Chapter 12: Noise and Vibration

12-1 INTRODUCTION

This chapter assesses the potential noise and vibration effects resulting from operation of the Tappan Zee Hudson River Crossing Project. The potential noise and vibration impacts of the project's construction are described in Chapter 18, "Construction Impacts."

Noise is unwanted sound. In a community, noise can come from a wide variety of sources including transportation sources (such as automobiles, trucks, buses, trains, and aircraft), stationary sources (such as manufacturing facilities, HVAC systems, and utility operations), natural sources (such as animals, insects, and wind) and from people (talking, and just going about their business). Environmental noise is composed of sounds from moving as well as stationary sources, and varies from place to place and from time to time.

The level of highway traffic noise primarily depends on four things:

- Volume of traffic;
- Speed of traffic;
- Number of trucks in flow of traffic; and
- Distance from the traffic.

12-2 REGULATORY REQUIREMENTS

The proposed project is a Type I project, as defined in 23 CFR § 772, *"Procedures for Abatement of Highway Traffic Noise and Construction Noise"* and the New York State Department of Transportation's (NYSDOT) *Environmental Manual (TEM)*, Chapter 4.4.18 "*Noise Analysis Policy and Procedures*." A Type I project is "a proposed Federal or Federal-aid highway project for the construction of a highway on new location or the physical alternation of an existing highway which significantly changes the horizontal or vertical alignment or increases the number of through-traffic lanes."

The Federal Highway Administration (FHWA) has established noise analysis procedures for federally aided highway projects, such as the replacement of the Tappan Zee Bridge, to provide guidance and criteria for noise studies and noise abatement measures. FHWA requires (1) identification of existing activities, developed lands, and undeveloped lands for which development is planned, designed, and programmed that may be affected by noise from the replacement; (2) measurement of existing noise levels; (3) prediction of existing and future traffic noise levels; (4) determination of traffic noise impacts; (5) examination and evaluation of alternative noise abatement measures to reduce or eliminate noise impacts (where impacts are determined to occur); (6) analysis of construction noise; and (7) coordination with local officials.

Vibration is a periodic motion or oscillation about an equilibrium position. Vibration can result in the noticeable movement of building floors, rattling of windows, shaking of items on shelves or hanging on walls, and even rumbling sounds. High vibration levels can result in architectural or structural damage. Similar to noise, vibration can come from a variety of sources including the operation of mechanical equipment and from transportation. Absent roadway discontinuities vehicular roadways do not result in vibration levels that are perceptible or result in architectural or structural damage. As such, an assessment of vibrations from the highway and bridge operations for the project is not warranted. However, sensitive receptor locations near construction-related activities have the potential for exposure to high vibration levels (see Chapter 18, "Construction Impacts," for further discussion of potential construction-related impacts).

12-3 METHODOLOGY

12-3-1 NOISE AND VIBRATION FUNDAMENTALS AND TERMINOLOGY

12-3-1-1 NOISE

Noise levels are measured in units called decibels (dB). A 1-decibel change in noise is about the smallest change detectable by the human ear under ideal laboratory conditions. Outside a laboratory, a change of 3 decibels or more can be detected without the use of instruments. A change of more than 5 decibels is an appreciable change in noise level. A 10-decibel increase is considered large and represents a doubling of loudness. (For example, 50 decibels sounds twice as loud as 40 decibels.)

The human ear does not respond equally to all frequencies (or pitches). Measured sound levels are often adjusted or weighted to correspond to the human perception of loudness; it is filtered to reduce the strength of very low- and high-pitched sounds. This adjusted unit is known as the A-weighted decibel, or dBA. **Table 12-1** lists typical noise levels, in dBA, generated by different sources.

It is also important to understand that, because of the logarithmic nature of sound when measured in dBA's, combinations of different sources are not additive in an arithmetic manner. For example, two noise sources—a vacuum cleaner operating at approximately 72 dBA and a telephone ringing at approximately 58 dBA—do not combine to create a noise level of 130 dBA, the equivalent of a jet airplane or air raid siren (Table 12-1). In fact, the noise produced by the telephone ringing may be masked by the noise of the vacuum cleaner and not be heard. The logarithmic combination of these two noise sources would yield a noise level of 72.2 dBA. Similarly, the addition of two equal noise sources would result in a 3 dBA increase in sound level. Consequently, a doubling of traffic would result in a 3 dBA increase in sound level, a barely perceptible change in sound level.

Noise varies with distance. Highway traffic 50 feet away from a receptor (such as a person listening to the noise) typically produces sound levels of approximately 70 dBA. Assuming soft ground, the same highway noise source would result in a sound level of approxdimately66 dBA at a distance of 100 feet. This decrease is known as "drop-off." The outdoor drop-off rate for line sources, such as traffic, is a decrease of approximately 4.5 dBA (for soft ground) for every doubling of distance between the noise source and receiver (for hard ground the outdoor drop-off rate is 3 dBA for line

Table 12-1
Common Noise Levels

Sound Source	(dBA)
Military jet, air raid siren	130
Amplified rock music	110
Jet takeoff at 500 meters	100
Freight train at 30 meters	
Train horn at 30 meters	90
Heavy truck at 15 meters	
Busy city street, loud shout	80
Busy traffic intersection	
Highway traffic at 15 meters, train	70
Predominantly industrial area	60
Light car traffic at 15 meters, city or commercial areas or residential areas close to industry	
Background noise in an office	50
Suburban areas with medium density transportation	
Public library	40
Soft whisper at 5 meters	30
Threshold of hearing	0

Note: A 10 dBA increase in level appears to double the loudness, and a 10 dBA decrease halves the apparent loudness.

Source: Cowan, James P. *Handbook of Environmental Acoustics*, Van Nostrand Reinhold, New York, 1994. Egan, M. David, *Architectural Acoustics*, McGraw-Hill Book Company, 1988.

sources). Assuming soft ground, for point sources, such as noise produced by construction equipment such as a compressor, the outdoor drop-off rate is a decrease of approximately 7.5 dBA for every doubling of distance between the noise source and receiver (for hard ground the outdoor drop-off rate is 6 dBA for point sources).

Since an instantaneous noise measurement (measured in dBA) describes noise levels at just one moment of time, and since very few noises in a community area are constant, other descriptors representing noise levels over extended periods of time are used. The $L_{eq(1)}$ is an hourly measure representing a constant noise level with the same sound energy as the actual fluctuating noise sources recorded during the same hourly period. In accordance with FHWA regulations and NYSDOT policy, the noise descriptor used in this study is the $L_{eq(1)}$.

12-3-1-2 VIBRATION

Generally, ground-borne vibration from highway traffic is not an environmental concern unless there is a significant discontinuity in the roadway surface. Vehicles that travel on properly maintained roadways do not generate vibrations of concern. Therefore, an assessment of vibrations from the highway and bridge operations for the project is not warranted. However, construction activities can cause ground vibration levels that may result in low rumbling sounds, be perceptible, result in annoyance or interference with vibration sensitive equipment and/or activities, and may even result in levels which can cause architectural and/or structural damage, particularly when there are fragile structures in close proximity to construction sites. Potential impacts associated with construction-related vibrations are discussed further in Chapter 18, “Construction Impacts.”

Vibration consists of rapidly fluctuating motions with an average motion of zero. There are several different methods that are used to quantify the magnitude of vibration levels. One method uses the peak particle velocity (PPV) in inches per second (in/sec) to describe the maximum instantaneous positive or negative peak of the vibration signal. While this descriptor is appropriate for evaluating the potential for architectural or structural damage, it is not suitable for evaluating human responses. It takes a longer time interval for humans to respond to a vibration signal and therefore the average vibration amplitude is more appropriate for assessing human response. Because the net average of a vibration signal is zero, the root mean square (rms) amplitude is used to describe the “smoothed” average vibration amplitude. Decibel notation is frequently used to compress the range of rms values used to describe vibration, and rms velocity values used in evaluating human responses are typically expressed in terms of the metric of VdB (velocity level in decibels) defined as:

$$VdB = 20 \log10 (v/v_o)$$

where:

v is the vibration velocity in inch/sec, and

v_o is the reference velocity at 10^{-6} inch/sec.

12-3-2 TRAFFIC NOISE ANALYSIS METHODOLOGY

The methods used in determining noise impacts for this project are in accordance with FHWA regulations and New York State Department of Transportation (NYSDOT) policy. The following methods were used to determine existing noise levels, predict future noise levels, and assess potential noise impacts resulting from the proposed project:

- Existing land uses were established for the project area;
- Based upon existing land uses and travel patterns, receptor locations were selected;
- A noise measurement program was conducted to determine existing noise levels;
- Measured existing noise levels were compared to modeled existing noise levels obtained using the FHWA Traffic Noise Model (TNM 2.5) to validate the use of the model;

- Noise levels for each alternative of the project were modeled for a future analysis condition—30 years from the estimated year of completion (ETC+30)—utilizing the TNM 2.5 model;
- Predicted ETC + 30 noise levels were compared to the existing noise levels and the FHWA/NYSDOT noise impact criteria to determine if any noise impacts would result from each alternative; and
- Noise abatement measures were examined and evaluated at potentially impacted locations.

TNM 2.5 calculates the noise contribution of each roadway segment to a given noise receptor and sums the contributions to estimate the noise level at a given receptor location. The noise from each vehicle type (auto, medium truck [two axles with six wheels], heavy truck [more than 2 axles], bus, and motorcycle) is determined as a function of the reference energy-mean emission level, corrected for vehicle volume, speed, roadway grade, roadway segment length, and source-receptor distance. Further adjustments needed to model the propagation path include shielding provided by building structures, the effects of different ground types, source and receptor elevations, and effect of any intervening noise barriers. Traffic parameters used in the noise analyses were taken from the information developed for the traffic analyses presented in Chapter 4, "Transportation."

12-3-3 IMPACT CRITERIA

12-3-3-1 FHWA AND NYSDOT CRITERIA

In accordance with FHWA regulations and NYSDOT policy, a traffic noise impact occurs when either one of the following conditions occurs:

- The predicted traffic noise levels associated with a project alternative would approach or exceed the FHWA established noise abatement criteria (NAC); or
- The predicted traffic noise levels would substantially exceed the existing noise levels.

