4.13 NOISE

Summary

Existing noise levels in the United States Highway 36 (US 36) corridor were measured at 20 sites and generally range from 63 to 73 decibels (A-weighted scale) (dBA). The highest levels were measured at locations that are relatively close to the highway (within 200 feet), and that have unobstructed views of the highway (i.e., no existing sound wall or large commercial building blocking the view to the highway). Noise levels were predicted for the traffic and roadway conditions that would exist in the design year under each package being evaluated. Under Package 1, loudest-hour noise levels are expected to increase by only 1 dBA over existing conditions because no additional capacity would be added to the highway and the highway is already operating at capacity during peak hour traffic movements. Any additional traffic during rush hour would increase congestion, reduce speeds, and subsequently reduce noise levels.

Under Package 2, noise levels are predicted to range from an average of 65 dBA to a maximum of 77 dBA, which on average is an increase of 3 dBA over existing conditions. The increase in noise level is the result of additional traffic capacity, and the widening of the highway outward (toward residences) to accommodate the additional lanes in the median. Under Package 4, noise levels are predicted to range from an average of 66 dBA to a maximum of 77 dBA, which is an increase of 4 dBA over existing conditions. This slight difference is because the general-purpose lanes in Package 4 are projected to carry more traffic volume than Package 2. Under the Combined Alternative Package (Preferred Alternative), noise levels are predicted to range from an average of 64 dBA to a maximum of 75 dBA, which is an average increase of 2 dBA over existing noise levels.

The noise analysis was conducted according to Colorado Department of Transportation (CDOT) noise guidelines, which are set forth in the document entitled *Noise Analysis and Abatement Guidelines* (CDOT 2002). The CDOT noise guidelines are consistent with those of the Federal Highway Administration (FHWA) (23 Code of Federal Regulations [CFR] 772) and have been approved by the FHWA for use on federally aided projects in Colorado. Noise levels from the proposed project could be reduced through the application of sound walls. Walls were analyzed at each of the residential areas located in the corridor where noise levels are predicted to exceed CDOT's 66 dBA Noise Abatement Criteria. Walls were evaluated and found to meet CDOT requirements at the Madison Hill and Tuscany Trail developments north of 92nd Avenue in Westminster, the Rock Creek Apartments in Superior, and at the Moorhead and Apache Avenue/Pima Court neighborhoods north of Table Mesa Drive in Boulder. Also, there are a number of locations, particularly in the Adams Segment, where existing sound walls would need to be removed to accommodate the proposed highway improvements. These walls would be replaced, and the new walls would be designed to achieve between 5 and 10 dBA of noise reduction at the closest homes.

Noise must also be addressed during construction. Primarily, construction noise would need to adhere to local ordinances. Construction noise can be minimized by constructing the proposed sound walls as early in the construction process as possible, by avoiding nighttime work, and through the use of quiet methods where needed.

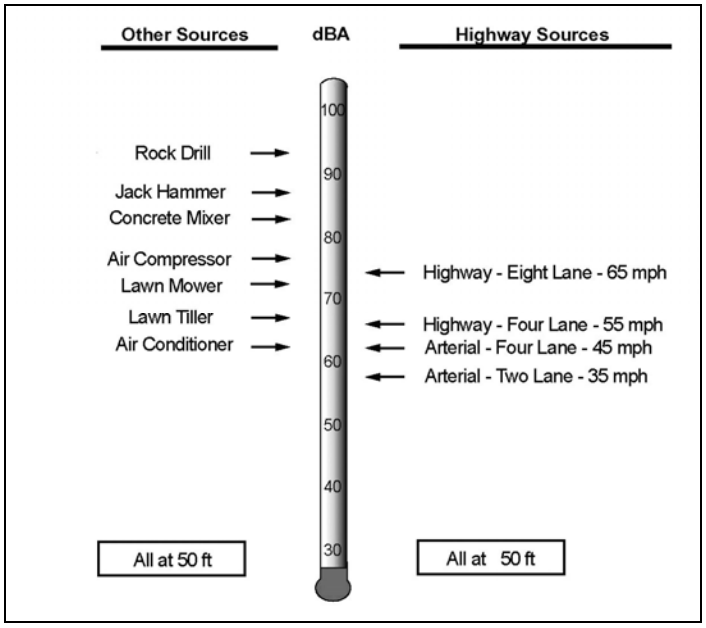
Noise Fundamentals and Descriptors

Noise is typically defined as unwanted or undesirable sound. The frequency content of noise is related to the tone or pitch of the sound, and is expressed based on the rate of the air pressure fluctuation in terms of cycles per second (called hertz [Hz]). The human ear can detect a wide range of frequencies from about 20 to 17,000 Hz. However, because the sensitivity of human hearing varies with frequency, an A-weighting system is commonly used when measuring environmental noise to provide a single number descriptor that correlates with human subjective response. Sound levels measured using this weighting system are called A-weighted sound levels, and are expressed in decibel (dB) notation as

Because the sensitivity of human hearing varies with frequency, an A-weighting system is commonly used when measuring environmental noise.

dBA. The "A-weighted" sound level is widely accepted by acousticians as a proper unit for describing environmental noise. To indicate what various noise levels represent, Figure 4.13-1, Typical A-Weighted Sound Levels, shows typical A-weighted sound levels for highway and other noise sources. As indicated in this figure, most commonly encountered outdoor noise sources generate noise levels within the range of 60 to 90 dBA at a distance of 50 feet.

Figure 4.13-1: Typical A-Weighted Sound Levels

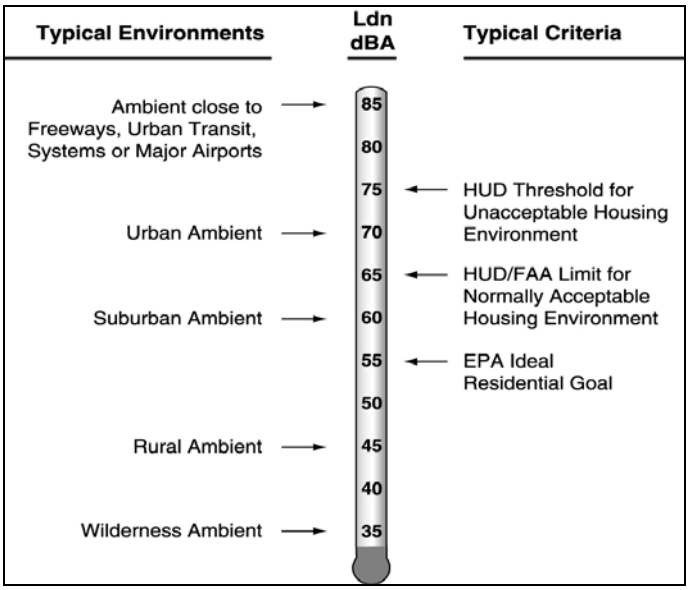


Source: FTA, 2006.

