Chapter 12B: Vibration

12B.1 INTRODUCTION

Chapter 12 of this Environmental Impact Statement (EIS) presents the evaluation the Federal Railroad Administration (FRA) and New Jersey Transit Corporation (NJ TRANSIT) conducted of the potential noise and vibration impacts associated with the construction and operation of the Hudson Tunnel Project. It is divided into two subchapters, Chapter 12A, "Noise," and Chapter 12B, "Vibration." Chapter 12A presents the assessment of potential noise impacts associated with the Preferred Alternative undertaken by FRA and NJ TRANSIT. In Chapter 12B, FRA and NJ TRANSIT have assessed the potential vibration impacts associated with the Preferred Alternative by examining projected future vibration levels resulting from the Project at sensitive receptors near the Project site. This chapter evaluates the potential for adverse vibration impacts from both construction and operation of the Preferred Alternative and presents potential measures to avoid, minimize, and mitigate vibration impacts. The Port Authority of New York and New Jersey (PANYNJ), in its role as Project Sponsor, has accepted and relied on the evaluations and conclusions of this chapter.

This chapter reflects the following changes made since the Draft EIS (DEIS) for the Hudson Tunnel Project:

- The DEIS provided the noise and vibration analyses in one chapter, Chapter 12, "Noise and Vibration." The chapter is now divided into two parts for the Final EIS (FEIS) to simplify the presentation of the analysis.
- FRA and NJ TRANSIT revised the vibration analyses using the Federal Transit Administration's updated methodology, *Transit Noise and Vibration Impact Assessment Manual*, FTA Report No. 0123, September 2018.
- FRA and NJ TRANSIT updated the vibration analysis to include new residences and a park on Paterson Plank Road in North Bergen, New Jersey and a future development currently under construction on Manhattan Avenue in Union City, New Jersey that were not present when the DEIS was prepared.
- The analysis incorporates revisions and refinements to the construction staging approach in New Jersey, including the addition of a new potential haul route for truck access to the Hoboken staging site. It also incorporates revisions and refinements to the construction methods in New York. For both New Jersey and New York, it includes more refined information on construction equipment that may be used at the construction sites. It also provides revised hours when blasting could occur at residential locations in New Jersey (not after 6 PM) and New York (not after 7 PM) to comply with local regulations.
- The discussion of the vibration monitoring plan that will be in place during construction is now expanded in response to comments received during the public comment period on the DEIS.

This chapter contains the following sections:

12B.2 ANALYSIS METHODOLOGY

During development of this EIS, FRA and NJ TRANSIT developed methodologies for evaluating the potential effects of the Hudson Tunnel Project in coordination with the Project's Cooperating and Participating Agencies (i.e., agencies with a permitting or review role for the Project). The methodology used for analysis of vibration is summarized in this chapter.

Following completion of the DEIS, the PANYNJ became the Project Sponsor for the Hudson Tunnel Project (see Chapter 1, "Purpose and Need," Section 1.1.2, for more information). Consistent with the roles and responsibilities defined in Section 1.1.1 of that chapter, as the current Project Sponsor, the PANYNJ will comply with mitigation measures and commitments identified in the Project's Record of Decision (ROD).

The analysis of vibration was conducted following procedures described in the Federal Transit Administration (FTA) guidance manual, *Transit Noise and Vibration Impact Assessment Manual*, FTA Report No. 0123, September 2018. FRA uses the FTA guidance manual for analysis of noise and vibration resulting from non-high-speed (i.e., 125 miles per hour or below) rail projects.

12B.2.1 VIBRATION FUNDAMENTALS AND DEFINITIONS

Fixed railway operations have the potential to produce high vibration levels, since railway vehicles contact a rigid steel rail with steel wheels. Train wheels rolling on the steel rails create vibration energy that is transmitted into the track support system. The amount of vibrational energy is strongly dependent on such factors as how smooth the wheels and rails are and the vehicle suspension system. The vibration of the track structure "excites" the adjacent ground, creating

vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. As the vibration propagates from the foundation through the remaining building structure, certain resonant, or natural, frequencies of various components of the building may be excited.

Vibrations consist of rapidly fluctuating motions in which there is no "net" movement. When an object vibrates, any point on the object is displaced from its initial "static" position equally in both directions so that the average of all its motion is zero. Any object can vibrate differently in three mutually independent directions: vertical, horizontal, and lateral. It is common to describe vibration levels in terms of velocity, which represents the instantaneous speed at a point on the object that is displaced. In a sense, the human body responds to average vibration amplitude, which is usually expressed in terms of the root mean square (RMS) amplitude.

The effects of **ground-borne vibration** may include discernable movement of building floors, rattling of windows, and shaking of items on shelves or hanging on walls. In extreme cases, the vibration can cause damage to buildings. The vibration of floors and walls may cause perceptible vibration, rattling of such items as windows or dishes on shelves. The movement of building surfaces and objects within the building can also result in a low-frequency rumble noise. The rumble is the noise radiated from the motion of the room surfaces, even when the motion itself cannot be felt. This is called **ground-borne noise**.

For vibration, VdB are used to distinguish vibration decibels from noise decibels. All vibration levels are referenced to $1x10^{-6}$ inches per second as is recommended in FTA and FRA guidance.

12B.2.1.1 EFFECT OF PROPAGATION PATH

Vibrations are transmitted from the source to the ground, and propagate through the ground to the receptor. Soil conditions have a strong influence on the levels of ground-borne vibration. Stiff soils, such as some clay and rock, can transmit vibrations over substantial distances. Sandy soils, wetlands, and groundwater tend to absorb movement and thus reduce vibration transmission. Because subsurface conditions vary widely, measurement of actual vibration conditions, or transfer mobility, at the site can be the most practical way to address the variability of propagation conditions.

12B.2.1.2 HUMAN RESPONSE TO VIBRATION LEVELS

Although the perceptibility threshold for ground-borne vibration is about 65 VdB, the typical threshold of human annoyance is 72 VdB. As a comparison, buses and trucks rarely create vibration that exceeds 72 VdB unless there are significant bumps in the road, and these vehicles are operating at moderate speeds. Vibration levels for typical human and structural responses and sources are shown in **Table 12B-1**.

Table 12B-1
Typical Levels of Ground-Borne Vibration

Human/Structural Response	Velocity Level (VdB)	Typical Sources (at 50 feet)
Threshold, minor cosmetic damage fragile buildings	100	Blasting from construction projects
		Bulldozers and other heavy tracked construction equipment
Difficulty with vibration-sensitive tasks, such as reading a computer screen	90	Locomotive powered freight train
Residential annoyance, infrequent events	80	Rapid Transit Rail, upper range
		Commuter Rail, typical range
Residential annoyance, frequent events		Bus or Truck over bump
	70	Rapid Transit Rail, typical range
Limit for vibration-sensitive equipment. Approximate threshold for human perception of vibration		Bus or truck, typical
	60	Typical background vibration
	50	

Source: FTA, *Transit Noise and Vibration Impact Assessment Manual,* FTA Report No. 0123, September, 2018.

12B.2.2 STANDARDS AND CRITERIA

12B.2.2.1 OPERATIONAL VIBRATION AND GROUND-BORNE NOISE STANDARDS AND CRITERIA

To examine potential impacts during operation, the FTA guidance document (similar to the approach for assessing airborne noise described in Chapter 12A, "Noise") lays out a three-step approach for the analysis of vibration and ground-borne noise: a screening procedure, a general assessment methodology, and a detailed analysis methodology. The screening procedure is used to determine whether any vibration-sensitive receptors are within distances where impacts are likely to occur. The general assessment methodology is used to determine locations or rail segments where there is the potential for impacts. The detailed analysis methodology is used to predict impacts and evaluate the effectiveness of mitigation with greater precision than can be achieved with the general assessment.

