56TH AVENUE

ENVIRONMENTAL ASSESSMENT

Quebec Street to Havana Street

NOISE IMPACTS TECHNICAL REPORT

APRIL 2008

PREPARED FOR:

DENVER
THE MILE HIGH CITY

City and County of Denver
in partnership with

U.S. Department of Transportation
Federal Highway Administration

US Department of Transportation
Federal Highway Administration

DOT
DEPARTMENT OF TRANSPORTATION

Colorado Department of Transportation

PREPARED BY:

HANKARD ENVIRONMENTAL
ACOUSTICS AND VIBRATION CONSULTING

Hankard Environmental
Acoustics and Vibration Consulting
Lakewood, Colorado

56th Avenue, Quebec Street to Havana Street Environmental Assessment

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EXECUTIVE SUMMARY

On behalf of the City and County of Denver, Hankard Environmental performed traffic noise impact analysis for the 56th Avenue Environmental Assessment – Quebec Street to Havana Street. This analysis was conducted according to Colorado Department of Transportation (CDOT) Noise Analysis and Abatement Guidelines (2002).

Noise levels were measured at five locations along 56th Avenue in September 2007 as part of the 56th Avenue, Havana Street to 1500 feet east of Pena Boulevard Corridor Study, which lies directly east of the EA study area. A TNM version 2.5 model of the noise study area was constructed. Included in the model were 56th Avenue, major cross streets, and terrain features such as berms and building rows. The model was validated by comparing measured noise levels to those predicted at the measurement locations using traffic conditions present during the measurement.

The validated TNM model was used to predict the location of the 66 dBA noise level contour using 2007 peak-hour traffic volumes provided by the project. Sixty-six dBA is CDOT's Noise Abatement Criterion (NAC) for residential land use and parkland. The contour lies approximately 75 feet north and south of the center of 56th Avenue.

The validated TNM model was also used to predict the location of the 66 dBA noise level contour and the 71 dBA noise level contour using the design year (2035) peak-hour traffic volumes and the proposed EA Alternative 7 – 6 Lanes roadway design, both provided by the project. Seventy-one dBA is CDOT's NAC for commercial properties. Where unobstructed by barriers (buildings), the 71 dBA noise level contour lies approximately 95 feet from the center of 56th Avenue, while the 66 dBA contour lies approximately 195 feet from the center of 56th Avenue.

Noise impact was assessed on this project by comparing predicted noise levels to CDOT's Noise Abatement Criteria. Category B receptors include residences, churches, daycare facilities, hospitals, parks and trails, and there are no such receptors within the project study area. Category C receptors include commercial properties, such as industrial complexes, warehouses, and restaurants. There are a number of commercial properties located between the 71 dBA noise level contour and 56th Avenue, meaning that predicted levels are higher than 71 dBA. However, there are no active outdoor use areas at any of these facilities that would benefit from noise abatement. Therefore, there is no noise impact to Category C facilities on this project.

In summary, implementation of the proposed project will not create any noise impacts, as defined by Colorado Department of Transportation Noise Analysis and Abatement Guidelines (2002).

1.0 INTRODUCTION

Hankard Environmental has completed its analysis of traffic noise conditions along the 56th Avenue between Quebec Street and Havana Street as part of the Environmental Assessment (EA) process. This analysis was conducted according to Colorado Department of Transportation (CDOT) Noise Analysis and Abatement Guidelines (2002), which are discussed in Section 2.0.

The analysis consisted of measuring existing noise levels, and using the measured data to validate a Traffic Noise Model (TNM) of the existing roadway network and surrounding terrain. TNM is a Federal Highway Administration software program that is approved for use on Federal-aid projects. The measurements and model validation results are described in Section 3.0

The TNM model was then used to predict noise levels at sensitive receptors located within the project study area. Noise levels were predicted for both existing (2007) conditions and for conditions that will exist under the Preferred Alternative in the design year (2035). Existing noise levels are described in Section 4.0. Design year (2035) noise levels are described and compared to CDOT Noise Abatement Criteria in Section 5.0.

2.0 NOISE ANALYSIS STANDARDS

The noise analysis for the 56th Avenue Environmental Assessment was conducted according to Colorado Department of Transportation (CDOT) noise guidelines, which are set forth in CDOT Noise Analysis and Abatement Guidelines, December 1, 2002. The CDOT noise guidelines are consistent with those of the Federal Highway Administration (FHWA) (23 CFR 772) and have been approved by the FHWA for use on Federal-aid projects in Colorado. CDOT's guidelines establish noise abatement criteria and design requirements for noise mitigation. The guidelines state that noise mitigation should be considered for any receptor or group of receptors where predicted traffic noise levels, using future traffic volumes and roadway conditions, equal or exceed CDOT's Noise Abatement Criteria (NAC), which are shown in Table 2-1. The guidelines also state that noise mitigation should be considered for any receptors where predicted noise levels for future conditions are greater than existing noise levels by 10 dBA or more. This standard is referred to hereafter as the Increase Criterion.