Because environmental noise fluctuates from moment to moment, it is common practice to condense all of this information into a single number. One such quantity is called the equivalent sound level (Leq), which can be thought of as the steady sound level that represents the same sound energy as the varying sound levels over a specified time period. Highway noise impact is assessed using the loudest 1-hour Leq. This is the hour of the day when there is a large amount of traffic on a roadway traveling at free flow speeds.

Often the Leq values over a 24-hour period are used to calculate cumulative noise exposure in terms of the day-night sound level (Ldn). Day-night sound level is the A-weighted Leq for a 24-hour period with an added 10-dB penalty imposed on noise that occurs during the nighttime hours (between 10:00 p.m. and 7:00 a.m.). Many surveys have shown that Ldn is well correlated with human annoyance; therefore, this descriptor is widely used for environmental noise impact assessment of transit systems and airports. Figure 4.13-2, Examples of Typical Outdoor Noise Exposure, provides examples of typical noise environments and criteria in terms of Ldn. While the extremes of Ldn are shown to range from 35 dBA in a wilderness environment to 85 dBA in noisy urban environments, Ldn is generally found to range between 55 and 75 dBA in most communities. As shown in Figure 4.13-2, this spans the range between an "ideal" residential environment and the threshold for an unacceptable residential environment according to criteria established by several federal agencies.

Figure 4.13-2: Examples of Typical Outdoor Noise Exposure



Source: FTA, 2006.

Affected Environment

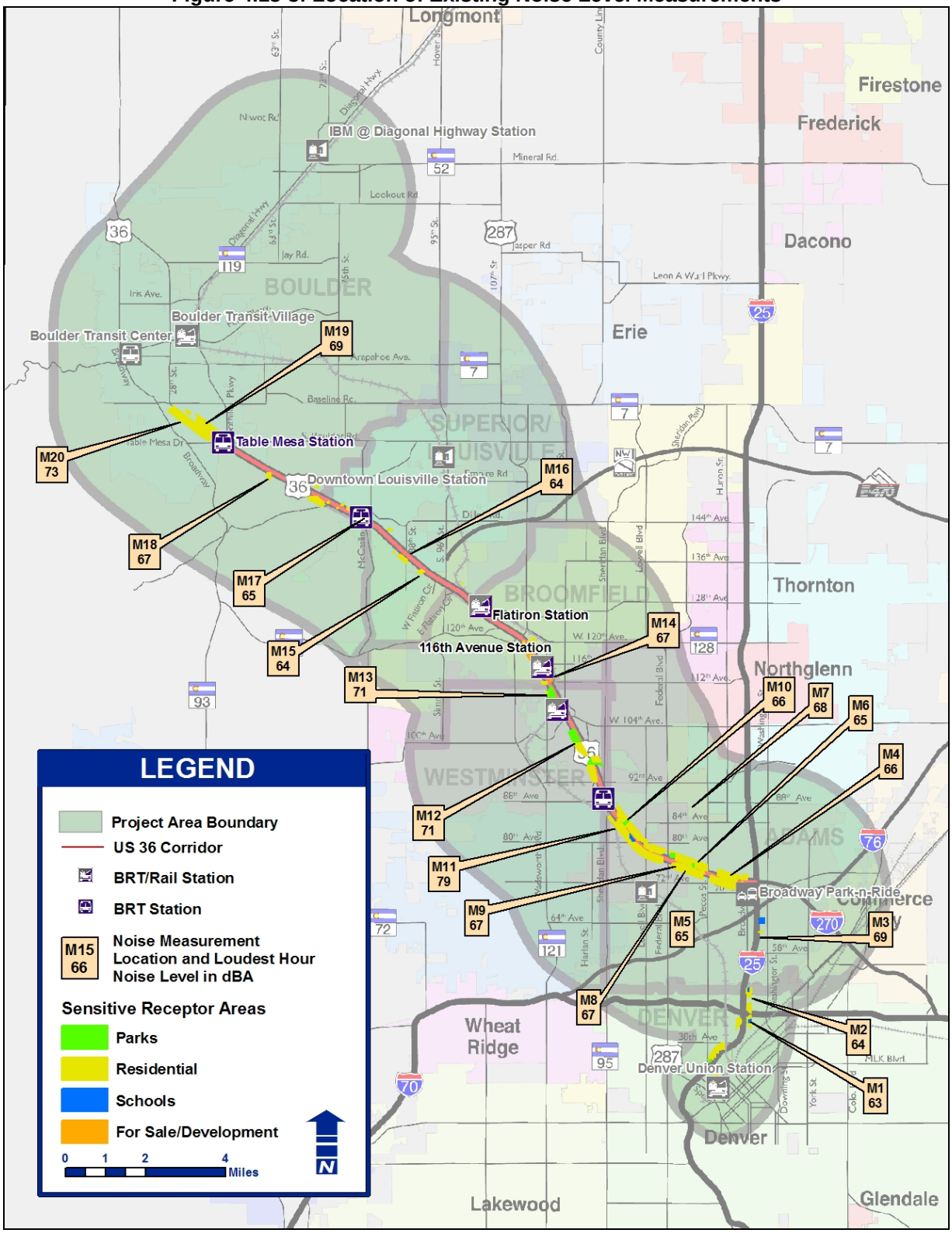
This section describes existing noise conditions along the US 36 corridor. Existing noise levels are used as a comparison for predicting impacts related to highway improvements called for in the build packages.

Residences are the primary focus of noise impacts, as these are places where people sleep and spend a considerable amount of other time as well. Residences are present in proximity to Interstate 25 (I-25) and US 36 in all segments of the corridor. Lower downtown Denver has experienced substantial condominium and townhome development, and existing neighborhoods and scattered homes occur along I-25 between downtown and US 36. There is almost continuous residential development along US 36 between Broadway and Sheridan Boulevard. A mix of commercial, residential, and undeveloped lands exist between Sheridan Boulevard and 112th Avenue. Between 112th Avenue and StorageTek Drive there is a predominance of commercial and undeveloped land. There are a number of multi-family residences on the south side of US 36 between StorageTek Drive and McCaslin Boulevard. Between the McCaslin Boulevard interchange and Table Mesa Drive there is a predominance of open land, with some scattered residences. Neighborhoods exist along both sides of US 36 between Table Mesa Drive and Baseline Road in Boulder. Also, as described below, there are a number of existing sound walls in the corridor.

Measured Noise Levels

Existing highway noise levels were measured at the 20 sites shown in Figure 4.13-3, Location of Existing Noise Level Measurements. The figure also shows the approximate location of noise-sensitive land uses adjacent to I-25 and US 36 within the project area. The measurement locations were selected to be representative of the closest residences to I-25 and US 36. A-weighted, hourly Leq(s) were measured continuously for approximately 1 week at each location. The measurements were taken between May 4 and June 10, 2004. The measured loudest-hour noise levels at each site are listed in Table 4.13-1, Summary of Existing Highway Noise Level Measurements, and the results are summarized in the following paragraphs. More detailed information is contained in the *Highway Noise Analysis Technical Report (Addendum)* (Hankard Environmental 2009) prepared for this Final Environmental Impact Statement (FEIS).