The FTA criteria for environmental impact from ground-borne vibration and noise are based on the maximum levels for a single event. The impact criteria as defined in the FTA guidance manual are shown in **Table 12B-2**. The criteria for acceptable ground-borne vibration are expressed in terms of RMS velocity levels in decibels and the criteria for acceptable ground-borne noise are expressed in terms of A-weighted sound level. As shown in the table, the FTA methodology provides three different impact criteria—one for "infrequent" events, when there are fewer than 30 vibration events per day, one for "occasional" events, when there are between 30 and 70 vibration events per day, and one for "frequent" events, when there are more than 70 vibration events per day. These impacts occur only if a project causes ground-borne noise or vibration levels that are higher than existing vibration levels. Thus, if the vibration level for a building in Category 1 is already 70 VdB (5 VdB above the 65 VdB threshold listed in **Table 12B-5**) but a hypothetical project will not increase that level, then the project will not be considered to have an impact.

Table 12B-2
Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment

Land Use Category	GBV Impact Levels (VdB re 1 micro-inch/sec)			GBN Impact Levels (dB re 20 micro Pascals)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations	65 VdB[4]	65 VdB[4]	65 VdB[4]	N/A[4]	N/A[4]	N/A[4]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

Notes:
1 "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2 "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3 "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail systems.
4 This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5 Vibration-sensitive equipment is not sensitive to ground-borne noise.

Source: FTA. *Transit Noise and Vibration Impact Assessment Manual,* FTA Report No. 0123, September, 2018.

The limits are specified for the three land use categories defined below:

- **Category 1: High Sensitivity** - Buildings where low ambient vibration is essential for the operations within the building, which may be well below levels associated with human annoyance. Typical land uses are vibration-sensitive research and manufacturing, hospitals, and university research operations.
- **Category 2: Residential** - This category covers all residential land uses and any buildings where people sleep, such as hotels and hospitals. No differentiation is made between different types of residential areas. This is primarily because ground-borne vibration and noise are experienced indoors and building occupants have practically no means to reduce their exposure. Even in a noisy urban area, the bedrooms often will be quiet in buildings that have effective noise insulation and tightly closed windows. Hence, an occupant of a bedroom in a noisy urban area is likely to be just as sensitive to ground-borne noise and vibration as someone in a quiet suburban area.
- **Category 3: Institutional** - This category includes schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference.

There are some buildings, such as concert halls, TV and recording studios, auditoriums, and theaters that can be very sensitive to vibration and ground-borne noise, but do not fit into any of these three categories. Special vibration level thresholds, shown in **Table 12B-3**, are defined in the FTA guidance manual for these land uses that have special sensitivity to vibration and ground-borne noise.

Table 12B-3
Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for Special Buildings

Type of Building or Room	GBV Impact Levels (VdB re 1 micro-inch/sec)		GBN Impact Levels (dB re 20 micro Pascals)	
	Frequent Events[1]	Occasional or Infrequent Events[2]	Frequent Events[1]	Occasional or Infrequent Events[2]
Concert Halls	65 VdB	65 VdB	25 dBA	25 dBA
TV Studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording Studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

Notes:

[1] "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.

[2] "Occasional or Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

[3] If the building will rarely be occupied when the trains are operating, there is no need to consider impact.

Source: FTA. *Transit Noise and Vibration Impact Assessment Manual,* FTA Report No. 0123, September 2018.

12B.2.2.2 CONSTRUCTION VIBRATION AND GROUND-BORNE NOISE STANDARDS AND CRITERIA

12B.2.2.2.1 FTA Vibration Impact Criteria

Table 12B-4 and **Table 12B-5** show architectural and structural damage risk and perceptibility thresholds for residential and historic structures in proximity to the types of construction activities that would occur during construction of the Preferred Alternative. Architectural damage includes cosmetic damage, such as cracked plaster, etc. Architectural damage is not considered potentially dangerous. As shown in **Table 12B-6**, pile driving has the greatest potential to result in architectural damage to most building types. Most other construction activities require very small (i.e., less than 25 feet) distances between the structure and the construction equipment or the presence of highly fragile buildings for impacts to occur. For fragile and highly fragile buildings respectively, FTA recommends a limit of peak particle velocities (PPV) of 0.2 and 0.12 inches per second or 94 and 90 VdB.

Table 12B-4
Vibration Source Levels for Construction Equipment

Equipment	PPV at 25 ft (in/sec)	Approximate L_v[1] at 25 ft
Pile Driver (impact)	0.644 – 1.518	104 – 112
Pile Driver (sonic)	0.170 – 0.734	93 - 105
Blasting	>0.400[2]	>100[2]
Clam Shovel drop (slurry wall)	0.202	94
Hydromill (slurry wall in soil)	0.008	66
Hydromill (slurry wall in rock)	0.017	75
Vibratory Roller	0.210	94
Hoe Ram	0.089	87
Large bulldozer	0.089	87
Caisson drilling	0.089	87
Loaded trucks	0.076	86
Jackhammer	0.035	79
Small bulldozer	0.003	58

Note: [1] RMS velocity in decibels (VdB) re 1 micro-inch/second
[2] Estimated minimum based on approximately 0.75 pounds explosive
Source: FTA. *Transit Noise and Vibration Impact Assessment Manual*, FTA Report No. 0123, September 2018.

Table 12B-5
Construction Vibration Damage Criteria

Building Category	PPV (in/sec)	Approximate L_v*
I. Reinforced-concrete, steel or timber (no plaster)	0.50	102
II. Engineered concrete and masonry (no plaster)	0.30	98
III. Non-engineered timber and masonry buildings	0.20	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Note: * RMS velocity in decibels (VdB) re 1 micro-inch/second
Source: FTA. *Transit Noise and Vibration Impact Assessment Manual*, FTA Report No. 0123, September 2018.

12B.2.2.2.2 NYCDOB Construction Vibration Evaluation Criteria

For the portions of the Project in New York City, FRA and NJ TRANSIT also considered the New York City criteria for evaluating vibration. Specifications for construction-generated vibration are set forth in the New York City Department of Buildings' (NYCDOB) Technical Policies and Procedures Notice (TPPN #10/88). As per TPPN #10/88, PPV from project construction is not permitted to exceed the vibration damage threshold criterion of 0.5 inches per second at historic structures. While NYCDOB does not provide a definition of "historic structures," it is generally interpreted to mean a nationally or locally listed landmark structure or a contributing structure in a listed historic district. For buildings that are not historic, the 0.5 inches per second threshold is often used as a conservative criterion to evaluate vibration although non-historic buildings are typically able to safely withstand PPV up to 2.0 inches per second as specified by U.S. Bureau of Mines vibration evaluation criteria.

12B.2.3 METHODOLOGY FOR EVALUATING VIBRATION AND GROUND-BORNE NOISE

12B.2.3.1 CONSTRUCTION IMPACTS

Following the general analysis procedures described in the FTA guidance manual, for each construction work area using impact equipment (i.e., pile drivers or rock excavation equipment),

FRA and NJ TRANSIT projected vibration levels to nearby receptors and compared them to FTA vibration impact criteria.