An overview of the CDOT noise analysis procedure is shown in Figure 2-1. To be included in a project, a proposed noise mitigation measure must first be found to be feasible. A summary of the feasibility criteria is as follows:

- The proposed mitigation measure must be predicted to achieve at least 5 dBA of noise reduction at front row receptors.
- The proposed mitigation measure must not create any "fatal flaw" safety or maintenance issues such as reduced sight distances, shadowing of ice-prone areas, and interference with snow/debris removal.
- If a barrier, it must be possible to construct it in a continuous manner, as gaps in noise barriers, e.g. for driveways, significantly degrade their performance.

If a mitigation measure is found to be feasible, it is then analyzed for its "reasonableness". A summary of the reasonableness criteria is as follows:

The cost benefit index of the proposed measure should not exceed $4,000 per dB of reduction per benefited receptor.

The predicted design year noise levels should equal or exceed the Noise Abatement Criteria shown in Table 2-1, below.

At least 50% of the affected properties should approve of the proposed measure.

Land use in the affected area should be at least 50% Category B (refer to Table 2-1).

Table 2-1
CDOT Noise Abatement Criteria
(Based on FHWA's Noise Abatement Criteria, 23 CFR 772)

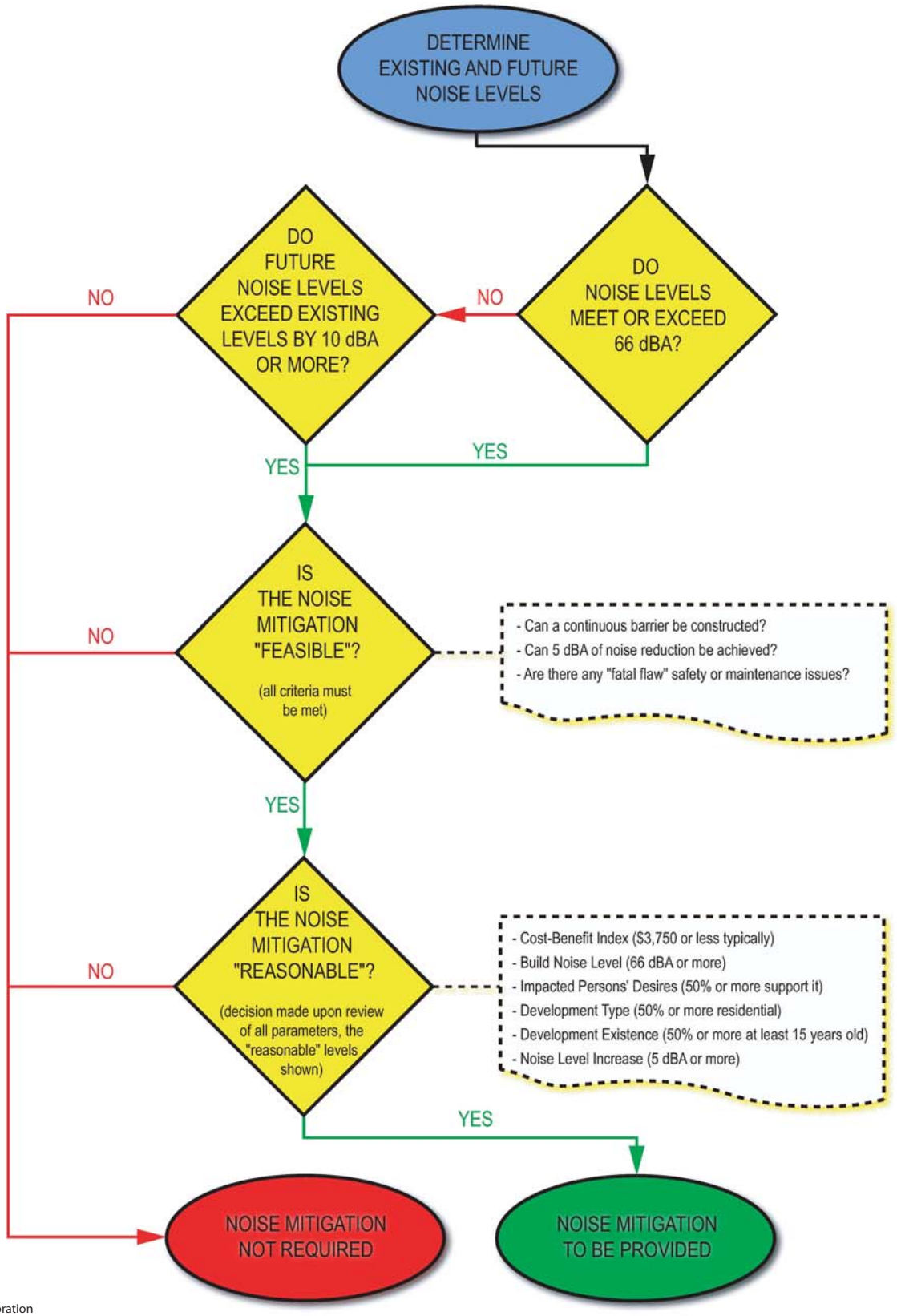
Activity Category	L_{eq} [1], [2] (dBA)	Description of Activity Category
A	56 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
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.

