APPENDIX G
NOISE METHODOLOGY

G.1 RAILROAD NOISE

SEA used the following methods to determine if the proposed project would result in a 3 dBA increase and if railroad noise levels would be 65 L_{dn} or greater:

- Develop noise models: SEA used a noise model based on measurements from BNSF trains (SEA, 1995) to estimate existing and future wayside noise levels. The equations for this model are shown in Section G.1.1. The horn noise model, discussed in Section 4.5.2.2, is based on data from FRA's nationwide horn noise study (FRA, 1999). The overall noise model results are sensitive to the horn, locomotive and rail car noise, train length and train speed. SEA used CADNA, an environmental noise prediction computer program, and wayside and horn noise reference levels to calculate building shielding effects and generate noise contours.

- Project existing and future noise exposure: SEA estimated noise exposure in terms of the L_{dn} using information on distances and noise propagation paths to sensitive receptors and existing and future operation plans. See Table 4.5-1 for details on train speeds and Appendix C for information on train length and number of trains.

- Measure ambient noise: In order to establish a baseline for determining if there would be a 3 dBA or greater increase in noise, SEA measured ambient noise in the project area where there is currently no rail traffic. For areas where there is currently train activity, assessment of the 3 dBA increase was based upon estimated (modeled) existing train noise levels.

- Count noise-sensitive receptors: SEA estimated the number of noise-sensitive receptors within the 65 L_{dn} contours for existing and projected future train volumes or where L_{dn} would increase by at least 3 dBA. SEA used digital aerial photographs, land use parcel data, and Geographic Information System (GIS) software to estimate the number of noise-sensitive receptors, including residences, schools, and places of worship, within the 65 L_{dn} contour for both the pre- and post-construction train volumes. The final result of this analysis was an estimate of the total number of sensitive receptors likely to be exposed to noise levels of 65 L_{dn} or greater and number of receptors where L_{dn} would increase by at least 3 dBA because of the Proposed Action and Alternatives.

G.1.1 Wayside Noise Model Methodology

SEA used noise measurements of BNSF trains to provide a basis for the noise level projections. Wayside noise level projections (at locations away from grade crossings where horns are not sounded) were based on data from SEA (1995). Noise from freight cars is caused by the steel wheels rolling on the steel rails. This is referred to as wheel/rail noise. Wheel/rail noise varies as a function of speed and can increase by as much as 15 dBA when wheels or rail are in poor condition. One of the most common problems that creates additional noise is the formation of flat areas on wheels caused by wheels sliding under hard braking.

The main components of locomotive noise are the exhaust of the diesel engines, cooling fans, general engine noise, and the wheel/rail interaction. Noise associated with the engine exhaust and cooling fans usually dominates; this noise is dependent on the throttle setting (most locomotives have eight throttle settings) and not on locomotive speed.

Tests have shown locomotive noise to change by about 2 dBA for each step change in throttle setting. This means that noise levels increase by about 16 dBA as the locomotive throttle is moved from notch one to notch eight. Because locomotive engineers constantly adjust throttle setting as necessary to achieve the desired train speed, only rough estimates of throttle settings are usually available for noise projections. Numerous field measurements of freight train operations indicate that assuming a base condition of throttle position six and adjusting noise levels when better information about typical throttle position is known results in reasonably accurate projections of locomotive noise.

Given the L_{max}, or maximum train passby sound level, of freight cars and locomotives under a specific set of reference conditions, the noise models allow estimating L_{max}, Sound Exposure Level (SEL), L_{dn} and other noise metrics for varying distance from the track, train speeds, and schedules. The standard approach to projecting freight car noise is to model freight cars as moving, incoherent (i.e., random), dipole line sources, wherein the cars are sources of sound moving in a straight line with no fixed pattern to the generation of the sound, which is equal in both directions from the track center line. The basic equations used for the wayside noise model projections are:

- $L_{max} = K_c + 10\log[\alpha + 0.5\sin(2\alpha)] - 10\log(Y) - 10\log(s/s_{ref}) - c_g - c_a - c_s$
- $K_c = L_{max\text{-}ref} - 10\log[\alpha_{ref} + 0.5\sin(2\alpha_{ref})] - 10\log(Y_{ref})$
- $SEL = L_{max} + 10\log(len/v) - 10\log[2\alpha + \sin(2\alpha)] + 3.3$

For locomotives, which can be modeled as moving monopole point sources, the corresponding equations are as follows:

- $L_{max} = K_L + 10\log(2\alpha) - 10\log(Y) + 10\log(s/s_{ref}) - c_g - c_a - c_s$
- $K_L = L_{max\text{-}ref} - 10\log(2\alpha_{ref}/Y_{ref})$
- $SEL = L_{max} + 10\log(len/v) - 10\log(2\alpha) + 3.3$

The parameters which apply to the equations above are:

- Y = observer perpendicular distance from track centerline, feet
- Y_{ref} = reference observer distance from track centerline, feet
- len = train length, feet
- len_{ref} = reference train length, feet
- α = $\tan^{-1}(len/2/Y)$
- α_{ref} = $\tan^{-1}(len_{ref}/2/Y_{ref})$

- s = train speed, feet/second
- s_{ref} = reference train speed, feet/second
- v = train speed, mph
- L_{max} = maximum sound level during train passby, dBA
- $L_{max-ref}$ = maximum sound level during train passby with reference conditions, dBA
- c_g = excess ground attenuation, dBA
- c_a = excess air absorption, dBA
- c_s = excess shielding attenuation, dBA

G.1.2 Horn Noise Model Methodology

The individual operating rules of each railroad require train engineers to sound horns before most public highway/rail at-grade crossings. FRA Regulation 229.129 requires all lead locomotives to have an audible warning device that produces a minimum sound level of 96 dBA at a distance of 100 feet in front of the locomotive. Most freight train audible warning devices are air horns. The maximum sound level of the air horns usually can be adjusted to some degree by adjusting the air pressure. Maximum sound levels are typically 105 to 110 dBA at 100 feet in front of the trains, well above the 96 dBA value required by the FRA. The exact manner in which the horns are sounded varies depending on local and state ordinances.

Because of the high noise levels created by train horns, noise exposure will be dominated by horn noise near any grade crossing where sounding horns is required. Additional noise sources associated with grade crossings are the grade crossing bells that start sounding just before the gates are lowered and idling traffic that must wait at the crossing. This noise is usually insignificant in comparison to the horn noise.

The key components in projecting noise exposure from horn noise are the horn sound level, the duration of the horn noise, the distance of the receptor from the tracks, and the number of trains during the daytime and nighttime hours.

G.1.3 Results

Figures G.1-1a and G.1-1b show the overall project area and the specific areas for which SEA mapped noise contours for the Proposed Action and Alternatives. Each specific area indicated in Figures G.1-1a and G.1-1b is then shown in more detail in Figures G.1-2 through G.1-15 (which appear at the end of this Appendix). In Figures G.1-2 through G.1-15, the outermost edge of the noise contour (shown in either green or purple) corresponds to 65 dBA L_{dn} following implementation of the Proposed Action or Alternatives. Areas that are currently at 65 dBA L_{dn} or above are shown in green. Areas that would be at 65 dBA L_{dn} or above only following project implementation are shown in purple. For the build segments, the noise contours are shown in purple because all of the noise shown would occur following project implementation. The tear-drop shapes occur at grade crossings where horns are sounded; noise contours in other areas are due to wayside noise. The jagged portions of these contours are due to the effects of building shielding. Buildings tend to block sound, and more so when they are located close together.