12B.2.3.2 OPERATIONAL IMPACTS

The FTA vibration analysis methodology begins with a vibration screening to determine whether any vibration-sensitive receptors are within a distance where an impact is likely to occur. According to the FTA screening methodology, potential impacts may occur if high-sensitivity vibration receptors are within 600 feet of the centerline of a commuter rail mainline, residential receptors are within 200 feet from the track centerline, or institutional/office receptors are located within 120 feet from the track centerline. For the Preferred Alternative, residences are located within the screening distance of the Preferred Alternative.

For each receptor identified within the screening distances, future rail vibration levels with the Preferred Alternative were calculated according to the FTA guidance manual's general analysis methodology. The predicted vibration levels were compared to the FTA vibration shown above in **Table 12B-5** to identify potential operational vibration impacts associated with the Preferred Alternative.

12B.2.3.3 SELECTION OF RECEPTOR LOCATIONS

The study area for the operational and construction vibration and ground-borne noise studies includes receptors within the FTA guidance manual screening distances for construction activities and receptors within the screening distances above the proposed new tunnel alignment.

12B.3 AFFECTED ENVIRONMENT: EXISTING CONDITIONS

12B.3.1 NEW JERSEY

FRA and NJ TRANSIT identified residential receptors within the FTA guidance manual's vibration analysis screening distances from the Preferred Alternative. This included nine receptors in New Jersey. The receptors used for the vibration analyses in New Jersey are listed in **Table 12B-6** and shown in **Figure 12B-1**.

Table 12B-6
Vibration Receptor Locations in New Jersey

Receptor	Location[1]	Distance/Relation to Vibration Source
1	78 West 18th St, Weehawken	120 feet north of Hoboken shaft and fan plant site
2	1700 Park Ave, Weehawken	215 feet from Willow Avenue underpinning
3	Rebuild By Design Flood Protection Wall	Approximately 40 to 100 feet above new tunnel
4	1806 Park Ave, Weehawken	450 feet from Willow Avenue underpinning
5	2215 Grand Ave, North Bergen	100 feet above new tunnel
6	2200 Paterson Plank Rd, North Bergen	345 feet from tunnel portal, 90 feet above new tunnel
7	2000 Tonnelle Ave, North Bergen	620 feet from tunnel portal, 118 feet from staging area
8	2600 Tonnelle Ave, North Bergen	580 feet from the North River Tunnel staging area
9	Henry St (near Secaucus Rd on north side of NEC), Secaucus	105 feet from new on-structure track
10	1300 Manhattan Avenue, Union City	100 feet west of Hoboken shaft and fan plant site

Notes: [1] See **Figure 12B-1** for locations.
[2] Receptors outside the screening distance for the operational vibration analysis, but in proximity to construction work areas, so included in the construction vibration analysis only.

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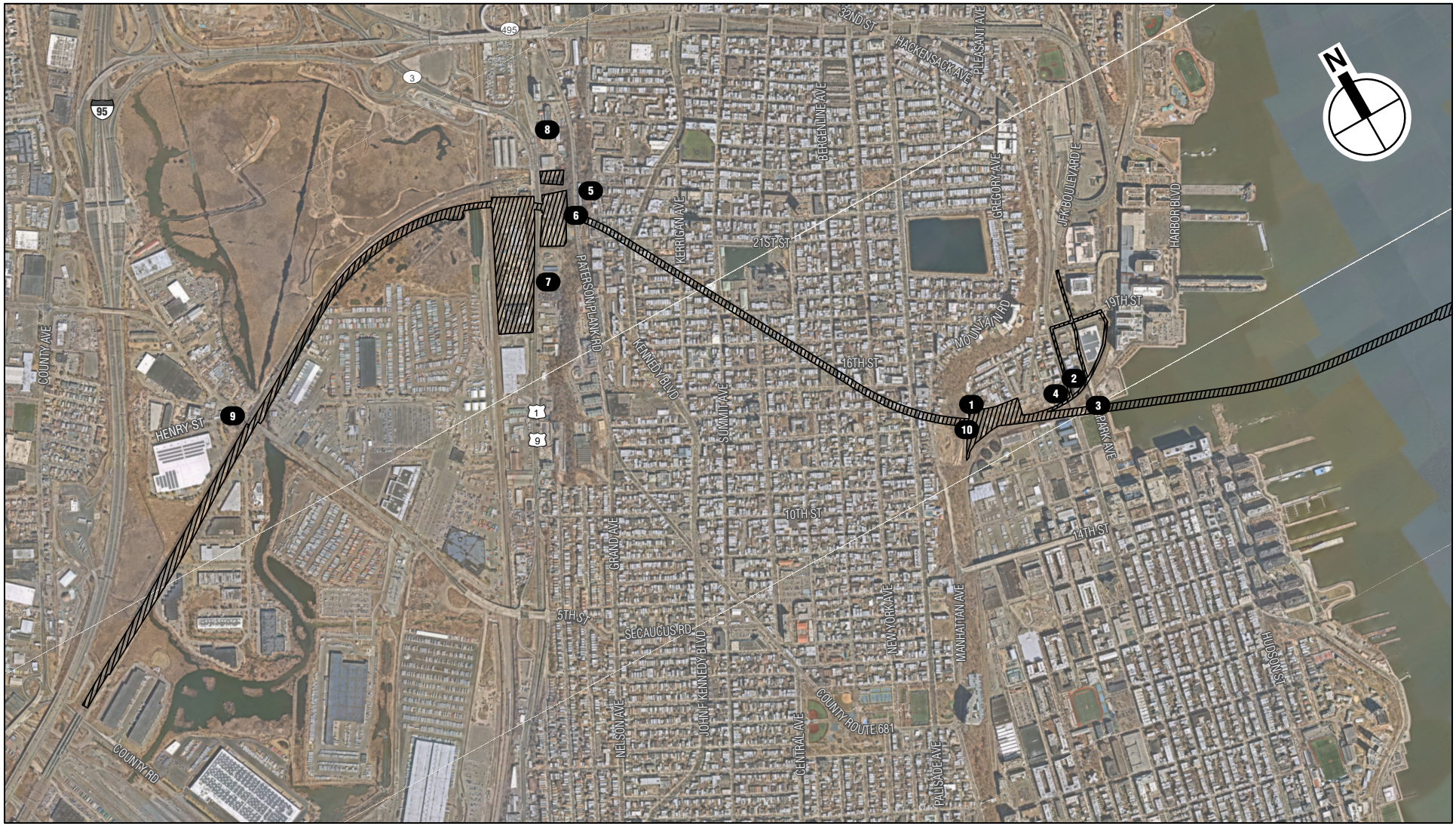

Project Site

1 *Vibration Receptor*

HUDSON TUNNEL PROJECT

New Jersey Vibration Receptor Locations

Figure 12B-1

12B.3.2 HUDSON RIVER

There are no vibration receptors within the Hudson River that would have the potential to experience adverse impacts as a result of the Preferred Alternative. The nearest upland area or structure to the work area within the river would be the bulkhead along the west side of Manhattan, approximately 700 feet to the east. At this distance, vibration produced by construction of the Preferred Alternative would not have the potential to result in damage, even to fragile structures. For discussion of construction noise and vibration effects on the in-water environment, please see Chapter 11, "Natural Resources," Section 11.6.3.1.3.