Figure 4.13-3: Location of Existing Noise Level Measurements



Source: US 36 Mobility Partnership, 2009.
Note: The 116th Avenue Rail Station is not a part of the 2004 FasTracks Program. Additional stations were added in the early planning stages of the US 36 Environmental Impact Statement. Exact rail station locations and additional stations may be reconsidered in the U.S. Army Corps of Engineers/Regional Transportation District Northwest Rail Environmental Assessment/Environmental Evaluation.

Table 4.13-1: Summary of Existing Highway Noise Level Measurements

Site No.	Measurement—Segment	Distance to Centerline of Highway (feet)	Loudest Hour Leq (dBA)	Description
M1	Lincoln Street—Denver	925	63	Closer to I-70 than I-25
M2	Broadway—Denver	350	64	Second row of homes from I-25
M3	East 62nd Avenue—Adams County	325	69	I-25 elevated above measurement location
M4	Bronco Drive—Adams	150	66	First row, masonry wall
M5	Worley Drive—Adams	270	65	Second row
M6	Raritan Street—Adams	290	65	Second row, near Pecos Street on-ramp
M7	Apple Blossom Lane—Adams	185	68	First row, near Federal Boulevard on-ramp, at transition between wooden and masonry walls
M8	Bradburn Boulevard—Adams	200	67	First row with interceding street, near 80th Avenue overpass
M9	Turnpike Drive—Adams	115	67	First row, wooden fence on berm
M10	Wagner Boulevard—Adams	125	66	First row, wooden fence
M11	Madison Hill—Westminster	150	79	Approximately 30 feet nearer to highway than closest residence; unobstructed view of US 36
M12	Westcliff Apartments—Westminster	225	71	Near apartment complex; distance is comparable to nearest unit
M13	111th Street—Westminster	330	71	Side road intercedes between location and highway; unobstructed view of US 36
M14	Wadsworth Boulevard—Westminster	445	67	Approximately 350 feet between US 36 and residence
M15	Stoneham Street—Superior/Louisville	720	64	Wooden privacy fence and open field between location and US 36
M16	LaQuinta Inn—Superior/Louisville	505	64	Near McCaslin Boulevard off-ramp; view of US 36 partially obstructed by ramp
M17	Dyer Road—Superior/Louisville	175	65	Unobstructed view of US 36 across field
M18	Cherryvale Road—Boulder	500	67	Field and some trees between location and US 36
M19	Apache Road—Boulder	200	69	First row, no barriers, side road intercedes
M20	Moorhead Avenue—Boulder	135	73	First row, no barriers, field between location and US 36

Source: US 36 Mobility Partnership, 2004.

Notes:

dBA = decibel (A-weighted scale)
I-# = Interstate #
Leq = equivalent sound level
US 36 = United States Highway 36

Denver Segment

Existing loudest-hour noise levels in lower downtown range from 65 dBA to over 70 dBA, and are typical of urban environments.

Noise-sensitive receptors along this segment of the corridor include high-rise apartments and condominiums in lower downtown Denver, and single-family residences along I-25. Existing loudest-hour noise levels in lower downtown range from 65 dBA to over 70 dBA, and are typical of urban environments. Noise levels are the result of automobile, bus, and train traffic; air-conditioning equipment on nearby buildings; and other sources. Traffic noise levels were measured at two neighborhoods adjacent to I-25 in Denver. The loudest-hour levels measured range from 63 to 64 dBA. Both neighborhoods have existing sound walls.

Adams Segment

Noise-sensitive receptors in this segment include scattered residences and Academy of Charter School along I-25; large neighborhoods on both sides of US 36 between Broadway and Sheridan Boulevard; Westminster Hills Park; Westminster Open Space; and Oakwood, Rotary, and Commissioners parks. Existing loudest-hour noise levels range from 65 to over 70 dBA where there is no existing sound wall. Loudest-hour noise levels are generally 65 dBA where there are existing walls.

Westminster Segment

Noise-sensitive receptors in this segment include the Madison Hill and Westcliff multi-family developments, the Tuscany Trail residences, and Lower Church Park. Existing loudest-hour noise levels in these areas are greater than 70 dBA.

Broomfield Segment

There are only a few scattered single-family residences along US 36 in Broomfield as well as the recent multi-family Arista development just south of 120th Avenue. Other noise-sensitive receptors in this segment include East Interlocken Park, Interlocken Golf Course, and Interlocken West Trail. Existing loudest-hour noise levels at the single-family residences are approximately 65 dBA, and 59 dBA for the multi-family homes within the Arista development.

Superior/Louisville Segment

Noise-sensitive receptors in this segment include a multi-family development east of 88th Street, a single-family development west of 88th Street, the Rock Creek Apartments, Coal Creek Golf Course, hotels just east of McCaslin Boulevard, residences along Dyer Road west of McCaslin Boulevard, and additional scattered residences farther west. Existing loudest-hour noise levels at these residences range from 65 to 70 dBA; levels at the hotels are approximately 63 dBA, and levels in portions of the Coal Creek Golf Course are approximately 70 dBA.

Boulder Segment

Noise-sensitive receptors in this segment include single-family residences near Cherryvale Road and neighborhoods along both sides of US 36 between Table Mesa Drive and Bear Creek. Existing loudest-hour noise levels at these single-family residences range from 67 to over 73 dBA.

Impact Evaluation

Methodology

Evaluation Criteria

Because this project involves state and federal funds, it is subject to CDOT noise guidelines, which are set forth in the *Noise Analysis and Abatement Guidelines* (CDOT 2002). The CDOT noise guidelines are consistent with those of the FHWA (23 CFR 772) and have been approved by the FHWA for use on federally aided projects. CDOT's guidelines establish Noise Abatement Criteria (NAC) and design requirements for noise mitigation. The guidelines state that noise mitigation must be considered for any receptor or group of receptors (e.g., residences) where predicted loudest-hour traffic noise levels, using future traffic volumes and roadway conditions, equal or exceed CDOT's NAC, which are shown in Table 4.13-2, Colorado Department of Transportation Noise Abatement Criteria. 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 dBA or more.

Table 4.13-2: Colorado Department of Transportation Noise Abatement Criteria

Activity Category	Leq(h) [1,2] (dBA)	Description of Activity Category
A	56 (exterior)	Lands on which serenity and quiet are of extraordinary significance, and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	66 (exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	71 (exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	--	Undeveloped lands.
E	51 (interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Source: CDOT NAC (based on FHWA 23 CFR 772).

Notes:

[1] Hourly A-weighted equivalent level for the loudest hour of the day in the design year.

[2] Colorado Department of Transportation noise impact criteria are 1 decibel (A-weighted scale) lower (more stringent) than Federal Highway Administration values in 23 Code of Federal Regulations 772 to identify noise levels that "approach" the Federal Highway Administration criteria.