These criteria are discussed in greater detail below.

FHWA Noise Abatement Criteria (NAC)

A proposed project is considered to cause a traffic noise impact if predicted noise levels with a project alternative approach or exceed the FHWA NAC shown in **Table 12-2**. "Approach" is defined as being within 1 dBA of the NAC.

Substantial Increase of Existing Noise Levels

Noise impacts also occur when the predicted future traffic noise levels from a roadway project substantially exceed or increase the existing noise levels. NYSDOT defines substantially exceeding or a substantial noise increase as an increase of six (6) decibels or more above existing noise levels. Typically, such an increase could occur if traffic volumes quadrupled (assuming no change in vehicle mix or speed) or the distance between the receptor and the source decreased by a factor of four. A combination of a less than fourfold traffic increase with a less than fourfold decrease in source-receptor distance could also increase noise levels by 6 decibels.

Table 12-2
FHWA Noise Abatement Criteria
Hourly A-Weighted Sound Levels (dBA)

Activity Category[1]	$L_{eq(1)}$[2]	Description of Activity Category
A	57 Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 Exterior	Residential.
C	67 Exterior	Active sport areas, amphitheatres, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52 Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E[3]	72 Exterior	Hotels, motels, offices, restaurants/bars and other developed lands, properties or activities not included in A to D or F.
F		Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (e.g., water resources, water treatment, electrical), and warehousing.
G		Undeveloped lands that are not permitted.

Note:
(1) Activity Criteria are for impact determination only and are not design standards for noise abatement measures.
(2) $L_{eq(1)}$ means hourly A-weighted equivalent sound level, in dBA.
(3) Includes undeveloped lands permitted for this Activity Category.

12-4 AFFECTED ENVIRONMENT

12-4-1 INTRODUCTION

Existing conditions along the project corridor have been assessed as follows:

- Surveys were conducted along the corridor to determine land use criteria for selecting noise measurement locations;
- Existing noise levels were measured to establish sufficient baseline data to confirm that the noise model is in agreement with measurements;
- Predictions were made of existing noise levels along the corridor within the project limit; and
- Existing noise contours were developed for informational purposes[1].

[1] Noise contours are presented for informational purposes only and are not used in determining potential adverse impacts.

12-4-2 POTENTIALLY AFFECTED LAND USES

Potentially affected land uses in the project study area, which runs approximately from Interchange 9 to Interchange 10, on either side of Interstate 87/287 within Rockland and Westchester Counties, mainly include: residences (FHWA NAC Activity Category B); active recreational areas, parks, churches, schools, etc. (FHWA NAC Activity Category C); and commercial uses, offices, restaurants, etc. (FHWA NAC Activity Category E). In addition, there are a small number of FHWA NAC Activity Category D sites.

Figure 12-1 shows existing land uses in the project study area along Interstate 87/287, with the potential to be impacted by the project. (**Table 12-2**, above, provides descriptions of the types of land uses that pertain to each of the NAC categories, as well as activity criteria $L_{eq(1)}$ noise levels for each land use category.) A description of land uses in the study area is provided in Chapter 5, “Community Character”.

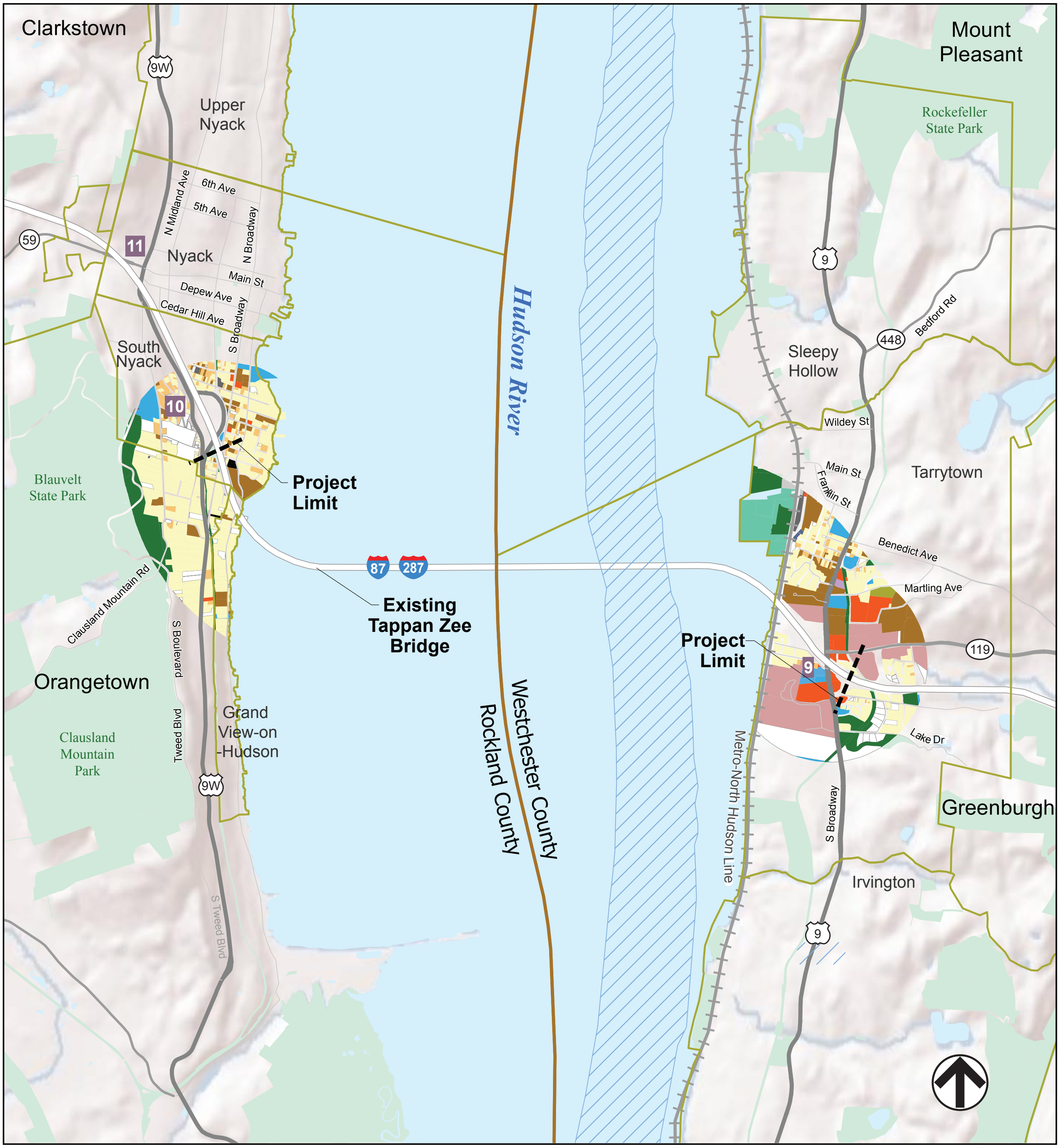
12-4-3 MEASUREMENTS OF EXISTING NOISE LEVELS

In general, traffic noise is greater when traffic volumes or speeds increase. However, this not always the case, and for congested roadways such as the Tappan Zee Bridge and Interstate 87/287, traffic noise may decrease with lower, congestion-reduced speeds. Therefore, the hour with peak traffic volume may not be the hour with highest noise levels. FHWA regulations, and NYSDOT policy based on these regulations, require prediction of the worst hourly traffic-generated noise impacts. Consequently, for noise impact analysis of roadways, it is important to first determine the critical analysis hour(s) [the hour(s) with the highest noise level condition(s)] at locations near the roadway. Once the critical analysis hour(s) are determined, then short term measurements can be conducted at additional locations to use for model validation studies to determine the appropriateness of using the TNM 2.5 model for determining existing noise levels and project impacts in the affected project study area. Generally, sensitive land use locations throughout the study area are selected for these additional monitoring sites for the model validation studies.

12-4-3-1 DETERMINATION OF CRITICAL ANALYSIS HOUR(S)

Continuous 24-hour noise measurements previously conducted by the New York State Thruway Authority (NYSTA) along Interstate 87/287 in Rockland County (May 2004) indicated that the peak noise hour occurs within the AM peak traffic period. To further confirm the hour(s) with the highest noise levels along the corridor in the study area, a 24-hour noise measurement was made at a site adjacent to Interstate 87/287 at Ferris Lane between Interchange 10 and the Tappan Zee Bridge in the Village of South Nyack (see **Figure 12-2**). Continuous measurements at this site were conducted from the morning of November 7 to noon on November 9, 2005.

Measurements were made following the procedures described in NYSDOT’s manual *Field Measurement of Existing Noise Levels*. All measurements were performed using Type I precision Sound Level Meters (SLM). The SLMs meet or exceed the requirements set forth in the ANSI S1.4-1983 Standards for Type I quality and accuracy. Acoustical calibrators were used to calibrate the SLMs before and after each measurement period. The SLMs were operated on the A-weighting network and slow-meter response, as recommended by the manufacturer. Microphone height for all receptors was 1.5 meters above ground level. Measurements were made during a time



- - - Project Limit
One Family Residential
Two Family Residential
Multi Family Residential
Rural Residence
Mixed Use
Commercial-Retail
Manufacturing, Industrial & Warehouse
Office and Research
Institutional/Quasi-Public
Public Park/Open Space
Private Recreation/Private Open Space
Transportation
Utility
Vacant/Undeveloped
Not Yet Classified

Note: GIS land use databases from Rockland County (2005) and Westchester County (2009).