12B.3.3 NEW YORK

FRA and NJ TRANSIT identified residential receptors within the FTA guidance manual's vibration analysis screening distances from the Preferred Alternative. This included three locations in New York. These receptors are listed in **Table 12B-7** and shown in **Figure 12B-2**.

Table 12B-7
Vibration Receptor Locations in New York

Receptor*	Location	Distance/Relation to Vibration Source
10	606 West 30th St	45 feet above and 55 feet southeast of new tunnel; 55 feet from Twelfth Avenue shaft
11	High Line Park	45 feet above new tunnel; 45 feet from Twelfth Avenue shaft
12	Hudson River Park	65 feet above new tunnel

Note: * See **Figure 12B-2** for locations.

12B.4 AFFECTED ENVIRONMENT: FUTURE CONDITIONS

In the future, absent implementation of the Preferred Alternative, train traffic on the NEC will increase slightly during off-peak periods and rail speed will remain constant for National Railroad Passenger Corporation (Amtrak) and NJ TRANSIT trains. This will result in a slight increase in the frequency of vibration events at some of the receptors included in the analysis.

In addition, by the 2033 analysis year, a number of private development and public infrastructure projects will occur in the Project vicinity in New Jersey and New York. These include the PANYNJ's Lincoln Tunnel Helix Replacement Program in Weehawken, New Jersey; Hudson County's rehabilitation of the Willow Avenue bridge over the Hudson-Bergen Light Rail (HBLR) in Hoboken and Weehawken, New Jersey; the Rebuild By Design project in Hoboken, New Jersey, and ongoing large-scale waterfront redevelopment within the Lincoln Harbor Redevelopment Area just north of Weehawken Cove, in Weehawken, New Jersey. There will also be numerous new developments in the New York study area, including new development on the same block as the proposed Twelfth Avenue staging area—the block between West 29th and West 30th Streets, Eleventh and Twelfth Avenues (Manhattan Block 675). At the east end of the block, two private developers are constructing new high-rise, predominantly residential buildings for completion in 2022.

12B.5 IMPACTS OF NO ACTION ALTERNATIVE

Under the No Action Alternative, construction of the Preferred Alternative would not occur. The No Action Alternative would not include major sustained construction, and the typical maintenance of the North River Tunnel under the No Action Alternative would also not have the potential to result in adverse vibration impacts.

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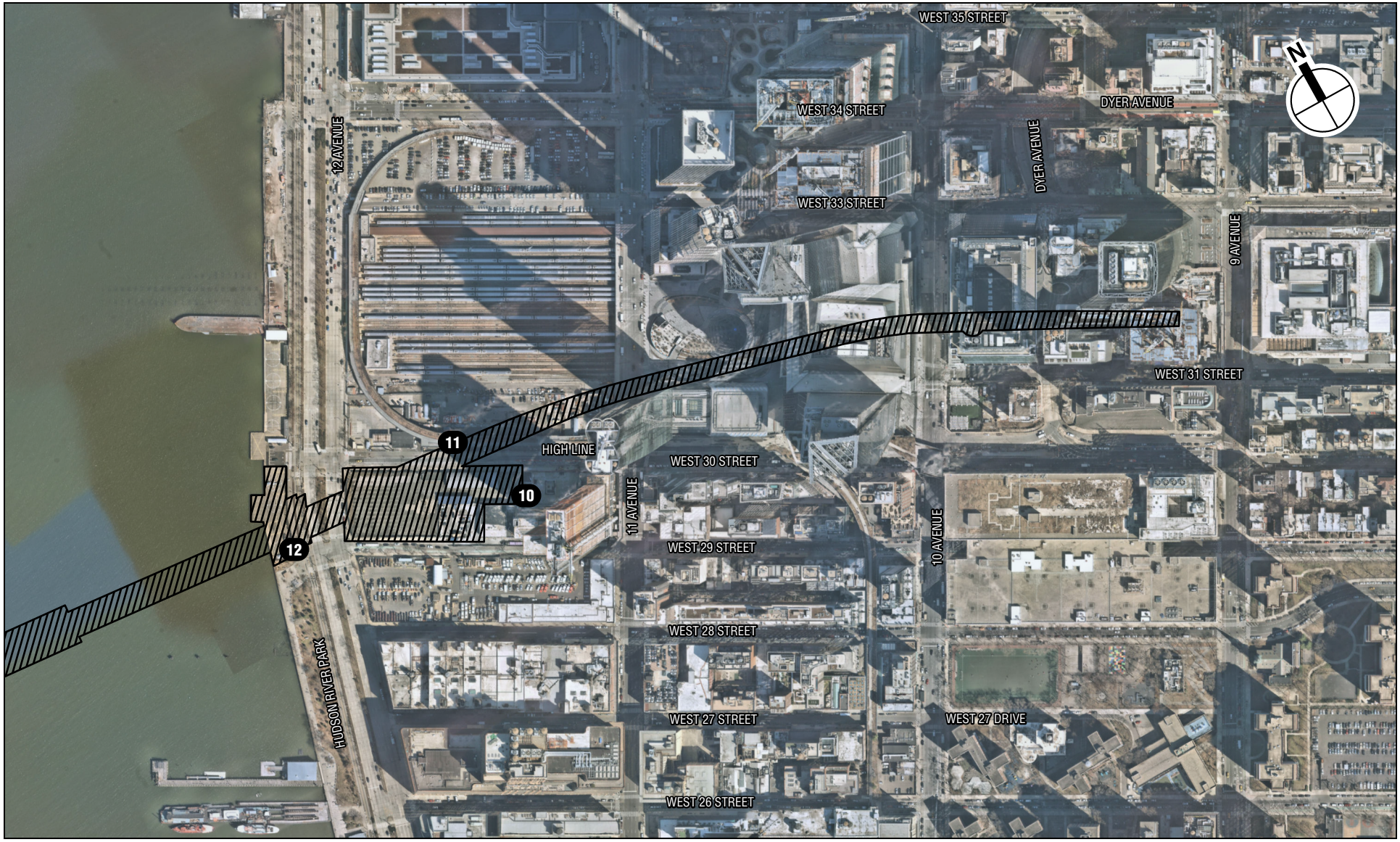

Project Site

10 *Vibration Receptor*

HUDSON TUNNEL PROJECT

New York Vibration Receptor Locations

Figure 12B-2

12B.6 CONSTRUCTION IMPACTS OF THE PREFERRED ALTERNATIVE

12B.6.1 OVERVIEW

Construction of the Preferred Alternative would include construction of the new tracks, portal, tunnel, and fan plants for the new Hudson River Tunnel alignment south of the existing North River Tunnel, as well as the rehabilitation of the existing North River Tunnel, as described in detail in Chapter 2, "Project Alternatives and Description of the Preferred Alternative." Collectively, the construction activities associated with the Preferred Alternative, as described in detail in Chapter 3, "Construction Methods and Activities," would have the potential to result in vibration along the construction alignments, and at the various staging areas used to facilitate construction of the Preferred Alternative.

Construction vibration could potentially be generated by operation of on-site construction equipment. FRA and NJ TRANSIT examined the potential effects of these sources in the vibration analyses described below.