SEA used the noise contours shown in Figures G.1-2 through G.1-15, aerial photographs (for Liberty County), land use parcel data (for Harris County), and Geographic Information Systems software to identify and count noise-sensitive receptors (parcels) exposed to 65 dBA L_{dn} or greater for the Proposed Action and Alternatives. Table G.1-1 and Figures G.1-2 through G.1-15 show the results of this analysis. Table G.1-1 summarizes the number of noise-sensitive receptors identified within the 65 L_{dn} contour. The figures show the portions of the project area in which noise sensitive receptors were identified within the 65 L_{dn} contour. In addition, the figures show the Build Segments associated with the Build Alternatives. Noise-sensitive receptors that are currently exposed (No-Action conditions) to 65 L_{dn} or above are shown as black polygons in Figures G.1-2 through G.1-15 while additional receptors that would be exposed as a result of the Proposed Action and Alternatives are shown as blue polygons. In Harris County, the polygons shown as noise-sensitive receptors are land parcels indicated to contain noise-sensitive receptors based on the land use code for the parcel. In Liberty County, the polygons shown are structures identified as potential noise-sensitive receptors based on review of aerial photographs.[1]

Table G.1-1
Noise-Sensitive Receptors at 65 dBA L_{dn} and Greater

Build Alternatives	**Existing**	**Future**	**Increase**
Build Segments	0	0	0
GH&H south of Tower 30	202	293	91
Tower 30 to Tower 85	101	114	13
Tower 85 to Tower 87	445	495	50
Tower 87 to CMC Yard	571	646	75
Total	1,319	1,548	229
No-Build Alternative			
Bayport Industrial Lead	0	0	0
Strang	275	325	50
Tower 30 to Tower 85	101	114	13
Tower 85 to Tower 87	445	495	50
Tower 87 to CMC Yard	571	646	75
Total	1,392	1,580	188

[1] SEA was not able to obtain parcel data for Liberty county in an electronic form that was readily adaptable to the GIS system used to perform the analysis.

Counts of noise-sensitive receptors are approximate for several reasons. First, a land parcel generally was counted as a receptor if it contained a sensitive receptor (e.g., residence, school, place of worship) and any portion of the parcel was located within the 65 L_{dn} noise contour, when in fact the actual location of the receptor on the parcel may be outside of the 65 L_{dn} noise contour. Second, land uses may have changed since the land use parcel data were collected or the aerial photographs were taken. Third, it is sometimes difficult to determine whether a structure shown on an aerial photograph falls within a sensitive receptor category or not. In developing the receptor results shown in Table G.1-1, SEA took a conservative approach and included structures of unknown type in the count of noise-sensitive receptors.

As shown, the Proposed Action would result in an increased number of receptors at 65 dBA L_{dn} (an additional 229 receptors) and the No-Build Alternative would result in an increase of 188 receptors. There are no affected receptors in areas where new track would be constructed. (Inspection of aerial photographs indicates that the noise contours do not include sensitive receptors along the Build Segments or along the Bayport Industrial Lead or the Bayport Loop.)

As discussed in Section 4.5.2.3, for all of the Build Alternatives, SEA's analysis indicates that increases in noise level would be less than or equal to 2 dBA. This is not a substantial increase in railroad noise level, although additional receptors would be exposed to 65 dBA L_{dn} as a result of the increase. The No-Build Alternative railroad noise level increases would be less than or equal to 1.5 dBA.

G.2 CONSTRUCTION NOISE

SEA based this construction noise impact assessment on Federal Transit Administration (FTA) methods and construction noise guidelines (see Table G.2-1).

Table G.2-1
FTA Construction Noise Guidelines

	8-hour Leq (dBA)		L_{dn} (dBA)
Land Use	Day	Night	30-day Average
Residential	80	70	75[a]
Commercial	85	85	80[b]
Industrial	90	90	85[b]

(a) In urban areas with very high ambient noise levels (L_{dn} > 65 dBA), L_{dn} from construction projects should not exceed existing ambient + 10 dB.
(b) Twenty-four hour Leq, not L_{dn}.

The noise levels created by construction equipment vary greatly depending on such factors as the type of equipment, the specific model, the operation being performed, and the condition of the equipment. In addition, the proximity of the equipment to noise sensitive locations, duration of the activity, and time of day will influence the effects of construction noise. The results of SEA's assessment reflect the uncertainty about the exact details of construction activities that would be required.

The FTA construction noise analysis method suggests using the two noisiest pieces of equipment to estimate noise levels at sensitive locations. Based on construction equipment information provided by the Applicant, SEA used heavy trucks and bulldozers as the two noisiest pieces of equipment. SEA also estimated the effects of pile driving separately because mobile noise sources such as trucks are likely to traverse the entire track alignment whereas pile driving would only occur at specific locations such as bridges. Table G.2-2 shows estimated mobile source construction noise levels for each alternative.

Table G.2-2. Estimated Construction Noise Levels

Alternative	Approximate Distance to Closest Receptor (ft.)	8-hour Dozer Leq	8-hour Truck Leq	Total 8-hour Leq (dBA)
Proposed Action	1,770	54	51	56
Alternative 1C	540	64	61	66
Alternative 2B	140	76	73	78
Alternative 2D	380	67	64	69
Alternative	**Approximate Distance to Closest Receptor (ft.)**	**30- day Dozer L_{dn}**	**30-day Truck L_{dn}**	**Total 30-day L_{dn} (dBA)**
Proposed Action	1,770	39	49	50
Alternative 1C	540	50	60	60
Alternative 2B	140	62	72	72
Alternative 2D	380	53	63	63

SEA developed 8-hour construction noise level estimates by assuming that a bulldozer (with an emission level of 85 dBA at 50 feet) would be at full operation for 8 hours at a given location along an alignment at the approximate minimum distance to the nearest residential receptor anywhere along the construction route. SEA also assumed that trucks (with an emission level of 88 dBA at 50 feet) would be at full power for 15 minutes per hour at the same location for 8 hours per day (this information is based in part on construction data provided by the Applicant).

SEA developed the 30-day construction noise level estimates by assuming that a bulldozer would only be at the minimum distance to a residence for one day out of 30. SEA also assumes that trucks will be at the minimum distance to the nearest residential receptor for 10 minutes out of each hour for eight hours per day for 30 days.

Based on information submitted by the applicants, these analyses assume that no construction would occur during the night.

The Applicants indicate that work activity at the borrow site and detention pond may be more concentrated than work activity along the rail corridor. However, at this point in the planning process, the exact details of such activity are not currently available. Because the distance from these areas to nearby receptors is large (600 feet to NASA facility and 1,100 feet to residences), SEA estimates that conventional construction activity at concentrated levels would result in noise levels well below the guidelines shown in Table G.2-1.

SEA also evaluated pile driving noise that may result from construction of bridges at Red Blufff Road and Space Center Boulevard, Taylor Bayou, Armand Bayou, Horsepen Bayou, Spring Gully, Big Island Slough, and Harris County Flood Control District ditches. The closest residential location is approximately 1,700 feet from these pile-driving locations. Assuming continuous pile driving for 8 hours per day and continuous use for 30 days (or longer at some locations), the 8-hour Leq and 30 day L_{dn} would be approximately 70 dBA at a distance of 1,700 feet.