-- = None
Leq(h) = equivalent sound level per hour
dBA = decibel (A-weighted scale)
FHWA = Federal Highway Administration

To be included in a project, a proposed noise mitigation measure must first be found to be feasible according to the following criteria:

- The proposed mitigation measure must be predicted to achieve at least 5 dBA of noise reduction at front row receptors (i.e., the closest row of homes to the highway in a given neighborhood), and preferably between 5 and 10 dBA of reduction.
- The proposed mitigation measure must not create any "fatal flaw" safety or maintenance issues, such as reduced sight distances, shadowing of ice-prone areas, or interference with snow and debris removal.
- Walls or earthen berms must be constructed in a continuous manner, as gaps in them (e.g., for driveways) substantially degrade their performance.

If a mitigation measure is found to be feasible, then it is analyzed for its "reasonableness" according to the following criteria. Each criterion does not need to be met explicitly, but overall the measure should be reasonable.

- The cost benefit of the proposed measure should not exceed $4,000 per dBA of reduction per benefited receptor using an estimated sound wall construction cost of $30 per square foot.
- The predicted design-year noise levels should equal or exceed the NAC shown in Table 4.13-2, Colorado Department of Transportation Noise Abatement Criteria.
- At least 50 percent of the impacted properties should approve of the proposed measure.
- Land use in the impacted area should be at least 50 percent Category B (e.g., residential).
- Design-year noise levels should exceed existing levels by 5 dBA or more.

Noise Prediction Methodology

Traffic noise levels were predicted using the STAMINA 2.0 software model, which was developed by the FHWA and has been used on many highway projects across the country. The STAMINA model calculates the A-weighted, hourly Leq (Leq[h]) at a receptor location (e.g., a residence) when provided the following input data:

- **Noise Emission Factors** — Amount of noise that a typical automobile or truck makes when traveling at a known speed and measured at a certain distance.
- **Location of Roadways** — Computer-aided drafting design topography and design mapping were used to determine the location and elevation of each roadways under study for each package.
- **Traffic Volumes and Speeds** — Traffic was modeled using level of service C/D volumes. Speeds were modeled as follows: US 36 – 55 to 65 miles per hour (mph); I-25 – 55 to 60 mph; ramps – 30 to 40 mph; and all other roads – 35 mph.
- **Location of Receptors** — 120 noise receptor locations were selected to be representative of all the residences, schools, parks, hotels, and churches located along I-25 and US 36.
- **Location of Terrain Features —** Existing terrain features such as the edge of the roadway, sound walls, earthen berms, hills, and large structures, such as buildings and bridges, were modeled as barriers.
- **Alpha Factors —** Alpha factors in STAMINA control how much of the noise is absorbed or reflected by the ground. Typical sound absorption was used for the majority of the prediction locations, and no sound absorption was used for just a few locations.
- **Shielding Factors** — These represent noise reductions due to non-modeled barriers such as rows of homes (3 dBA reduction for one row of homes, and 5 dBA for second row or further back).

Using these modeling techniques, the loudest-hour noise level was predicted at each of the 120 representative locations for existing (2004), and design-year (2030 for Packages 2 and 4, 2035 for the Combined Alternative Package [Preferred Alternative]) conditions for each package. A noise mitigation analysis was conducted for each area where design-year noise levels are predicted to equal or exceed CDOT's NAC, and where design-year noise levels are predicted to exceed existing noise levels by 10 dBA or more. The mitigation analysis assessed the feasibility and reasonableness of providing sound walls at impacted areas.

Predicted noise levels and the locations where noise levels exceed CDOT's 66-dBA threshold for residential and parkland use are discussed below for each package. Projected noise impacts should be viewed as preliminary, and impacts should be reviewed in more detail during final design.

Package 1: No Action

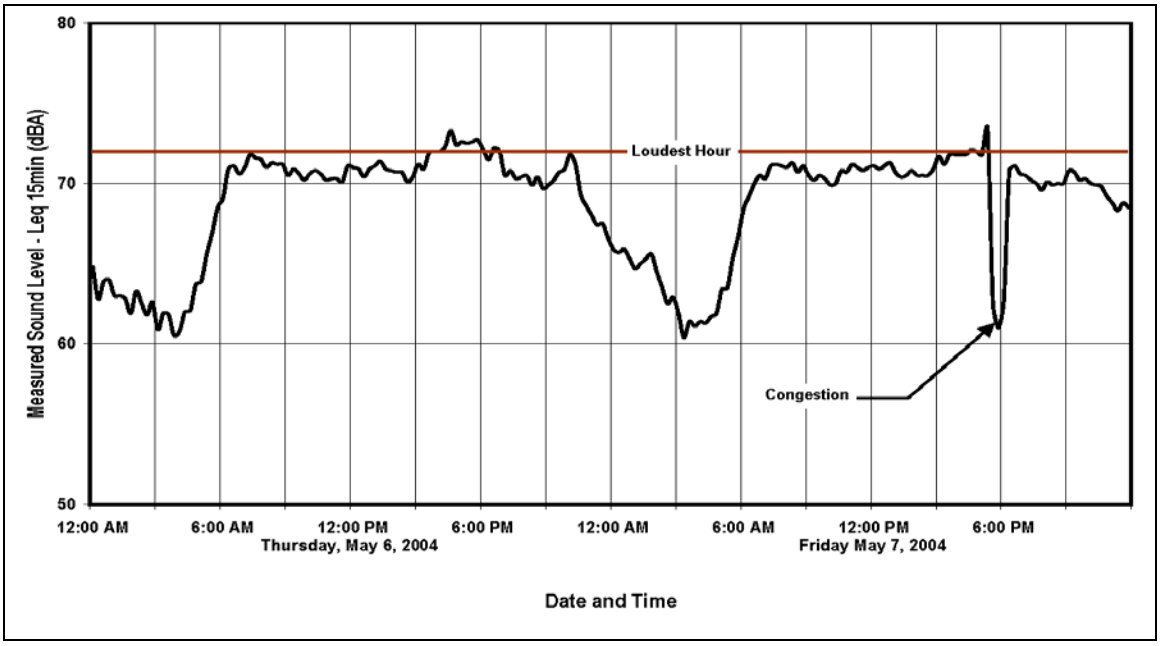
Direct Impacts

All Segments

Noise levels during the loudest hour of the day would not get any louder under Package 1 because the highway presently reaches its carrying capacity for at least 1 hour on most days, and no additional capacity would be added under Package 1. While loudest-hour noise levels would not increase, two other changes would occur. Congestion would increase, and during times of congestion noise levels would drop considerably. This is demonstrated in Figure 4.13-4, Effect of Congestion on Highway Noise Levels, which shows the noise levels measured over a 2-day period along I-25 in Denver. Note the 10-dBA drop in noise level during the period of congestion. The loudest 1-hour period occurs just before and just after rush hour. During these periods there is a large volume of traffic on the highway, and traffic is moving at a free flow speed. The other change that occurs between existing conditions and Package 1 conditions is that at non-peak times, the highway does have the ability to absorb additional traffic volume at free flow speeds. Therefore, at non-peak times, noise levels would increase (generally only 1 dBA to 2 dBA).