12B.6.2 NEW JERSEY

Construction-related vehicles including worker vehicles and/or materials and equipment deliveries generally do not have the potential to result in vibration levels that could result in building damage and/or human annoyance and consequently do not typically result in adverse construction vibration impacts. However, equipment operating within the Project area and/or in construction staging areas could potentially produce vibration levels that result in damage and/or annoyance. The equipment used in construction of the Preferred Alternative that would have the greatest potential to result in elevated vibration levels include impact and vibratory pile drivers, pile drilling rigs, and earth-moving equipment such as bulldozers. Vibration levels produced by these pieces of equipment are shown in **Table 12B-3**. Based on the general vibration analysis techniques described in the FTA guidance manual, for each construction work area, FRA and NJ TRANSIT determined the maximum vibration levels produced by the equipment used in that area for the nearest receptor locations and compared them to the vibration evaluation criteria shown above in **Table 12B-2** for human annoyance and **Table 12B-5** for potential building damage.

12B.6.2.1 SURFACE ALIGNMENT CONSTRUCTION

The nearest vibration receptor to the construction work area for the surface alignment construction between Secaucus and the new tunnel portal would be the residences on Henry Street (near Secaucus Road on the north side of the NEC), which is receptor 8. This receptor is approximately 110 feet from the nearest point of the construction work area. Impact pile driving would occur within this work area and would have the greatest potential to produce high levels of vibration. Pile driving within this work zone would produce approximately 0.164 inches per second PPV and 93 VdB at this receptor when it is occurring at its closest point to the receptor. This vibration would be perceptible and would exceed the threshold for human annoyance from vibration, although it would not have the potential to result in damage to the buildings. Vibration resulting from pile driving would exceed the threshold for potential human annoyance at the Henry Street residences any time that it occurred within approximately 550 feet of the residences, which constitutes less than 1/5 of the total area of pile driving for the surface and on-structure track construction. Since the pile driving would not result in vibration at a level that could potentially result in damage to the buildings on Henry Street and because it would result in potentially annoying vibration only over a very limited portion of the construction activity, it would not have the potential to result in an adverse construction vibration impact. At other receptors further from the work area than the Henry

Street residences, vibration levels would be lower and would also not constitute adverse vibration impacts.

12B.6.2.2 CONSTRUCTION OF NEW TUNNEL AND RELATED ELEMENTS AT THE TONNELLE AVENUE STAGING AREAS

The nearest vibration receptor to the construction work area for the new tunnel portal, Tonnelle Avenue underpass, and associated construction staging areas would be the residences on Paterson Plank Road, which is receptor 6 (approximately 345 feet from the nearest point of the construction work area), and the religious use at 2000 Tonnelle Avenue, which is receptor 7 (approximately 620 feet from the tunnel portal and 115 feet from the staging area on Tonnelle Avenue). Pile installation would occur within the work area at the tunnel portal and would have the greatest potential to produce high levels of vibration. General staging activities would occur in the staging area on Tonnelle Avenue potentially including the use of bulldozers. Pile driving within this work zone would produce approximately 0.014 inches per second PPV and 71 VdB at receptor 6 when it would occur at its closest point to the receptor. General construction staging activity would produce approximately 0.009 inches per second PPV and 67 VdB at receptor 7 when it would occur at its closest point to the receptor. These levels of vibration would be perceptible but would not exceed the threshold for human annoyance from vibration nor would they have the potential to result in damage to the buildings. At other receptors further from the work area than these receptors, vibration levels would be lower and would also not constitute adverse vibration impacts. Consequently, construction at the tunnel portal, Tonnelle Avenue underpass, and associated staging areas would not have the potential to result in adverse construction vibration impacts.

12B.6.2.3 HOBOKEN STAGING AREA

The nearest vibration receptors to the construction work area for the Hoboken shaft and fan plant and associated construction staging area would be the residences north of West 18th Street in Weehawken, represented by receptor 1, and the future residential development currently under construction at 1300 Manhattan Avenue in Union City, represented by receptor 10.

Receptor 1 is approximately 120 feet from the nearest point of the Hoboken shaft work area. Augured pile installation would occur within this work area and would have the greatest potential to produce high levels of vibration. Pile installation within this work zone would produce approximately 0.008 inches per second PPV and 67 VdB at this receptor when it is occurring at its closest point to the receptor. This vibration would be barely perceptible and would neither exceed the threshold for human annoyance from vibration nor have the potential to result in damage to the buildings. These projected vibration effects at this receptor are much lower than those discussed in the DEIS because FRA and NJ TRANSIT revised the analysis to reflect that the Project Sponsor will avoid impact pile driving for installation of the piles, since it produces much more vibration than augured pile installation.

Receptor 10 represents the new residential development at 1300 Manhattan Avenue in Union City that is currently under construction approximately 100 feet west of the Hoboken shaft. Augured pile installation would occur at the Hoboken staging area, and would be the construction activity that would have the greatest potential to produce high levels of vibration. The pile installation would produce approximately 0.011 inches per second PPV and 69 VdB at receptor 10 when the pile installation is occurring at its closest point to the receptor. This vibration would be barely perceptible and would not exceed the threshold for human annoyance from vibration or have the potential to result in damage to the buildings. In the absence of detailed design information for this residential development, the analysis in this chapter is based on a conservative assumption that the residential receptors would be located on the lot line immediately adjacent to the Hoboken shaft work area. If the completed residences are farther from the lot line, vibration levels at the residences would be lower than described in this chapter.

At other receptors farther from the Hoboken shaft work area than these residences, vibration levels would be lower and would also not constitute adverse impacts.

In addition to pile installation at the Hoboken shaft site, drilled piles would be installed under the Willow Avenue bridge over the HBLR right-of-way in proximity to the residential building at 1700 Park Avenue, (receptor 2). This building, at a distance of approximately 215 feet from the pile installation area, would experience a maximum of approximately 0.004 inches per second PPV and 59 VdB when pile drilling is occurring at the closest point to the residence. This vibration would be imperceptible to barely perceptible and would not exceed the threshold for human annoyance from vibration nor have the potential to result in damage to the buildings.

The future Rebuild By Design flood wall along Park Avenue in Weehawken would be above the new tunnel alignment for the Preferred Alternative, and would have structural elements extending as deep as approximately 40 to 100 feet above the new tunnel alignment. As the tunnel boring machine (TBM) moves along the tunnel alignment, it has the potential to result in vibration at receptors above. Predicted levels of vibration for the TBM presented in Chapter 5.07 of the Access to the Region's Core (ARC) FEIS, which is incorporated by reference into this analysis, are representative of those that would occur from TBM work associated with the Preferred Alternative, since the tunnel mining operations included in the Preferred Alternative are essentially identical to those included in the ARC Project as studied in the FEIS.[1] The ARC FEIS vibration analysis indicates that the largest diameter TBM (8 meters) at the most shallow depth (16 feet) in bedrock would produce a PPV of 0.319 inches per second. This level of vibration would not have the potential to result in structural damage to a newly constructed flood protection wall. Furthermore, since the TBM typically progresses at a pace of approximately 30 to 35 feet per day, the vibration would not last for more than two days at most at this location. Consequently, vibration from the TBM does not have the potential to result in an adverse construction vibration impact at this location.

At other receptors farther from the work area than the West 18th Street, Chestnut Avenue, and Willow Avenue residences, vibration levels would be lower and would also not constitute adverse vibration impacts.