0 1/2 1 MILE
SCALE

Figure 12-1
Study Area Land Use

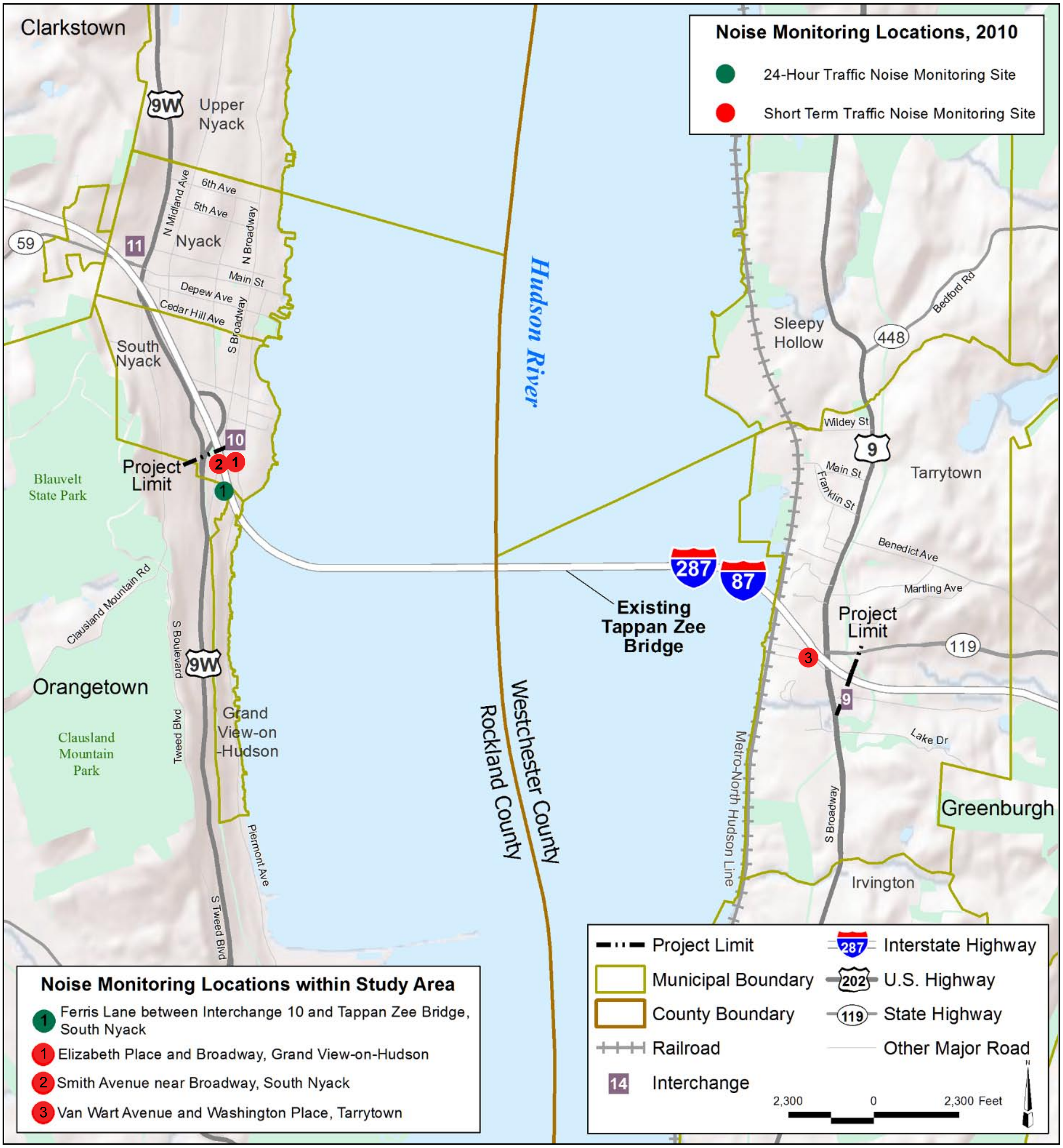


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Figure 12-2
Noise Measurement Sites

period when wind speeds were below 12 miles per hour. A wind screen was used to minimize wind noise across the face of the microphone.

Figure 12-3 shows the measured $L_{eq(1)}$ during the measurement period. Hourly detailed data is provided in **Appendix D**. The measurement site is adjacent to Interstate 87/287 and the measured existing noise levels are dominated by noise due to roadway traffic. It is readily seen from **Figure 12-3** that the peak noise period is between 7 AM and 9 AM, the AM peak traffic period. This peak period coincides with NYSTA's published results along Interstate 87/287 in Rockland County (May 2004). Consequently, subsequent analyses use the AM peak period as the critical or design hour for traffic impact analysis purposes.

12-4-3-2 ANALYSIS HOUR NOISE MEASUREMENTS

In consultation with the NYSDOT Office of Environment (OE), three (3) receptor site locations along Interstate 87/287 in the study area were selected to measure existing noise levels during the AM peak period. **Table 12-3** lists each of the selected short-term noise measurement sites. They are also shown in **Figure 12-2**. All three of the selected receptor sites can be considered sensitive receptor sites, since they all have residential land uses and are considered NAC Category B land use type sites. They are representative of other nearby receptor sites which have similar land uses.

Table 12-3
Selected Measurement Locations

Site #	Location	Municipality
1	Smith Ave near Broadway	South Nyack
2	Elizabeth Pl and Broadway	Upper Grand View
3	Van Wart Ave and Washington Pl	Tarrytown

Short-term measurements were made at each of the three selected sites following the procedures described in NYSDOT's manual *Field Measurement of Existing Noise Levels*. Measurements at each site were made during the AM peak period for between 15 to 25 minutes, depending on the time required for the noise reading to become stable.

At each measurement site, the dominant noise source was the traffic from Interstate 87/287. For receptors immediately behind existing noise barriers, the measured condition included noise contributed from other sources rather than Interstate 87/287 traffic only.

Measurements were initially made on November 18 and 19, 2005. However, to verify that the levels initially measured were representative of existing noise conditions, a second set of measurements was made at Site 1 and 2 on October 5, 2006, and at Site 3 on September 12, 2006. Both sets of measured $L_{eq(1)}$ are shown in **Table 12-4**. Hourly detailed data is provided in **Appendix D**. As shown in the table, at each site, the difference between the two measurements is small (i.e., less than 3 dBA, a barely perceptible change), and it can be concluded that both data sets are representative of existing conditions at the measurement sites.

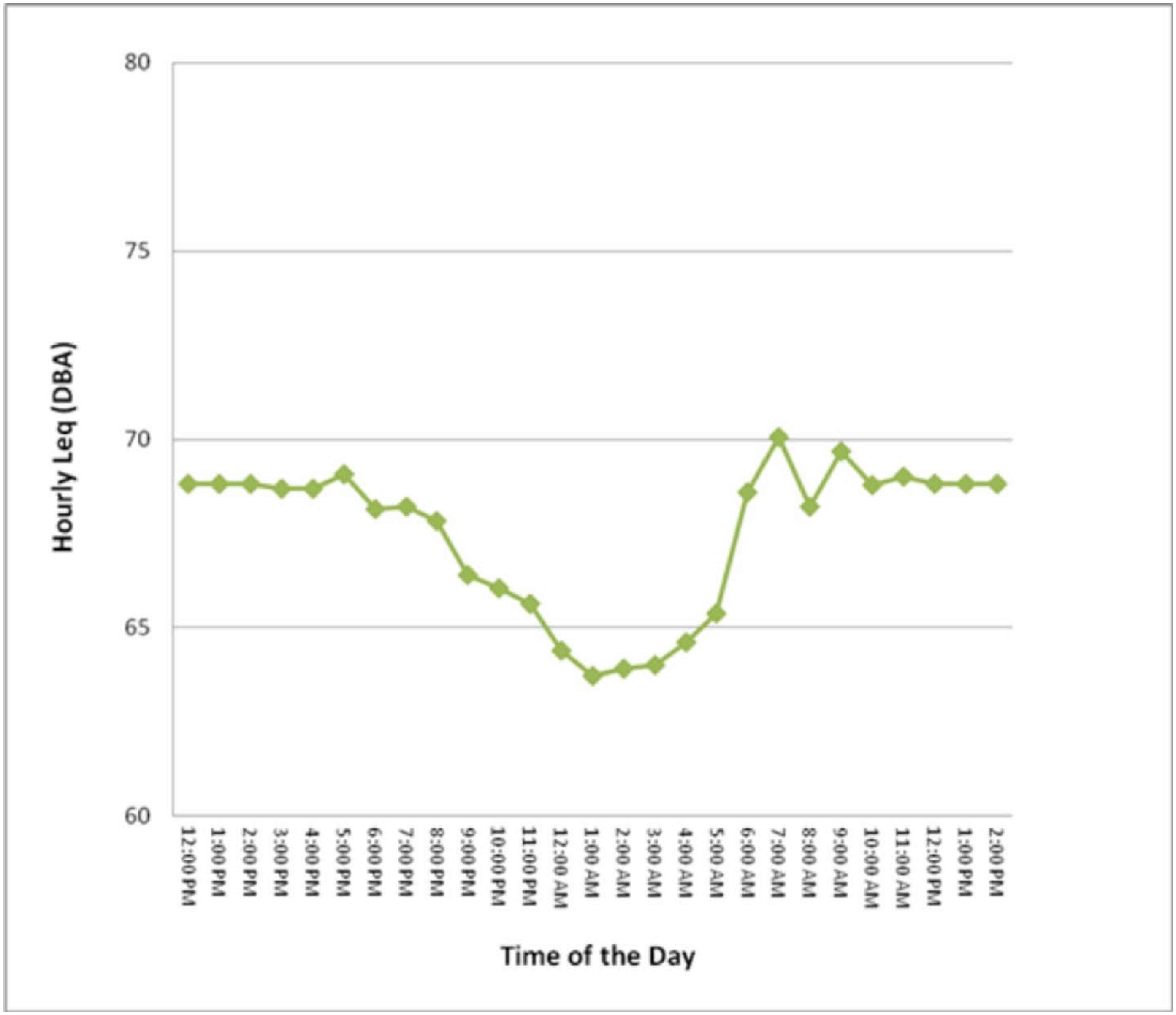

Figure 12-3

Hourly L_{eq} in dBA at Long-Term (24 Hour) Measurement Site

Table 12-4
2005 $L_{eq(1)}$ AM Peak Hour Noise Measurement Results

Site #	First AM Peak Hour Measurement Leq(1) (dBA)	Second AM Peak Hour Measurement Leq(1) (dBA)	Dominant Noise Source	Difference (First Measurement – Second Measurement) (dBA)	Note
1	69	69	I-287	0	
2	62	61	I-287	1	
3	65	63	I-287	2	Behind barrier

12-4-4 COMPARISON OF MEASURED AND MODELED EXISTING NOISE LEVELS

Although TNM 2.5 has been shown to be an accurate predictor of noise levels for most situations, a model validation study was performed to compare measured and model predicted existing noise levels for site-specific conditions for this project.