The loudest 1-hour period occurs just before and just after rush hour.

Figure 4.13-4: Effect of Congestion on Highway Noise Levels



Source: US 36 Mobility Partnership, 2006.

Indirect Impacts

The highway, as it stands today, indirectly impacts residences that live along feeder routes. Even though no capacity will be added to US 36 under Package 1, traffic in the area is projected to increase due to increased population and mobility provided by other planned projects. Noise levels along feeder routes would increase correspondingly.

Package 2: Managed Lanes/Bus Rapid Transit

Direct Impacts

The implementation of Package 2 is predicted to increase loudest-hour noise levels by an average of 2 to 3 dBA over existing levels. Increases of up to 8 dBA are expected at some locations. In terms of distance, the direct noise impacts are located in areas immediately adjacent to the highway. Noise from the highway is and will continue to be audible at farther distances (more than 500 feet), and along feeder routes. Noise levels at these locations are predicted to increase by approximately 2 to 3 dBA more than they would under Package 1.

The increases are the result of shifting the traffic closer to residences to accommodate the improvements in the median, as well as the additional free flowing traffic that the highway would be able to carry in the managed lanes. The following paragraphs describe the locations of residences and parks where design year (2030) loudest-hour noise levels are predicted to equal or exceed CDOT's Category B NAC of 66 dBA. These locations are shown in Figure 4.13-5, Residential and Major Park Highway Noise Impact Locations, and the number of impacted residences is listed in Table 4.13-3, Number of Residences Impacted by Highway Noise.

Table 4.13-3: Number of Residences Impacted by Highway Noise

Segment	Package 1		Package 2		Package 4		Combined Alternative Package (Preferred Alternative)	
	Single-family	Multi-family	Single-family	Multi-family	Single-family	Multi-family	Single-family	Multi-family
Denver	0	0	0	0	0	0	0	0
Adams	6	0	6	0	6	0	6	0
Westminster	0	48	10	48	10	48	10	48
Broomfield	5	0	5	0	5	0	4	0
Superior/Louisville	6	0	8	0	8	0	6	12
Boulder	39	10	39	10	39	10	39	10
Subtotal	*56*	*58*	*68*	*58*	*68*	*58*	*65*	*70*
Total	114		126		126		135	

Source: US 36 Mobility Partnership, 2009.

Adams Segment

Noise levels at the five single-family homes located along I-25 near 62nd Avenue and one home near Broadway are predicted to exceed 66 dBA.

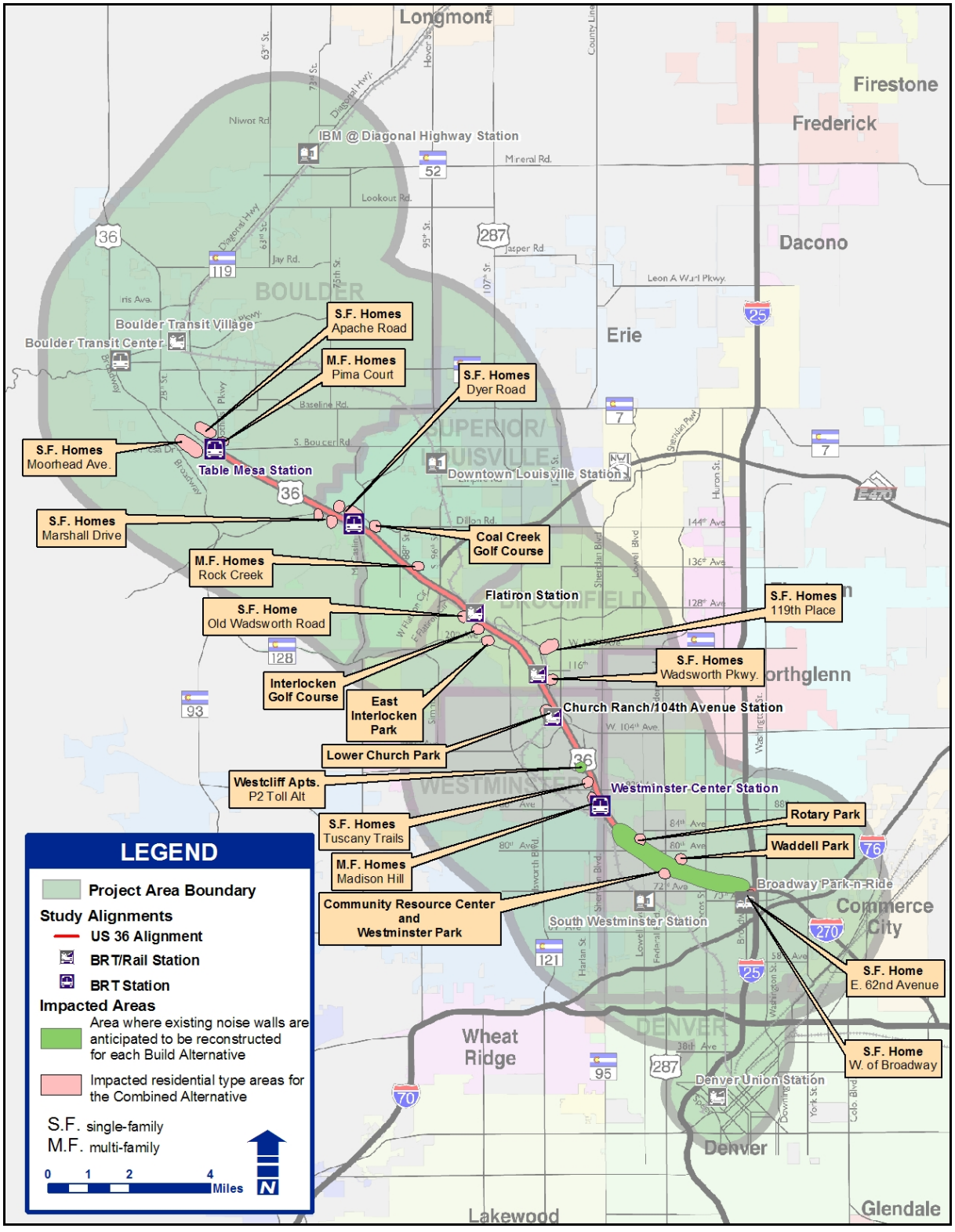
Westminster Segment

Noise levels at Lower Church Park are predicted to be 71 dBA, which is a 3-dBA increase over existing levels. Noise levels are predicted to exceed 66 dBA at a total of 58 residences within the Madison Hills and Tuscany Trail developments in 2030, which is an increase of 4 dBA over existing levels. The existing sound wall in front of the Westcliff Apartments would need to be removed to accommodate the proposed improvements. A new wall would need to be constructed, and its height should be designed to achieve 5 to 10 dBA of noise reduction at the closest residences.