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

[2] CDOT noise impact criteria are 1 dBA lower (more stringent) than FHWA values in 23 CFR 772, to identify noise levels that "approach" the FHWA criteria.

CDOT NOISE ANALYSIS PROCEDURE

Noise Analysis and Abatement Guidelines - December 1, 2003



Source: URS Corporation

56th Avenue Environmental Assessment
Quebec Street to Havana Street

FIGURE 2 - 1
Overview of CDOT Noise Analysis Procedure

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3.0 NOISE MEASUREMENTS AND TNM VALIDATION

The EA noise study area extends along 56th Avenue from 500 feet west of Quebec Street to 1,000 feet east of Havana Street. Land use on the north side of 56th Avenue in this area is a mix of commercial (near Quebec Street), undeveloped (Stapleton property), and parkland (Rocky Mountain Arsenal National Wildlife Refuge). Land use on the south side of 56th Avenue near Quebec Street and east of Havana St is commercial, and is otherwise undeveloped (but slated for development as part of the Stapleton Redevelopment Project) except at the east end of the project where a small portion of the Denver Business Center lies east of Havana Street. The following sections describe the measurement of existing noise levels, the creation of a Traffic Noise Model (TNM), and the validation of the TNM model.

3.1 Noise Level Measurements

Noise levels were measured at five locations along 56th Avenue on September 10, 2007 as part of the 56th Avenue, Havana Street to Pena Boulevard Corridor Study, which lies directly east of the EA study area. Noise levels were measured for 20 minutes at each of the five locations, which are shown in Figure 3-1 (the measurement locations are labeled as M1 through M5). Table 3-1 lists the neighborhood where each measurement was taken, a brief description of the measurement location, and the measured 20-minute Leq (dBA).

A Larson Davis Model 820 sound level meter was deployed at each location. The Model 820 meets American National Standards Institute (ANSI) Type II specifications (accuracy of ±2 dB), was calibrated within the past year by the manufacturer, and was field calibrated prior to the measurement. The meter was configured to record the A-weighted, overall sound level in terms of the Leq. Also, traffic volumes were counted during each of the measurements and speeds were estimated in order to provide data with which to validate the TNM model of the site. The measured traffic data is listed in Table 3-2.

Source: URS Corporation and Hankard Environmental Inc.

56th Avenue Environmental Assessment
Quebec Street to Havana Street

FIGURE 3 - 1
Noise Measurement Locations

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Table 3-1
Measured Noise Levels (dBA)

Location	Neighborhood	Description	Measured Noise Level (20 minute L_{eq}, dBA)
M1	Montbello	Direct line of sight to 56th, 83 feet from centerline of 56th eastbound lane, 88 feet from northbound Potomac Way lane.	60.3
M2	Montbello	Behind first row of houses (line of sight to 56th obscured), approximately 250 feet from centerline of 56th eastbound lane.	53.8
M3	Montbello	Direct line of sight to 56th, 60 feet from centerline of eastbound 56th, just west of Fairplay Street intersection.	59.8
M4	Parkfield	Partially blocked line of sight to 56th, 89 feet from centerline of eastbound 56th, near west Randolph Place cul-de-sac.	54.1
M5	Parkfield	Direct line of sight to 56th, 30 feet from centerline of eastbound 56th, just east of Laredo Street intersection.	65.9

3.2 TNM Model

To determine where noise levels exceed the Noise Abatement Criteria and the Increase Criterion, existing and future loudest hour noise levels were predicted along 56th Avenue within the noise study area. All of the noise predictions and analyses conducted for this project were made using the Federal Highway Administration's TNM, version 2.5. This model is approved for use on federal aid projects in Colorado and is the most recent version of the software. TNM calculates the hourly, A-weighted Leq at a receptor location given the noise emission level of automobiles, medium, and heavy trucks, the volume and speed of each of these vehicle types on each roadway of interest, the relative location of all roadways, receptors, and terrain features (i.e., natural and man-made barriers), and the type of terrain between each receptor and each roadway.

A TNM model of existing conditions was created using the procedures outlined in Evaluation of the FHWA Traffic Noise Model (TNM) for Highway Traffic Noise Prediction in the State of Colorado, CDOT Research Report No. 2005-21. The location and widths of existing roadways, the location of buildings that act as noise barriers, and the location of terrain features that effect sound propagation were determined from scaled aerial photographs.