Figure G.1-1a
Reference Grid for Noise Contours in the Project Area

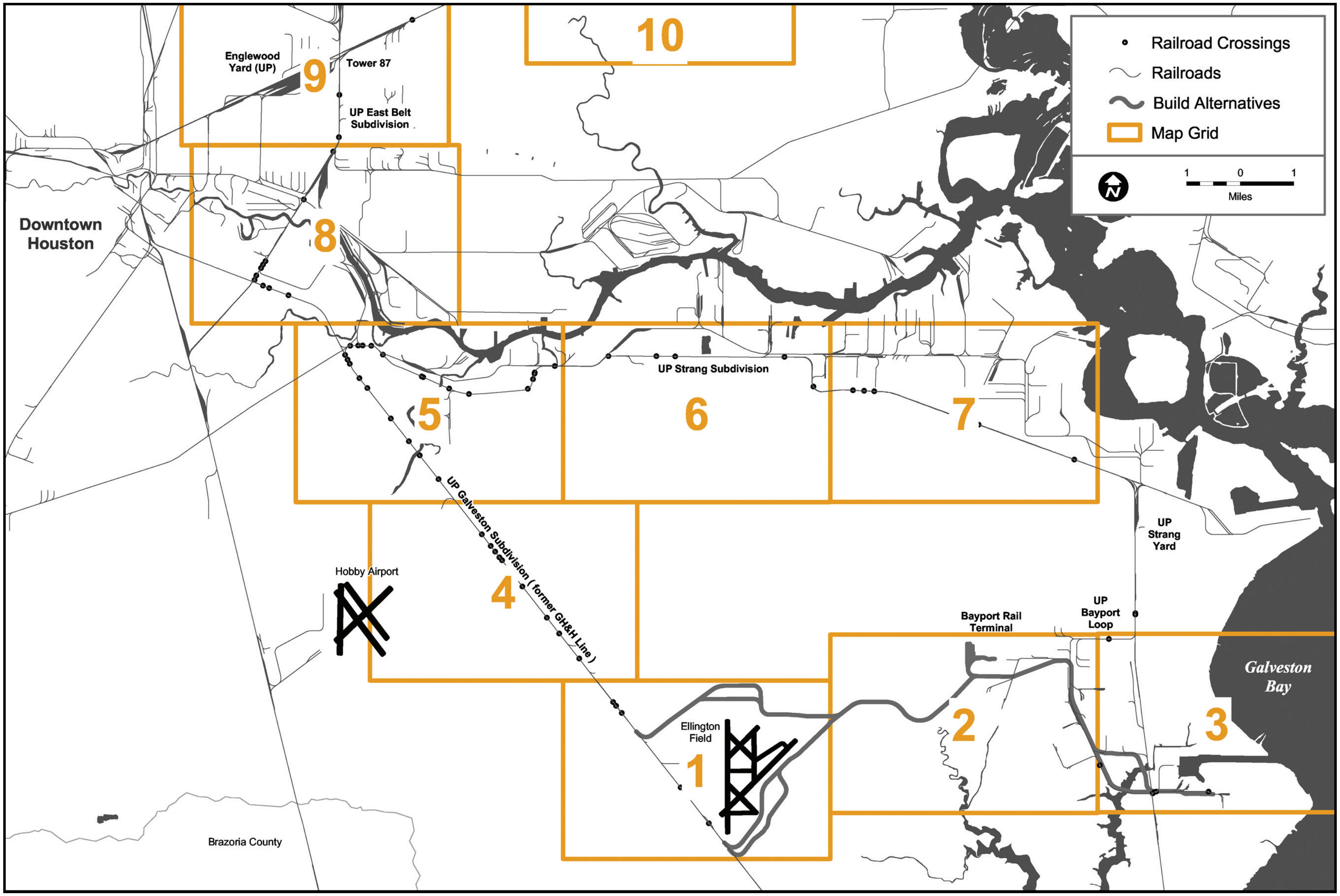

Figure G.1-1b
Reference Grid for Noise Contours in the Project Area

Figure G.1-2
Noise Contours in the Project Area - Part 1