Broomfield Segment

Noise levels at the four single-family homes just east of US 36 near Wadsworth Boulevard are predicted to reach 73 dBA in 2030. Noise levels at the one single-family home to the west of US 36 on Old Wadsworth Boulevard are predicted to exceed 66 dBA. East Flatiron Park and Interlocken Golf Course would also be impacted.

Figure 4.13-5: Residential and Major Park Highway Noise Impact Locations



Source: US 36 Mobility Partnership, 2009.

Note: The 116th Avenue Rail Station is not a part of the 2004 FasTracks Program. Additional stations were added in the early planning stages of the US 36 Environmental Impact Statement. Exact rail station locations and additional stations may be reconsidered in the U.S. Army Corps of Engineers/Regional Transportation District Northwest Rail Environmental Assessment/Environmental Evaluation.

Superior/Louisville Segment

Noise levels at the six homes in the Dyer Road neighborhood are predicted to range from 67 to 70 dBA, which is an increase of approximately 2 dBA over existing levels. Also, two single-family homes located just west of this neighborhood (one on either side of US 36) would be impacted. The terrain at these homes is currently acting as a barrier to traffic noise. If this terrain would be removed to accommodate the widening of the road, it should be replaced with either a berm or wall of similar or greater height. Noise levels at the Coal Creek Golf Course are predicted to exceed 66 dBA.

Boulder Segment

Noise levels in the Moorhead Avenue neighborhood are predicted to be in the low 70s (dBA). The Apache Avenue neighborhood on the north side of US 36 would also be impacted, with predicted 2030 noise levels ranging from 66 to 69 dBA. Also, noise levels are predicted to exceed 66 dBA at the Pima Court residences. In all, approximately 39 single-family homes and 10 multi-family homes are predicted to be impacted.

Bus Rapid Transit Options at Table Mesa Drive

Two options were considered for the project terminus at Foothills Parkway/Table Mesa Drive for Packages 2 and 4. In Option A (which was identified as part of the Combined Alternative Package [Preferred Alternative]), the special lanes would be located in the median of US 36. The special lane designation would end or the lane would terminate west of Cherryvale Road. These lanes would extend to 28th Street. Traffic exiting to Foothills Parkway or South Boulder Road would merge into the general-purpose lanes. Option B would provide a bus-only lane to and from the special lanes in the median that goes out and over the general-purpose lanes directly to the Table Mesa Station via a new bridge. All westbound vehicles in the special lanes, except for buses, would be required to exit the special lanes just west of Cherryvale Road and merge into the general-purpose lanes. Considering the relative high mainline traffic volume for this area, the resulting loudest-hour noise levels for either bus rapid transit (BRT) option should be very similar. Also, the surrounding properties in this area are commercial without any known outdoor use areas; thus, any minor difference in noise level between these two options should not result in a noise impact.

Transit Station Impacts

A Federal Transit Administration (FTA) noise screening analysis using the methods in the *Transit Noise and Vibration Impact Assessment*, Report No. FTA-VA-90-1003-06 (FTA 2006) was conducted for the three transit stations that will be expanded under the build alternatives. This includes the Westminster Center Station at Sheridan Boulevard, 116th Avenue Station, and the McCaslin Station. For the Westminster Center Station, the nearest residence is about 1,300 feet away and surrounded by a mall, commercial properties, and US 36. Per the screening analysis, buses and automobiles accessing the Westminster Center Station are not predicted to create a noise impact. For the 116th Avenue Station, there are commercial properties to the north, open lands to the east, US 36 to the west, and one unobstructed single-family home approximately 100 feet to the south. This single-family home is within the 225 feet screening distance for a noise impact. According to the analysis conducted as part of the FEIS, buses and automobiles accessing the 116th Avenue Station are not predicted to create a noise impact. For the McCaslin Station, the nearest residence is about 1,500 feet to the west, and is blocked by at least one large building. The nearest hotel is about 400 feet to the east, and on the other side of McCaslin Boulevard. Directly surrounding this station is a movie theater, other commercial properties, McCaslin Boulevard, and US 36. No noise impacts are predicted.

Drop-Ramp Impacts

In Package 2, drop-ramps are proposed for Westminster Boulevard near the Westcliff Apartments, and for Midway Boulevard near the Interlocken office complex. The primary noise consideration for these drop-ramps is the increase in traffic along arterial roads that pass by residential properties. The traffic analysis for the Westminster Boulevard drop-ramp shows that a majority of the increased traffic will be to the north of US 36, and not to the south where the residential properties are located. Overall, a 1 or 2 dBA increase in noise could result at properties adjacent to Westcliff Parkway and Harlan Street due to this drop-ramp. For the Midway Boulevard drop-ramp, this area is nearly all commercial office space. The increase in noise for this area is not expected to create a noise impact as US 36 should remain the primary noise source for this area.

Indirect Impacts

Noise impacts are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. In terms of time, once a highway is built it is reasonable to assume that traffic noise would be present in perpetuity. In Package 2, noise levels in the future would be greater than those that would occur in Package 1 due to the added traffic carrying capacity. The added capacity may spur population growth that would not have otherwise occurred. Added population brings with it a corresponding increase in traffic noise.

The transit stations would also create indirect impacts, as both automobile and bus traffic would be increased on local roads near the stations. For the Westminster Center Station, indirect impacts would be generated at the residences located west of the station along 88th Avenue. According to transit ridership forecasts in Chapter 3, Transportation Impacts and Mitigation, of the FEIS, daily ridership would increase in both build packages at this station by about 250 patrons. About two-thirds of the increase, or 120 patrons, would use the north side parking area. Of these, 60 percent, or 102 patrons, would arrive in the a.m. peak-hour. This equates to about one or two additional automobiles per minute. This level of increased activity would not cause indirect noise impacts.

For the 116th Avenue Station, indirect impacts would be generated at the residences to the north as traffic on Allison Street and Wadsworth Boulevard increase. Transit ridership forecasts indicate that 120 additional riders would access this station in the two build packages. About two-thirds, or 80 new patrons, would use the northeast side parking area. During the a.m. peak-hour, less than 50 new trips would travel past the residential uses. The low level of increased traffic would not cause indirect noise impacts.

At the Table Mesa Station, an increase of 170 daily patrons in Package 2, and 210 daily patrons in Package 4 is forecasted. Of these, 60 percent, or 102 and 126 additional vehicles, respectively, would access the facility during the a.m. peak-hour. It is estimated that 70 percent, or 70 and 90 vehicles, respectively, would travel past residential uses west of the station. These rates of increase are less than two vehicles per minute. Therefore, indirect noise impacts from increased traffic volumes are not expected. Similarly, the increase in buses on Table Mesa Drive would be about eight per hour, or a bus every 7.5 minutes, to 16 per hour, or a bus every 4 minutes. Because of the long periods between buses, indirect noise impacts would not occur.

