater traffic noise impacts, Sometimes, the elevation difference serves to cut the line of sight to traffic and thereby reduce traffic noise. Sometimes, the elevation difference provides an opportunity where a shorter barrier may be needed to reduce traffic noise than an at-grade road. The outcome depends on the individual circumstances and cannot be accurately presented with broad generalizations. Public comments throughout the study have indicated some interest in using tunnels in some areas. A fully enclosing traffic tunnel could certainly reduce traffic noise at adjoining properties, but an overriding constraint in changing the vertical alignments is that the project roads must tie into the connecting roads in a reasonable manner. Wholesale changes in some road elevations could have secondary impacts on connecting roads that would not be reasonable or desirable. Therefore, vertical elevation changes were evaluated and included to some extent in the build alternatives, but additional vertical realignment opportunities were not believed to reduce traffic noise without increased access impacts.

Noise buffer zones could reduce noise. Near the impacted receivers, there generally is little available undeveloped land along the project roads that could be used for a noise buffer zone or a vegetative planting area that would provide substantial noise benefit. Often, the past development has been purposely near the roads for access, which left little or no space for a buffer. It should be noted that none of the privately owned buildings were calculated to be so severely impacted by traffic noise that noise insulation measures were justified.

Pavement types and surfaces can affect traffic noise. Quieter pavement types would be preferred for the project when minimum requirements for safety, durability, and so on, are also met. However, this cannot be counted as a mitigation action under the noise reduction evaluation because it is not "permanent". Research efforts to learn more about the long-term noise benefits of different pavement types and surface treatments are ongoing.

4.7.3.2 Noise Barrier Evaluations

To permit the evaluation of potential noise barriers, computer models of barriers protecting the impacted areas were developed and the models were re-run to assess barrier effectiveness (see **Northwest Corridor Supporting Document-Noise Impact Assessment**). Each potential barrier was assessed for effectiveness and feasibility. If the minimum parameters for an effective barrier were met and the barrier was feasible, it was processed through a reasonability assessment according to CDOT guidance (CDOT, 2002). The feasibility and reasonableness of each barrier determined whether or not the barrier was recommended for the project.

The general locations evaluated for noise barrier placement are shown below (see **Figure 4.7-11**). The normal barrier locations were on CDOT right-of-way, but off right-of-way locations were also evaluated where physical conditions warranted additional investigation (see **Northwest Corridor Supporting Document-Noise Impact Assessment**). In instances where only part of a neighborhood was impacted by noise, barriers benefiting the entire neighborhood were also evaluated for thoroughness. Each of these various barriers were assessed for feasibility and reasonableness (CDOT, 2002) and barrier recommendations were made based on these findings.

It is important to note that the noise barriers could be either earth berms or constructed walls. Either material could be effective. Berms can be more effective than walls but require considerably more space. Throughout the study area, the impacted receivers tend to be rather close to the project roads. Often, either the road or the receivers may be considerably higher in elevation than the other. In many of these places, the minimum effective barrier might be rather tall (15–25 feet). This combination of constraints usually makes earth berms impractical or impossible choices for noise barriers. Barriers more than 25 feet tall were not considered due to impracticality.

Some areas are impacted by traffic noise for multiple alternatives. However, the road designs for the alternatives may be different enough that completely different noise barriers are necessary for each alternative. Therefore, a barrier for a given area may be feasible and reasonable for one alternative but not others.