The TNM model included the following settings:

- One roadway representing each direction of travel on 56th Avenue and each major cross street
- Building rows representing rows of buildings adjacent to 56th Avenue
- TNM's built-in Reference Energy Mean Emission Levels (REMELs)
- Standard temperature and relative humidity settings
- "Lawn" as the default terrain type which is the most commonly used ground type in TNM, as it best matches the typical condition.
- Roadway widths matched to existing conditions

3.3 Validation of TNM Model

The TNM model described above was validated by predicting noise levels at the measurement locations described in Section 3.1, and comparing the predicted and measured levels. The area around each of the five measurement sites was modeled individually. The relative location and elevation of the measurements, roadway centerlines per direction of travel, existing noise barriers, and buildings were obtained from the scaled aerials produced for this project. The measured traffic volumes and speeds listed in Table 3-2 were then used with the models to predict noise levels at each measurement location. Ideally, the measured and predicted values would be identical, but the generally held desired accuracy for highway noise modeling is ± 3dBA. Table 3-3 shows the measured and predicted traffic noise levels, and the differences between them at each site. The differences are all less than 3 dBA, except at location M3. We were not able to discern the reason for the discrepancy at M3. A description of the modeling procedures and results at each location is described in the following paragraphs.

M1 and M5

The modeling at M1 and M5 was straightforward, as both locations are close to the roadway (83 and 30 feet, respectively), there are no significant barriers of any kind, and the terrain is flat and acoustically soft ("lawn" ground type modeled). The difference between the predicted and measured noise levels at these locations is within the desired range.

M2

The model of M2 included the nearby houses represented as a TNM Building Row element. With this element in the model the difference between the predicted and measured noise levels is within the desired range.

M3

The modeling at M3 was straightforward, as this location is close to the roadway (60 feet), there are no significant barriers of any kind, and the terrain is flat and acoustically soft ("lawn" ground type modeled). However, the model predicted 3.2 dBA higher than the measured level for reasons unknown.

M4

The initial model of M4 had the receiver at the same level as the road. However, the resulting predicted level at M4 was too high. Upon further analysis of the site it was decided that the sound meter actually stood approximately 8 feet below road level on the side of a drainage area. The elevation was corrected, a terrain line was added, and the resulting prediction was within the desired range.

Table 3-2
Traffic Volumes and Speeds Observed During Noise Measurements

Noise Measurement Location	Roadway	Autos (one-hour volume)	Medium Truck (one-hour volume)	Heavy Truck (one-hour volume)	Measured Speed (mph)
M1	56th Avenue WB	209	5	14	40
	56th Avenue EB	211	19	19	40
M2	56th Avenue WB	219	3	21	40
	56th Avenue EB	282	33	21	40
M3	56th Avenue WB	263	10	26	40
	56th Avenue EB	368	18	16	40
M4	56th Avenue WB	126	12	6	45
	56th Avenue EB	162	15	12	45
M5	56th Avenue WB	165	18	9	45
	56th Avenue EB	174	6	18	45

Table 3-3
Results of TNM Model Validation

Location	Measured Noise Level (one-hour Leq, dBA)	Predicted Noise Level (one-hour Leq, dBA)	Predicted Minus Measured Noise Level (20 minute L_{eq}, dBA)
M1	60.3	59.4	-0.9
M2	53.8	51.8	-2.0
M3	59.8	63.0	3.2
M4	54.1	56.7	2.6
M5	65.9	66.0	0.1

4.0 EXISTING NOISE LEVELS

The validated TNM model (discussed in Section 3) was used to predict existing year (2007) traffic noise levels along 56th Avenue. Noise levels were predicted using the peak-hour 2007 traffic volumes shown in Table 4-1. Posted speeds were used, which are also shown in Table 4-1. These traffic volumes were calculated from the 56th Avenue Corridor – Quebec Street to Pena Boulevard Traffic and Safety Report (Figure 4-1, Existing [2007] Intersection Turning Movement Counts), which is included here as Figure 4-1. Two sets of traffic volumes were computed from the data in Figure 4-1. One used the turning movement data and the other used 10% of the Average Daily Traffic volume. The greater of these two was used in the noise analysis. The percentage of truck traffic on each roadway section was provided by URS Corporation. This percentage was split equally to obtain medium and heavy truck counts.

Figures 4-2 and 4-3 show the location of the 66 dBA noise level contour for existing year (2007) conditions. All of the area between the contour and 56th Avenue has a predicted noise level greater than 66 dBA, which is CDOT's Noise Abatement Criterion for residential and park land use. The contour lies approximately 75 feet from the center of 56th Avenue except at the east end of the project (east of Havana Street) where the south contour skirts around two commercial buildings.