Using the inputs for the 2005 traffic volumes, speeds, roadway alignments, ground reflections, and existing buildings, the TNM 2.5 model was run to predict the AM peak analysis period traffic noise levels at the three measurement sites. A difference of 3 dBA or less between the modeled $L_{eq(1)}$ noise levels and measured $L_{eq(1)}$ noise levels indicates that the TNM 2.5 model can be used with confidence. **Table 12-5** shows that all of the modeled existing $L_{eq(1)}$ noise levels were within 3 dBA of measured existing values. These results demonstrate that the TNM 2.5 model is appropriate to be used in predicting existing and future noise conditions.

Table 12-5
Comparison of 2005 Measurement and TNM-Predicted $L_{eq(1)}$ Noise Levels

Site #	First AM Peak Hour Measurement $L_{eq(1)}$ (dBA)	Second AM Peak Hour Measurement $L_{eq(1)}$ (dBA)	TNM 2.5 Modeled AM Peak Hour Level $L_{eq(1)}$ (dBA)	Difference (TNM 2.5 – First Measurement) (dBA)	Difference (TNM 2.5 – Second Measurement) (dBA)
1	69	69	70	1	1
2	62	61	64	2	3*
3	65	63	63	-2	0
Note: * Difference is less than 3.0 dBA					

12-4-5 EXISTING NOISE CONTOURS

The validated TNM 2.5 model was used to develop existing 2010 AM peak hour $L_{eq(1)}$ noise levels along Interstate 87/287 in the study area. For prediction purposes a grid of receptor sites was developed on both sides of Interstate 87/287 in the study area. This grid included receptor locations at distances up to 500 feet from the edge of Interstate

87/287. Predicted traffic noise levels within this receptor grid were used to develop the 66 dBA and 71 dBA Leq(1) noise contours. These contours are shown in **Figures 12-4 and 12-5**[1]. They show the areas where existing noise levels are likely to be approaching or exceeding the NACs.

Table 12-6 shows the number of properties in the project study area (i.e., between Interchanges 9 and 10 adjacent to Interstate 87/287) where, based upon modeling performed using TNM 2.5, existing 2010 noise levels are predicted to exceed the NACs. There are a total of 91 properties where existing noise levels are predicted to be exceeding the NACs.

Table 12-6
2010 Existing Conditions-Number of Properties Exceeding NAC*

Land Use Category	Existing Conditions	
	B&C	**E**
Rockland County	83	0
Westchester County	7	1

Note: *Some properties may contain multiple dwelling units, which results in multiple noise receptors.

12-5 ENVIRONMENTAL EFFECTS

Potential noise impacts of the project were evaluated using the analysis methodology and impact criteria previously discussed. The TNM 2.5 model and predicted future traffic conditions in the year 2047 were used to predict $L_{eq(1)}$ noise levels at sensitive receptor locations within the study area (between Interchanges 9 and 10 adjacent to Interstate 87/287). The impact analysis examines the change in AM peak hour noise levels in the study area comparing future 2047 No Build and Build Alternatives (Short Span and Long Span Options) with existing $L_{eq(1)}$ noise levels. Impacts are based upon whether future No Build or Build Alternatives result in exceedances of either the NAC or substantial increase criteria previously described. Specific AM peak hour $L_{eq(1)}$ noise levels are shown for eleven representative “worst-case” receptor locations (which include the three measurement receptor site locations) for existing conditions and for each alternative. The location of the eleven selected receptor sites is shown in **Figure 12-6**.

12-5-1 NO BUILD ALTERNATIVE

As described in Section 12-3-2 above, FHWA’s noise assessment methodology compares future build (with project) conditions to existing conditions in determining whether or not a project would result in adverse noise impacts. However, future noise conditions without the Tappan Zee Bridge Hudson River Crossing Project, which is referred to as the No Build Alternative, are presented for informational purposes.

[1] Noise contours are presented for informational purposes only and are not the basis noise impact assessment.

Figure 12-4

Existing 2010 AM Peak Hour Noise Contours: Westchester County

12.5.11

Figure 12-5

Existing 2010 AM Peak Hour Noise Contours: Rockland County

12.5.11

Figure 12-6
Selected Noise Receptor Sites

Table 12-7 shows predicted $L_{eq(1)}$ noise levels at the selected eleven receptor sites during the AM peak period in the year 2047 for the No Build Alternative. As shown in the table, future noise levels at the eleven receptor sites would be within 3 dBA of existing $L_{eq(1)}$ noise levels. (The decreases in noise levels at some locations are due to predicted changes in vehicle speeds.) The maximum increase in $L_{eq(1)}$ noise levels at any property in the study area, comparing the No Build Alternative with existing conditions, would be less than 2 dBA, a barely perceptible change. More importantly, the predicted increases in $L_{eq(1)}$ noise levels with the No Build Alternative would be significantly less than the FHWA/NYSDOT 6 dBA substantial increase criteria.

Table 12-7
No Build Alternative-AM Peak Hour $L_{eq(1)}$ Noise Levels

Site #	2010 Existing Conditions	2047 No Build Alternative	Difference (No Build Alternative – Existing Conditions)	Exceedance of Substantial Increase Criteria
R1	70	71	1	No
R2	66	67	1	No
R3	72	73	1	No
R4	78	75	-3	No
R5	72	69	-3	No
R6	68	66	-2	No
W1	69	68	-1	No
W2	73	73	0	No
W3	63	62	-1	No
W4	76	76	0	No
W5	76	73	-3	No
Note: Noise levels and differences are rounded-off to the nearest decibel.				

Figures 12-7 and 12-8 show sensitive receptor locations where the 2047 AM peak hour $L_{eq(1)}$ noise levels for the No Build Alternative are predicted to exceed the FHWA/NYSDOT NAC impact criteria. Properties where the NAC B and C levels are predicted to be exceeded are shown in red, and properties where the NAC E level are predicted to be exceeded are shown in orange. At 86 properties in the project study area, the No Build Alternative would result in exceedances of the FHWA/NYSDOT NACs (see **Table 12-8**). These exceedances of the NACs would not be abated.

Table 12-8
No Build Alternative-Number of Properties Exceeding NAC*

Land Use Category	No Build Alternative	
	B&C	E
Rockland County	76	0
Westchester County	8	2
Note: *Some properties may contain multiple dwelling units, which results in multiple noise receptors.		

12.5.11

Figure 12-7

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the No Build Alternative: Westchester County

Figure 12-8

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the No Build Alternative: Rockland County

Compared to the existing conditions, results obtained using the TNM 2.5 model predict that the No Build Alternative would result in a reduction of five properties where the NAC impact criteria would be exceeded. There are no locations where noise levels with the No Build Alternative would exceed the FHWA/NYSDOT 6 dBA substantial increase impact criteria.

12-5-2 REPLACEMENT BRIDGE ALTERNATIVE

12-5-2-1 SHORT SPAN OPTION

Table 12-9 shows predicted $L_{eq(1)}$ noise levels at the selected 11 receptor sites during the AM peak period in the year 2047 for the Short Span Option. As shown in the table future noise levels at the eleven receptor sites would be within 4 dBA of existing $L_{eq(1)}$ noise levels. Changes in geometric alignment, vehicle speed, as well as the realignment of the toll plaza planned as part of this alternative account for the reduction in noise levels at some of the receptor sites. The maximum increase in $L_{eq(1)}$ noise levels at any property in the study area, comparing the Short Span Option with existing conditions, would be less than 3 dBA, a barely perceptible change. More importantly, the predicted increases in $L_{eq(1)}$ noise levels with the Short Span Option would be significantly less than the FHWA/NYSDOT 6 dBA substantial increase criteria.

Table 12-9
Short Span Option-AM Peak Hour $L_{eq(1)}$ Noise Levels

Site #	2010 Existing Conditions	2047 Short Span Option	Difference (Short Span Option – Existing Conditions)	Exceedance of Substantial Increase Criteria
R1	70	71	1	No
R2	66	67	1	No
R3	72	73	1	No
R4	78	74	-4	No
R5	72	73	1	No
R6	68	70	2	No
W1	69	68	-1	No
W2	73	70	-3	No
W3	63	59	-4	No
W4	76	75	-1	No
W5	76	73	-3	No

Note: Noise levels and differences are rounded-off to the nearest decibel.

Figures 12-9 and 12-10 show receptor locations where the 2047 AM peak hour $L_{eq(1)}$ noise levels for the Short Span Option are predicted to exceed the FHWA/NYSDOT NAC impact criteria. Properties where the NAC B and C levels are predicted to be exceeded are shown in red, and properties where the NAC E level are predicted to be exceeded are shown in orange. At 87 properties in the project study area, the Short Span Option would result in exceedances of the FHWA/NYSDOT NACs (see **Table 12-10**). Compared to the existing conditions, results obtained using the TNM 2.5 model predict that the Short Span Option would result in a reduction of four properties where

Figure 12-9

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Short Span Option: Westchester County