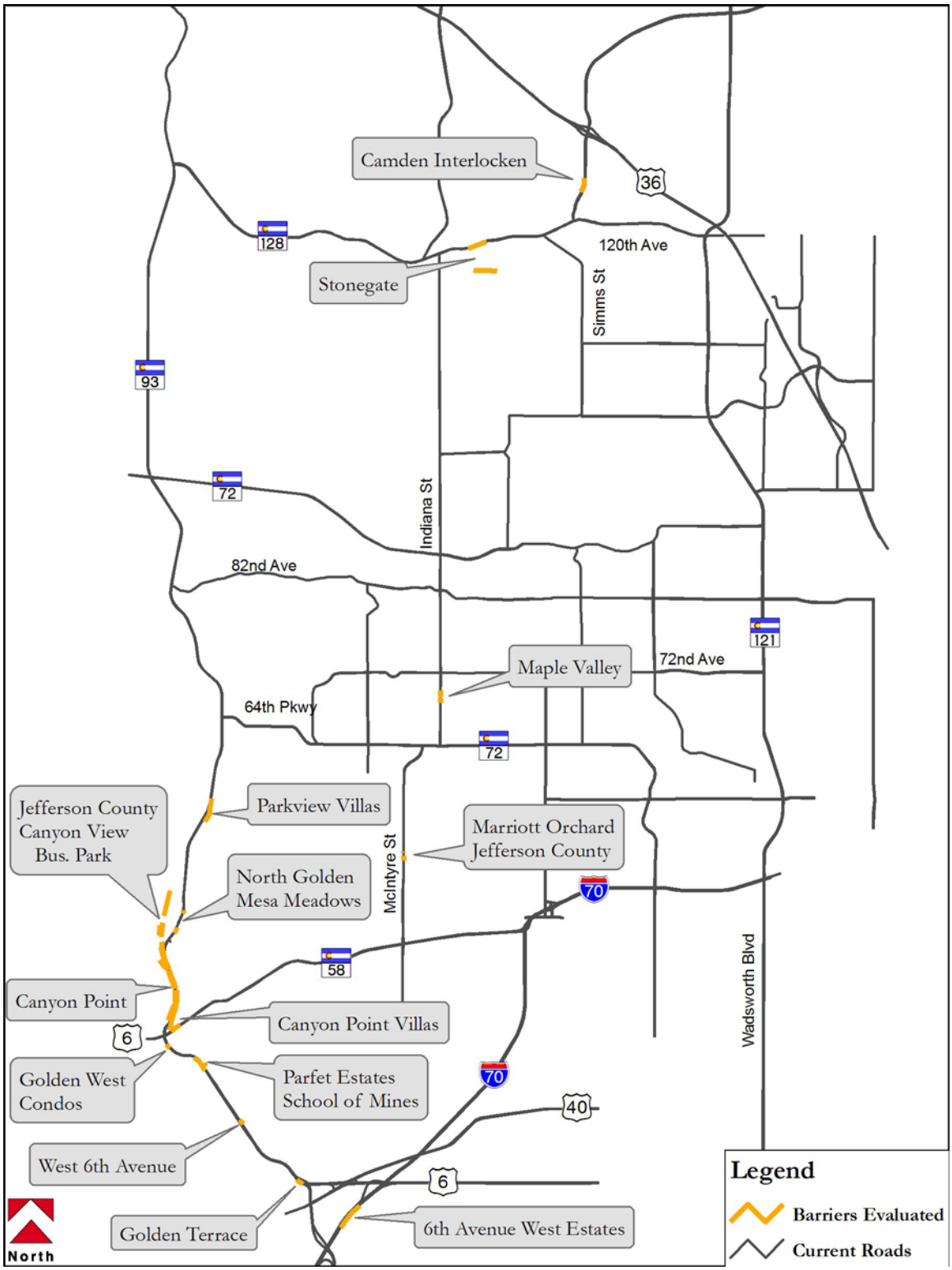
The topography of the alternative alignments plays a very important role in the overall noise environment. There are some dramatic topographic changes between the project roads and the adjoining properties throughout the study area, and this has an impact on the effectiveness and constructability of noise barriers.

Physical placement of the barriers is also a consideration. The preferred location is on CDOT right-of-way for several reasons. In many places in the study area, the land adjoining CDOT right-of-way may be generally incompatible to use for noise mitigation measures. Also, there would be long-term ownership, access, maintenance, and cost concerns for CDOT if a mitigation measure needed to be on someone else's property or if more property needed to be acquired for noise mitigation but was not needed for road right-of-way. Nevertheless, placement of traffic noise barriers off CDOT right-of-way may be possible and several such barriers were considered for this study (see **Northwest Corridor Supporting Document-Noise Impact Assessment**).

Results from the traffic noise mitigation evaluations for barriers located on CDOT property are summarized below. Noise barrier placements off CDOT right-of-way, especially where barriers on the right-of-way are found not to be effective, could be further considered in the future.