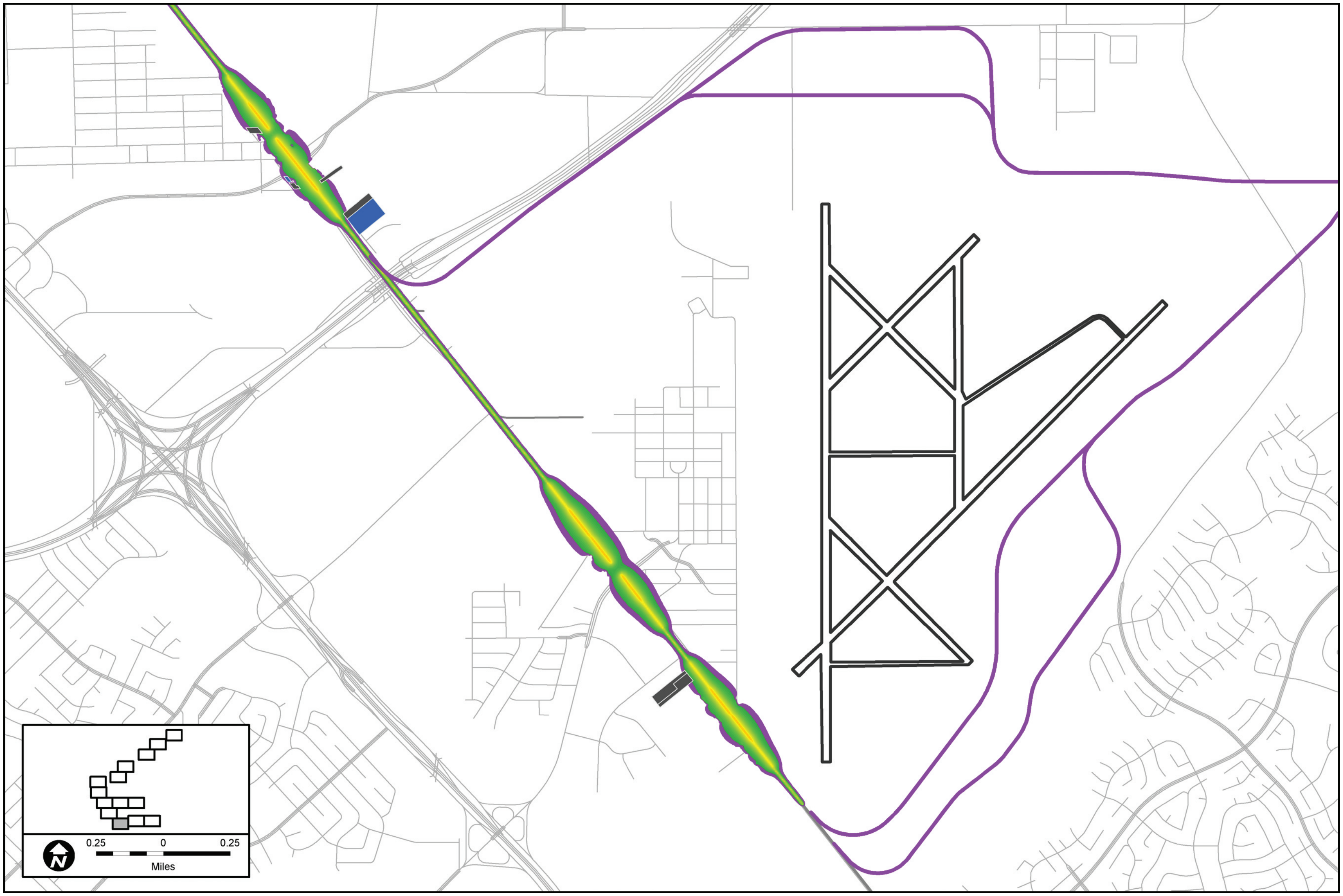

Figure G.1-3
Noise Contours in the Project Area - Part 2

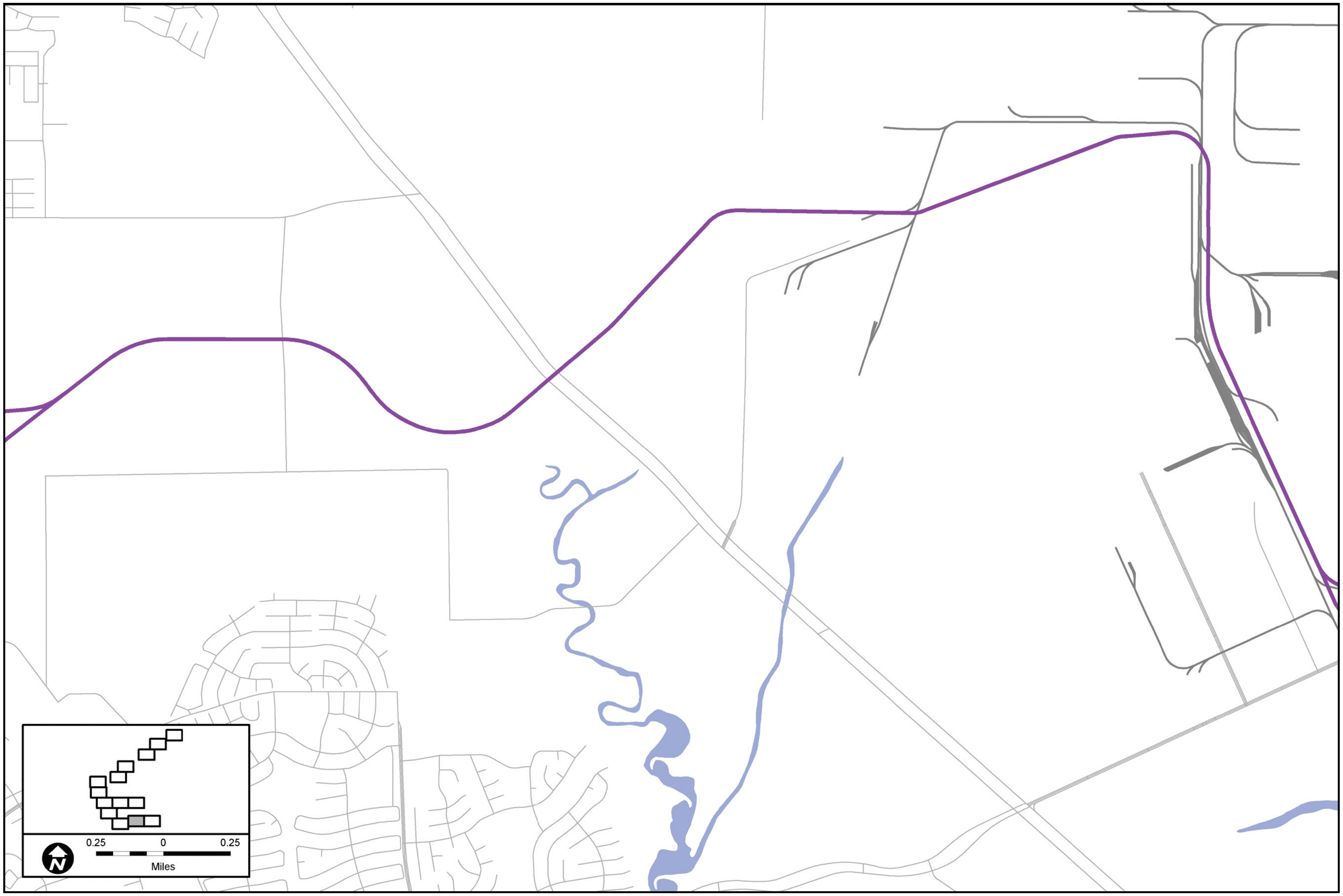

Figure G.1-4
Noise Contours in the Project Area - Part 3

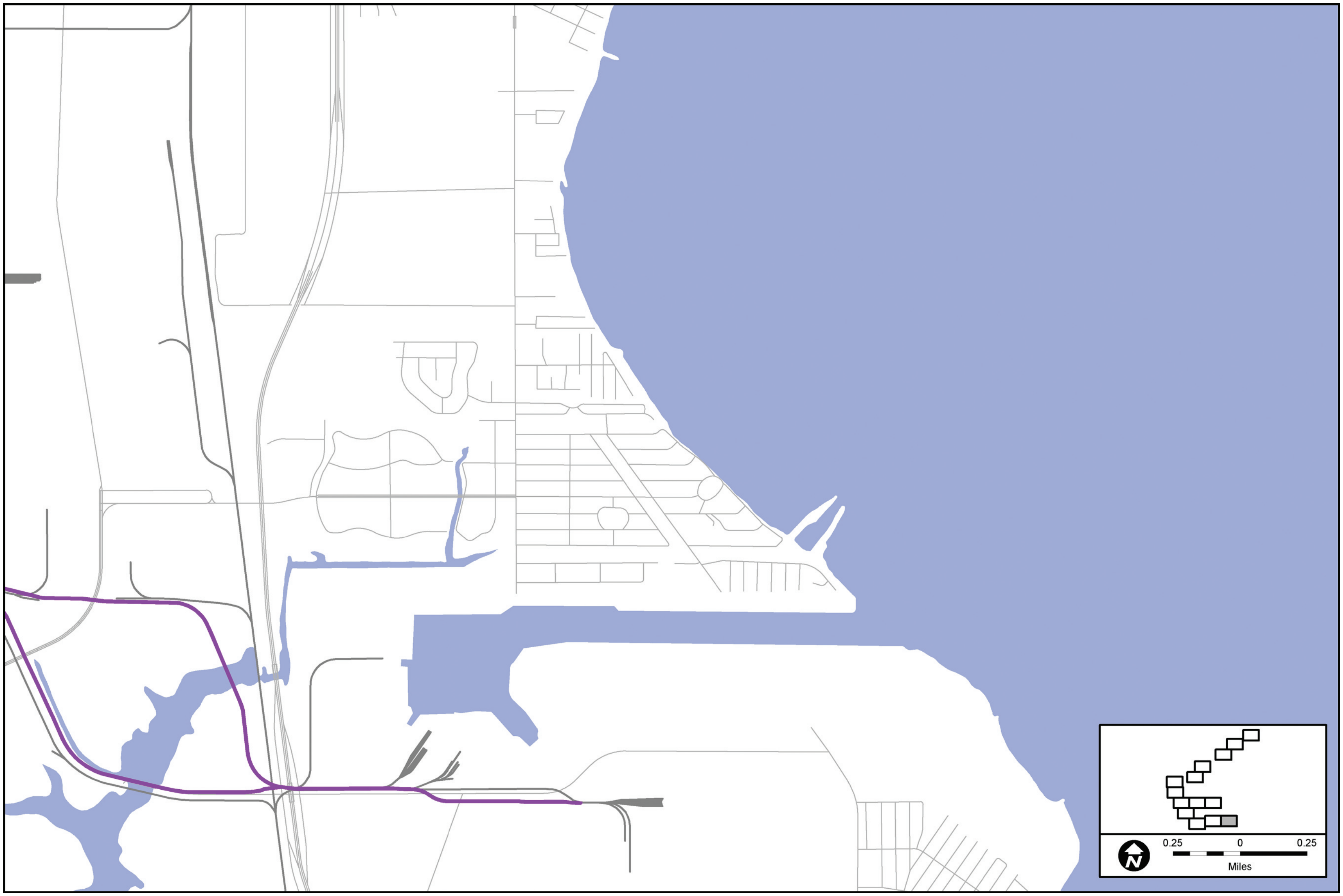

Figure G.1-5