There would be no indirect noise impacts to sensitive receptors resulting from the Church Ranch and McCaslin stations, since these stations are surrounded by commercial land uses.

Downtown Boulder has a broad mix of uses including retail, employment, and some residential. The area around the downtown Boulder Station is commercial in nature. Transit ridership is expected to increase by 140 and 170 boardings per day at the downtown Boulder Station in Package 2 and Package 4, respectively. The peak-hour would see about 60 percent of these boardings, or about 85 to 105 boardings between the two packages. Because the station is in the downtown area, less than half of the peak-hour patrons would arrive by automobile at the rate of about a minute per new vehicle. A barely perceptible

impact from additional noise generated by automobiles would be expected. Ten more buses would be added during the peak-hours to the downtown station, resulting in a bus every 3 to 3.5 minutes. These volumes would be accommodated in the downtown street network with no additional noise or vibration impact expected. The Regional Transportation District will continue to work with the City of Boulder and others through the FasTracks local organization process to accommodate the additional bus traffic in downtown Boulder.

The Boulder Transit Village is currently in the planning stages as a mixed-use, transit, and pedestrian-oriented development at 30th Street and Pearl Street. Residential uses as well as employment and retail commercial uses are planned. Immediately to the north, residential areas exist, including the Steel Yard redevelopment project with a combination of live-work units. The bus-oriented transit facilities would be located off Pearl Street on the southern portion of the site. The commuter rail station in Package 1 would be located on the north portion of the area. In all packages, the added BRT service would draw riders from the commuter rail service for no change in ridership on a daily basis. The number of new bus trips to provide the BRT service would increase by 20 in the peak-hours for a rate of a bus every 2.5 minutes. Noticeable noise and vibration increases from the bus operations would not be expected.

Vibration Impacts from Buses

A screening analysis was performed to determine potential vibration impact from the increased number of buses associated with all of the packages. According to the *Transit Noise and Vibration Impact Assessment* (FTA 2006), rubber-tire vehicles rarely create ground-borne vibration problems unless there is a discontinuity or bump in the road that causes the vibration. Since there are no unusually sensitive land uses (such as a major concert hall, research facility, or laboratory facility) within 50 to 100 feet from the BRT facility, no further vibration analysis was completed.

Package 4: General-Purpose Lanes, High-Occupancy Vehicle, and Bus Rapid Transit

Noise levels are predicted to be very similar in all of the packages. On average, noise levels in Package 4 are predicted to be 1-dBA louder than those in Package 2, and 2 dBA louder than those predicted for the Combined Alternative Package (Preferred Alternative). This is due to the fact that Package 4 would add general-purpose lanes, while Package 2 and the Combined Alternative Package (Preferred Alternative) would add managed lanes. There are no differences between the Package 2 and Package 4 in terms of noise impacts (i.e., where predicted noise levels are 66 dBA or more). In terms of mitigation, the only difference between the two packages is that in Package 4 the existing sound wall at the Westcliff Apartments in Westminster will not need to be removed and rebuilt, as it will under Package 2.

Combined Alternative Package (Preferred Alternative): Managed Lanes, Auxiliary Lanes, and Bus Rapid Transit

Direct Impacts

The implementation of the Combined Alternative Package (Preferred Alternative) is predicted to increase loudest-hour noise levels by an average of 2 dBA over existing conditions. This increase would be due to the shifting of general-purpose lanes outward to accommodate the managed lanes and the additional capacity that the managed lanes would create. This increase would be 1 dBA less than Package 2 because of the slightly narrower footprint, and 2 dBA less than Package 4 because Package 4 would add general-purpose capacity. The following paragraphs describe the locations of residences and parks where design year (2035) loudest-hour noise levels are predicted to equal or exceed CDOT's Category B NAC of 66 dBA. These locations are shown in Figure 4.13-5, Residential and Major Park Highway Noise Impact Locations, and the number of impacted residences is listed in Table 4.13-3, Number of Residences Impacted by Highway Noise.

Adams Segment

Noise levels at the five single-family homes located along I-25 near 62nd Avenue and one home near Broadway are predicted to exceed 66 dBA.

Westminster Segment

Noise levels at Lower Church Park are predicted to be 69 dBA, which is a 1 dBA increase over existing levels. Noise levels are predicted to exceed 66 dBA at a total of 58 residences within the Madison Hills and Tuscany Trail developments in 2035. The existing sound wall in front of the Westcliff Apartments would need to be removed to accommodate the proposed improvements. A new wall would need to be constructed, and its height should be designed to achieve 5 to 10 dBA of noise reduction at the closest residences.

Broomfield Segment

Noise levels at the four single-family homes just east of US 36 near Wadsworth Boulevard are predicted to reach 71 dBA in 2035. East Flatiron Park and Interlocken Golf Course would also be impacted.

Superior/Louisville Segment

Noise levels at the six homes in the Dyer Road neighborhood are predicted to range from 67 to 68 dBA. Noise levels at the Rock Creek Apartments and Coal Creek Golf Course are predicted to equal or exceed 66 dBA.

Boulder Segment

Noise levels in the Moorhead Avenue neighborhood are predicted to be in the low 70s (dBA). The Apache Avenue neighborhood on the north side of US 36 would also be impacted, with predicted 2035 noise levels ranging from 66 to 68 dBA. Also, noise levels are predicted to exceed 66 dBA at the Pima Court residences. In all, approximately 39 single-family homes and 10 multi-family homes are predicted to be impacted.

A total of 39 single-family homes and 10 multi-family homes would be impacted in the Boulder Segment.

Mitigation

Noise mitigation was analyzed for each of the impacted areas.

Noise mitigation was analyzed for each of the impacted areas discussed above. Available highway noise mitigation measures and their applicability to this project are:

- **Shifting of Highway Alignment** — Shifting US 36 to reduce impacts is not applicable to this project because extensive development exists along both sides of the highway.
- **Depression of Highway** — Depressing the highway into the ground such that it is not visible from adjacent residences is not applicable to this project because of the complexity and cost of the retaining walls that would be required.
- **"Quiet" Pavements** — Particular types of new asphalt pavement have been demonstrated to be as much as 3 to 5 dBA quieter than concrete. The ability of these pavements to retain their noise-reducing qualities is currently being studied by CDOT, FHWA, as well as states other than Colorado. It should be noted that noise is only one issue involved in the pavement selection process; others include life-cycle cost, durability, and safety. In general, CDOT has found concrete to be the most cost-effective pavement type in urban areas.
- **Earthen Berms** — Earthen berms require a substantial amount of undeveloped land between the highway and homes, which does not exist at any of the impacted sites along the corridor.
- **Speed Reduction —** Each 5-mph reduction in speed results in approximately 1 dBA of noise reduction. However, a reduction in speed means less traffic flow, which does not meet the Purpose and Need for this project. In addition, speed reductions are difficult to enforce.
- **Sound Walls** — As is often the case in developed areas, sound walls are a viable noise mitigation measure for this project. CDOT policy requires that sound walls achieve between 5 and 10 dBA of noise reduction, and must be cost-effective. Analyses were conducted at the Madison Hill/Tuscany Trail, Moorhead, and Apache Avenue/Pima Court residential areas, and the results of these analyses are described below. Formal analyses were not conducted at the locations where existing sound walls would need to be removed. It is assumed that these walls will be replaced in kind. Noise mitigation was not analyzed for Package 1, as no noise mitigation would be provided if the project is not constructed. Note that the mitigation recommendations contained herein are preliminary, and will be refined during final design.