CDOT guidelines state that for a traffic noise mitigation action to be reasonable, the cost-benefit should be no more than $4,000/receiver/decibel of noise reduction (CDOT, 2002). Values higher than that are deemed unreasonable; however, cost-benefit is not the only consideration for reasonableness (CDOT, 2002). Isolated receivers (e.g., dispersed homes) are a special case worth noting in this context. For a wall protecting a single receiver to be reasonable, the barrier could be no more than about 670 square feet if it reduces noise by 5 dBA or no more than about 1,300 square feet if it reduces noise by 10 dBA, assuming $30/square foot of barrier. It is a rare situation where barriers of those small sizes provide that much noise reduction. Therefore, it is usually not reasonable to construct barriers for isolated receivers. The traffic noise barriers that were evaluated for this study were assessed for feasibility and reasonableness (see **Table 4.7-3**).

Figure 4.7-11 Locations of Evaluated Noise Mitigation Barriers



Source: Compiled by FHU, 2006.

Table 4.7-3 Noise Mitigation Barrier Summary

Noise Impacted Area	Barrier Height (feet)	Barrier Length (feet)	Cost Analysis ($/dB/receiver)	Reduction (dBA)	Feasible?[1]	Reasonable?1	Recommended?	Comment
Category B								
Golden Terrace Mobile Home	25	590	5,000	3-9	Yes	Yes	Yes	Recommended for all build alternatives.
West 6th Avenue	8	400	19,000	5	Yes	No	No	Cost-benefit was calculated to be prohibitive.
Parfet Estates	14-25	1,200	9,200	4-9	Yes	No	No	Not recommended due to prohibitive cost-benefit, but should be reevaluated in a future study.
School of Mines	15	450	14,000	7	Yes	No	No	Cost-benefit was calculated to be prohibitive.
Golden West Condos	8	500	2,000	5	Yes	Yes	Yes	Recommended for the Freeway Alternative and Tollway Alternative.
Canyon Point Villas (south side)	N/A	N/A	N/A	<5	No	N/A	No	Could not achieve 5-dBA noise reduction.
Canyon Point Villas (west side)	20-45	1,400	16,500	0-8	Yes	No	No	Cost-benefit was calculated to be prohibitive.
Canyon Point (west of SH 93)	12-24	up to 5,400	up to 5,800	2-9	Yes	Yes	Yes	Recommended for all build alternatives (varies by alternative).
Canyon Point (east of SH 93)	15	850	3,300	3-11	Yes	Yes	Yes	Recommended for all build alternatives except the Tollway Alternative.
Golden (Jackson Street)	8-12	440	4,300	5-11	Yes	Yes	Yes	Recommended only for the Tollway Alternative.
Mesa Meadows	12	300	6,400	5-6	Yes	Yes	Yes	Recommended only for the Tollway Alternative.
Parkview Villas	8	1,750	1,000	7-12	Yes	Yes	Yes	Recommended only for the Freeway Alternative.
Maple Valley	12	850	4,500	4-8	Yes	Yes	Yes	Recommended only for the Combined Alternative (Recommended Alternative).
Marriott Orchard	12	290	5,000	4-9	Yes	No	No	Cost-benefit was calculated to be prohibitive.

Noise Impacted Area	Barrier Height (feet)	Barrier Length (feet)	Cost Analysis ($/dB/receiver)	Reduction (dBA)	Feasible?[1]	Reasonable?1	Recommended?	Comment
Jefferson County (McIntyre Street)	N/A	N/A	N/A	N/A	No	No	No	Barrier would block property access
Stonegate	N/A	N/A	N/A	<5	No	N/A	No	Could not achieve 5-dBA noise reduction.
Camden Interlocken	14-25	up to 1,900	1,500-4,700	6-10	Yes	Yes	Yes	Recommended for all build alternatives (varies by alternative).
6th Avenue West Estates	25	2,100	12,000	2-11	Yes	No	No	Cost-benefit was calculated to be prohibitive.
Isolated receiver	12	400	49,000	5	Yes	No	No	An example of an isolated receiver. Cost-benefit was calculated to be prohibitive.
Category C								
Commercial-1500 Brickyard Road	5	1,680	9,100	5	Yes	No	No	Freeway Alternative only. Cost-benefit was calculated to be prohibitive.

Source: FHU modeling results, 2006.