Noise Contours in the Project Area - Part 4

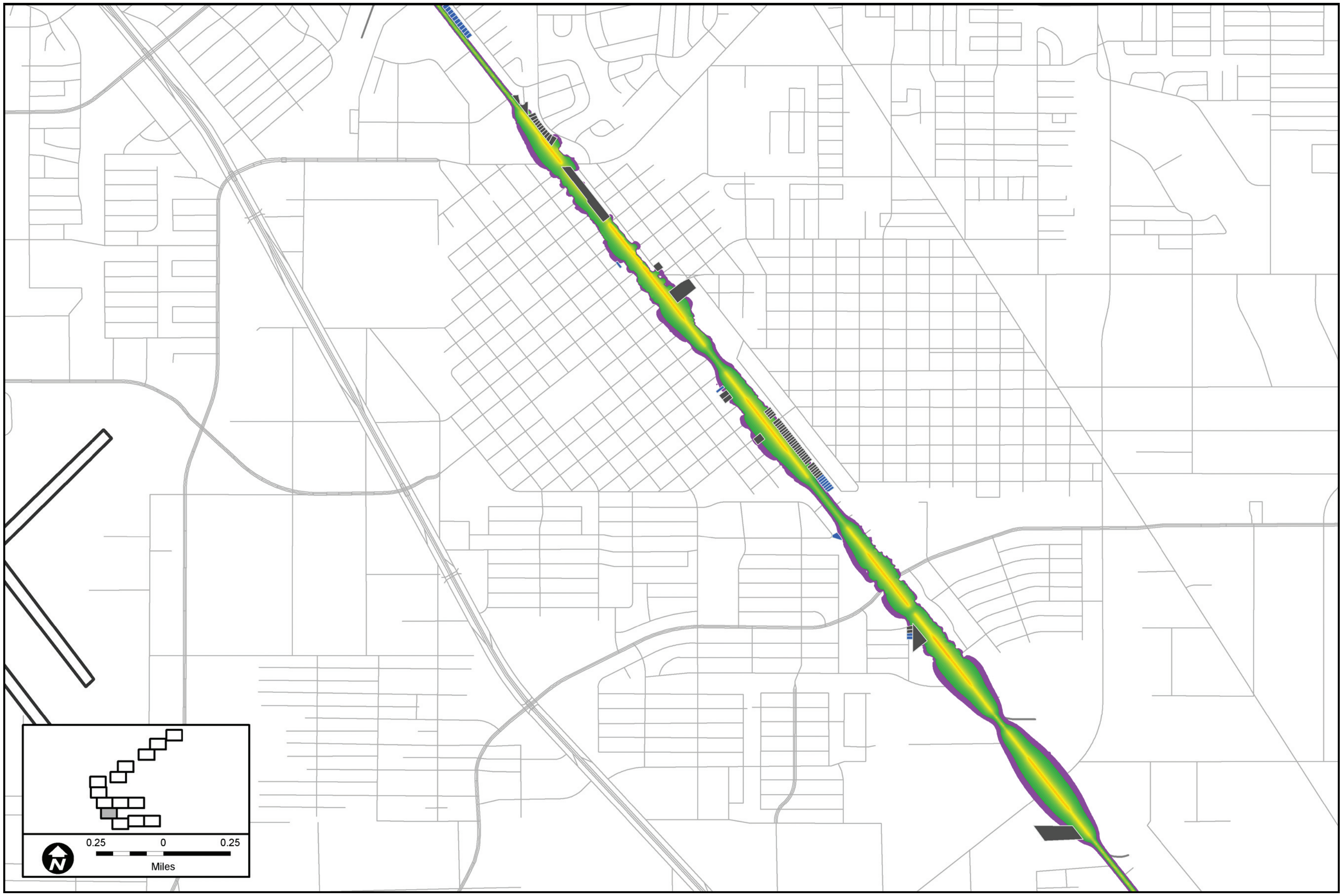

Figure G.1-6
Noise Contours in the Project Area - Part 5

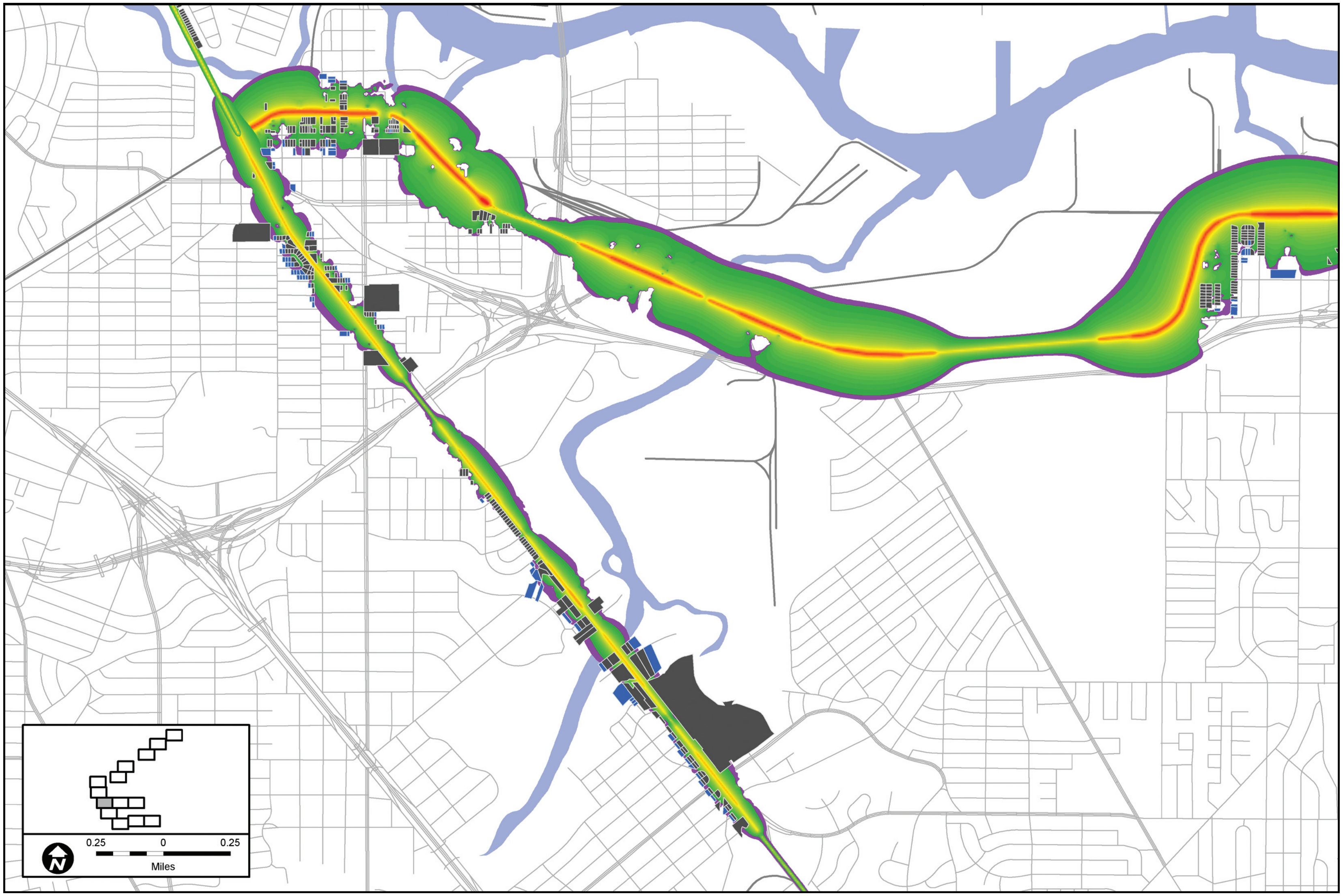

Figure G.1-7
Noise Contours in the Project Area - Part 6