Table 4-1
Traffic Volumes and Speeds Used to Predict Existing Peak Hour Noise Levels

Roadway	Automobiles (vehicles per hour)	Percentage of Truck Traffic	Medium Trucks (vehicles per hour)	Heavy Trucks (vehicles per hour)	Speed (miles per hour)
56th Eastbound - Quebec to Havana	713	5	19	19	40
56th Westbound - Quebec to Havana	698	7	26	26	40
Havana (South of 56th)	187	15	17	17	35
Quebec (North of 56th)	1145	4	24	24	35
Quebec (South of 56th)	622	3	10	10	35

AM [NOON] (PM) ADT

ROCKY MOUNTAIN ARSENAL
NATIONAL WILDLIFE REFUGE

56TH AVENUE

15,000 | 11,600 | 10,500 | 8,100 | 14,800

QUEBEC ST.
ROSLYN ST.
SPRUCE WY.
VALENTIA ST.
DALLAS ST.
HAVANA ST.
JOLIET ST.
OSWEGO ST.
PEORIA ST.
REVERE ST.
TUCSON ST.
UVALDA ST.
WORCHESTER ST.
POTOMAC ST.
BLACKHAWK WY.
CROWN BLVD.
FAIRPLAY ST.
N. CHAMBERS RD.
AIRPORT WY.
PEÑA BLVD.
TOWER RD.
270

27 [63] (13)
632 [482] (463)
335 [137] (227)
187 [90] (501)
343 [165] (415)
76 [45] (119)
25 [115] (22)
186 [112] (385)
106 [119] (59)
136 [91] (130)
317 [454] (670)
97 [144] (194)

0 [1] (4)
1 [6] (36)
1 [1] (19)
2 [15] (2)
569 [205] (581)
93 [96] (50)
2 [3] (0)
381 [210] (637)
280 [140] (134)
132 [126] (442)
10 [12] (1)
46 [53] (82)

517 [189] (280)
177 [82] (71)
207 [172] (533)
121 [83] (172)
198 [96] (170)
39 [1141] (200)

581 [244] (327)
12 [15] (28)
296 [269] (694)
9 [19] (64)
56 [31] (36)
21 [7] (20)

357 [11] (164)
106 [38] (82)
144 [125] (394)
183 [125] (278)
167 [37] (190)
60 [51] (88)

2 [4] (4)
1163 [347] (554)
45 [30] (92)
147 [37] (305)
70 [23] (37)
0 [1] (1)
119 [133] (415)

3 [13] (28)
41 [27] (58)
211 [75] (230)
701 [332] (1027)
3 [28] (62)
663 [353] (771)

546 [223] (336)
11 [29] (33)
316 [254] (723)
18 [46] (38)
37 [27] (19)
27 [37] (37)

79 [55] (50)
2 [5] (0)
6 [223] (4)
399 [123] (273)
834 [247] (368)
186 [000] (393)
53 [00] (84)

NOT TO SCALE

Data Source: URS Corporation

56th Avenue Environmental Assessment
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FIGURE 4 - 1
Existing (2007) Intersection Turning Movement Counts

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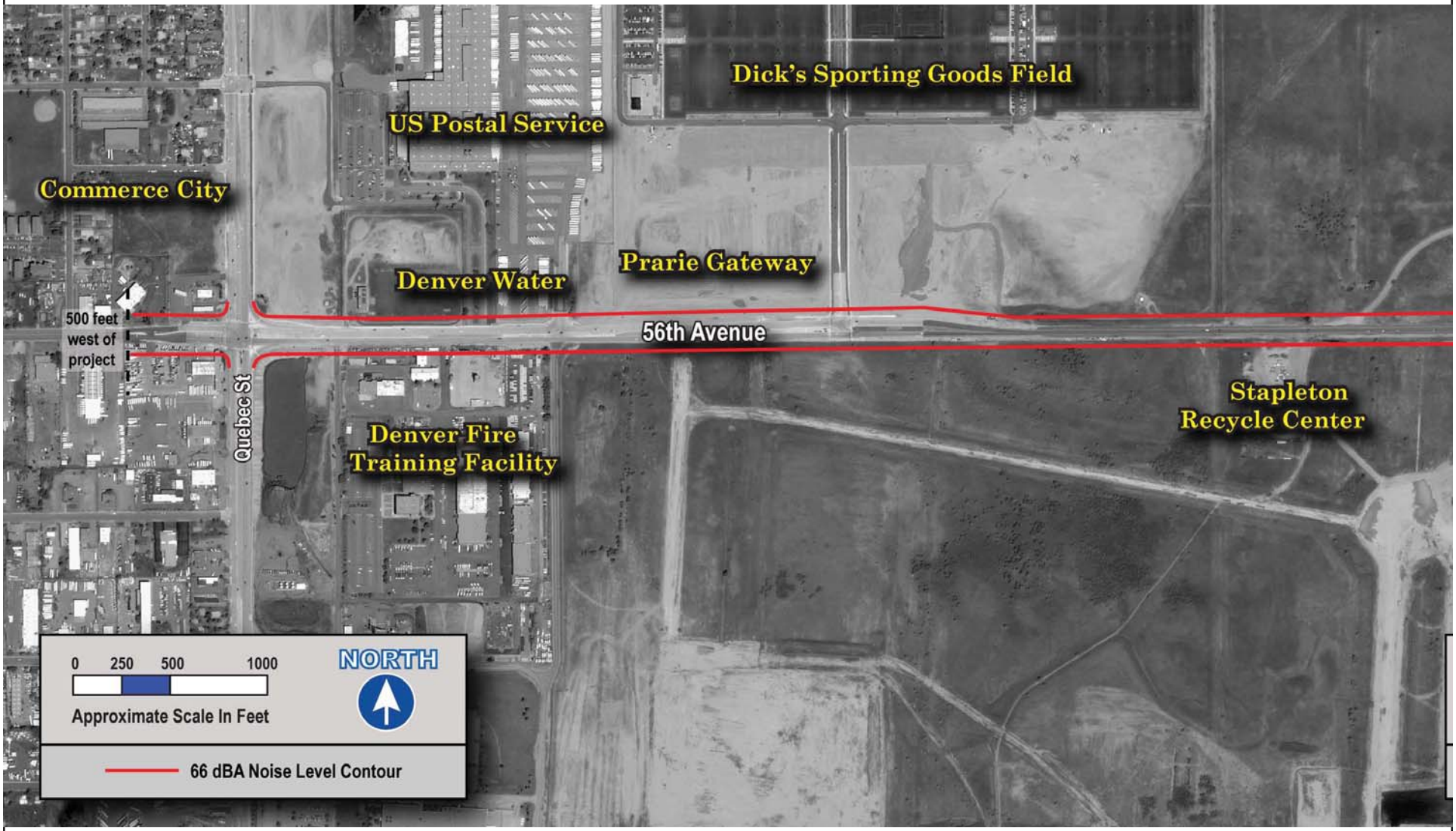