4.7.3.3 NOISE BARRIER RECOMMENDATIONS

Traffic noise barriers were assessed to be feasible and reasonable for the following locations and are therefore recommended for construction (see **Table 4.7-3**):

- Camden Interlocken for all build alternatives
- Maple Valley for the Combined Alternative (Recommended Alternative) only
- Parkview Villas area for the Freeway Alternative only
- Mesa Meadows area for the Tollway Alternative only
- Golden at Jackson/Virginia Streets for the Tollway Alternative only
- North side of Canyon Point for the Tollway Alternative only
- Canyon Point east of SH 93 for the Freeway Alternative, Regional Arterial Alternative, and Combined Alternative (Recommended Alternative)
- Canyon Point west of SH 93 for all build alternatives
- Golden West Condos for the Freeway Alternative and Tollway Alternative
- Golden Terrace Mobile Home Park for all build alternatives

The locations of the recommended noise barriers are illustrated (see **Figure 4.7-12** through **Figure 4.7-18**). The design requirements for noise barriers in a given location will vary by alternative. As an example, a barrier in the same location designed for the Freeway Alternative may be different than a barrier designed for the Regional Arterial Alternative.

It is also recommended that a noise barrier for the Parfet Estates neighborhood be thoroughly reexamined in a future study to assess whether a cost-effective barrier is available when the project design has been refined.

These recommendations are based on specific project road designs. The recommended barriers are all within the proposed right-of-way. If the final designs differ from the designs proposed in this study, the barriers in these evaluations may require corresponding adjustments to the mitigation evaluations. More details on the noise barriers can be found in the technical report (see **Northwest Corridor Supporting Document-Noise Impact Assessment**).

Figure 4.7-12 Recommended Noise Barrier near Camden Interlocken

Source: Compiled by FHU, 2006.

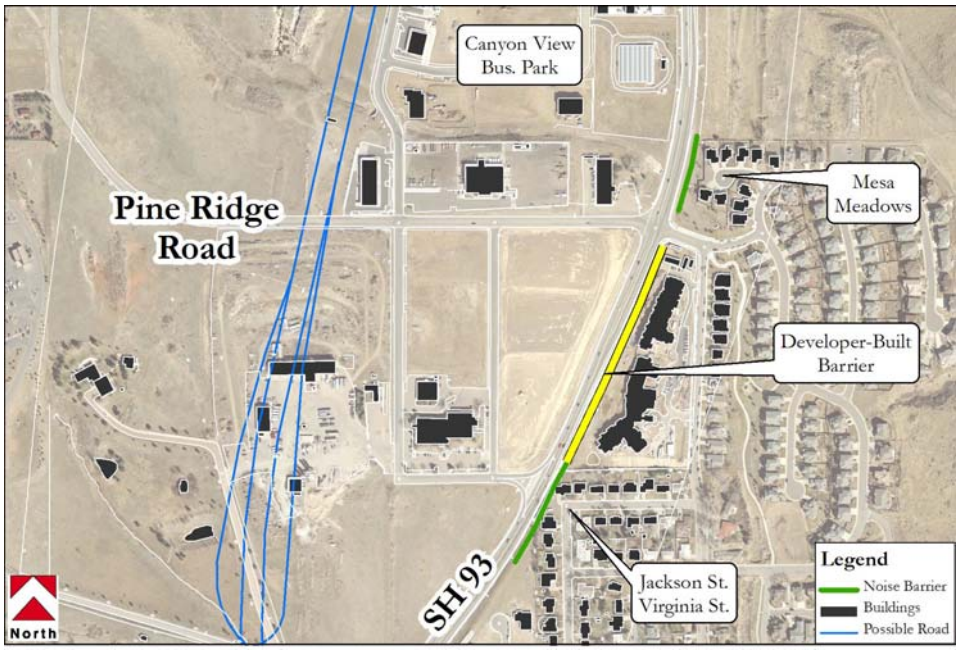
Figure 4.7-13 Recommended Noise Barriers near Maple Valley

Source: Compiled by FHU, 2006.

Figure 4.7-14 Recommended Noise Barrier near Parkview Villas

Source: Compiled by FHU, 2006.

Figure 4.7-15 Recommended Noise Barriers near North Golden/Mesa Meadows



Source: Compiled by FHU, 2006.