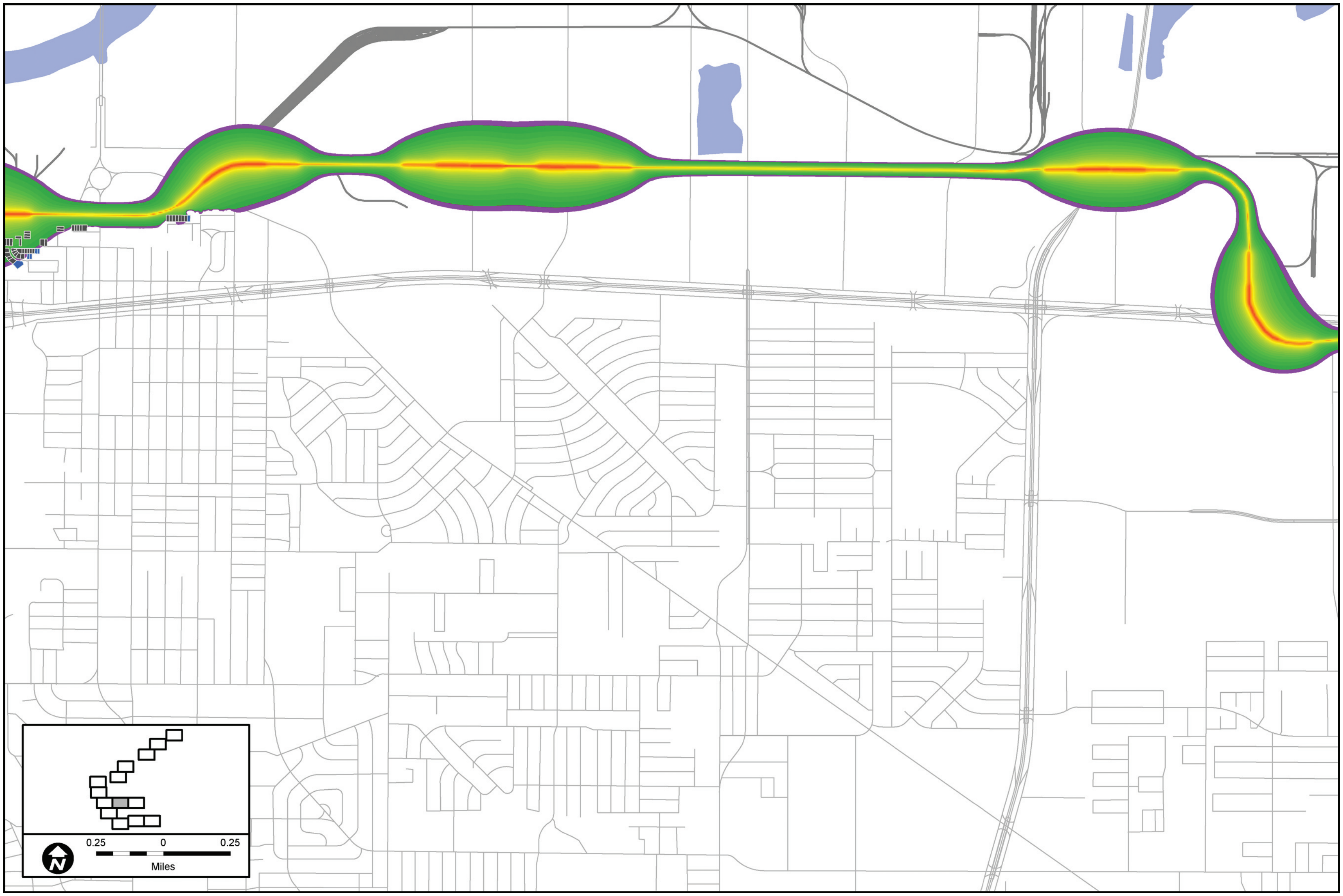

Figure G.1-8
Noise Contours in the Project Area - Part 7

Figure G.1-9
Noise Contours in the Project Area - Part 8

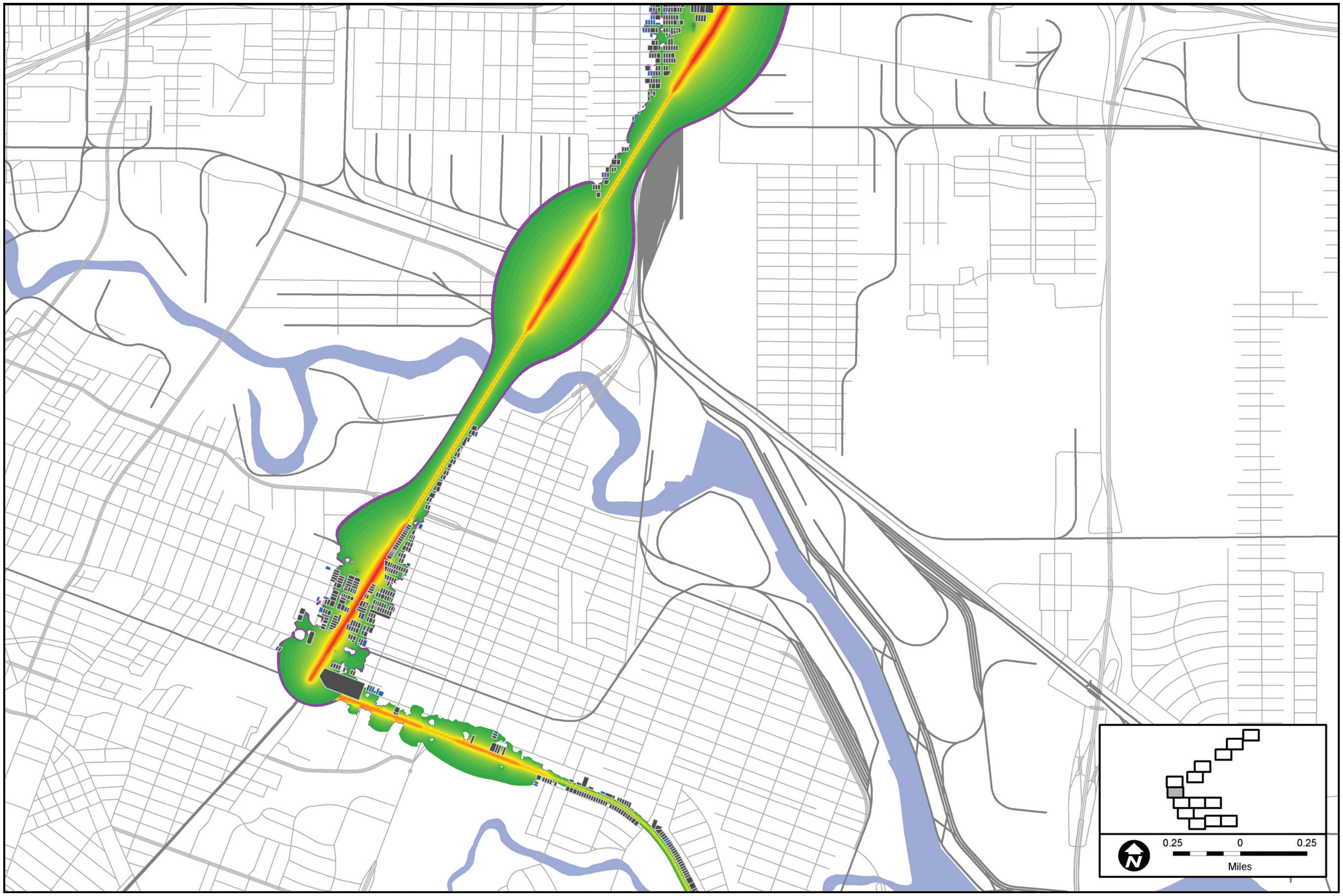

Figure G.1-10
Noise Contours in the Project Area - Part 9