12B.6.2.4 TUNNEL BORING MACHINE OPERATION ALONG THE TUNNEL ALIGNMENT

As the TBM moves along the tunnel alignment, it has the potential to result in vibration at receptors above. Predicted levels of vibration for the TBM presented in Chapter 5.07 of the ARC FEIS are representative of those that would occur from TBM work associated with the Preferred Alternative, since the tunnel mining operations included in the Preferred Alternative are essentially identical to those included in the ARC Project as studied in the FEIS. The FEIS vibration analysis indicates that the largest diameter TBM (8 meters) at the most shallow depth (16 feet) in bedrock would produce a PPV of 0.319 inches per second. This level of vibration would not have the potential to result in building damage, but may be perceptible and annoying to humans in buildings directly over the tunnel alignment. However, since the TBM typically progresses at a pace of approximately 30 to 35 feet per day, the perceptible vibration does not last for more than at most

[1] The ARC Project was an initiative proposed by NJ TRANSIT to increase passenger rail capacity into Midtown Manhattan. FTA and NJ TRANSIT conducted detailed studies and design for the ARC Project from 1995 through 2010, including a Draft, Supplemental Draft, and Final EIS, as well as supplemental studies after completion of the FEIS in support of that project's construction. The ARC Project was cancelled in 2010 shortly after initial construction had begun. Additional information on the ARC Project is provided in Chapter 1, "Purpose and Need," Section 1.2.1. This analysis incorporates the vibration analyses from that study, which were provided in the FEIS, October 2008, Chapter 5.2 and Appendix 5.7. Those analyses are provided in Appendix 12 of this FEIS.

two days at any one receptor. At deeper portions of the tunnel alignment, vibration levels would be substantially lower. Consequently, vibration from the TBM does not have the potential to result in an adverse construction vibration impact.

12B.6.2.5 NORTH RIVER TUNNEL REHABILITATION

The nearest vibration receptor to the construction work area for rehabilitation of the North River Tunnel would be the hotel on Tonnelle Avenue, receptor 8. This receptor is approximately 580 feet from the nearest point of the construction work area. Use of a hydraulic demolition hammer would occur within this work area and would have the greatest potential to produce high levels of vibration. Pile driving within this work zone would produce approximately 0.001 inches per second PPV and 46 VdB at this receptor when it is occurring at its closest point to the receptor. Additionally, the maximum vibration-producing activity that would occur within the North River Tunnel would be demolition of the bench walls using jackhammers. At the shallowest point of the tunnel below a receptor (i.e., approximately 80 feet), this activity would produce approximately 0.006 inches per second PPV and 64 VdB at the receptor immediately above. These vibration levels would not be perceptible and would not exceed the threshold for human annoyance from vibration nor have the potential to result in damage to the buildings. At other receptors further from the work area than the Tonnelle Avenue hotel or residences immediately above the tunnel, vibration levels would be lower and would also not constitute adverse vibration impacts. Consequently, repair and restoration of the North River Tunnel would not have the potential to result in adverse construction vibration impacts.

12B.6.3 NEW YORK

Construction-related vehicles including worker vehicles and/or materials/equipment deliveries generally do not have the potential to result in vibration levels that could result in building damage and/or human annoyance and consequently do not typically result in adverse construction vibration impacts. However, equipment operating within the Project area and/or in construction staging areas could potentially produce vibration levels that result in damage and/or annoyance. The equipment used in construction of the Preferred Alternative that would have the greatest potential to result in elevated vibration levels include pile drilling rigs, and earth-moving equipment such as bulldozers. Vibration levels produced by these pieces of equipment are shown in **Table 12B-3**, above. Based on the general vibration analysis techniques described in the FTA guidance manual, for each construction work area, the maximum vibration levels produced by the equipment used in that area were determined for the nearest receptor locations and compared to the vibration evaluation criteria shown above in **Table 12B-2** for human annoyance and **Table 12B-5** for potential building damage.

12B.6.3.1 MANHATTAN WATERFRONT AREA

The nearest vibration receptors to the construction Manhattan waterfront work area (i.e., from the Hudson River to Twelfth Avenue between West 29th and West 30th Streets) would be Hudson River Park and the High Line, receptors 12 and 11, respectively. As described in Chapter 3, “Construction Methods and Activities,” Section 3.3.6, the Project Partners are evaluating two potential construction methods for ground improvement in this area prior to boring the tunnel with TBMs. With the use of vertical ground freezing, construction activity in this work area would consist primarily of ground freezing followed by tunneling with TBMs, neither of which would have the potential to result in substantial levels of vibration. With the use of Sequential Excavation Method (SEM) mining together with ground freezing, construction activity in this work area would include construction of a shaft at the Manhattan waterfront in the Hudson River Park heliport area, SEM construction, spoils removal, and backfilling. This construction would include drilled pile installation, which would be the construction activity with the greatest potential to produce vibration in this area. At a distance of 21 feet from pile installation, projected vibration levels would be below

the FTA criteria for damage to structures. As there are no structures located within 21 feet of this work area, construction would not have the potential to result in adverse vibration impacts at these receptors or others. In addition, as described in Chapter 9, "Historic and Archaeological Resources," monitoring will be implemented at the Hudson River bulkhead in Hudson River Park to monitor the structure for movement/tilt and settlement during construction of the new tunnel.

At other receptors farther from the work area than Hudson River Park or the High Line, vibration levels would be lower and would also not constitute adverse impacts.

12B.6.3.2 TWELFTH AVENUE SHAFT AND FAN PLANT

The nearest vibration receptor to the construction work area for the Twelfth Avenue shaft and fan plant and associated construction staging area would be the future residence in construction at 606 West 30th Street (as well as the adjacent future residence at 601 West 29th Street) and the High Line, receptors 10 and 11, respectively. The nearest point of the 606 West 30th Street receptor is approximately 55 feet from the nearest point of the construction work area and the nearest point of the High Line is approximately 45 feet from the nearest point of the construction work area. Pile installation would occur within this work area and would have the greatest potential to produce high levels of vibration.

Augured pile installation within this work zone would produce approximately 0.027 inches per second PPV and 76 VdB at 606 West 30th Street when it is occurring at its closest point to the receptor. This vibration would be perceptible and would exceed the threshold for human annoyance from vibration, although it would not have the potential to result in damage to the building. Vibration resulting from pile installation would exceed the threshold for potential human annoyance at 606 West 30th Street within approximately 80 feet of the receptor, which would include approximately half of the Twelfth Avenue shaft site. Pile installation would occur for a total of four months at the Twelfth Avenue shaft, and during about two months of that time, vibration from augured pile installation would produce vibration levels that would exceed the threshold for potential annoyance at this receptor. Based on the conceptual Project construction schedule FRA and NJ TRANSIT evaluated in this FEIS, this work would occur after the 2022 completion date for the new residential buildings at 606 West 30th Street and 601 West 29th Street. The pile installation would produce vibration levels exceeding the human annoyance threshold for up to approximately two months. Since the pile installation would result in potentially annoying vibration only over a limited duration, it would not have the potential to result in an adverse construction vibration impact at 606 West 30th Street or the adjacent building at 601 West 29th Street.

Pile installation within this work zone would have the potential to produce up to approximately 0.038 inches per second PPV and 80 VdB at the High Line when it is occurring at its closest point to the receptor. As described in Chapter 9, "Historic and Archeological Resources," Section 9.6.3.1.3, the High Line is a historic structure and the Project Sponsor will develop and implement a Construction Protection Plan (CPP) for construction activities near the High Line to protect it from accidental damage during construction of the Preferred Alternative. Consequently, construction of the Preferred Alternative would not have the potential to produce vibration levels at the High Line that would damage the structure.