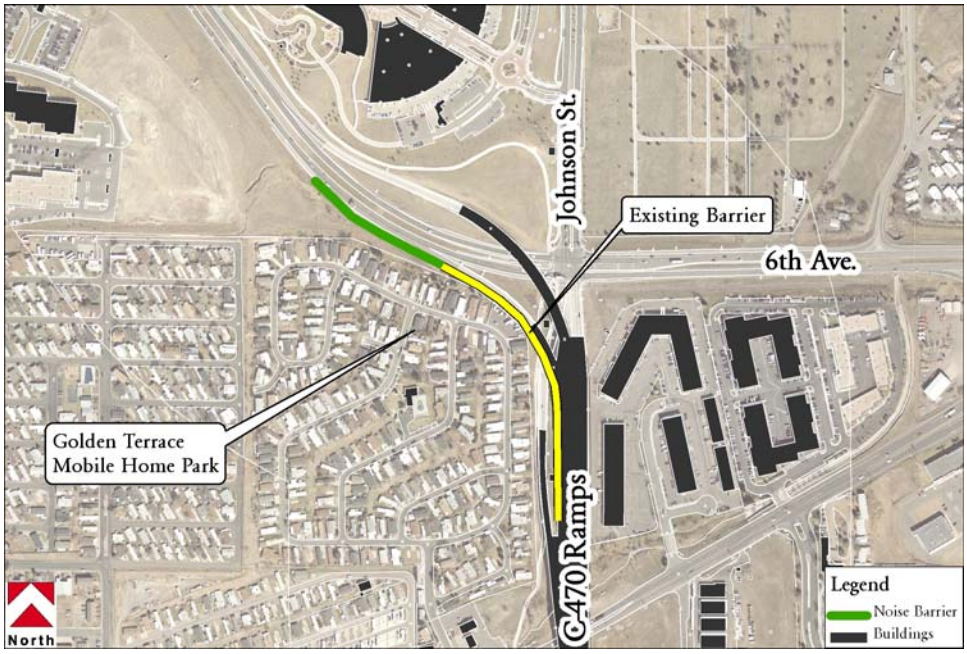
Figure 4.7-16 Recommended Noise Barriers near Canyon Point

Source: Compiled by FHU, 2006.

Figure 4.7-17 Recommended Noise Barrier near Golden West Condos

Source: Compiled by FHU, 2006.

Figure 4.7-18 Recommended Noise Barrier near Golden Terrance



Source: Compiled by FHU, 2006.

4.7.3.4 IMPACTED RECEIVERS AFTER RECOMMENDED MITIGATIONS

For a noise mitigation action to be recommended, it must be both feasible and reasonable according to CDOT evaluation guidelines. In many of the areas with noise impacts, effective noise barriers were not feasible or the cost-benefit value for an effective barrier was prohibitive (see **Table 4.7-3**). Therefore, not all impacted areas have been recommended for mitigation.

The recommended mitigation actions would serve to reduce traffic noise impacts for each of the build alternatives (see **Section 4.7.3**). The results differ among the alternatives for a number of reasons, including:

- different routes
- different road designs within the same route
- different traffic volumes and speeds
- different vertical road profiles

The recommended mitigation actions would not eliminate all of the calculated traffic noise impacts; some residual impacts would remain. These residual noise impacts are described below for each of the alternatives.

NO ACTION ALTERNATIVE

The No Action Alternative does not include any noise mitigation actions, so there would be no change from the traffic noise impacts (see **Section 4.7.2.1**). The same 56 Category B receivers would still be impacted by traffic noise.

FREEWAY ALTERNATIVE

The Freeway Alternative would include several recommended noise mitigation actions (see **Section 4.7.3.2**). The recommended mitigations would provide traffic noise reductions to these impacted receivers:

- Ten receivers in Camden Interlocken
- Fifty potential receivers in the Parkview Villas area (under construction)
- Ninety-one homes in Canyon Point
- Two receivers in Golden West Condos
- Fifteen homes in the Golden Terrace Mobile Home Park

The remaining areas, with an estimated 66 Category B receivers and 12 Category C receivers, would still be impacted by traffic noise.

TOLLWAY ALTERNATIVE

The Tollway Alternative would include several recommended noise mitigation actions (see **Section 4.7.3.2**). The recommended mitigations would provide traffic noise reductions to these impacted receivers:

- Seven receivers at Camden Interlocken
- Six homes at Golden/Mesa Meadows
- Eight homes in Canyon Point
- One receiver in Golden West Condos
- Fifteen homes in the Golden Terrace Mobile Home Park

The remaining areas, with an estimated 73 Category B receivers and 10 Category C receivers, would still be impacted by traffic noise.