12.5.11

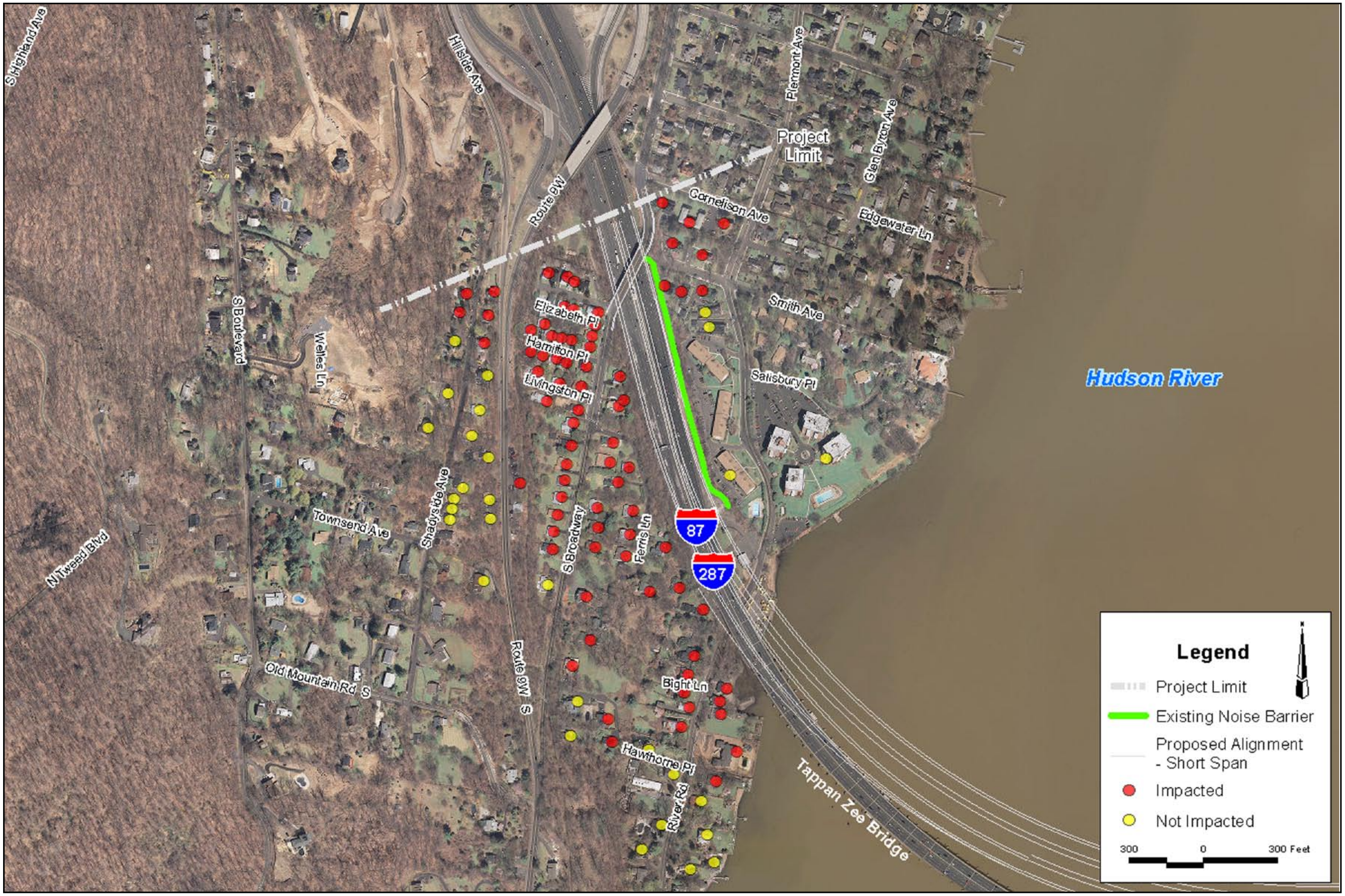

Figure 12-10

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Short Span Option: Rockland County

Table 12-10
Short Span Option-Number of Properties Exceeding NAC*

Land Use Category	Short Span Option	
	B&C	E
Rockland County	79	0
Westchester County	7	1

Note: *Some properties may contain multiple dwelling units, which results in multiple noise receptors.

the NAC impact criteria would be exceeded. There are no locations where noise levels with the Short Span Option would exceed the FHWA/NYSDOT 6 dBA substantial increase impact criteria. Exceedances of the FHWA/NYSDOT impact criteria (in this case of the NACs) require the examination and evaluation of noise abatement measures.

12-5-2-2 LONG SPAN OPTION

Table 12-11 shows predicted $L_{eq(1)}$ noise levels at the 11 measurement receptor sites during the AM peak period in the year 2047 for the Long Span Option. As shown in the table future noise levels at the eleven receptor sites would be within 4 dBA of existing $L_{eq(1)}$ noise levels. Similar to the Short Span Option, changes in geometric alignment, vehicle speed, as well as the realignment of the toll plaza planned as part of this alternative account for the reduction in noise levels at some of the receptor sites. The maximum increase in $L_{eq(1)}$ noise levels at any property in the study area, comparing the Long Span Option with existing conditions, would be less than 3 dBA, a barely perceptible change. More importantly, the predicted increases in $L_{eq(1)}$ noise levels with the Long Span Option would be significantly less than the FHWA/NYSDOT 6 dBA substantial increase criteria.

Table 12-11
Long Span Option-AM Peak Hour $L_{eq(1)}$ Noise Levels

Site #	2010 Existing Conditions	2047 Long Span Option	Difference (Long Span Option – Existing Conditions)	Exceedance of Substantial Increase Criteria
R1	70	71	1	No
R2	66	67	1	No
R3	72	74	2	No
R4	78	75	-3	No
R5	72	70	-2	No
R6	68	66	-2	No
W1	69	68	-1	No
W2	73	70	0	No
W3	63	59	-4	No
W4	76	75	-1	No
W5	76	73	-3	No

Note: Noise levels and differences are rounded-off to the nearest decibel.

Figures 12-11 and 12-12 show receptor locations where the 2047 AM peak hour $L_{eq(1)}$ noise levels for the Long Span Option are predicted to exceed the FHWA/NYSDOT NAC impact criteria. Properties where the NAC B and C levels are predicted to be exceeded are shown in red, and properties where the NAC E level are predicted to be exceeded are shown in orange. At 84 properties in the project study area, the Long Span Option would result in exceedances of the FHWA/NYSDOT NACs (see **Table 12-12**). Compared to the existing conditions, results obtained using the TNM 2.5 model predict that the Long Span Option would result in a reduction of seven properties where the NAC impact criteria would be exceeded. There are no locations where noise levels with the Long Span Option would exceed the FHWA/NYSDOT 6 dBA substantial increase impact criteria. Exceedances of the FHWA/NYSDOT impact criteria (in this case of the NACs) require the examination and evaluation of noise abatement measures.

Table 12-12
Long Span Option-Number of Properties Exceeding NAC*

Land Use Category	Long Span Option	
	B&C	E
Rockland County	76	0
Westchester County	7	1

Note: *Some properties may contain multiple dwelling units, which results in multiple noise receptors.

12-5-3 CONCLUSIONS

There is no substantial difference in the noise analysis results for the project alternatives—the No Build Alternative, and the Replacement Bridge Alternative (the Short Span Option and the Long Span Option). For each option, predicted traffic noise levels would be comparable to, and not substantially different from existing noise levels. For each alternative, noise levels would exceed the FHWA/NYSDOT NACs at approximately the same properties, and these same properties have exceedances of the NACs for existing conditions.

12-6 MITIGATION

12-6-1 INTRODUCTION

As described above, while each project alternative—the No Build Alternative, and the two options for the Replacement Bridge Alternative—would not result in exceedances of the FHWA/NYSDOT substantial increase criteria, they would result in exceedances of the NACs at a number of locations resulting in adverse noise impacts. Consequently, noise abatement techniques were examined to determine if there are feasible and reasonable techniques for substantially reducing or eliminating the noise impacts for the Replacement Build Alternative.

Feasibility deals primarily with engineering considerations (e.g., can the noise abatement measure be built, can noise reduction be achieved given certain other engineering and site constraints, are noise sources other than those of the project present in the area, etc.). Feasibility involves the practical capability of the noise abatement measure being considered as well as the capacity to achieve a minimum

Figure 12-11

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Long Span Option: Westchester County

12.5.11

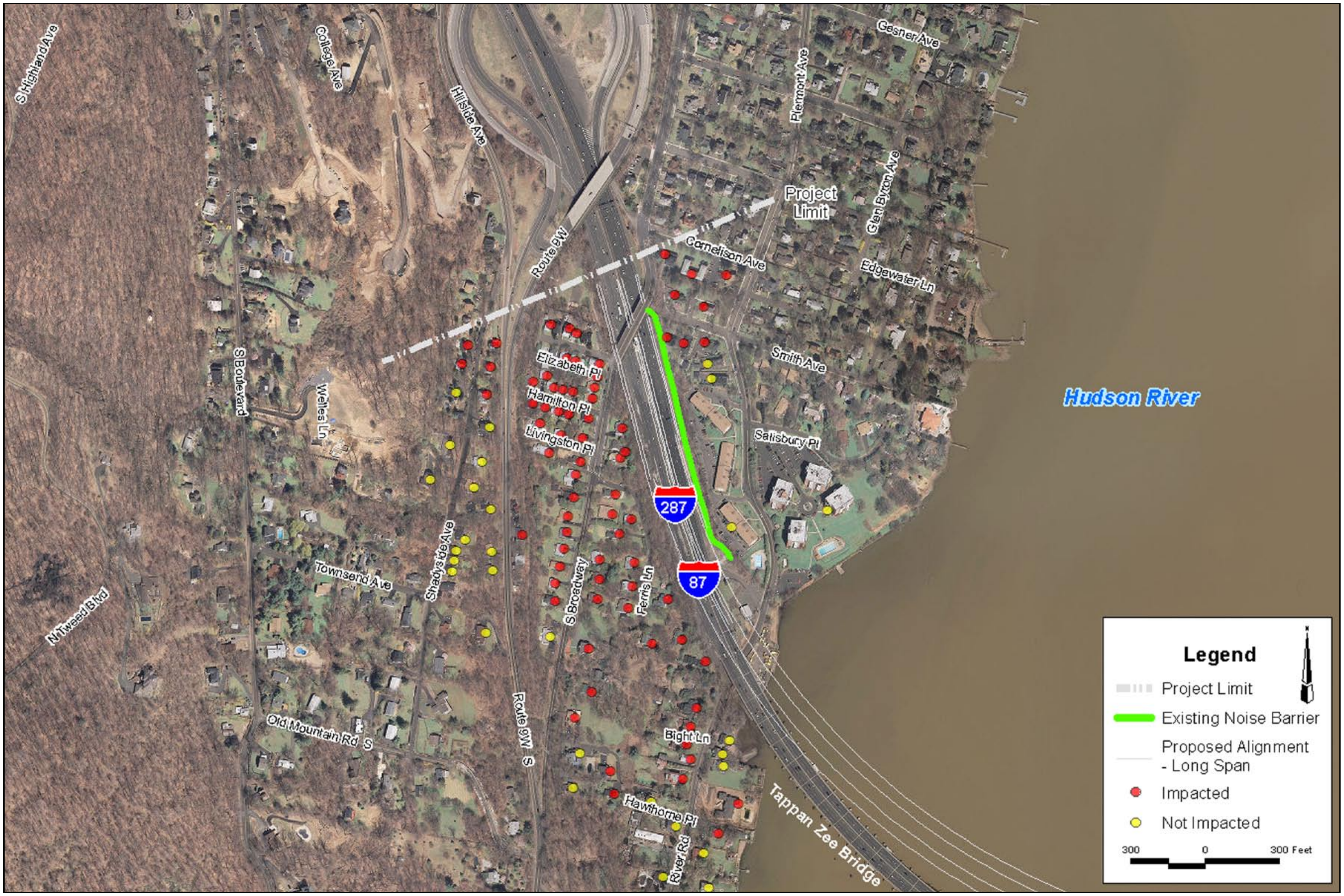

Figure 12-12

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Long Span Option: Rockland County