Source: URS Corporation and Hankard Environmental Inc.

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FIGURE 4 - 2
66 dBA Noise Level Contours (West end of Project)

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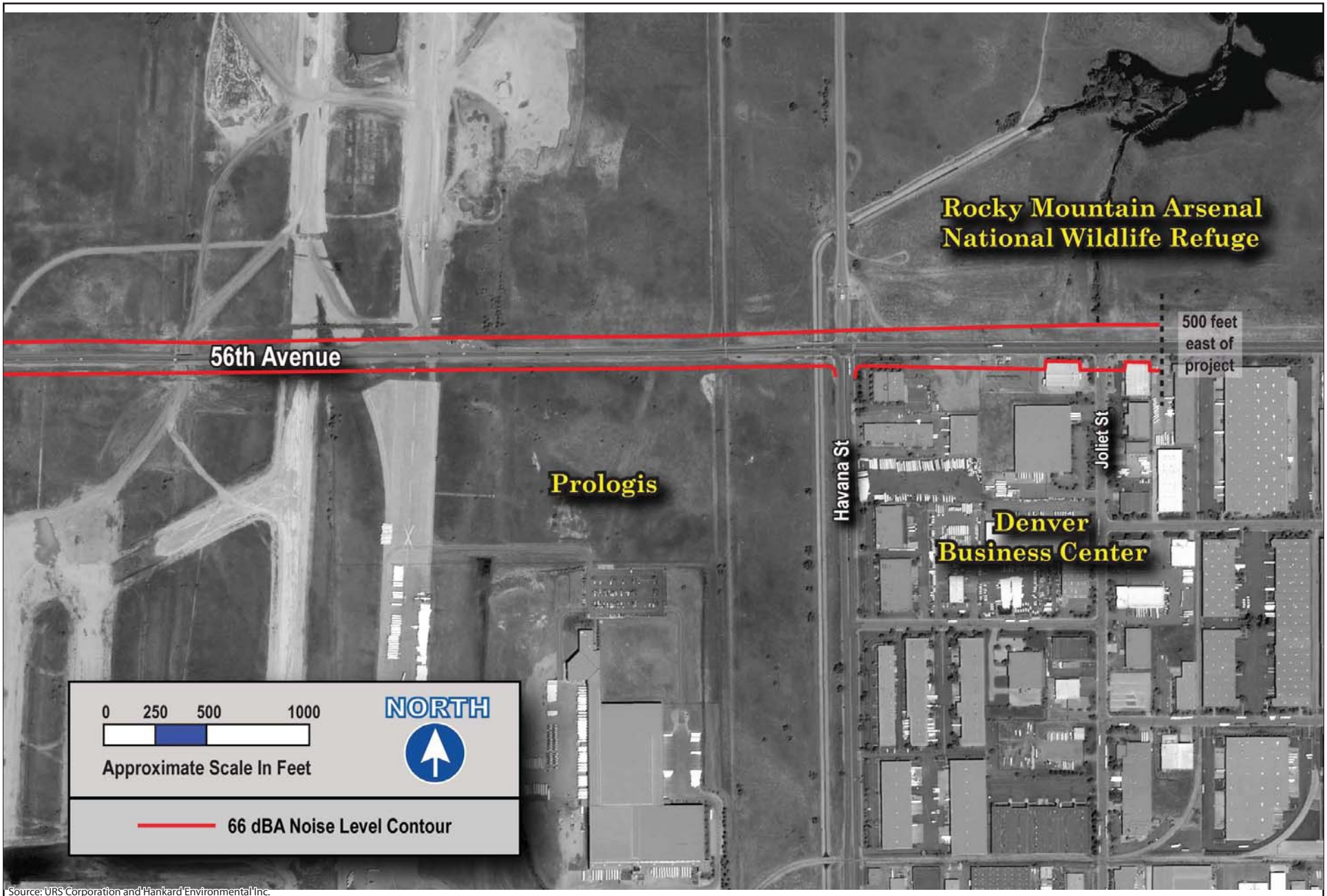

Source: URS Corporation and Hankard Environmental Inc.