REGIONAL ARTERIAL ALTERNATIVE

The Regional Arterial Alternative would include several recommended noise mitigation actions (see **Section 4.7.3.2**). The recommended mitigations would provide traffic noise reductions to these impacted receivers:

- One receiver at Camden Interlocken
- Forty-seven homes in Canyon Point
- Seven homes in the Golden Terrace Mobile Home Park

The remaining areas, with an estimated at 49 Category B receivers and 20 Category C receivers, would still be impacted by traffic noise.

COMBINED ALTERNATIVE (RECOMMENDED ALTERNATIVE)

The Combined Alternative (Recommended Alternative) would include several recommended noise mitigation actions (see **Section 4.7.3.2**). The recommended mitigations would provide traffic noise reductions to these impacted receivers:

- One receiver at Camden Interlocken
- Eight homes in Maple Valley
- Forty-one homes in Canyon Point
- Fourteen homes in the Golden Terrace Mobile Home Park

The remaining areas, with an estimated 76 Category B receivers and 14 Category C receivers, would still be impacted by traffic noise.

4.7.3.5 CONSTRUCTION NOISE

Construction noise impacts will be minimized somewhat because the majority of the alternative alignments do not abut residential areas. At locations where the alternative alignments do pass through residential areas, construction activities should comply with the relevant local noise regulations and ordinances. To address the temporary elevated noise levels that may be experienced during construction, standard mitigation measures should be incorporated into construction contracts, where it is feasible to do so. These would include:

- Exhaust systems on equipment in good working order. Equipment maintained on a regular basis, and subject to inspection by the project manager to ensure maintenance.
- Properly designed engine enclosures and intake silencers would be used where appropriate.
- New equipment subject to new product noise emission standards.
- Stationary equipment located as far from sensitive receivers as possible.
- Most construction activities in noise sensitive areas to be conducted during hours that are least disturbing to adjacent and nearby residents.

4.7.4 SUMMARY

A number of traffic noise impacts were predicted for each of the build alternatives most affecting residential areas in Golden and Broomfield (see **Section 4.7.2**). The predicted impacts were summarized and mitigation actions for these impacts were evaluated (see **Section 4.7.3.2** and **Table 4.7-4**). From the feasibility and reasonableness evaluations for the barriers, traffic noise barriers were recommended for the following locations (see **Section 4.7.3.3**):

- Camden Interlocken for all build alternatives
- Maple Valley for the Combined Alternative (Recommended Alternative) only
- Parkview Villas area for the Freeway Alternative only
- Mesa Meadows area for the Freeway Alternative and Tollway Alternative only
- Golden at Jackson/Virginia Streets for the Tollway Alternative only
- Canyon Point east of SH 93 for all of the build alternatives except the Tollway Alternative
- Canyon Point west of SH 93 for all build alternatives
- Golden West Condos for the Freeway Alternative and Tollway Alternative
- Golden Terrace Mobile Home Park for all build alternatives

These results are preliminary and based on specific project road designs. If the designs in the future differ from those used in these evaluations, corresponding adjustments to the traffic noise mitigation evaluations may be required. A more detailed traffic noise mitigation analysis with recommendations could be performed for future studies. Noise barrier placements off of CDOT right-of-way, especially where barriers on the right-of-way are found not to be effective, could also be further considered in future studies.

These recommended mitigation actions will not eliminate all the predicted traffic noise impacts, therefore, some residual noise impacts will remain (see **Section 4.7.3.4**).

Somewhat similar noise analysis results were produced by the build alternatives because the alignments share several existing roadways. There are not large differences in impacts between some alternatives. In the order of increasing noise impacts, the ranking of the alternatives are: No Action Alternative, Regional Arterial Alternative, Tollway Alternative, Combined Alternative (Recommended Alternative), and Freeway Alternative.

Table 4.7-4 Summary of Traffic Noise Impacts

Land Use Category	Number of Noise-Impacted Receivers (without mitigation)					
	Existing Conditions	2030 No Action Alternative	2030 Freeway Alternative	2030 Tollway Alternative	2030 Regional Arterial Alternative	2030 Combined Alternative Recommended Alternative)
B-residential	39	56	276	118	104	133
C-commercial	0	0	19	10	20	14

Source: Compiled by FHU, 2006.

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