reduction in noise levels. Consistent with NYSDOT policy, noise abatement measures that are implemented should obtain a substantial noise reduction, which is defined as ten (10) or more decibels. For a measure to be deemed feasible, it must provide a minimum reduction in noise levels of at least five (5) decibels to the majority of impacted receptors.

Reasonableness deals with social, economic, and environmental factors. NYSDOT uses the following three considerations in evaluating reasonableness:

- Viewpoints. The viewpoints of the property owners and residents of the benefited receptors are a major consideration in reaching a decision on the reasonableness of an abatement measure. Property owners and residents affected are contacted to determine the desirability and acceptability of proposed abatement measures.
- Cost. NYSDOT has established the following reasonableness cost indices for abatement measures: for noise berms or noise insulation, a cost index of $80,000 per benefited receptor shall be used; and, for barrier walls, a maximum of 2,000 square feet of wall per benefited receptor shall be used.
- Noise reduction. For an abatement measure to be determined to be reasonable, a majority of the benefited receptors must achieve a noise reduction design goal of 7 dBA.

For an abatement measure to satisfy the reasonableness criteria all three considerations enumerated above must be satisfied.

Consistent with FHWA/NYSDOT policy, primary consideration for noise abatement is given to exterior areas. Abatement would usually be necessary only where frequent human use occurs and a lowered noise level would be of benefit.

Noise abatement techniques considered to reduce traffic noise for the proposed project include the following: traffic management measures; alteration of horizontal and vertical alignments; noise barriers, acquisition of real property or interests therein to serve as buffer zones; and use of noise insulation.

Each of these measures is discussed below.

12-6-2 TRAFFIC MANAGEMENT

The following traffic management measures were considered as possible noise abatement measures:

- Traffic control devices and signing for prohibition of certain vehicle type;
- Time-use restrictions for certain vehicle types;
- Modified speed limits; and
- Exclusive lane designations.

Time-use restrictions, traffic control devices and signing for prohibition of certain vehicle types (namely heavy duty vehicles, such as trucks and buses) would not be feasible noise control measures. The majority of these heavy-duty vehicles are trucks operating in the corridor. The Interstate 87/287 corridor is the major east/west truck route through this part of New York State, and prohibition of trucks is not feasible and would be inconsistent with current USDOT regulations regarding designated interstate truck routes.

While use of modified speed limits may reduce noise levels in the corridor, the benefits of small reductions in speeds would not be significant, and such restrictions would likely result in substantial opposition from current roadway users (particularly commuters and the trucking industry), would be costly to enforce, and would be inconsistent with NYSDOT's goal of improving traffic flow in the corridor.

Exclusive lane designations would not be expected to achieve significant noise reductions. Further use of exclusive lane designation would not be warranted.

12-6-3 ALTERATION OF VERTICAL AND HORIZONTAL ALIGNMENT

Alteration of the roadway alignment in the project study area was considered and small changes in alignment were incorporated in the Short Span and Long Span Options. As shown in Section 12-5, the proposed alignments produce no substantial changes in noise levels compared to the existing or no-build condition at receptor locations in the study area. In order to achieve a perceptible change (i.e., more than 3 dBA) in noise level there would have to be a considerable change in the roadway alignment, which would substantially increase the distance from the roadway to receptors, thus providing a noise buffer zone between the roadway and affected receptors. For example, in order to achieve a 5 dBA reduction in noise levels, the distance between the roadway and receptors would have to be increased by a factor of three. Such large shifts in alignment are not feasible within the study area.

12-6-4 NOISE BARRIERS

In general, noise barriers are among the most effective traffic noise mitigation measures. A well-designed noise barrier breaks the line-of-sight between the source and receiver, and may achieve a substantial reduction in noise levels. To be acoustically effective, these barriers would have to be continuous and, of sufficient length and height to achieve these goals. Generally, on flat terrain with high truck volumes a noise barrier would have to be a minimum of 8 to 10 feet to be effective in reducing truck exhaust noise.

A noise barrier is recommended for traffic noise abatement when it satisfies the following FHWA/NYSDOT criteria:

- **Acoustic Effectiveness:** The noise barrier is considered acoustically effective and a feasible option if it provides a minimum 5 dBA reduction to the majority of impacted receptors.
- **Cost Effectiveness:** A benefited property is defined as one where a minimum 5-dBA noise reduction occurs at a point where there is frequent human use regardless of whether or not the property is identified initially as impacted. A maximum cost index of $80,000 per benefited receptor shall be used for berms and insulation, and a maximum of 2,000 square feet of barrier wall per benefited receptor shall be used for barrier walls.
- **Noise Reduction:** For an abatement measure to be determined reasonable, a majority of the benefited receptors must achieve a design goal of 7 dBA.

Noise analyses were performed using the TNM 2.5 model for the Short Span and Long Span Options examining barriers at various locations (including barriers both on and off structure), and barrier of various heights and widths to determine where this type of noise abatement measure satisfied FHWA/NYSDOT criteria regarding acoustic and cost effectiveness. **Tables 12-12 through 12-14** summarize the results of the analysis and **Figures 12-13 through 12-18** summarize the results of a conceptual barrier feasibility study. Any decision regarding whether barriers will be installed will be made after the viewpoints of property owners and residents of the benefited receptors are solicited. In addition, if a decision is made to construct any of the barriers discussed below, the barrier locations and heights would be optimized during the final design phase of the project.

As shown in **Figures 12-13 and 12-14**, noise barriers at two locations north of Interstate 87/287, in Westchester County within the project limits were examined for both the Short Span and Long Span Options. In addition, it was assumed that the existing barrier south of Interstate 87/287 would be relocated. Wall 1 was assumed to be on the ground, and Wall 2 was assumed to be on structure. (No barrier was evaluated for the commercial uses at 400 South Broadway where the NAC is exceeded.) **Table 12-14** shows the barrier analysis results. Both barriers would satisfy NYSDOT criteria for acoustic effectiveness and cost effectiveness. The 12-foot tall Wall 1 barrier would have a higher total cost, but would achieve the minimum 5 dBA noise reduction at 9 rather than 6 properties.

Table 12-14
Summary of Noise Barrier Feasibility and Cost-Benefit Analysis
Short Span Option and Long Span Option--Westchester County

Location (See Figures 12-13 and 12-14) Wall ID	Wall Length (ft)	Wall Height (ft)	Is max IL>=7 dBA	Benefited Properties with IL>=5 dBA	Approximate Wall Cost	Barrier Wall Size per Benefited Property (ft^2)	Meets NYSDOT Criteria?
TZB South to Exit 9							
Wall 1	1,055	10	Yes	6	$ 422,000	1,760	Yes
Wall 1	1,055	12	Yes	9	$ 506,000	1,410	Yes
Wall 2	212	10	Yes	2	$ 85,000	1,060	Yes
Note: Costs rounded off to nearest $1,000 and barrier wall size rounded off to nearest 10 square feet.							

As shown in **Figures 12-15, 12-16, 12-17 and 12-18**, noise barriers at one location south of Interstate 87/287 and one location north of Interstate 87/287 in Rockland County were examined for both the Short Span and Long Span Options. In addition, it was assumed that the existing barrier north of Interstate 87/287 would be relocated.

Table 12-15 shows the barrier analysis results for the Short Span Option. For analysis purposes, both Wall 1 and Wall 2 are assumed to be located on the ground. As shown in **Table 12-15**, only Wall 1 would satisfy NYSDOT criteria for acoustic effectiveness and cost effectiveness. Even when Wall 2 was increased to 24 feet in height, it would

12.5.11

Figure 12-13

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Short Span Option with Noise Barriers: Westchester County

TAPPAN ZEE HUDSON RIVER CROSSING
Environmental Impact Statement

Figure 12-14

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Long Span Option with Noise Barriers: Westchester County