Vibration resulting from pile installation would exceed the threshold for potential human annoyance at portions of the High Line within approximately 65 feet of non-impact pile installation activity, which would be a very small portion of the full extent of the High Line. Furthermore, at an urban outdoor open space area, people would typically be less sensitive to vibration than in a residence. Vibration at this receptor would not have the potential to result in structural damage due to the implementation of a CPP. The High Line is a linear park where people can walk a short distance to avoid the annoyance from construction vibration. Consequently, the predicted level of vibration would not have the potential to result in an adverse construction vibration impact.

At other receptors farther from the work area than 606 West 30th Street or the High Line, vibration levels would be lower and would also not constitute adverse impacts.

12B.6.3.3 WEST 30TH STREET CUT-AND-COVER EXCAVATION

As discussed in Chapter 3, "Construction Methods and Activities," Section 3.3.8, excavation for the new tunnel in West 30th Street could include cut-and-cover construction, as described and evaluated in the DEIS, or a second option for the construction using underground SEM mining.

If cut-and-cover excavation is used at West 30th Street, some pile installation would be required using impact pile driving. In that case, the pile driving is the construction activity that would have the greatest potential to produce vibration. Pile driving within this work zone would produce approximately 0.453 inches per second PPV and 101 VdB at 606 West 30th Street when the pile driving is occurring at its closest point to the receptor. This vibration would be perceptible and would exceed the threshold for human annoyance from vibration, although it would not have the potential to result in damage to the building. Vibration resulting from pile driving would exceed the threshold for potential human annoyance at 606 West 30th Street and the adjacent 601 West 29th Street residential building within approximately 550 feet of the receptor, which would constitute all of the West 30th Street construction zone. This would occur for approximately seven months. Given this relatively short duration, the vibration associated with the pile driving would not constitute an adverse impact at 606 West 30th Street or the adjacent building at 601 West 29th Street.

Pile driving within this work zone would have the potential to produce up to approximately 1.97 inches per second PPV and 114 VdB at the High Line when it is occurring at the closest point, approximately 21 feet away. Impact pile driving during cut-and-cover excavation would have a duration of approximately seven months. The High Line is a steel structure, which would have a damage criterion of 0.5 in/sec according to the FTA guidance manual. As noted earlier, the Project Sponsor will develop and implement a CPP to protect the High Line from accidental damage during construction of the Preferred Alternative. Consequently, construction of the Preferred Alternative would not have the potential to produce vibration levels at the High Line that would damage the structure.

Vibration resulting from pile installation would exceed the threshold for potential human annoyance at portions of the High Line within approximately 425 feet of impact pile driving, which would be a very small portion of the full extent of the High Line.

At other receptors farther from the work area than 606 West 30th Street or the High Line, vibration levels associated with impact pile driving in West 30th Street would be lower and would also not constitute adverse impacts.

12B.7 PERMANENT IMPACTS OF THE PREFERRED ALTERNATIVE

12B.7.1 OVERVIEW

The Preferred Alternative would consist of a new two-track tunnel, parallel to the North River Tunnel, extending from the NEC in Secaucus, New Jersey, beneath the Palisades (North Bergen and Union City) and the Hoboken waterfront area, and beneath the Hudson River to connect to the existing approach tracks at Penn Station New York (PSNY). The new Hudson River Tunnel and the rehabilitated North River Tunnel would incorporate a low-vibration track system, which would reduce the potential noise and vibration from train operations. Potential sources of vibration included in the Preferred Alternative would be the same surface and on-structure track in New

Jersey as well as the new Hudson River Tunnel. FRA and NJ TRANSIT examined the potential effects of these sources in the noise and vibration analyses described below.

At each of the vibration receptor sites identified and described in Section 12B.3 above, FRA and NJ TRANSIT calculated vibration levels resulting from rail operations included in the Preferred Alternative for the nearest Project element (i.e., surface or on-structure rail tracks or the new tunnel). FRA and NJ TRANSIT compared the calculated vibration levels at each receptor to FTA's vibration impact criteria to identify potential impacts.

12B.7.2 NEW JERSEY

As described above, there are receptors located within the screening distance from the Preferred Alternative; therefore, a general vibration analysis was conducted for the Preferred Alternative. Two residential receptors and a recording studio in New Jersey were identified for this general analysis methodology. FRA and NJ TRANSIT added consideration of the recording studio to this analysis in response to comments received on the DEIS. FRA and NJ TRANSIT calculated vibration levels resulting from rail activity with the Preferred Alternative for these receptors using the general vibration assessment methodology previously described. Receptors 4 and 5 are proximate to the proposed new tunnel alignment included in the Preferred Alternative but not the existing rail alignment. Receptor 9 is proximate to the existing NEC rail alignment, on which the frequency of rail activity in the existing condition or with the No Action Alternative would fall into the "frequent events" category as described above in **Table 12B-2**. At receptors 4, 5, and 9, the frequency of rail activity in Preferred Alternative would fall into the "frequent events" category. For receptor 4, which represents a recording studio, the impact thresholds for "recording studios" as indicated in **Table 12B-3** were used, including a 65 VdB vibration impact threshold and a 25 dBA ground-borne noise threshold. At receptors 5 and 9, the vibration impact threshold is 72 VdB and the ground-borne noise impact threshold is 35 dBA for category 2 uses (i.e., residences). **Table 12B-8** shows the results of the general vibration assessment for receptors in New Jersey.

Table 12B-8
New Jersey Operational
Vibration and Ground-Borne Noise Analysis Results

Receptor	Alternative	Vibration Levels (VdB)			Ground-Borne Noise Levels (dBA)		
		Impact Threshold	Rail-Generated Level	Impact?	Impact Threshold	Rail-Generated Level	Impact?
4 1806 Park Ave, Weehawken	Existing	65	n/a	No Impact	25	n/a	No Impact
	No Action	65	n/a	No Impact	25	n/a	No Impact
	Preferred	65	59	No Impact	25	9	No Impact
5 2215 Grand Ave, North Bergen	Existing	72	n/a	No Impact	35	n/a	No Impact
	No Action	72	n/a	No Impact	35	n/a	No Impact
	Preferred	72	70	No Impact	35	20	No Impact
6 2200 Paterson Plank Rd, North Bergen	Existing	72	n/a	No Impact	35	n/a	No Impact
	No Action	72	n/a	No Impact	35	n/a	No Impact
	Preferred	72	71	No Impact	35	21	No Impact
9 Henry St (near Secaucus Rd on north side of NEC), Secaucus	Existing	72	85	Moderate Impact	35	35	Moderate Impact
	No Action	72	85	Moderate Impact	35	35	Moderate Impact
	Preferred	72	83	Moderate Impact	35	33	No Impact

As shown in **Table 12B-8**, the calculated vibration and ground-borne noise levels resulting from rail activities associated with the Preferred Alternative would be less than the impact thresholds at receptors 4 and 5. These receptor locations represent the closest sensitive locations in New Jersey to the new tunnel included in the Preferred Alternative. At other locations and other sensitive receptors that are farther from the tunnel, vibration and ground-borne noise levels would be lower and consequently would also not exceed the vibration impact threshold.

Also as shown in **Table 12B-8**, the calculated ground-borne noise level resulting from rail activities associated with the Preferred Alternative would be less than the impact thresholds at receptor 9. However, the calculated levels of vibration resulting from rail activity would constitute moderate impacts in the existing condition, No Action Alternative, and Preferred Alternative. The Preferred Alternative would not result in changes to train volume or speed as compared to the No Action Alternative. Since the Preferred Alternative would not have the potential to increase vibration levels at this receptor, the vibration levels in the "moderate impact" range would not constitute an adverse impact.