56th Avenue Environmental Assessment
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FIGURE 4 - 3
66 dBA Noise Level Contours (East end of Project)

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5.0 DESIGN YEAR NOISE LEVELS

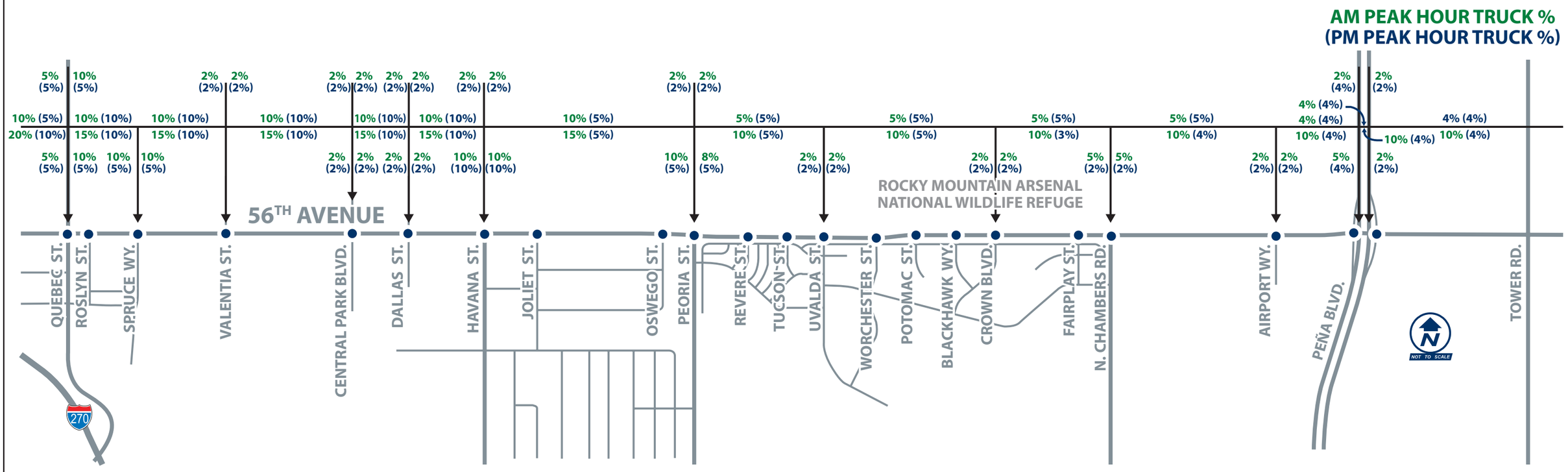
The TNM model of existing conditions was modified to reflect design year conditions by altering the location and width of 56th Avenue to reflect the proposed design, and altering traffic conditions to reflect projected volumes, speeds, and truck percentages. The location and width of 56th Avenue in the model was changed to match the EA Preferred Action (Alternative 7 – 6 Lanes) design. One TNM roadway was placed along each direction of travel. The traffic volumes and speeds used to predict design year conditions are shown in Table 5-1. These volumes were calculated from the "EA Alt 7 6 lanes" document provided by URS Corporation, which is shown in Figure 5-1. The percentage of truck traffic on each roadway section was provided by URS Corporation. This percentage was split such that three quarters of the truck volume was considered medium trucks and one quarter was considered heavy trucks. The traffic speeds used in the model are shown in Table 5-1, and are those that will be posted along 56th Avenue under the proposed design.

Figure 5-1 shows the location of the 66 dBA and 71 dBA noise level contours for design year (2035) roadway and traffic conditions. The contours were located by predicting noise levels at approximately 100 locations, and interpolating between these points. All of the area between the 71 dBA contour and 56th Avenue has a predicted noise level greater than 71 dBA, which is CDOT's Noise Abatement Criterion for developed lands not including residential and park land use. Where unobstructed by barriers (buildings), the 71 dBA contour lies approximately 95 feet from the center of 56th Avenue, while the 66 dBA contour lies approximately 195 feet from the center of 56th Avenue.

Noise impact was assessed on this project by comparing predicted noise levels to CDOT's Noise Abatement Criteria (described in Table 2-1 above). Category B receptors include residences, churches, daycare facilities, hospitals, parks and trails, and there are no such receptors within the project study area. Category C receptors include commercial properties, such as industrial complexes, warehouses, and restaurants. There are a number of commercial properties located between the 71 dBA noise level contour and 56th Avenue, meaning that predicted levels are higher than 71 dBA. However, there are no active outdoor use areas at any of these facilities that would benefit from noise abatement. Therefore, there is no noise impact to Category C facilities on this project.