  Residences on East 62nd Avenue in Denver — A 500-foot long, 10-foot tall sound wall would be required to provide at least 5 dBA of noise reduction at these residences. This equates to a cost benefit of $6,000 per dB per receptor, which exceeds CDOT's $4,000 standard. Also, this wall lies outside of the area where physical construction will take place, as no improvements are proposed for I-25 as part of this project. Therefore, this wall is considered feasible but not reasonable and is not recommended.

  Madison Hill and Tuscany Trail Multi-family Homes — A 2,400-foot long, 15-foot tall sound wall at this location would reduce noise levels by an average of over 9 dBA and would protect 100 residences. The cost benefit value would be $1,200. The wall is considered both feasible and reasonable and is recommended.

  Wadsworth Boulevard Single-Family Homes — An 890-foot-long wall with a height up to 15 feet was analyzed. While an average of 5 dBA to 9 dBA of noise reduction would be achieved for four of the homes, the cost benefit value would be excessive at over $13,000. As a result, this wall is not considered reasonable and is not recommended.

Rock Creek Apartments — A 600-foot long, 15-foot tall wall at this location is predicted to reduce noise levels by an average of 5 dBA at front-row residences, and to protect at least 18 residences. This would result in a cost benefit of approximately $3,800. Therefore, this wall is considered feasible and reasonable, and is recommended.

Dyer Road Residences — A 1,600-foot-long wall with a height of 15 feet was analyzed. While an average of 5 dBA of noise reduction would be achieved at the residences, the cost benefit value would be excessive at over $37,000. As a result, this wall is not considered reasonable and is not recommended.

Moorhead Avenue Homes — A 15-foot tall sound wall or wall/berm combination is warranted in this area. The wall should start just north of Table Mesa Drive and continue to the Bear Creek Trail underpass. This 4,100-foot long wall is predicted to achieve over 5 dBA of noise reduction at approximately 100 residences at a cost benefit of less than $3,600. It is considered feasible and reasonable and is recommended.

Apache Road and Pima Court Homes — A 3,800-foot long, 15-foot tall sound wall is predicted to provide over 6 dBA of noise reduction at approximately 80 residences at a cost benefit of less than $2,600. The wall is considered feasible and reasonable and is recommended.

Other Residences — Sound walls are not considered reasonable at the one home on Broadway, the four homes near Wadsworth Boulevard, the home on Old Wadsworth Road, the homes on Marshall Drive, and the homes on Dyer Road due to the relative high cost and low number of benefited homes.

The decision to provide noise mitigation for impacted parks needs to be assessed by the municipality where the park is located, in consultation with CDOT and FHWA. Priority should be given to parks where there is regular outdoor use, and where noise mitigation measures would provide a clear benefit.

The decision to provide noise mitigation for impacted parks needs to be assessed by the municipality where the park is located.

Table 4.13-4, Length of Sound Wall Anticipated in Each Package, shows the total length of sound walls anticipated for the US 36 corridor in each package. Shown are both the total length of new and reconstructed walls. For example, in Adams County, no new walls are proposed, but 34,000 feet of existing sound wall would need to be torn down and rebuilt.

Table 4.13-4: Length of Sound Wall Anticipated in Each Package

Segment	Package 1		Package 2		Package 4		Combined Alternative Package (Preferred Alternative)	
	New (feet)	Reconstructed (feet)	New (feet)	Reconstructed (feet)	New (feet)	Reconstructed (feet)	New (feet)	Reconstructed (feet)
Denver	0	0	0	0	0	0	0	0
Adams	0	0	0	34,000	0	34,000	0	34,000
Westminster	0	0	2,400	1,800	2,400	0	2,400	1,800
Broomfield	0	0	0	0	0	0	0	0
Superior/Louisville	0	0	0	0	0	0	600	0
Boulder	0	0	7,900	0	7,900	0	7,900	0
Subtotal (linear feet)	*0*	*0*	*10,300*	*35,800*	*10,300*	*34,000*	*10,900*	*35,800*
Total (linear feet)	0		46,100		44,300		46,700	

Source: US 36 Mobility Partnership, 2009.

A summary of mitigation measures appears in Table 4.13-5, Mitigation Measures — Noise.

Table 4.13-5: Mitigation Measures — Noise

Impact	Impact Type	Mitigation Measures
Noise impacts to local communities during construction	Construction	The following noise control measures will be implemented during construction: • Permanent sound walls will be constructed at the beginning of the project when feasible. • The contractor will be required to prepare a noise control plan that outlines allowable daytime and nighttime uses, projected noise levels, and locations and types of noise abatement measures that may be required to meet specified noise limits. • The contractor will comply with all applicable local sound control and noise ordinances and regulations. • The following is a list of construction noise mitigation measures that will be employed where the noise control plan specifies (note that these measures will be implemented only where feasible and needed): - Use low-noise equipment with mufflers, intake silencers, engine enclosures, and acoustically attenuating shields or shrouds. - Use hydraulically or electrically powered equipment. - Stage construction timing or sequencing to avoid sensitive times of the day. Combine noisy operations so they occur in the same time period. The total noise level produced will not be substantially greater than the level produced if the operations were performed separately. - Locate stationary noise sources as far from sensitive receptors as possible. - Use natural and artificial barriers, such as ground elevation and existing buildings, to shield construction noise. Staging areas should be kept as far from sensitive noise receptors as possible. - Limit pile driving and blasting to daytime working hours near land uses with sensitive receptors. - Use sonic or vibratory pile drivers instead of impact pile drivers. - Avoid placing haul routes through residential areas. • Use quieter demolition methods where possible, such as sawing bridge decks into sections that can be loaded onto trucks, resulting in lower cumulative noise levels than impact demolition by pavement breakers.
When noise levels exceed NAC due to traffic and buses	Operations	• Sound walls are the only feasible noise mitigation measure, and will be provided in1 the following locations (subject to refinement as part of final design): - All locations where existing sound walls will need to be removed to accommodate the proposed improvements. - Madison Hill homes. - Tuscany Trail. - Rock Creek Apartments. - Apache Road and Pima Court neighborhood. - Moorhead Avenue neighborhood.

Source: US 36 Mobility Partnership, 2006.
Note:
NAC = noise abatement criteria