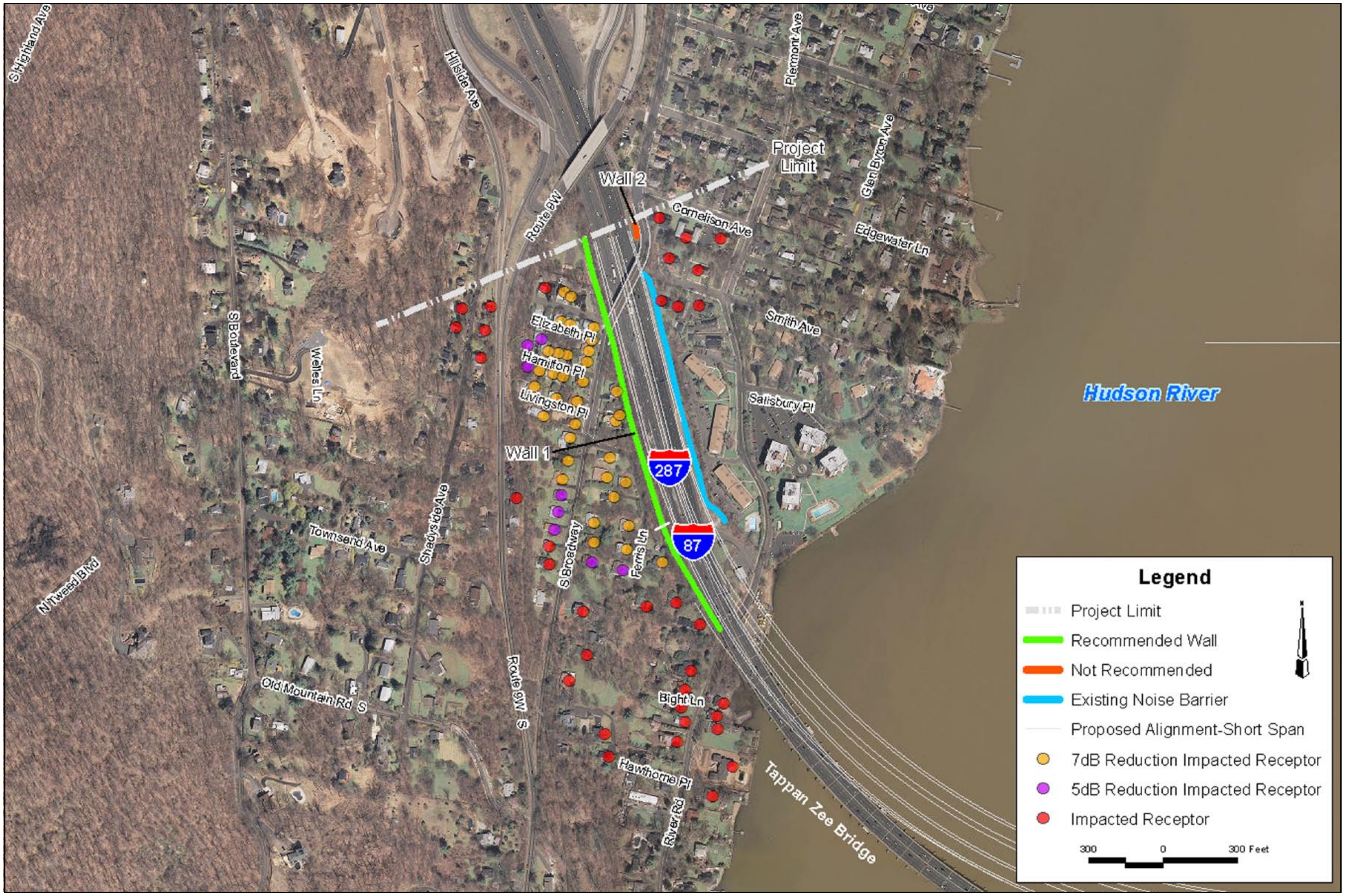

Figure 12-15

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Short Span Option with Noise Barriers: Rockland County

12.5.11

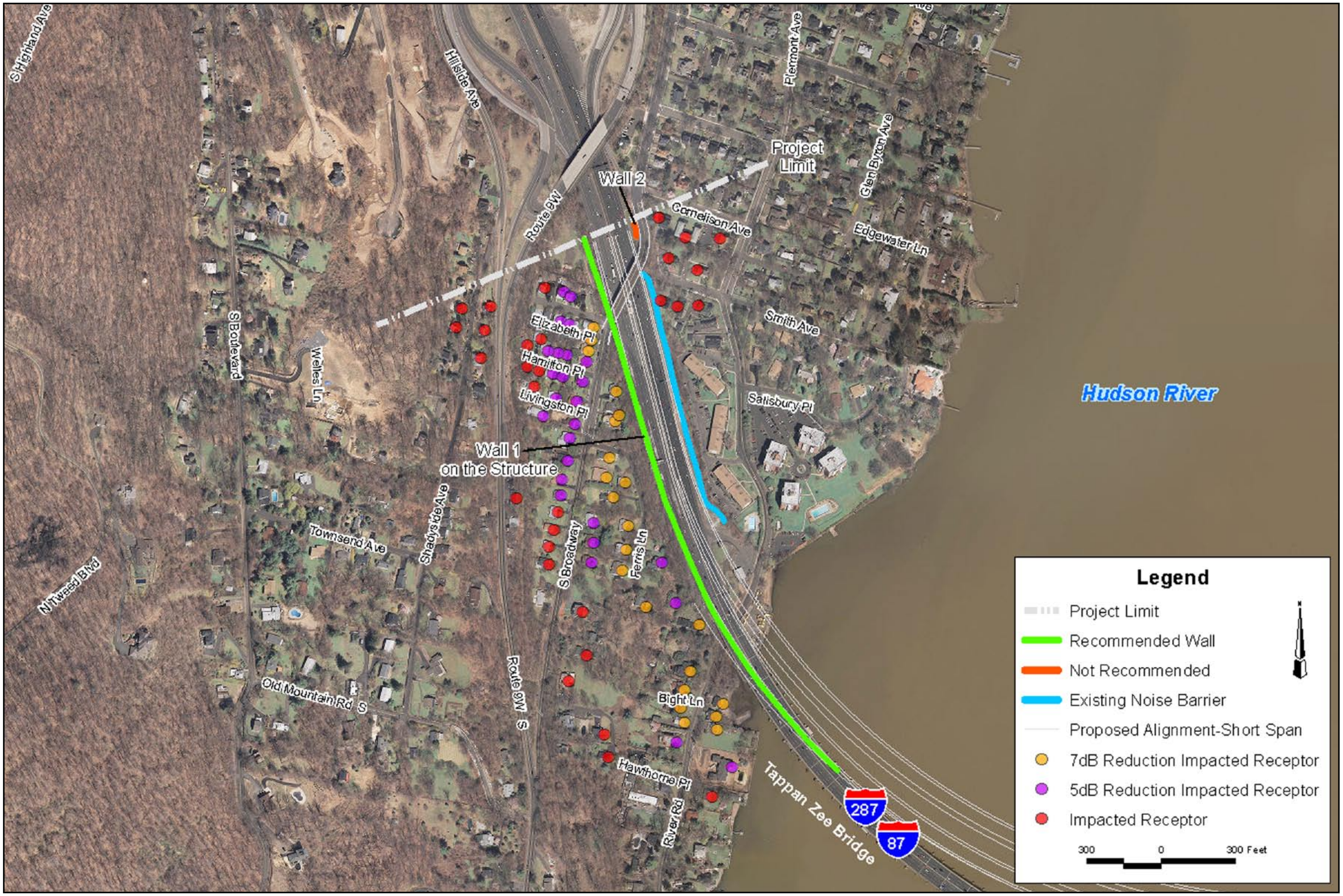

Figure 12-16

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Short Span Option with Wall 1 on Structure: Rockland County

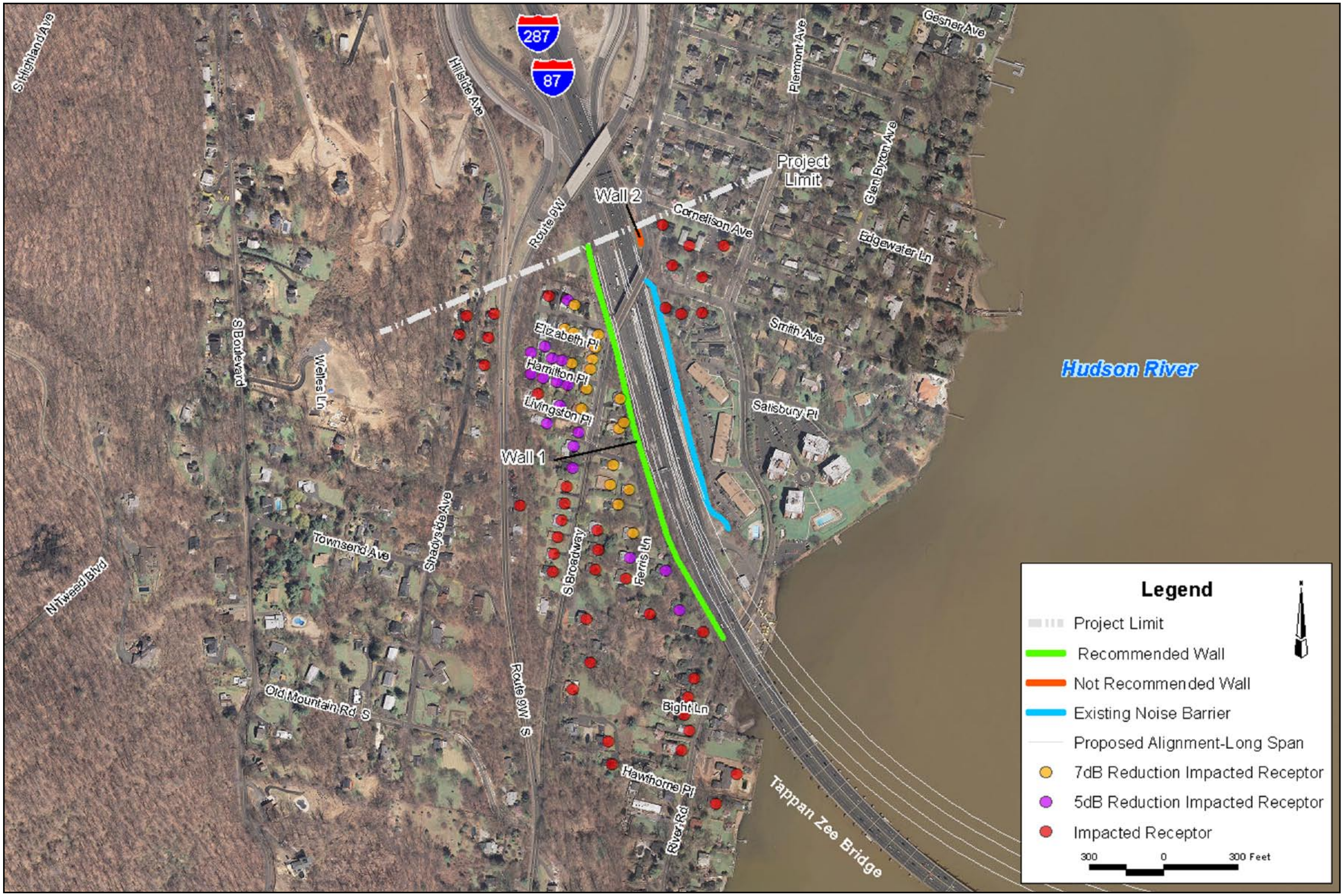

Figure 12-17

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Long Span Option with Noise Barriers: Rockland County