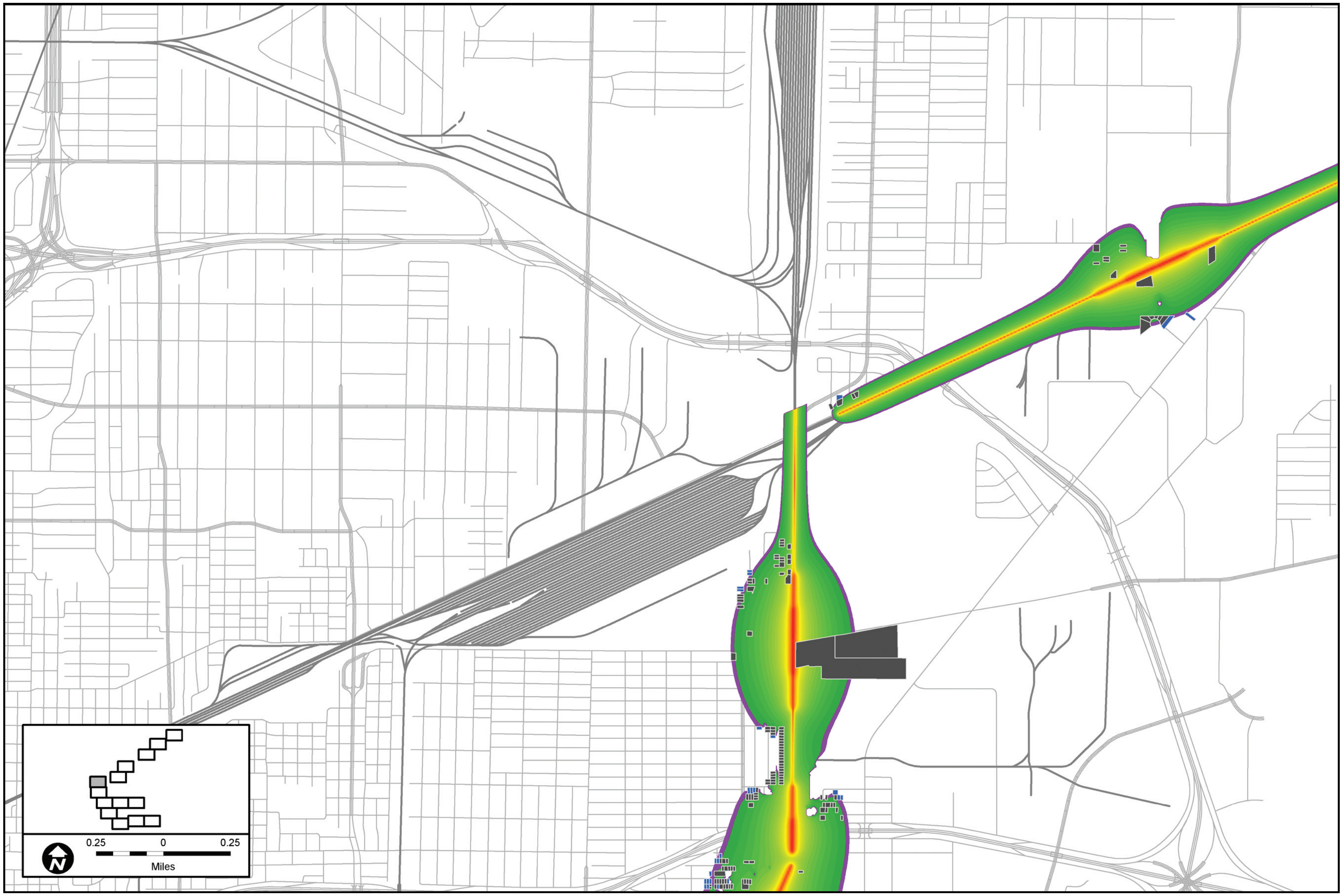

Figure G.1-11
Noise Contours in the Project Area - Part 10

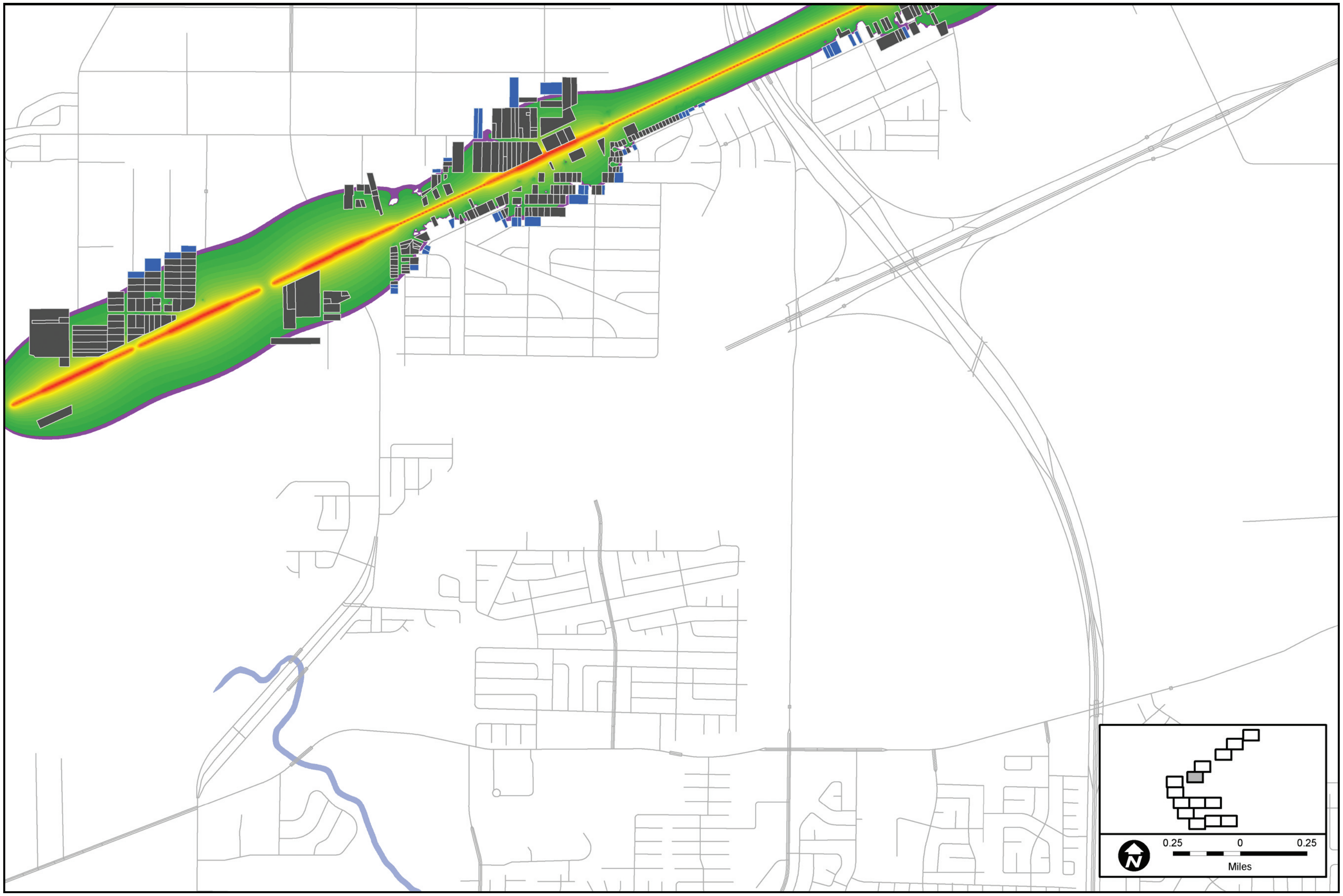

Figure G.1-12
Noise Contours in the Project Area - Part 11

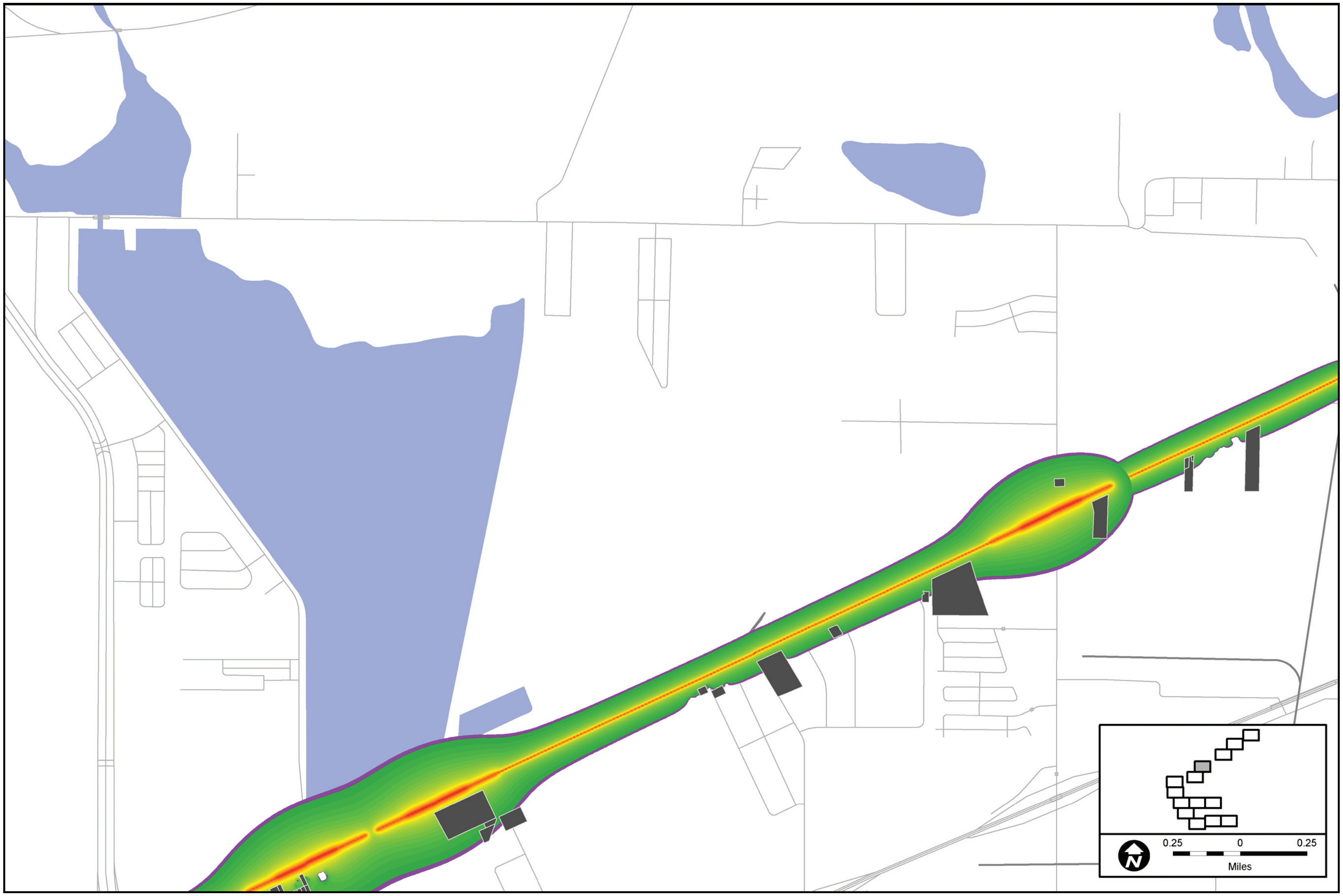

Figure G.1-13