Table 5-1
Traffic Volumes and Speeds Used to Predict 2035 Peak Hour Noise Levels

Roadway	Automobiles (vehicles per hour)	Percentage of Truck Traffic	Medium Trucks (vehicles per hour)	Heavy Trucks (vehicles per hour)	Speed (miles per hour)
56th Eastbound - Quebec to Dallas	2108	10	176	59	40
56th Eastbound - Dallas to Havana	2160	10	180	60	40
56th Westbound - Quebec to Dallas	1617	10	135	45	40
56th Westbound - Dallas to Havana	1472	10	123	41	40
Dallas (South of 56th)	73	2	1	1	35
Havana (South of 56th)	1355	10	113	38	35
Quebec (North of 56th)	4555	5	180	60	35
Quebec (South of 56th)	3311	5	131	44	35



Data Source: URS Corporation

56th Avenue Environmental Assessment
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FIGURE 5 - 1
Noise Model Design Volumes (2035)

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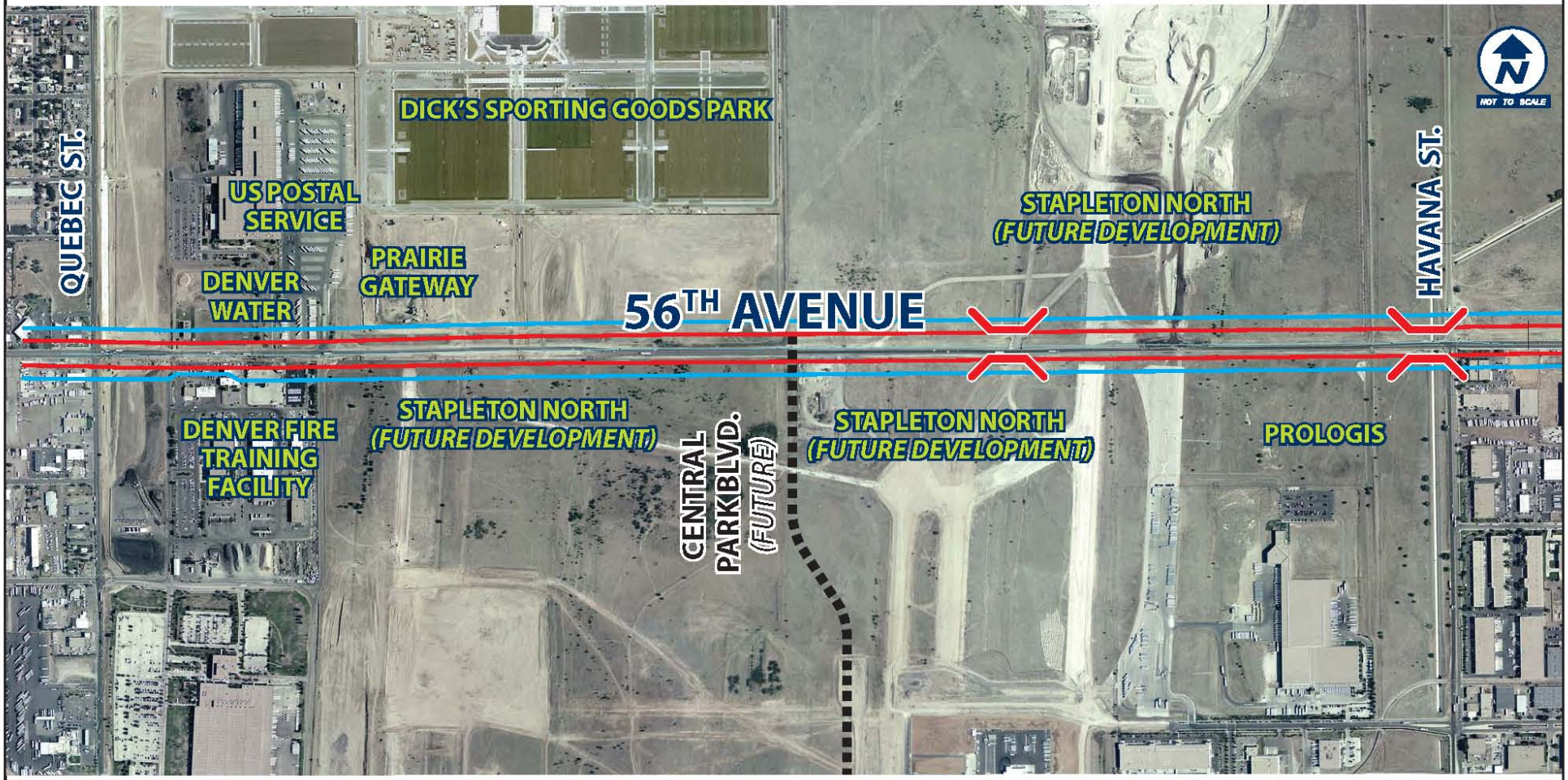

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FIGURE 5-2
56th Avenue Design Year Noise Level Contours for the Preferred Alternative

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