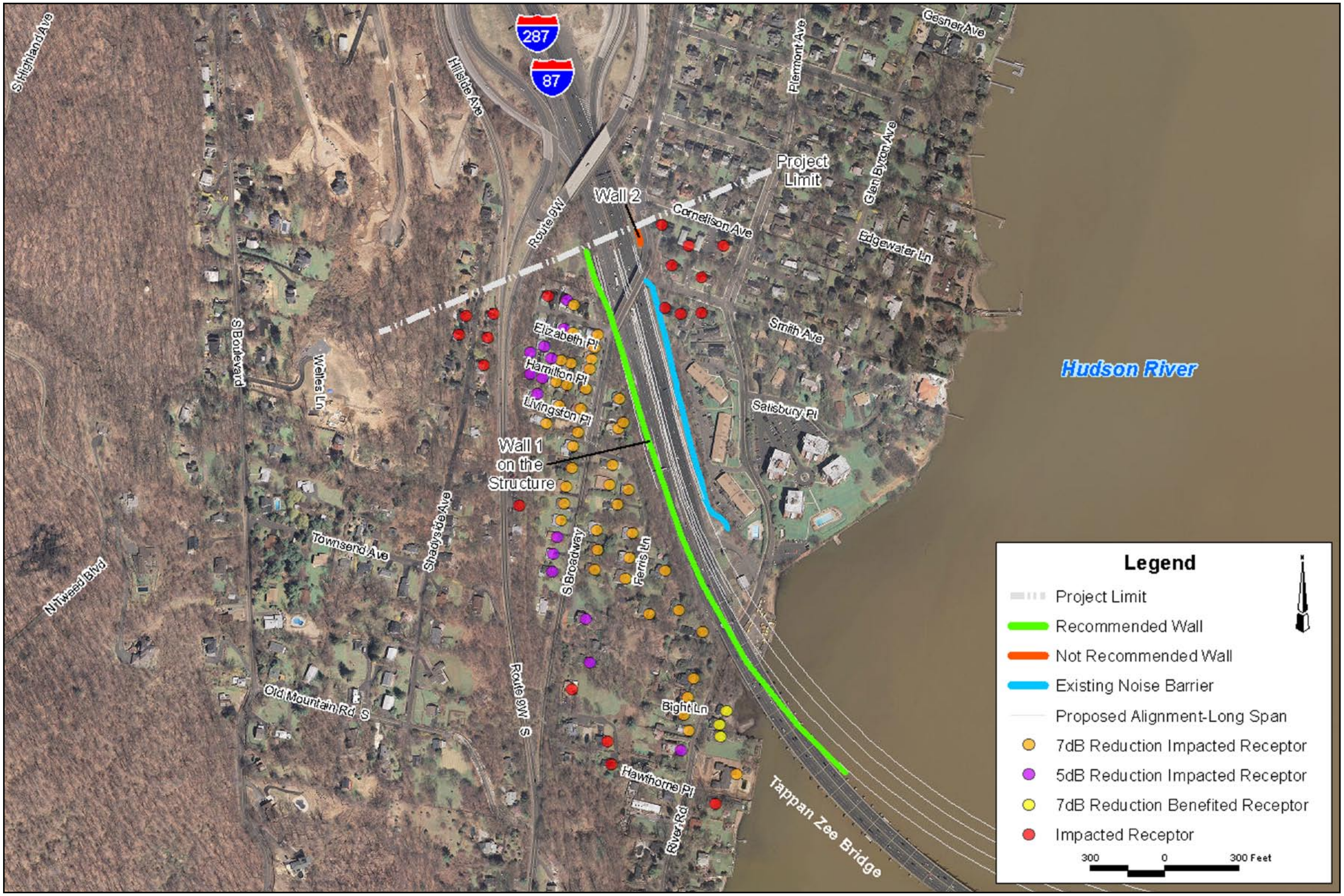

Figure 12-18

Locations Where the 2047 AM Peak Hour Levels Exceed the NACs for the Long Span Option with Wall 1 on Structure: Rockland County

Table 12-15
Summary of Noise Barrier Feasibility and Cost-Benefit Analysis
Short Span Option--Rockland County

Location (See Figure 12-15) / Wall ID	Wall Length (ft)	Wall Height (ft)	Is max IL>=7 dBA	Benefited Properties with IL>=5 dBA	Approximate Wall Cost	Barrier Wall Size per Benefited Property (ft^2)	Meets NYSDOT Criteria?
TZB North to Exit 10							
Wall 1	1,687	16	Yes	45	$ 1,080,000	600	Yes
Wall 1	1,687	20	Yes	46	$ 1,350,000	730	Yes
Wall 2	290	16	No	0	$ 185,000	N/A	No
Wall 2	290	24	No	0	$ 278,000	N/A	No
TZB North to Exit 10 (Wall 1 on the Structure)							
Wall1	2,421	10	No	9	$ 968,000	2,680	No
Wall1	2,421	18	Yes	51	$ 1,743,000	850	Yes

Note: Costs rounded off to nearest $1,000 and barrier wall size rounded off to nearest 10 ft^2.

not be acoustically effective, and consequently this noise barrier would not be considered to be a feasible and reasonable noise abatement measure. Wall 1 would be acoustically effective at 16 feet. Increasing the height of Wall 1 from 16 to 20 feet would result in achieving the minimum acoustical effectiveness 5 dBA noise reduction at 46 rather than 45 properties. However, Wall 1 at either height would satisfy NYSDOT acoustical effectiveness and cost effectiveness criteria. The analysis results show that locating Wall 1 on the highway structure increases the number of benefited properties. Both for barrier Wall 1 located on the ground and on highway structure, increasing the height of Wall 1 would increase the number of benefited properties that would achieve the minimum 5 dBA noise reduction.

Table 12-16, shows the barrier analysis results for the Long Span Option. For analysis purposes two options were examined for Wall 1—one with the barrier on the ground and the other with the barrier on structure. Wall 2 was assumed to be on the ground.

The result shown in **Table 12-16** are similar to the results obtained for the Short Span Option. Only Wall 1 would satisfy NYSDOT criteria for acoustic effectiveness and cost effectiveness. Even when Wall 2 was increased to 24 feet in height, it would not be acoustically effective, and consequently, this barrier would not be considered a feasible and reasonable abatement measure. The analysis results show that locating Wall 1 on the highway structure substantially increases the number of benefited properties. Both for barrier Wall 1 located on ground and on highway structure, increasing the height of Wall 1 would increase the number of benefited properties that would achieve the minimum 5 dBA noise reduction. However, locating Wall 1 on highway structure would be the most cost effective location. As previously mentioned both Wall 1 options would satisfy NYSDOT acoustical effectiveness and cost effectiveness criteria.

Table 12-16
Summary of Noise Barrier Feasibility and Cost-Benefit Analysis
Long Span Option--Rockland County

Location (See Figures 12-16 and 12-17) Wall ID	Wall Length (ft)	Wall Height (ft)	Is max IL>=7 dBA	Benefited Properties with IL>=5 dBA	Approximate Wall Cost	Barrier Wall Size per Benefited Property (ft^2)	Meets NYSDOT Criteria?
TZB North to Exit 10 (Wall 1 on the Ground)							
Wall 1	1,687	16	Yes	18	$ 1,080,000	1,500	Yes
Wall 1	1,687	24	Yes	38	$ 1,619,000	1,070	Yes
Wall 2	290	16	No	0	$ 185,000	N/A	No
Wall 2	290	24	No	0	$ 278,000	N/A	No
TZB North to Exit 10 (Wall 1 on Structure)							
Wall 1	2409	10	Yes	51	$ 964,000	470	Yes
Wall 1	2409	18	Yes	64	$ 1,735,000	680	Yes

Note: Costs rounded off to nearest $1,000 and barrier wall size rounded off to nearest 10 ft2.

The effective implementation of noise-compatible planning measures is a shared responsibility between NYSDOT and the local governments where barriers are proposed. NYSDOT will contact the local officials for jurisdictions where noise barriers are recommended in this DEIS. During this outreach effort, NYSDOT will provide the local officials with information to support the recommendations and will solicit comments on the proposed barriers. NYSDOT will document all contact and meetings with local government officials for the project record.

NYSDOT and NYSTA have identified potential noise barrier locations based on the above described study results. These initial indications of likely recommended abatement are based on a preliminary design. However, if conditions should change substantially during the final design phase of the Replacement Bridge Alternative or if public involvement indicates an adverse reaction to the barriers proposed, one or more of the barriers may no longer be recommended and not included in the project's contract phase. A final decision on the recommendations will be made upon completion of the project design and public involvement process.

Additional information regarding the barrier analysis is provided in **Appendix D**.

12-6-5 BUFFER ZONES

The use of buffer zones would require the acquisition of considerable property along the roadway alignment. The exact width of the buffer zones required to abate traffic noise impacts varies from location to location and would include all NAC B and C lands where L_{eq} noise levels approach or exceed 67 dBA. Acquisition of this additional right-of-way on either side of the proposed alignment would not be possible without the taking of significant properties and/or large numbers of residential and/or commercial structures. Consequently, this was not considered to be a feasible noise abatement measure.

12-6-6 NOISE INSULATION

Noise insulation can be effective in reducing interior noise levels. These treatments may include caulking and sealing gaps in building envelopes, adding additional building insulation, and/or installing window and door treatments and alternative ventilation, to provide additional attenuation (i.e., increase the building transmission loss between exterior and interior levels). FHWA regulations allow funds to be spent to improve the noise insulation of public use and nonprofit institutional buildings. However, there are no impacted institutional facilities in the corridor. Consequently, an investigation of noise insulation as a possible noise abatement measure was not warranted.