Noise Contours in the Project Area - Part 12

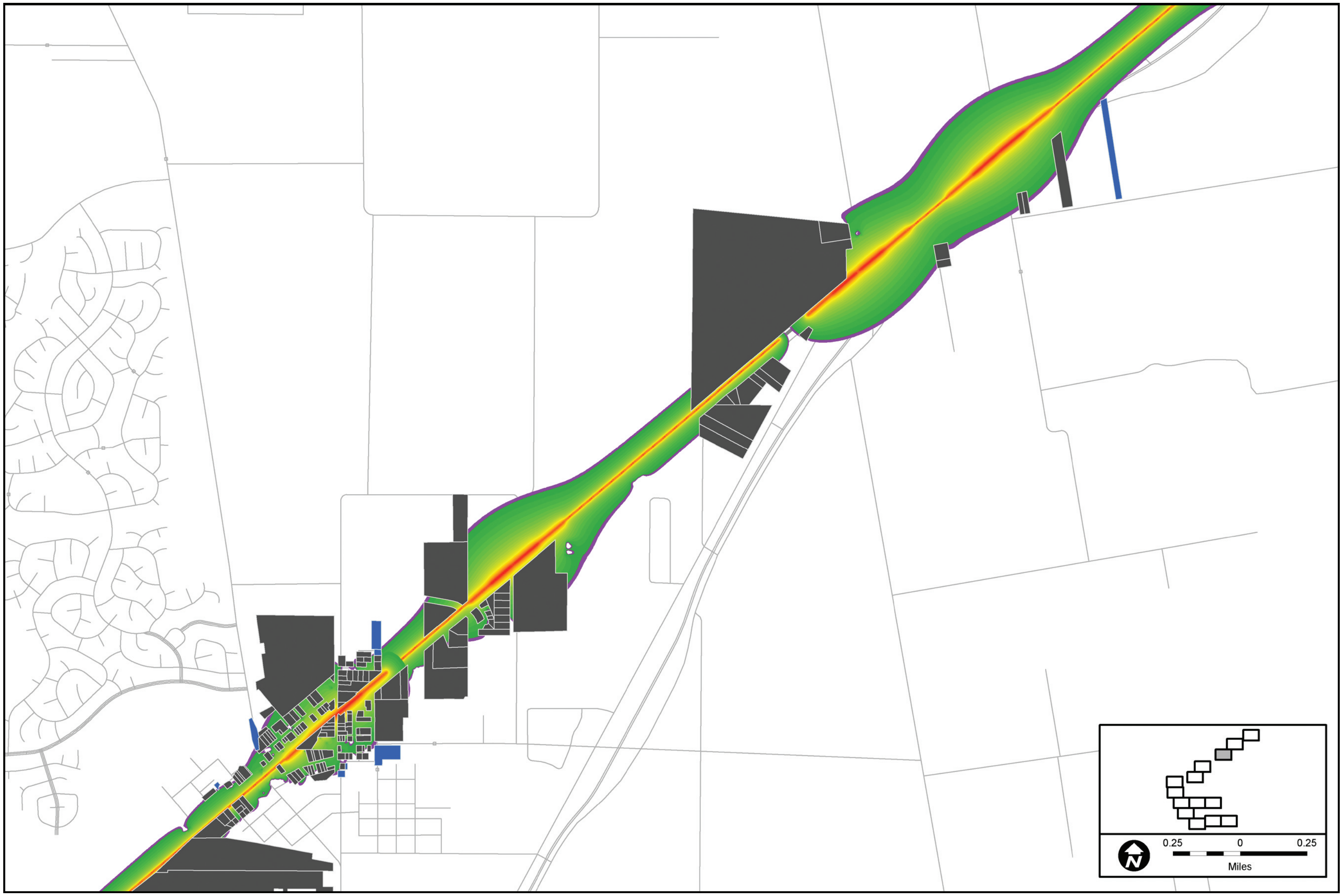

Figure G.1-14
Noise Contours in the Project Area - Part 13

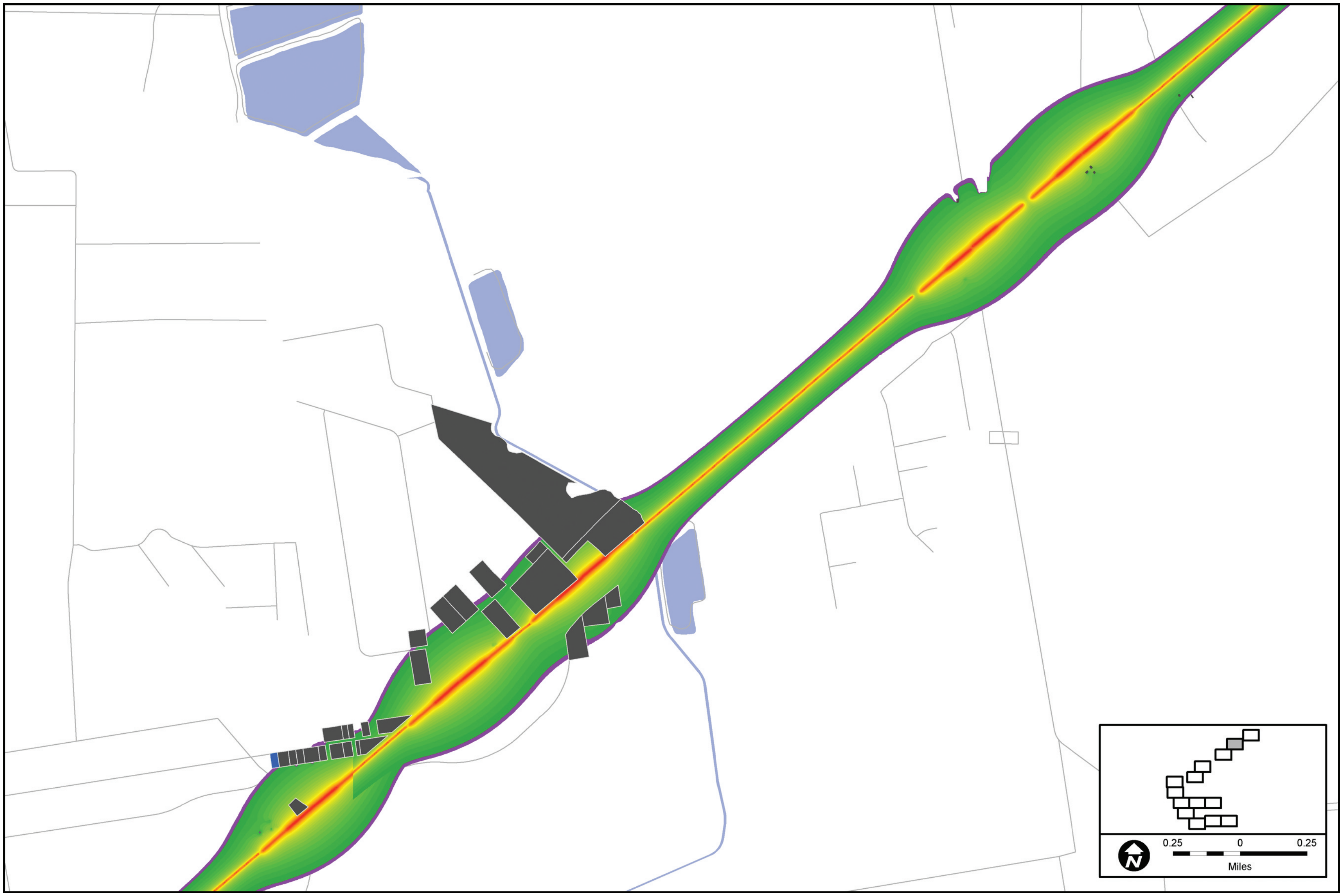

Figure G.1-15
Noise Contours in the Project Area - Part 14