Consequently, the Preferred Alternative would not result adverse vibration or ground-borne noise impacts at receptors in New Jersey.

12B.7.3 NEW YORK

As described above in Section 12B.3.1, there are receptors located within the screening distance from the Preferred Alternative; therefore, FRA and NJ TRANSIT conducted a general vibration analysis for the Preferred Alternative and identified one residential receptor in Manhattan.

FRA and NJ TRANSIT calculated vibration levels resulting from rail activity with the Preferred Alternative for these receptors using the general vibration assessment methodology described in Section 12B.2.3.2. At receptor 10, which is proximate to the new tunnel included in the Preferred Alternative but not the existing rail alignment, the frequency of rail activity in Preferred Alternative would fall into the "frequent events" category as described above in **Table 12B-2**. Consequently, the vibration impact threshold is 72 VdB and the ground-borne noise impact threshold is 35 dBA for category 2 use (i.e., residences). **Table 12B-9** shows the results of the general vibration assessment for receptors in New York.

Table 12B-9
New York Operational
Vibration and Ground-Borne Noise Analysis Results

Receptor		Alternative	Vibration Levels (VdB)			Ground-Borne Noise Levels (dBA)		
			Impact Threshold	Rail-Generated Level	Impact?	Impact Threshold	Rail-Generated Level	Impact?
10	606 West 30th St	Existing	72	n/a	No Impact	35	n/a	No Impact
		No Action	72	n/a	No Impact	35	n/a	No Impact
		Preferred	72	68	No Impact	35	18	No Impact

As shown in **Table 12B-9**, the calculated vibration and ground-borne noise levels resulting from rail activities associated with the Preferred Alternative would be less than the impact thresholds at the analyzed receptor. This receptor location represents the closest sensitive location in New York to the rail right-of-way. At other locations and other sensitive receptors, which would be located further from the railway, vibration and ground-borne noise levels would be lower and consequently would also not exceed the vibration impact threshold. Consequently, the Preferred Alternative would not result adverse vibration or ground-borne noise impacts at any receptors in New York.

12B.8 CONCLUSIONS

The construction vibration analysis found that vibration resulting from construction of the Preferred Alternative may result in noticeable levels of vibration, but the vibration would occur over only a limited period of time or would not rise to the level of an adverse impact.

The general vibration and ground-borne noise analysis conducted according to FTA guidance found that there would be no potential for exceedances of the vibration or ground-borne noise impact criteria. Based on the conclusion that the Preferred Alternative would not have the potential to result in adverse impacts relating to airborne noise, vibration, or ground-borne noise at any of the analyzed receptor sites, and that these receptor sites represent the sites closest to the Project site and would thus have the greatest potential to experience vibration impacts as a result of the Preferred Alternative, the Preferred Alternative would not result in any adverse impacts related to vibration upon completion.

12B.9 MEASURES TO AVOID, MINIMIZE, AND MITIGATE IMPACTS

The Project Sponsor will implement the following measures to avoid, minimize, and mitigate potential adverse noise impacts of the Project. The lead Federal agency will be responsible for ensuring that the Project Sponsor implements these measures, which will be identified in the ROD.

12B.9.1 COMMUNITY OUTREACH

- At each construction site, the Project Sponsor will implement a comprehensive, active and responsive community outreach program during construction that will include a staffed local neighborhood outreach office; a dedicated Project liaison who will coordinate with the community about construction activities, address concerns, and work with the community to accommodate special events where possible; a 24-hour hotline for emergencies and construction complaints; and regular meetings and notifications about construction status and upcoming activities.
- During construction, the Project Sponsor will coordinate construction activities with affected municipalities in New Jersey, New York City, and nearby property owners to schedule construction to avoid or minimize adverse impacts where practicable.
- A vibration complaint procedure will be established to promptly address community concerns and implement additional control methods where necessary.

12B.9.2 BLASTING CONTROLS

- Blasting will be conducted using controlled blasting techniques, including timed multiple charges; covering the area where blasting is being conducted with blast mats to control fly rock; and pre-auguring the rock, where possible.
- Blasting in New Jersey will not be conducted after 6 PM except under special circumstances and only with permission from the appropriate local regulatory agency (i.e., North Hudson Regional Fire and Rescue). The Project Sponsor will provide advance notice of blasting events nearby to residents. This includes residents of Paterson Plank Road and Grand Avenue in North Bergen, New Jersey near the tunnel portal and tunnel alignment and residents of the Shades neighborhood in Weehawken near the Hoboken shaft site.
- Blasting activities in Manhattan will not occur after 7 PM except under special circumstances and only with permission from the Fire Department of the City of New York (FDNY). A blasting schedule will be provided to neighboring building owners and occupants. The areas of

potential blasting are limited to rock removal at the tunnel section crossing beneath Tenth Avenue and re-grading the track in A Yard.

12B.9.3 PILE INSTALLATION

- The Project Sponsor will use drilled piles rather than driven piles for installation of piles at the Hoboken staging area and for underpinning of the Willow Avenue bridge over the HBLR right-of-way in Hoboken and Weehawken, New Jersey, to the extent practicable.
- The Project Sponsor will use drilled piles rather than driven piles for installation of piles at the Twelfth Avenue shaft site in Manhattan, New York, to the extent practicable.

12B.9.4 VIBRATION MONITORING PROGRAM

- The Project Sponsor will implement a vibration monitoring program within the area of potential influence of the construction to monitor impacts of construction vibration and ground movement, to protect nearby structures from accidental damage during construction. To account for the variable ground conditions and different construction activities that would occur, the vibration monitoring program will be implemented within an approximately 200-foot distance from the Project construction. In addition, although the three Hudson Tea Buildings on Hudson Street in Hoboken are at a greater distance (approximately 260 feet at the closest point), given their size and historic nature, the Project Sponsor will monitor these buildings as part of the vibration monitoring plan.
- The vibration monitoring program would include the following:
  - A preconstruction survey of buildings in the Project's construction area of influence for potential vibration concerns. Monitoring procedures and instrumentation to be installed on adjacent properties will be coordinated with each property owner.
  - Monitoring of structures within this area during construction. During construction, copies of monitoring data will be made available to the property owners. Where instrumentation identifies excessive vibration and/or ground movement that exceeds established thresholds, the construction activities will be examined and the construction approach altered to minimize further movements. Also, in any areas where vibration or ground movement exceeds threshold values, the properties will be re-surveyed to document potential construction impacts.
  - Upon completion of construction activities within an area, the Project Sponsor will perform post-condition surveys and compare them with the pre-construction survey information to determine if damage has occurred, in concurrence with the property owner. Where construction operations cause damage to adjacent properties, the Project Sponsor will promptly repair or replace damaged items to the condition that existed before the damage, to the satisfaction of each adjacent property owner, at no cost to the property owner.

12B.9.5 CONSTRUCTION PROTECTION PLANS

- The Project Sponsor will develop CPPs for the protection of historic architectural resources located in proximity to Project construction prior to any Project demolition, excavation, and construction activities. The CPPs will include provisions for vibration monitoring, adherence to vibration limit thresholds, measures to reduce vibration levels, and modification of construction methods if necessary.

12B.9.6 OPERATION OF THE PREFERRED ALTERNATIVE

- The new Hudson River Tunnel and the rehabilitated North River Tunnel would incorporate a low-vibration track system, which would reduce the potential noise and vibration from train operations. ✷